Shannon Technology and Energy Park

Natura Impact Statement (NIS)

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Shannon Technology and Energy Park

Screening Statement for Appropriate Assessment

and Natura Impact Statement

Volume 1 – Main Report

Prepared by

AQUAFACT International Services Ltd

On behalf of

Shannon LNG Ltd

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1. Introduction

This *Screening Statement for Appropriate Assessment and Natura Impact Statement* (Screening Statement for AA and NIS) has been prepared by AQUAFACT International Services Limited (AQUAFACT) to accompany a Strategic Infrastructure Development (SID) application by Shannon LNG Limited (Shannon LNG) for statutory approval for the Shannon Technology and Energy Park (STEP) development to An Bord Pleanála (ABP) and a foreshore licence amendment application to the Department of Housing, Local Government and Heritage (DHLGH) for the STEP development. The application for the STEP development (the 'Proposed Development') is made under Section 37E of the Planning and Development Act 2000 (as amended). The line boundary of the Proposed Development is shown in **Figure 1-1.**

1.1. Overview of the Proposed Development

The STEP development consists of a Liquefied Natural Gas (LNG) Terminal and a Power Plant. The STEP development addresses Ireland's significant security of supply policy goals and provides additional flexible power generation capacity to support intermittent renewable generation and resolve a predicted generation capacity shortfall.

Ireland's Climate Action Plan[2], sets a target of 70% of electricity to be generated from renewable sources by 2030. It also commits to an early and complete phase-out of coal and peat-fired electricity generation. This leaves natural gas as being the only back up for intermittent wind generation at that point.

Despite its reliance on natural gas for renewable energy support, Ireland has very limited supply sources of natural gas. The country's sole gas field, Corrib, is rapidly declining by about 20% per year, resulting in a growing reliance on UK imports to meet its gas demand. Ireland currently imports over 50% of its gas needs from the UK via a single supply point and these imports will grow to over 80% by 2025 and 90% by 2030. The impact of losing this single gas supply from the UK has been assessed[3] by the Commission for Energy Regulation (CRU) as being *"disastrous"* for electricity production in Ireland.

Recently[4], the Minister for the Environment, Climate and Communications has also noted "*the UK has left the European Union which will lead, at the end of the withdrawal period, to difficulties for Ireland in meeting the requirements of EU law in relation to gas security of supply including potential challenges for future compliance with EU law including the "N-1" infrastructure standard and the supply standard*".

Consequently, Government polices clearly support the urgent need for the development. For example, the *National Energy & Climate Plan (NECP) 2021-2030* contains a policy goal to support natural gas infrastructure projects, such as the STEP development, that enhance Ireland's security of supply. Eirgrid's *All-Island Generation Capacity Statement 2020-2029* confirms the need for additional conventional power plants.

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[2] Climate Action Plan 2019. [Department of the Environment, Climate and Communications](). 17th June 2019

[3] Identification of National Electricity Crisis Scenarios for Ireland. CRU/20/138. Commission for energy regulation. 20/11/2020

[4] Request for Tenders dated 2 November 2020 for the provision of Consultancy Services to undertake a Technical Analysis to inform a Review of the Security of Energy Supply of Ireland's Electricity and Natural Gas Systems

The STEP development addresses Ireland's significant gas security of supply concerns and provides additional flexible power generation capacity to support intermittent renewable generation and resolve a predicted generation capacity shortfall.

The STEP development is to be located on a *circa* 200 acre site on the Shannon Estuary at Ralappane, between Tarbert and Ballylongford in Co. Kerry and accessed off the existing L-1010 (Coast Road). The line boundary of the Proposed Development site is shown in red in **Figure 1-1**.

The *Kerry County Development Plan 2015-2021* has zoned the site 'Industry' as part of the Tarbert/Ballylongford Land Bank, and more specifically for marine related industry and compatible industries requiring deep water access.

The Proposed Development consists of two main components:

1. Power Plant; and
2. LNG Terminal.

The proposed Power Plant will comprise of:

- A flexible modular Power Plant design with three (3) blocks of Combined Cycle Gas Turbines (CCGT), each block with a capacity of approximately 200 MW for a total installed capacity of up to 600 MW. The multishaft arrangement of the Power Plant provides fast acting response with very low minimum stable generation and is ideally suited to support increased intermittent renewable generation;
- Each block shall comprise of two (2) gas turbine generators, two (2) heat recovery steam generator and one (1) steam turbine generator and an air-cooled condenser; and
- A 120 MW for 1 hour (120 MWhr) Battery energy storage system (BESS). Due to its very fast response, the BESS supports intermittent renewable generation.

The proposed LNG Terminal will comprise of:

- A floating storage regasification unit (FSRU), which will have an LNG storage capacity of approximately 170,000 cubic metres (m^3) (up to 180,000 m^3). The LNG vaporisation process equipment to regasify the LNG to natural gas shall be on-board the FSRU. The heat for LNG regasification shall be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate. Loading of LNG onto the FSRU shall be via a ship to ship transfer from another LNG carrier (LNGC) berthed alongside;
- Jetty and access trestle, with the jetty comprising of an unloading platform, mooring dolphins and breasting dolphins with capacity to accommodate up to four tugs;
- Onshore facilities including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator, fire water system and
- An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, gas metering and pressure control equipment. The AGI facilitates the connection of the LNG Terminal to the consented 26 km Shannon Pipeline which was subject to a separate EIA.

Power Plant

The Power Plant will be a flexible multi-shaft design with three blocks of CCGT, each block with a nominal capacity of up to 200 MW for a total capacity of up to 600 MW. The Power Plant will use the following process:

In each 200 MW block: Two gas turbines burning natural gas will be connected to a generator for electricity production. Exhaust gases from the gas turbines will pass through heat recovery steam generators to generate steam at several different pressures. The steam generated will be routed through a steam turbine, which will also be connected to a generator to produce further electrical power. The spent steam exiting the steam turbine will then be directed into an air-cooled steam condenser. The resulting condensate will then be pumped back into the heat recovery steam generator to repeat the steam cycle.

The Power Plant will be located directly adjacent to the LNG Terminal. The multi-shaft arrangement of the Power Plant provides fast acting response with very low minimum stable generation and is ideally suited to support increased intermittent renewable generation. A 120 MW for 1-hour (120 MWhr) BESS shall also be included in the development. The BESS is comprised of 27 battery containers, approximately 4.5 MWh each, containing lithium ion batteries.

The Power Plant will generate power for its own needs and for the LNG Terminal, and for sale to the market via the national electricity grid which will be exported via the 220 kV connection (and is subject to a separate planning application). Natural gas will be supplied to the Power Plant from the nearby LNG Terminal. The Power Plant will use up to 2.8 million Sm^3 per day when operating at full capacity. The LNG Terminal will have sufficient capacity to supply gas requirements of the facility.

An application to connect to the national electrical transmission system via a 220 kV connection was submitted to EirGrid in September 2020. An offer has yet to be received. It is expected that the connection will run 5 km east under the L-1010 road to the Eirgrid Killpaddogue 220 kV substation. Once the connection offer is made, this 220 kV connection will be subject to a separate planning design and planning application.

The Power Plant will not be operational all year round. For example, during periods of high wind (renewable) generation it is expected that the Power Plant could be turned off by the system operator (Eirgrid) to give priority to renewable power. However, the LNG Terminal will need to be operational all year round. The LNG Terminal could also be operational before the Power Plant and the 220 kV grid connection are completed. Therefore, a medium voltage (10/ 20 kV) connection to supply power to the LNG Terminal in the absence of the 600 MW Power Plant will be required; however, this will be subject to a separate assessment and planning application. It is likely that the medium voltage connection will be via an underground cable route that will follow the L-1010 route in parallel with the 220 kV cables. An onsite back-up power generation, consisting of three 8 MW gas fired electricity generators will supply power to the LNG Terminal until the Power Plant is operational, in the absence of the 220 kV and medium voltage grid connections.

If the 220 kV and medium voltage (10/ 20 kV) grid connections are consented, these back-up power generators will be used as back-up power generation if the grid connections fails, or are unavailable.

The AGI will be capable of providing reverse flow fuel gas for both the 600 MW Power Plant and LNG Terminal back up power generators from the grid in the event that supply from the FSRU is interrupted.

LNG Terminal

The Proposed Development will supply up to 22.6 million Sm^3/d of natural gas to the Irish gas transmission system via the consented 26 km Shannon Pipeline (PL08.GA0003).

The FSRU will be up to 300 m long and up to 50 m wide, with LNG storage capacity of approximately 170,000 m^3 (up to 180,000 m^3). The FSRU stores LNG at a temperature of 163 degrees Celsius below zero (-163 ^oC) in cryogenic storage tanks. The cold temperature keeps the LNG in its liquid state until it is required to be supplied into the gas network.

Visiting LNG carriers, (LNGCs) will be berth alongside the FSRU to transfer LNG from the LNG carriers to the FSRU. Up to 60 LNGC visits per year are anticipated with unloading from the LNGC to the FSRU via ship-to-ship transfer estimated to take an average of 35 hours.

The FSRU will store the LNG as a liquid, and when required, return the LNG back into a gaseous state by heating the LNG using either seawater or gas-fired water heaters (a process known as regasification). Regasification will use an ‘open loop mode’, meaning that only the heat from the seawater will be used to regasify the LNG into a gaseous state. When the water temperatures are insufficient, the FSRU will operate in “combined loop” regasification mode where supplementary heat is provided by onboard gas fired seawater water heaters.

Following regasification, the natural gas will be transferred through gas piping along the jetty from the FSRU to the onshore facilities. The onshore facility may inject nitrogen into the gas to adjust its calorific value to ensure it complies with the Irish gas specifications. Following calorific adjustment, the gas shall then route to the Above Ground Installation (AGI) where metering, odorant injection and pressure adjustment shall occur before the gas enters the gas transmission network via the consented 26 km Shannon Pipeline that will be built between the Terminal and Foynes.

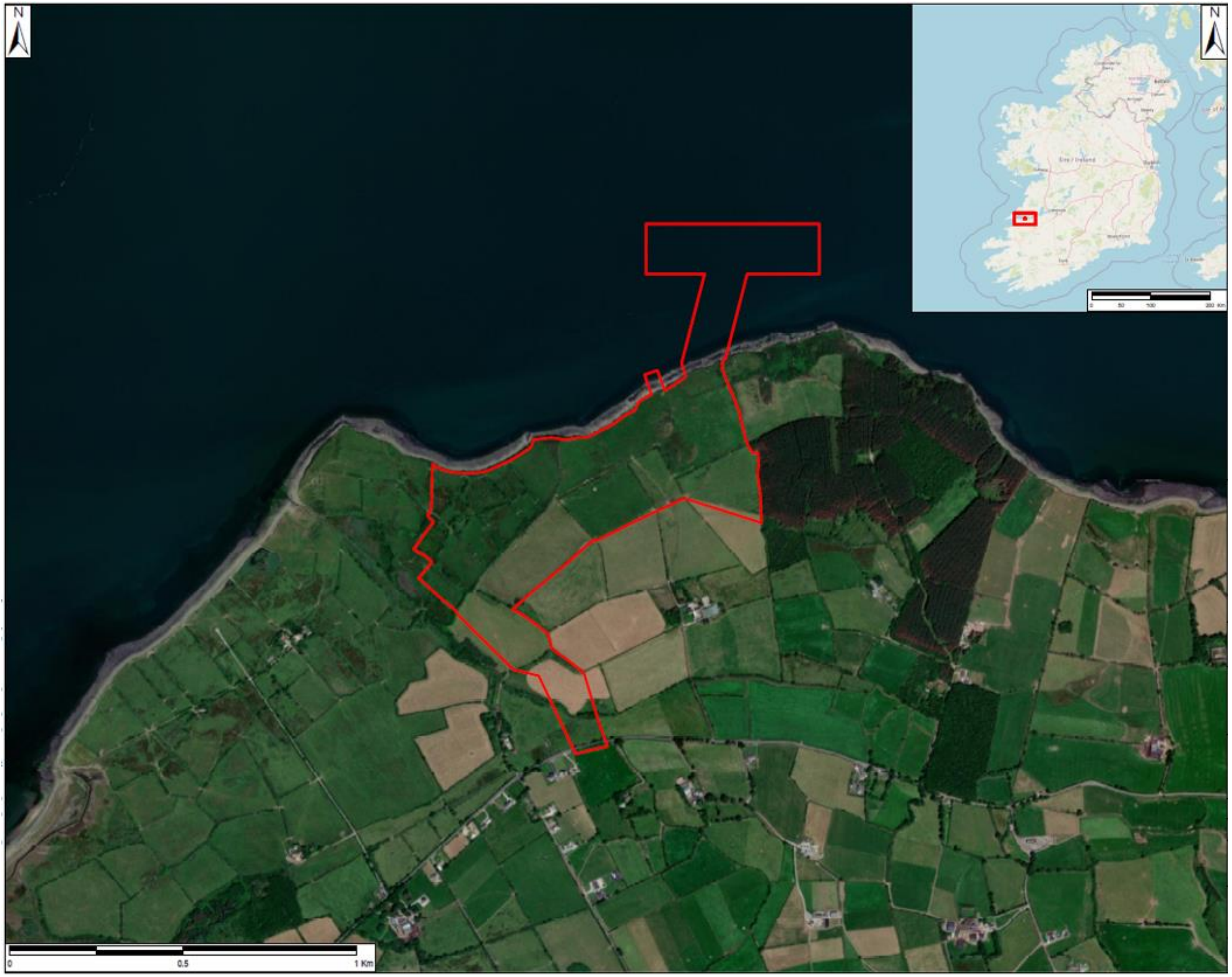

Figure 1-1: Site location.

1.2. *Requirement for Appropriate Assessment*

Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (commonly known as the Habitats Directive) is European Community legislation regarding nature conservation established to ensure biodiversity is conserved through the conservation of natural habitats and wild fauna and flora in Europe.

Under Article 6(3) and 6(4) of the Habitats Directive competent authorities are required to conduct a screening for Appropriate Assessment (AA) and, if necessary, an AA on any plan or project for which it receives an application for consent, or which the authority itself wishes to undertake or adopt.

The Habitats Directive was originally transposed into Irish law by the *European Communities (Natural Habitats) Regulations, 1997* (S.I. No. 94 of 1997). The 1997 Regulations were subsequently revoked and replaced by the *European Communities (Birds and Natural Habitats) Regulations 2011*, as amended (herein referred to as the 2011 Birds and Natural Habitats Regulations).

Under Regulation 42 of the 2011 Birds and Natural Habitats Regulations all competent authorities are required to conduct a screening for Appropriate Assessment (AA) and, if necessary, an AA on any plan or project on the foreshore for which it receives an application for consent, or which the authority itself wishes to undertake or adopt. This obligation derives from Article 6(3) and 6(4) of the Habitats Directive.

The AA provision of the Habitats Directive is also transposed in Ireland by the Planning and Development Act 2000 (as amended) in respect of land use plans and proposed developments requiring development consent.

A network of sites of conservation importance hosting habitats and species as needing to be either maintained at or, where appropriate, restored to favourable conservation status have been identified by each Member State. Sites, species, and habitats protected under Directive 92/43/EEC (Habitats Directive) and Directive 2009/147/EC (Birds Directive) are referred to as Natura 2000 sites. Natura 2000 sites are referred to as European sites in the Planning and Development Act 2000 (as amended). These terms are synonymous. European sites in Ireland that form part of the Natura 2000 network of protected sites comprise Special Area of Conservation (SAC) sites designated due to their significant ecological importance for habitats and species protected under Annex I and Annex II respectively of the Habitats Directive, and Special Protection Area (SPA) sites designated for the protection of populations and habitats of bird species protected under the EU Birds Directive (Council Directive 2009/147/EC). The specific named habitat and/or (non-bird) species for which a SAC or SPA is selected are called 'Qualifying Interests' (QI) of the site while specific named bird species for which a SPA is selected are called 'Special Conservation Interest' (SCIs) of the site (OPR, 2021[5]). In this report, QIs and SCIs are collectively referred to as ‘conservation features’. European sites are formally designated under a statutory instrument. Candidate SAC sites (cSAC) or candidate SPA sites (cSPA) have the same level of protection as fully designated sites under Irish Law[6].

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[5] OPR 2021. Office of the Public Regulator Practice Note PN01. Appropriate Assessment Screening for Development Management https://www.opr.ie/wp-content/uploads/2021/03/9729-Office-of-the-Planning-Regulator-Appropriate-Assessment-Screening-booklet-15.pdf

[6] Candidate sites are those that have been submitted to the European Commission, but not yet formally adopted under Ministerial Statutory Instrument (S.I.) (OPR, 2021). Legal protection, and therefore, the requirement for AA, arises from the date that the Minister gives notice of his/her intention to designate the site.

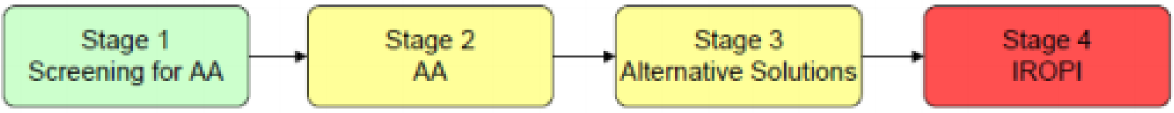
1.2.1. Stages of the Appropriate Assessment Process

Articles 6(3) and Article 6(4) of the Habitats Directive outline the decision-making tests for considering plans and projects that may have a significant effect on a Natura 2000 site.

The Department of the Environment Heritage and Local Government guidelines (DoEHLG, 2009, rev 2010) promotes a four stage process to complete the AA and outlines the issues and tests at each stage. An important aspect of the process is that the outcome at each successive stage determines whether a further stage in the process is required.

The four stages are summarised diagrammatically below, and an outline of the steps and procedures involved in completing each stage follows below. Stage 1 and Stage 2 deal with the main requirements for assessment under Article 6(3) of the Habitats Directive. Stage 3 may be part of the Article 6(3) Assessment or may be a necessary precursor to Stage 4. Stage 4 is the main derogation step of Article 6(4).

In complying with the obligations under Article 6(3) this report has been structured as a stage by stage approach.



1.2.2. Stage 1: Screening for Appropriate Assessment.

Stage I AA Screening is the process that addresses and records the reasoning and conclusions in relation to the first two tests of Article 6(3):

i. whether a plan or project is directly connected to or necessary for the management of European site, and
ii. Whether a plan or project, alone or in combination with other plans and projects, is likely to have significant effects on a European site in view of its conservation objectives.

If the effects are deemed to be significant, potentially significant, or uncertain, or if the screening process becomes overly complicated, then the process must proceed to Stage 2 (AA). Screening should be undertaken without the inclusion of mitigation, unless potential impacts clearly can be avoided through the modification or redesign of the plan or project, in which case the screening process is repeated on the altered plan. The greatest level of evidence and justification will be needed in circumstances when the process ends at screening stage on grounds of no impact.

1.2.2.1. Stage 1: Screening for Appropriate Assessment Determination

The Screening for AA is performed by the competent authority based on the information included in the Screening for AA and any other information considered necessary to reach a conclusion regarding likely significant effects associated with the proposed plan or project.

In the light of the conclusions of the screening assessment of the implications for the site(s), the competent authorities shall agree to the plan or project only after having ascertained that it will not result in likely significant effect to the site(s) concerned.

1.2.3. Stage 2: Appropriate Assessment

This stage considers whether the plan or project, alone or in combination with other projects or plans, will have adverse effects on the integrity of a European site, and includes any mitigation measures necessary to avoid, reduce or offset negative effects. The proponent of the plan or project will be required to submit a Natura Impact Statement (NIS) that examines the plan or project and the relevant European sites, to identify and characterise any possible implications for the sites in view of the site's conservation objectives, taking account of in-combination effects. This should provide information to enable the competent authority to carry out the appropriate assessment. If the assessment is negative, *i.e.* adverse effects on the integrity of a site cannot be excluded, then the process must proceed to Stage 3, or the plan or project should be abandoned.

The AA is carried out by the Competent Authority and is supported by the NIS with input from the National Parks and Wildlife Service (NPWS) who are a statutory consultee.

1.2.3.1. Stage 2: Appropriate Assessment Determination

An AA is performed by the competent authority based on the information included in the NIS and any other information considered necessary to ascertain whether the project will have an adverse effect on the integrity of the Natura 2000 site(s). This process and the conclusions should be clearly documented.

In the light of the conclusions of the assessment of the implications for the site(s) and subject to the provisions of Habitats Directive Article 6(3), the competent authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site(s) concerned.

1.2.4. Stage 3: Alternative Solutions

This stage examines any alternative solutions or options that could enable the plan or project to proceed without adverse effects on the integrity of a European site. The process must return to Stage 2, as any alternative proposal must be subject to a Stage 2 AA before it can be subject to the Article 6(4) test. If it can be demonstrated that all reasonable alternatives have been considered and assessed, the AA progresses to Stage 4.

1.2.5. Stage 4: Imperative Reasons of Overriding Public Interest/ Derogation

Stage 4 is the main derogation process of Article 6(4) which examines whether there are imperative reasons of overriding public interest (IROPI) for allowing a plan or project that will have adverse effects on the integrity of a European site. Where a project is to be permitted to proceed due to IROPI, the Member State shall take all compensatory measures required to ensure the coherence of Natura 2000 is protected.

1.3. Purpose of this Report

This *Screening Statement for AA and NIS* has been prepared to provide information to enable the competent authority to carry out a *Stage 1: Screening for AA* and a *Stage 2: AA* of the Proposed Development as required under Article 6(3) obligations under the Habitats Directive.

This report considers the potential effects of the Proposed Development to European sites. The Proposed Development site line boundary partially overlaps the Lower River Shannon candidate Special Area of Conservation (cSAC) (Site code 002165) (NPWS 2012, 2013) and the River Shannon and River Fergus Estuaries Special Protection Area (SPA) (Site code 004077) (NPWS 2012, 2015). The Proposed Development line boundary relative to the SAC and SPA is shown in **Figure 1-2**.

Detailed descriptions of the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA are included in the site synopsis reports presented in Appendix 1 of NIS Vol. 2.

1.4. Guidance

This report has been p0repared in accordance with the following guidance:

- EC (2018) Managing Natura 2000 sites. The provisions of Article 6 of the Habitats Directive 92/43/EEC Commission Notice (2018).
- OPR (2021) Appropriate Assessment Screening for Development Management. Practice Note PN01. Office of the Planning Regulator. March 2021.
- DEHLG (2009) Appropriate Assessment of Plans and Projects in Ireland Guidance for Planning Authorities (Revised 2010).
- DAHG - NPWS (2012) Marine Natura Impact Statements in Ireland Special Areas of Conservation, A Working Document.

This assessment includes a review of available records of protected species and habitats including the following sources:

- Baseline desk studies and field surveys[7] carried out for the Proposed Development.
- Conservation Status Assessment Reports, Backing Documents and Maps prepared to inform national reporting required under Article 17[8] of the Habitats Directive and Article 12[9] of the Bird Directive.
- Site Synopsis, Conservation Objective Reports and Natura 2000 Forms available from the NPWS website.
- Published and unpublished NPWS reports on protected habitats and species including Irish Wildlife Manual reports, Species Action Plans, and Conservation Management Plans.
- Existing relevant mapping and databases *e.g.* waterbody status, species and habitat distribution *etc.* (sourced from the Environmental Protection Agency - http://gis.epa.ie/, the National Biodiversity Data Centre - http://maps.biodiversityireland.ie and the NPWS - http://www.npws.ie/mapsanddata/)

This *Screening Statement for AA and NIS* report has also been informed by the Environmental Impact Assessment Report (EIAR) that was compiled by AECOM Ireland Limited (AECOM) for the STEP development on behalf of Shannon LNG.

The EIAR comprises the following parts;

- EIAR Vol. 1 - Non-technical Summary
- EIAR Vol. 2 - Main Report
- EIAR Vol. 3 - Figures
- EIAR Vol. 4 - Appendices

[7] Baseline desk studies and field surveys are described in detail in the Chapter 07A Marine Ecology and Chapter 07B Terrestrial Ecology of the Shannon Technology and Energy Park Environmental Impact Assessment Report which are included in Appendix 2 of NIS Vol. 2.

[8] Most recent Article 17 report is available at https://www.npws.ie/publications/article-17-reports/article-17-reports-2019

[9] Most recent Article 12 report is available at https://www.npws.ie/news/birds-directive-article-12-reporting

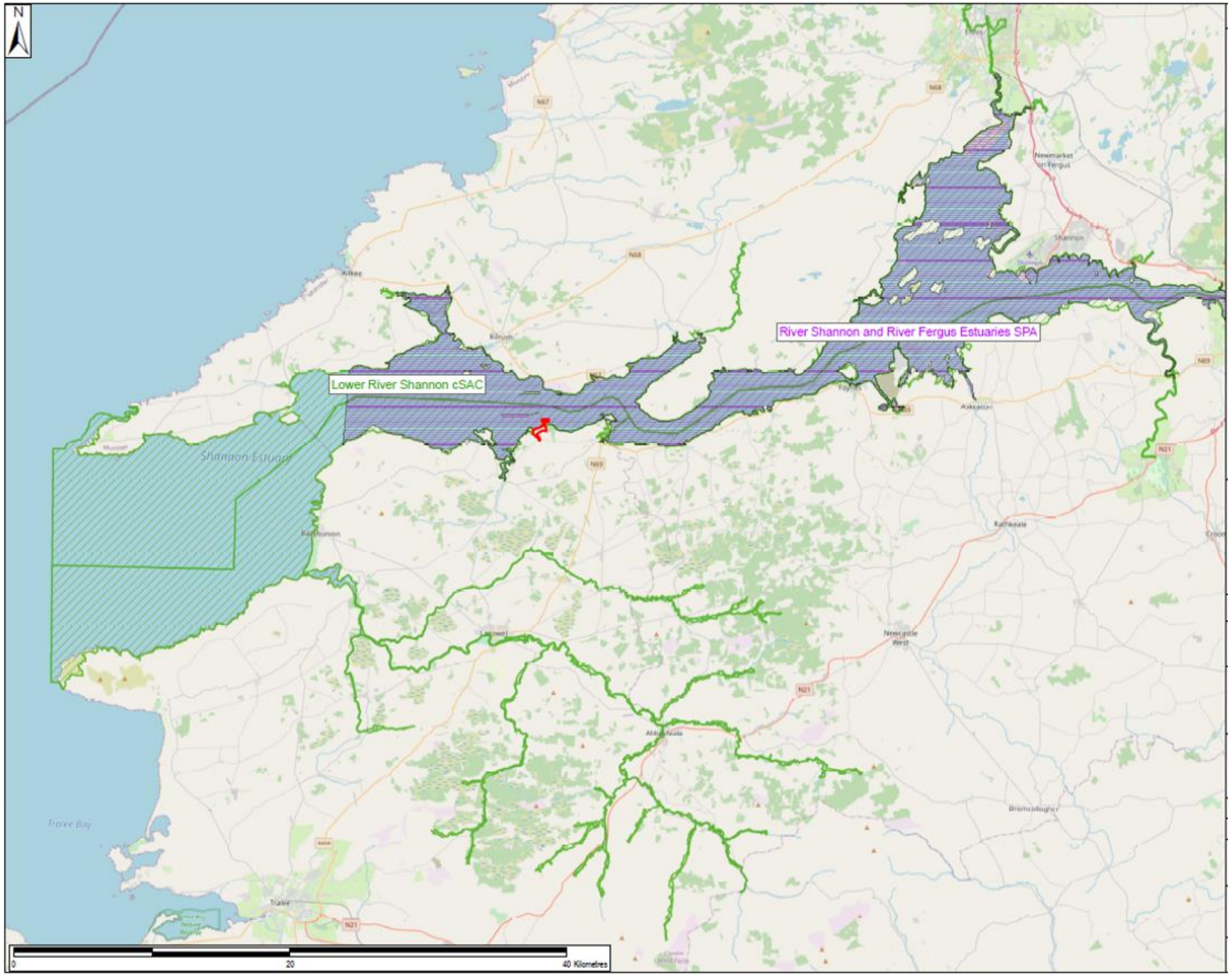


Figure 1-2: Proposed Development Site Boundary Relative to the Lower River Shannon cSAC and the River Shannon and River Fergus SPA.

1.5. *Statement of Authority*

This report has been prepared by Dr. Brendan O'Connor (B.Sc., Ph.D., MCIEEM), Dr. James Forde (B.Sc., M.Sc., Ph.D., MCIEEM), Carl Dixon (B.Sc., M.Sc.) and Dr. Sorcha Sheehy (B.Sc., Ph.D.). Other experts who contributed include Tony Cawley (B.Sc., MSc., BE, M.Eng.Sc, C.Eng, M.I.E.I) (Hydro Environmental), Dr. Simon Berrow BSc. Ph.D.) (Irish Whale and Dolphin Group), Darren Ireland (B.A, M.Sc.) (LGL Ecological Research Associates), and Per Trøjgård Andersen (B. Eng) (Vysus (formerly Lloyds Register)).

Dr. Brendan O'Connor is the marine ecology lead for the STEP development and has responsibility for all ecological surveys and reporting. He is expert in ecological matters and the full spectrum of environmental assessment techniques, methodologies, and statutes. Professionally, he is a member of relevant Institutes requiring the highest standards of professional competence and integrity. He is a member of the Chartered Institute of Ecology and Environmental Management (CIEEM).

Brendan has 40 years of experience in the field of marine science and has published *circa* 75 scientific papers and numerous reports specialising in the biology and ecology of sea-floor communities. Brendan is an internationally recognised polychaete taxonomist and has led numerous international workshops in polychaete taxonomy including workshops as part of the UK BEQUALM/NMBAQC. He has 33 publications on marine invertebrate taxa including descriptions of new species, revisions of families and additions to the European and Irish fauna.

As Managing Director of AQUAFACT Brendan has been responsible for all aspects of management including the design, execution and reporting of numerous desk studies, surveys, assessments, and environmental outputs including NIS, AA screening and EIARs.

Dr. James Forde has a PhD in Marine Ecology and is a full member of the CIEEM. James has over fifteen years' experience in marine research and environmental consultancy. James specialises in marine ecology and has a full appreciation of the objectives and mechanisms of national and international environmental legislation and policy.

James' academic research has focused on benthic habitats and communities, and techniques used to assess ecological impacts under European environmental legislation including the Habitats Directive and the Water Framework Directive.

As part of James' consultancy work, he has delivered assessment reports to meet the provisions of the Habitats Directive and EIA Directive to accompany planning applications for a wide range of developments including pier enhancement projects, coastal defence projects, and aquaculture.

James was a member of the International Union for Conservation of Nature (IUCN) expert working group for marine red-list habitats for the North Atlantic and has collaborated with international experts on the designation of sensitive marine habitats including *Ostrea edulis* beds, *Mytilus edulis* beds, seagrass meadows and offshore biogenic and geogenic reef habitats. James has collaborated with national experts on the assessment of deep-water reef habitats in Irish waters to support Ireland's national assessment of reef as required under Article 17 of the Habitats Directive. Recently James has also worked with national experts on the classification of lagoon habitats, a Habitats Directive Annex I priority habitat.

Of relevance to the STEP development is Brendan O'Connor's and James Forde's' specialist input on biodiversity for the recent Eirgrid Cross Shannon 400 kV Cable Project (Capital Project 0970).

Carl Dixon holds an Honours Degree (BSc) in Ecology and a Masters (MSc) in Ecological Monitoring from UCC. He is a senior ecologist who has over 25 years' experience in ecological assessment. Prior to setting up DixonBrosnan Environmental Consultants in 2000, Carl set up and ran Core

Environmental Services which included Rural Environmental Protection Scheme (REPS) planning for landowners and ecological assessments.

Carl has particular experience in freshwater ecology including electrofishing fish stock assessments and water quality assessments. He also has considerable experience in habitat mapping and mammal ecology including survey work and reporting in relation to badgers and bats. Other competencies include surveys for invasive species and bird surveys.

Carl has extensive experience with regards to EIAR and NIS mitigation and impact assessment. He has particular experience in large-scale industrial developments with extensive experience in complex assessments as part of multi-disciplinary teams. Such projects include gas pipelines, incinerators, electrical cable routes, oil refineries and quarries. Carl was the lead ecologist for the Shannon LNG project and associated pipeline and CHP plant from 2007 to 2012 and is the lead terrestrial ecologist for the current project.

Sorcha Sheehy PhD (ecology/ornithology) is an ecologist and ornithologist who has worked for 13 years in environmental consultancy. She has worked on Screening/NISs for a range of small and large-scale projects with expertise in assessing impacts on birds.

Sorcha's PhD research focused on bird behaviour at airports, where she studied bird avoidance behaviour and collision risk to aircraft. Her research involved field observations, post-mortem analysis and radar surveys. Sorcha has worked on bird collision risk assessments at airports throughout Ireland including Dublin airport, Cork airport, Shannon airport and Kerry airport.

During her consultancy work Sorcha carried out field-based surveys and environmental reports including NIS, AA screening and EIARs. Notable projects include the Arklow Bank Wind Park, Indaver Ireland Waste Management Facility at Ringaskiddy, Irving Oil Whitegate Refinery (IOWR), Shannon LNG and Greenlink Interconnector.

Anthony Cawley hold a honours degree in Civil Engineering and a post graduate master's degree in Engineering Hydrology. He is a Chartered Civil Engineer with Specialist education and 30years professional consulting experience in the water engineering field in a wide variety of activities relating to hydrology, hydrogeology and flooding, and hydrodynamic and hydraulic assessment of fluvial and tidal processes.

Anthony was expert witness on hydrology and flooding related issues at numerous Oral Hearings for major Infrastructure projects (such as many of the Motorways, M6, M20/M21 N23, Landsdown Stadium redevelopment).

Anthony was a lecturer in hydrology and hydraulics at the Hydrology and Civil Engineering Department at NUI Galway and is currently Lectures in Hydrology at the University of Limerick (2011 to date). Mr Cawley has provided training courses in Hydrology to the Western and Northwestern Fisheries Board and to Engineers Ireland, and Irish Rail and NRA Design Offices.

Anthony is a expert hydraulic and coastal processes modeller and analyst with considerable experience in application of 1D, 2D and 3D models to rivers, estuaries and coastal waters. Anthony has estuarine and coastal modelling experience using Telemac Software system with recent projects that include the Shannon Estuary hydrodynamic model and tidal harmonic analysis of tide elevations and velocities for oil spill tracking, the sediment transport, wave climate and hydrodynamic assessment of the proposed New Port for Galway and the flood impact and scour assessment of Arklow Bridge and Kish Bank Wind Farm and numerous Sewage outfall and numerous aquaculture studies in Irish coastal waters

Dr Simon Berrow is a marine mammal biologist with over 30 years experience. He is CEO of the Irish Whale and Dolphin Group and lecturer at the Galway-Mayo Institute of Technology. He started the Shannon Dolphin Project in the estuary in 1993, which has been ongoing each year for the last 28 years. The IWDG have extensive knowledge of the bottlenose dolphins in the estuary, having built the most comprehensive database and published widely.

For the current Proposed Development Simon prepared a series of survey reports on the use of the site by bottlenose dolphins including two years fieldwork, to assess potential impacts and provide advice on mitigation.

Darren Ireland holds a master's degree in ecology (fish and wildlife management) from Montana State University where he conducted research on Weddell seals in Antarctica. He is currently a Senior Wildlife Biologist and Vice President at LGL Ecological Research Associates, Inc. where he began working in 2005. While at LGL, Darren has worked primarily on projects related to anthropogenic sound impacts on marine mammals from a variety of activities including pile driving for wind farm and port development projects, deep penetration seismic surveys, high-resolution geophysical surveys, geotechnical investigations, exploration drilling programs, underwater explosions, and ice breaking.

Darren has authored or co-authored more than 45 environmental impact assessments and permit applications related to impacts of these activities on marine mammals, there habitat, and other marine life. Many of these projects also included developing and managing the implementation of multi-disciplinary monitoring plans to record and estimate potential impacts using methods such as vessel-based observers, manned and digital aerial surveys, unmanned aerial systems, static and towed passive acoustic recorders, and infrared camera systems.

Darren has also conducted baseline research on marine mammal distribution and abundance, conducted studies of novel research tools like unmanned aerial systems, infrared cameras, and satellite imagery, and performed evaluations of the potential impacts from new technologies and low-impact seismic sources. Through this work Mr. Ireland has gained a high level of expertise with the scientific and policy issues related to impacts of sound in the marine environment.

Per Trøjgård Andersen graduated from the Technical University in Denmark with a degree in acoustics in 1995. He has worked as consultant within noise, vibration, acoustics (including underwater noise) for more than 10 years in the company Odegaard & Danneskiold-Samsøe, and since 2005 at Lloyds Registers Engineering dynamics Team in Copenhagen, Denmark.

As part of the carve out of the Energy division from Lloyds Register, the Engineering Dynamics team became part of the Vysus Group in 2020, where he currently holds the position as Operations Manager for Engineering dynamics. Per's experience with underwater noise include consultancy on numerous projects with prediction and measurement of underwater noise from ships, wind turbines, oil & gas installations, as well as EU and privately funded research and development. He is the main author of the Lloyds Register underwater noise notation. He has further participated in ISO Technical Committee TC43 workgroup, developing the international standards for underwater noise measurements, including the ISO 17208 series

This Screening *Statement for AA and NIS* has been prepared inform the AA determination of the Proposed Development by the competent authorities as required under Article 6(3) of the Habitats Directive. Specifically, this *Screening Statement for AA and NIS* focuses on the potential effects of the Proposed Development to European sites.

1.6. Consultation

Consultations were carried out with the statutory and non-statutory bodies. The bodies are listed in alphabetical order below.

- ABP
- Commission for Regulation of Utilities
- Eirgrid

- Environmental Protection Agency
- Gas Networks Ireland (GNI)
- Health and Safety Authority
- Inland Fisheries Ireland (IFI)
- Irish Whale and Dolphin Group (IWDG)
- Kerry County Council (KCC)
    - County Archaeologist
    - Chief Fire Officer
    - Planning Department
- National Monuments Service's Underwater Archaeology Unit
- National Parks & Wildlife Service (NPWS) Development Applications Unit (DAU)
- Shannon Foynes Port Company

Of relevance to the assessment exercises undertaken for this *Screening Statement for AA and NIS* were consultations held with IFI and NPWS; the consultations comments raised are presented in **Table 1.1** and **Table 1.2** below. The tables indicate where the consultation comments have been addressed in this *Screening Statement for AA and NIS* report. Where possible summary responses to the comments are alongside the consultation comments.

Table 1.1: IFI (letter dated: 13/04/2021)

Consultation Comment	Response
With regard to tanker access to the new jetty, will additional dredging of the channel be required and if so, the impact of this must be adequately assessed.	For the Proposed Development there will be no marine dredging.
IFI request modelling of the impact and dispersion of the outlet water and its impact on the temperature and salinity regime in the vicinity of the proposed plant. This is particularly important given the proximity of the plant to the West Shannon Ballylongford Designated Shellfish Area. This is also relevant to the spawning of estuarine fish and other invertebrate species.	Detailed modelling of treated cooled water discharges is presented in Appendix 3 of NIS Vol 2).
IFI request detail of the proposals to prevent fish impingement/entrainment on any water intake pipes and the adequacy of any proposed systems to prevent same.	Assessment of the effect of impingement/entrainment of conservation feature species is presented below in **Section 3.4.8.** Assessment of the likely impact of impingement/entrainment on fish and crustaceans is included in Chapter 07A of EIAR Vol. 2 The seawater system has been designed to avoid significant impingement/entrainment of fauna occurring.
Fire water will likely be required for the plant and the BESS, the source of this should be addressed.	Details of firewater are provided in EIAR Vol2.
Detail should be provided as to the treatment and disposal of wastewater from on-site hygiene facilities.	Modelling of effluent has been undertaken (see Appendix 3 of NIS Vol 2). Assessment of impacts is presented below in **Section 3.4.9.**

	Given the scale of effluent and treatment proposed, and the diluting factor of the Shannon estuary significant impacts can be excluded.
A pollution prevention and rapid response plan should be prepared in the event of an oil spill during refuelling or a spill of LNG during the unloading/ regasification process.	Pollution Mitigation and Response Protocols are detailed below in **Section 3.6.7.**
The management of ballast water to prevent the further introduction of alien invasive species should be dealt with.	Details of the ballast management plans that will be implemented are provided below in **Section 3.6.6.**
The impact of construction/piling noise on the auditory and migratory response of resident estuarine and migrant fish species is of concern to IFI. Twaite Shad (*Allosa fallax fallax*) are particularly hearing sensitive and have been recorded in the estuary. The European Red Data Book species Smelt (*Osmerus eperlanus*) also migrates to spawn in the Upper Estuary at Limerick City during early Spring.	Detailed modelling of noise emissions is presented in Appendix 4 of NIS Vol. 2 while assessment of the impact of noise on fish and marine mammal species in presented in Appendix 5 of NIS Vol. 2. Assessment of impacts to conservation feature species is presented below in **Section 3.4.4.**
The in-combination effects of all of the above with the Data Centre and 220kV connection should be addressed.	In-combination effects are considered in **Section 2.22** below.

Table 1.2: NPWS DAU (letter dated: 26/04/2021)

Consultation Comment	Response
LNG FRSU terminal	
Net loss of Annex I habitat: See conservation target for area on Conservation Objectives for the Lower River Shannon cSAC[10]. The estimated extent of the loss of this habitats, permanently and/or during the lifetime of the development, due to the construction of the jetty and FSRU infrastructure, will need to be calculated. Net loss of habitats may constitute and adverse effect on the integrity of the cSAC.	An estimation of the habitat lost during the lifetime of the Proposed Development is presented in assessed in **Section 3.4.5** while an assessment of impact on the integrity of the cSAC is presented in **Section 3.5**.
Where post-development decommissioning of the jetty and marine infrastructure is proposed, the expected maximum lifetime of the project needs	The Proposed Development is expected to have a design life of 50 years. Details of the decommissioning phase is presented in **Section 2.16** below and in Chapter 02 of EIAR Vol. 2.

[10] https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO002165.pdf

to be clearly stated, as does the method of decommissioning envisaged, with comparable thoroughly researched examples of successful restoration carried out in similar circumstances elsewhere.	Habitat recovery following decommissioning is discussed in **Section 3.4.3**
A thorough and comprehensive baseline survey of the benthic biodiversity of the total effective footprint of the jetting and marine infrastructure needs to be carried out.	The baseline survey of the intertidal and subtidal environment is presented in **Section 3.3.2.3** and **Section 3.3.2.4**.
The area proposed for the jetty and FSRU infrastructure is within the area mapped as critical habitat for the bottle-nosed dolphin Map 16, Conservation Objectives). The conservation target for these areas is that they "should be maintained in a natural condition". The NIS will need to address the compatibility of the Proposed Development with the conservation objective for this species within the cSAC, and provide sufficient data and expert opinion to satisfy reasonable scientific doubt that the proposal will not adversely affect the integrity of the Lower River Shannon cSAC.	An assessment of the noise disturbance to bottlenose dolphin during the lifetime of the Proposed Development is presented in **Section 3.4.4**.
Sublethal effects of pile-driving (jetty and FSRU infrastructure), and any near-shore blasting, on dolphins using adjacent part of the estuary. Unless adequate data is already available, a *two-year* survey of dolphin use of the estuary within 2km of the proposed jetty and FSRU infrastructure is recommended, with a year being the minimum requirement, but open to query regarding its representivity.	Detailed modelling of noise emissions is presented in Appendix 4 of NIS Vol. 2 while assessment of the impact of noise on fish and marine mammal species in presented in Appendix 5 of NIS Vol. 2. Marine mammal monitoring reports are included in Appendix 6 of NIS Vol. 2, with the key findings summarised in **Section 3.3.3.1**. Assessment of noise disturbance impacts to species is presented below in **Section 3.4.4.**
Any increase in the risk of oil spills from increased ship traffic need to be fully assessed.	A Marine Navigation Risk Assessment, which was prepared by the Shannon Foynes Port Company in presented in Appendix A2-2 in EIAR Vol. 4. The risk assessment was used to assess potential risk of oil spills.
The risk of invasive organisms being imported in ballast water and as ship hull fouling need to be assessed.	Details of the ballast management plans that will be implemented are provided below in **Section 3.6.6** (also see Chapter 07B Section 7.5 of EIAR Vol. 2)**.**
Effect of the lighted jetty on bird mortality during poor weather condition, based on evidence from monitoring of jetties elsewhere.	An assessment of the effects of the bird collisions with lighting of the jetty associated with the Proposed Development is presented in **Section 3.4.12.** Bird surveys undertaken to inform the impact assessments for the Proposed Development are detailed in **Section 3.4.4.1.** Chapter 07B EIAR Vol. 2 also considers bird collisions.

Effect of pile-driving on estuarine birds: The seasonal timing and type of pile driving needs to be clearly described, and its impact of estuarine birds assessed. Unless adequate data is already available, a *two-year* survey of bird use of the estuary within 2km of the proposed jetty and FSRU infrastructure is recommended, with a year being the minimum requirement.	An assessment of the effects of the noise emissions on estuarine birds, including piling noise associated with the Proposed Development is presented in **Section 3.4.4**. Bird surveys undertaken to inform the impact assessments for the Proposed Development are detailed in **Section 3.4.4.1.** Chapter 07B EIAR Vol. 2 also considers noise effects to birds.
Modelling of pool fires and accidents: The impact of shipping accidents and pool fires on estuarine and sea-birds needs to be assessed. Although there is a good safety record for LNG ship transport, nevertheless it is recommended that such risks are formally modelled (*e.g.* Woodward & Pitbaldo (2010)[11]. The feasibility of bird surveys at and on each side of the slip lane within the SPA need to be established and if feasible such data is recommended to be collected.	A discussion on the potential risk of accidents associated with the Proposed Development is included in **Section 3.4.11.**
It needs to be established if dredging is required to facilitate ship access.	For the Proposed Development there will be no marine dredging.
Entrainment and/or impingement for fish and macrocrustaceans at water intake. An estimate of the number of fish and macrocrustaceans which are predicted to be killed by being entrained in the cooling water intake, or by being impinged on the filter screens of the intake, as a proportion of the fish and macrocrustaceans population available to predatory fauna in the estuary (see, for comparison, Henderson (1999)[12] and Hadderingh and Jager (2002)[13]	Assessment of the effect of impingement/entrainment on conservation feature species is presented below in **Section 3.4.8.** The seawater system has been designed to avoid significant impingement/entrainment of fauna occurring.
If any chemicals are proposed to be used to remove intake and outlet pipe fouling by marine organism, then this needs to be assessed for impact on the estuarine ecosystem.	To avoid fouling hypochlorite will be used to treat water. Modelling of treated cooled water discharge is discussed in **Section 3.4.7** while Detailed modelling of treated water discharges is presented in Appendix 3 of NIS Vol 2. Dispersion of residual chlorine at 0.5 mg/l was modelled. Results show that within 1.5 km both east and west of the discharge point

[11] Woodward, J. L. & Pitbaldo, R. (2010) LNG Risk Based Safety: modelling and consequence analysis. John Wiley & Sons. https://www.wiley.com/en-us/LNG+Risk+Based+Safety%3A+Modeling+and+Consequence+Analysis-p-9780470317648

[12] Henderson, P.A. (1999) Stepping back from the brink: estuarine communities and their prospect British Wildlife 11: 85-91.

[13] Hadderingh, R.H. and Jager, Z. (2002) Comparison of fish impingement by a thermal power station with fish population in the Ems Estuary. Journal of Fish Biology 61: 105-124.

	the predicted maximum residual chlorine concentration is less than 0.01 mg/l. Concentration above 0.1 mg/l are shown to occur only within 20 m of the discharge point and for a short period of time. Significant effects can be excluded.
Power Plant at Ralappane	
The requirement for blasting for the construction of the proposed power plant need to be established, and it impact fully assessed.	Detailed modelling of noise emissions is presented in Appendix 4 of NIS Vol. 2. Assessment of the impact of noise species in presented in Appendix 5 of NIS Vol. 2. Assessments of impacts to species are presented below in **Section 3.4.4.**
The full accounting of all excavated waste needs to be thoroughly controlled as part of a C & D waste management plan. The NPWS has been involved in several cases where construction waste has been illegally used for purposes of private coastal protection works in European sites.	See Chapter 02 of EIAR Vol. 2.
If any indirect effects are likely, a re-assessment of the small lagoon near the land bank site, for typical lagoonal species, is recommended; in particular the protected species *Lamprothamnium papillosum.*	The main sources of potential indirect effects to lagoons are pollutants and water discharges. Potential for impacts are considered in **Section 3.4.1**, **Section 3.4.3** and **Section 3.4.9**, and in Chapter 07A Section of EIAR Vol. 2. Indirect effects of pollutants and water discharges to lagoons are excluded. There is potential that lagoon may be indirectly affected by invasive species, however, the risk of invasive organisms will be managed through the implementation of mitigation (see in **Section 3.6**).
A re-assessment of the use of the terrestrial and shore development area by otter needs to be carried out.	A re-assessment of otter use of terrestrial and shore habitats at the Proposed Development is presented in **Section 3.3.3.3.** Chapter 07B EIAR Vol. 2 also details otter use of the Site.
Gas pipeline to Foynes	
As more than 12 years have elapsed since the Environmental Impact Statement (EIS) for the gas pipeline, and this being an integral part of the whole project, a revised assessment (Screening for appropriate assessment (at least) and Environmental Impact Assessment Report (EIAR) supplement (at least) would appear to be necessary.	The 26km gas pipeline that will connect the proposed development to the existing natural gas network is already permitted. By decision dated 17 February 2009, An Bord Pleanála granted approval for this gas pipeline under section 182D of the Planning and Development Act, 2000 (as amended) (Board ref. PL08.GA0003). It follows that the permitted pipeline is an "approved project", to which Annex IV(5)(e) of the EIA Directive applies. This means the EIA of the proposed development must include effects resulting from the cumulation of effects with the permitted pipeline. Similarly, the permitted pipeline is a project for the purposes of the "in combination" assessment under the Habitats Directive. The pre-application observations made by the Development Applications Unit of the Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media suggest that a revised assessment of the permitted pipeline would appear to them to be necessary. That revised assessment will be included within the required future application for consent under section 39A of the Gas Act 1976 (as amended). We are advised that no such revised assessment is necessary to complete necessary cumulative and in

	combination assessments. The necessary cumulative and in combination assessments have been completed, on the basis that the permitted pipeline is built in accordance with its existing approval. In-combination effects of the gas pipeline are considered in **Section 2.13** below.
Powerlines exporting electricity	
It is understood that an underground cable is the preferred means of exporting electricity. However, if powerlines remain an option then the impact on birds dispersing between different parts of the SPA need to be assessed, with particular reference to mortality and/or electrocution.	An application to connect to the national electrical transmission system was submitted to EirGrid in September 2020 under the Enduring Connection Policy 2 (ECP2) process. As part of this grid connection application, Shannon LNG Limited made a specific connection method request for underground cabling, in lieu of overhead lines. Given the expressed preference for underground cabling by the Applicant, and the resistance of the applicant to overhead powerlines, no assessment of collision risk to birds from overhead powerlines is required.
Powerlines exporting electricity	
It is understood that an underground cable is the preferred means of exporting electricity. However, if powerlines remain an option then the impact on birds dispersing between different parts of the SPA need to be assessed, with particular reference to mortality and/or electrocution.	The export of power from the site will form part of a separate application which is considered in **Section 2.22**.
It is recommended that the following conservation issues are addressed in the Environmental Impact Assessment Report (EIAR) for the proposed development.	
White-tailed sea eagles There us a current release site for white-tailed sea eagles, under Phase II of the White-tailed Sea Eagles Reintroduction Project, within 7 km of the proposed development, and the potential impact on recently-released young eagles needs to be assessed. This species is particularly susceptible to powerline collision and electrocution.	White-tailed sea eagles are not a SCI species for the River Shannon and River Fergus Estuaries SPA or any Natura 2000 site in Ireland. Therefore it is outside the scope of this report. This species is discussed in Chapter 07B of the EIAR. An application to connect to the national electrical transmission system was submitted to EirGrid in September 2020 under the Enduring Connection Policy 2 (ECP2) process. As part of this grid connection application, Shannon LNG Limited made a specific connection method request for underground cabling, in lieu of overhead lines. Given the expressed preference for underground cabling by the Applicant, and the resistance of the applicant to overhead powerlines, no assessment of the impact of collision to birds from overhead powerlines is required.
Protected mammals A re-assessment of the use of the terrestrial and shore development area by the strictly protected species, otter needs to be carried out. Use of the terrestrial development site by dispersing and migrating bats also needs re-assessment.	Details of Otter surveys at the proposed development site are included below in **Section 3.3.3** and in Appendix 7B-1 of EIAR Vol. 4. There are no bat species which are qualifying interests for Natura 2000 sites within the zone of influence. Therefore it is outside the scope of this report. The impact of the proposed development on dispersing and migrating bats is discussed in Chapter 07B of the EIAR.
Fracked gas source – USA	The application does not propose or request permission for any extraction, refining or liquefaction of natural gas. The potential

It is noted from the pre-palling meeting mentioned above that the project is not dependent on the use of shale (fracked) gas. However, in the event that this remains a possible option which is not strictly excluded from the proposed project, the following may need to be taken into account in the EIAR. There is concern of potential threats from gas fracking in Pennsylvania (in the Marcellus shale formation) to the listed species, rayed bean (*Villosa fabalis*), and snuffbox mussel (*Epioblasma triquetra*)[14]. While the obligation to assess impacts on jurisdictions outside of the European Union is not clear, nonetheless, it would be best practice to examine the impact of source gas extraction on protected wildlife, where such data is available.	sources of liquefied natural gas (LNG) are varied and, although not possible to identify, will all be located outside of the State and almost all will be located outside of the European Union. The pre-application observations made by the Development Applications Unit of the Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media suggest that the impacts of source gas extraction should be examined, where such data is available. In accordance with the decision of the High Court in An Taisce v. An Bord Pleanála [2021] IEHC 254 and 422, any impacts on the environment from extraction, refining or liquefaction of source gas are too remote from the proposed development to require examination, analysis and evaluation within the environmental impact assessment and appropriate assessment of the proposed development. We are advised that, for this reason, it is neither necessary nor appropriate to include particulars of any one place where source gas might be extracted.

1.7. Structure of this Report

This *Screening Statement for AA and NIS* has been prepared to provide information to enable the competent authority to carry out a *Stage 1: Screening for AA*, and if deemed necessary, a *Stage 2: AA* of the Proposed Development as required under Article 6(3) obligations under the Habitats Directive. Specifically, this report focuses on the potential effects of the Proposed Development on the conservation features of European sites. The content of this report is as follows:

- **Section 2**: Stage 1 Screening for Appropriate Assessment
    - **Section 2.1 – Section 2.11** Description of the Proposed Development
    - **Section 2.12** Screening Exercise
    - **Section 2.13** In-combination Effects
    - **Section 2.14** Outcome of Screening Exercise
- **Section 3**: Stage 2 Appropriate Assessment - Natura Impact Statement
    - **Section 3.1** Summary of Outcome of Screening Exercise
    - **Section 3.2** Proposed Development
    - **Section 3.3** Description of Receiving Environment
    - **Section 3.4** Impact Prediction
    - **Section 3.5** Potential for Adverse Effects on Site Integrity
    - **Section 3.6** Mitigation
    - **Section 3.7** Plans or Projects That Might Act In-Combination
    - **Section 3.8** Outcomes and Conclusions

[14] Federal Register (2012) 77:8650 https://www.govinfo.gov/content/pkg/FR-2012-04-14/pdf/2012-2940.pdf

2. Stage 1: Screening for Appropriate Assessment

Overview

The Planning and Development Act 2000 (as amended) requires that for onshore developments requiring development consent AA are carried out, while under the 2011 Birds and Natural Habitats Regulations all competent authorities are required to conduct a screening for AA and, if necessary, an AA on any plan or project for which it receives an application for consent including those projects on the foreshore. The obligation to undertake AA under the Planning and Development Act 2000 and the 2011 Birds and Natural Habitats Regulations derives from Article 6(3) and 6(4) of the Habitats Directive. Regulation 42 (1) of the 2011 Regulations requires that:

> *A screening for Appropriate Assessment of a plan or project for which an application for consent is received, or which a public authority wishes to undertake or adopt, and which* ***is not directly connected with or necessary to the management of the site as a European Site****, shall be carried out by the public authority 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*.

The proposed STEP development is not associated with the 'management' of European sites within the Natura 2000 Network having regard to Article 6 of the Habitats Directive, and as such it is appropriate that the Proposed Development is subject to a screening for AA.

This screening exercise assessment investigates, in view of best scientific knowledge, whether the Proposed Development, individually or in combination with other plans and projects, would be likely to have a significant effect on European sites.

This *Screening Statement for AA and NIS* focuses on the potential effect to European sites associated with the Proposed Development.

Section 2.1 through **Section 2.16** below describes the operation, construction and decommissioning phases of the Proposed Development.

Section 2.3 presents a screening exercise for potential effects to conservation features (*i.e.* QIs and SCIs) of European sites.

Where the screening exercise cannot exclude on the basis of objective information that the Proposed Development, individually or in combination with other plans or projects, will have a significant effect on a conservation feature of a European site then it is necessary to carry out a stage 2 appropriate assessment (*i.e.* the conservation feature is brought forward for further consideration of potential effects in **Section 3 Stage 2: AA – NIS**).

2.1. Project Description

This chapter describes the design, construction, operation, commissioning and decommissioning of the Proposed Development. It should be read in conjunction with the drawings in Volume 3 of the EIAR. The chapter provides an overview of the following:

- Site Location and Area Land Use (**Section 2.2**);
- Shannon Estuary Navigation and Port Operation (**Section 2.3**);
- Main Features of the Proposed Development (**Section 2.4**);
- Discharges and emissions (**Section 2.5**);
- Site Management (**Section 2.6**);
- Process Control and Monitoring (**Section 2.7**);

- Health, Safety and Environmental Aspects (**Section 2.8**);
- Construction Phase including environmental protection measures (**Sections 2.9**);
- Commissioning Phase (**Section 2.10**); and
- Decommissioning (**Section 2.11**).

2.2. Site Location and Area Land Project Description

The Proposed Development site is shown in **Figure 2-1**. The Proposed Development site is located within the boundary of two townlands: Kilcolgan Lower and Ralappane, Co. Kerry.

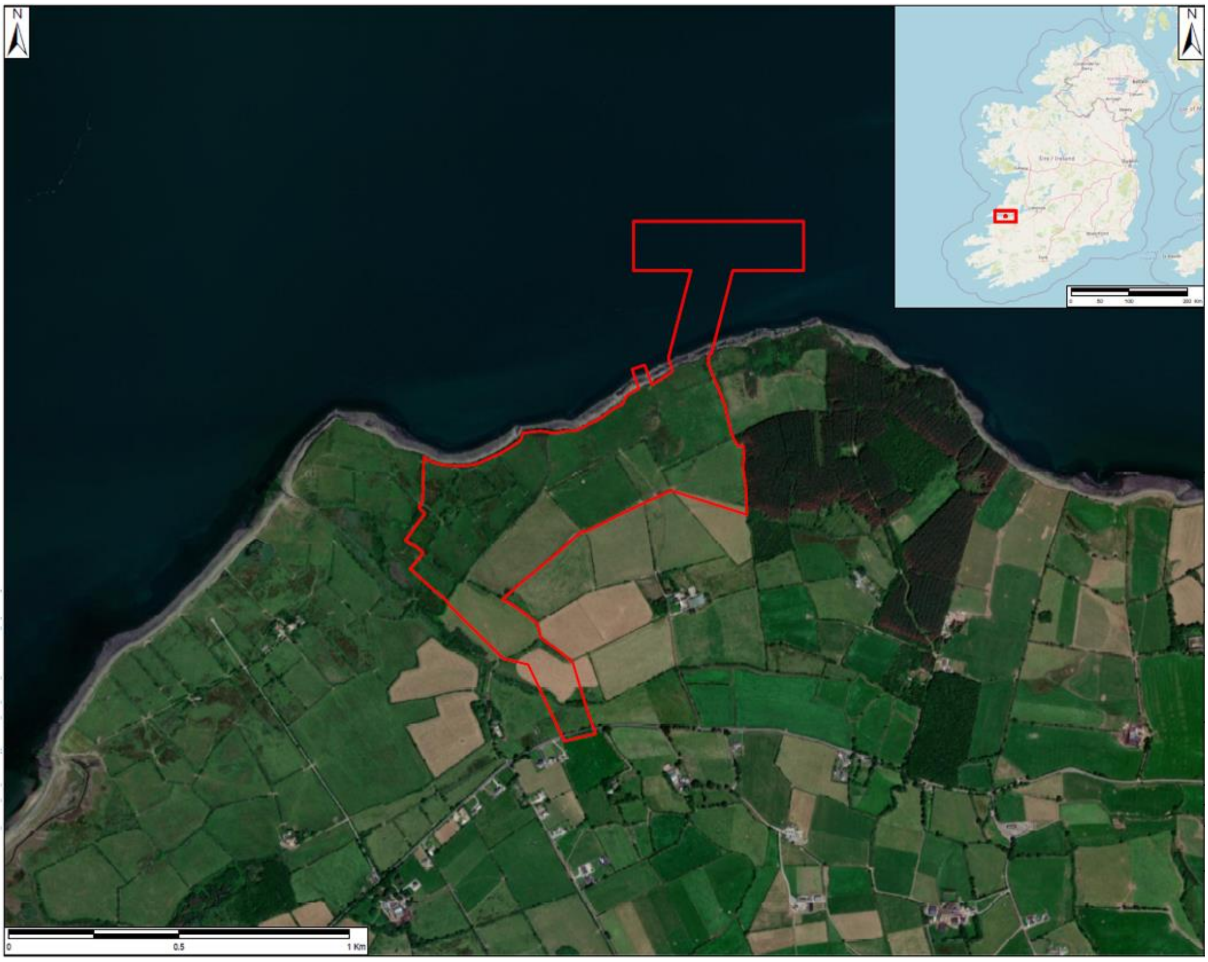


Figure 2-1 Site Location

The Proposed Development will be located on the Shannon Estuary, approximately 4.5 km from Tarbert and 3.5 km Ballylongford in the townlands of Kilcolgan Lower and Ralappane, Ballylongford, Co. Kerry. The site for the Proposed Development is 52 hectares (ha) (including both the onshore and offshore elements). The Shannon Landbank on which the site is located has a total area of 243 ha. The Proposed Development site is zoned for marine-related industry use by Kerry County Council (KCC) (County Development Plan 2015-2021), and has been identified as a Strategic Development location in the Shannon Integrated Framework Plan 2014-2020, the Regional Spatial and Economic Strategy (RSES) for the Southern Region 2020, the Kerry County Development Plan 2015-2021, and the Listowel

Municipal District Local Area Plan 2020 (refer to Chapter 04 – Policy (Energy and Planning) for further detail).

The Proposed Development site has access to deep water (approximately > 13 m depth) in the Shannon Estuary, which is suitable for navigation by large vessels. Given the natural depth of the water, no dredging is required for the Proposed Development. The Proposed Development site is also close to national gas and electricity transmission grids; 220 kilovolt kV and 110kV electrical transmission are available from the Electricity Supply Board Network (ESBN) / EirGrid Kilpaddoge 220 kV substation located approximately 3 km east of the Proposed Development site and a Gas Network Ireland (GNI) owned gas transmission pipeline located approximately 26 km east of the Proposed Development site, presenting a suitable location for an liquified natural gas (LNG) terminal and power plant. Planning permission exists for the development of a 26 km 30" natural gas pipeline which will facilitate connection from the Proposed Development site to the GNI transmission network at Foynes in Leahys, Co. Limerick.

The Lower Shannon Special Area of Conservation (SAC) is partly within and adjacent to the site along the northern/ north-western boundary and also along part of the eastern boundary (see Figure 7-1 in Chapter 07B – Terrestrial Biodiversity). The Ballylongford Bay proposed Natural Heritage Area (pNHA) is located adjacent to a part of the north-western boundary of the Proposed Development site. The Shannon-Fergus Estuary Special Protection Area (SPA) is to the west of the Proposed Development site (at a distance of approximately 750 m from the western extremity of the terrestrial elements of the Proposed Development site). The jetty will extend into the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA. Refer to Figures 7-1 and 72 in Chapter 07B – Terrestrial Biodiversity for the locations of these designated areas.

The Proposed Development site is in pasture, comprising primarily improved grassland with some wet grassland adjacent to the Shannon Estuary, as shown on the aerial photograph in **Figure 2-2**.

Figure 2-2 Proposed Development Site

The Proposed Development site is currently drained by a number of shallow drainage channels. Several longer drainage features cross the southern portion of the Proposed Development site, generally flowing in a west or northwest direction. The drainage features along the access road all ultimately drain to a single surface water course, the Ralappane Stream, which discharges into the Shannon Estuary. The Proposed Development site is bordered to the north by the Shannon Estuary and to the south by the Coast Road L1010, connecting Tarbert to Ballylongford. Fields in pasture and forestry lie beyond the eastern boundary and the Shannon Development Landbank extends westward beyond the Proposed Development site's western boundary.

The topography of the land within the Proposed Development site is generally undulating. Some of the fields are waterlogged in wet weather and there are pockets of marshy ground. There are a number of old disused farm buildings and structures on the Proposed Development site.

The Strategic Integrated Framework Plan for the Shannon Estuary (SIFP) is the inter-jurisdictional land and marine based framework to guide the future development and management of the Shannon Estuary. The SIFP states:

'*Ballylongford benefits from a significant deepwater asset and extant permission for a major LNG plant, the availability of natural gas, the proximity to the national grid and the potential for refrigeration from the regasification process, combined with the additional physical infrastructure in terms of roads and water. This makes the lands a very attractive location for other industries to locate in the future. There is also potential for gas fuelled electricity generation in the future. The SIFP proposes a Strategic Development Location around the Tarbert-Ballylongford complex to accommodate further development of the energy infrastructure and allow for economic development that will be attracted to such a significant site by virtue of its energy provision and deepwater facilities*'.

The Proposed Development site is currently owned by Shannon Commercial Enterprises DAC (formerly Shannon Free Airport Development Company Limited) registered at Shannon Airport, Co. Clare. The Applicant has entered into an agreement for the purchase of the land from Shannon Commercial Enterprises DAC.

There are a small number of residential properties located within 500 m of the onshore facilities on the Proposed Development site. Residential properties are also located along the existing L1010 (Coast Road) immediately south of the Proposed Development site, with additional residential properties to the east and west along the L1010.

Tarbert Power Station is located approximately 5 km to the north east of the Proposed Development site, with Moneypoint Power Station located on the northern shore of the Shannon Estuary, approximately 3 km to the north of the Proposed Development site.

2.3. Shannon Estuary Navigation and Port Operation

The Shannon Estuary comprises 500 square kilometres (km^2) of navigable water extending from Loop Head, in Co. Clare, and Kerry Head, in Co. Kerry, eastwards to the city of Limerick, a distance of 100 km. The naturally occurring deep and sheltered waters of the estuary are connected to the Atlantic Ocean and are accessible to large ocean-going vessels of varying types and sizes of up to 185,000 dwt (deadweight tonnes).

Within the estuary there are existing port facilities currently handling approximately 850 ships per year amounting to a total of 10 million dwt of shipping activity:

- Shannon Airport fuel jetty – 20 ships/ year, typically 6,500 dwt ships;
- Limerick Port – 220 ships/ year, typically 5,000 dwt general cargo ships;

- Aughinish Alumina – 50 ships/ year, typically over 75,000 dwt Panamax bulkers (bauxite import) and 220 ships/ year to 40,000 dwt (caustic import, process materials and supplies import and alumina export);
- Foynes Port – 325 ships/ year, typically from 4,000 to 50,000 dwt general cargo ships, bulk carriers and petroleum and chemical tankers;
- Tarbert Power Station (oil) – 4 ships/ year, typically 150,000 dwt bulkers and up to 185,000 dwt maximum size; and
- Moneypoint Power Station (coal) – 4 ships/ year, typically 150,000 dwt bulkers and up to 185,000 dwt maximum size.

Recently there has been an increase in Post Panamax Vessels, Oil Tankers in addition to Mini Cape and Cape size vessels.

Limited small vessel traffic includes local trade to Cappagh pier near Kilrush, with no ships recorded in recent years, though Kilrush has a large marina. A regular vehicle ferry service operates across the estuary between Tarbert on the south shore and Killimer on the north. Mariculture is a feature of the estuary.

Recreational marine activities include dolphin watching with over 500 trips per annum (reference) operating out of Carrigaholt and Cappa. The Shannon Estuary is a Special Area of Conservation (SAC) and is home to more than 100 bottlenose dolphins (which are one of the qualifying interests of the site).

Shannon Foynes Port Company (SFPC) is responsible for all maritime activities on the estuary. The Harbour Master & Pilotage Superintendent has authority over all matters related to pilotage, direction to vessels and movement of vessels. There are a total of 68 lights and shapes in the Shannon Estuary, making SFPC the second largest lighthouse authority in Ireland after the national authority. British Admiralty charts are used in Ireland, the relevant Shannon ones being numbers 1547, 1548 and 1819.

All vessels entering the Shannon have to cross the Ballybunion Bar, clearance over which is regulated for deep draught (>17 m) vessels. A wave rider buoy is positioned on the bar to provide real time information on the height of the swell which is used by SFPC in a customized computer programme to present 'go/ no-go' information. The maximum draft[15] of the proposed LNG ships is approximately 13 m, which will not pose any problems at the bar. The Atlantic swell is not experienced inside the Shannon Estuary and wind generated waves are restricted by the length of fetch available.

From Ballybunion Bar, the Beal Bar Channel leads into the estuary where arriving vessels transiting east, pass to the south of Scattery Island. Designated anchorages are available to the north of the main channel for vessels waiting to transit to berths upriver at Foynes and Limerick.

Port operations are managed on International Organization for Standardization (ISO) methods and a formal risk assessment is carried out for all trades. A Vessel Traffic Management Information System (VTMIS) employing three radar stations is able to observe, record and replay traffic movements in the estuary.

There are eight First Class Pilots licensed by the Port Authority who operate from Cappa Pier employing a 15 m, 20 knot pilot boat. The pilot boarding position varies depending upon the size of ship and for large displacement/ deep draught vessels the boarding station is outside Ballybunion Bar. Pilots can monitor some types of vessels on radar and talk/ guide them into the shelter of the Estuary

[15] The distance between the surface of the water and the lowest point of the vessel.

on a shore-based pilot system if the weather is too bad for safe pilot boarding. Pilots regularly carry Pilot Portable Units (PPUs) which will operate independently of ships' navigational equipment and assist pilots in the safe navigation and berthing of ships.

The tidal range in the Estuary is 4.5 m and the maximum observed current is approximately 4 knots on the spring ebb off Moneypoint jetty. The prevailing winds are from the west and south west and seldom reach hurricane force within the Shannon Estuary. An average of 9.8 days/ year experience gales, and 32 days/ year experience fog.

Two tugs are based at Foynes and are available to assist vessels berthing and sailing at all the existing facilities in the Estuary, however they are not suitable for the Proposed Development due to limited size and power. Appropriate tugs will be sourced by the Proposed Development and licensed separately by the Port Company. Mooring boats and gangs are independently contracted to terminal owners and ship operators.

SFPC is charged with oil pollution prevention and control in compliance with Irish national and international legislation and has established a response team with locally interested parties. The team carries out annual exercises to ensure readiness and swift reaction to any incident. Also, as required by legislation, SFPC in cooperation with the local authorities, the Irish Coast Guard and port users has developed a Marine Emergency Response Plan for the entire Shannon Estuary.

2.4. Main Feature of the Proposed Development

The Proposed Development will comprise the following components:

- A Power Plant;
- A LNG Terminal;

These components are described in the following sections and shown in **Figure 2-3**.

Figure 2-3 Site Layout

2.4.1. Power Plant

The proposed Power Plant, as shown in **Figure 2-4**, will comprise:

Three (3) blocks of Combined Cycle Gas Turbines (CCGT), each block with a capacity of approximately 200 megawatts (MW) for a total installed capacity of up to 600 MW (See Section 2.4.1.1);

- Battery Energy Storage System (BESS) (See **Section 2.4.1.2**);
- High voltage 220 kV Substation (See **Section 2.4.1.3**);
- Auxiliary Boiler (See **Section 2.4.1.4**);
- Raw water treatment building (See **Section 2.4.1.6.1**);
- Firewater storage tanks and fire water pumps (See **Section 2.4.3.1.4**);
- Fuel storage (See **Section 2.4.1.7**); and
- Ancillary buildings common to both the Power Plant and LNG Terminal (See **Section 2.4.3**).

Figure 2-4 Proposed Power Plant at the Proposed Development Site

The Power Plant will be operated using natural gas as its primary fuel, and generate power exported via the 220 kV connection to the national electricity grid. It will also provide electricity for its own needs and for those of the LNG Terminal. The 220 KV connection will have to be installed prior to commencing operation of the Power Plant, as such it is anticipated that the Power Plant will be constructed in parallel with the 220 KV grid connection.

The Power Plant is designed to operate alongside intermittent renewable electricity power generation and is expected to mainly operate at full capacity during periods of low renewable supply, and otherwise to be turned down or turned off. For example, during periods of high wind (renewable) generation it is expected that the Power Plant will be turned off by the system operator (EirGrid) to give priority to renewable power. Similarly, during periods of sudden low renewable generation, the system operator will call on the Power Plant to be ramped up to supply electricity. Due to the design of the CCGT with low minimum generation and the economic advantage of the Power Plant relative to other facilities, it is expected that the Power Plant would be called on earlier by the system operator than other gas plant. A battery system (BESS, see below) will provide electricity into the grid as the Power Plant is being ramped up. Once the Power Plant is up and running the supply from the BESS will be switched off.

The Power Plant will have an installed capacity of up to 600 MW and will be designed in accordance with best available techniques (BAT) for large combustion plants, industrial cooling systems, energy efficiency and emissions from storage.

The fuel supply to the Power Plant will normally be from the LNG Terminal, but it can also be powered from the gas grid via reverse flow through the Above Ground Installation (AGI) as defined in **Section 2.4.3**.

The Power Plant will use up to 2.8 million Sm^3 per day[16] (approximately 25.5 GWh per day) when operating at full capacity. The LNG Terminal will have sufficient capacity to supply gas requirements for the Power Plant.

It is not intended that diesel will be used as a secondary fuel for the Power Plant. However, small amounts of diesel fuel will be available onsite for the emergency power generators. Consequently, the Proposed Development, unlike most other large power plants in Ireland, will not store and combust large quantities of LNG. Avoiding storing, and combusting, large quantities of LNG on site significantly reduces safety and environmental risks. Refer to **Section 2.4.1.7** for further discussion.

A small amount (approximately 20 MW) of the electricity generated by the Power Plant will be used in the LNG Terminal, and in the operation of the Power Plant itself. The balance of the electricity produced is intended for the market and will be sold into the integrated Single Electricity Market (iSEM).

The electricity generated by the Power Plant will be exported through a new substation located between the Electricity Generation Facility and the LNG Terminal. It is anticipated that the new substation will be connected to the 220 kV transmission grid at the ESBN / EirGrid Kilpaddoge 220 kV substation but the location and precise nature of the connection are subject to further discussions between the Applicant and EirGrid and do not form part of the scope of this EIAR. The new substation and grid connection are assessed in the cumulative impact assessment within each technical chapter.

The Power Plant will use CCGT technology (see description in **Section 2.4.1.1** below), and its design will comply with all relevant national and international codes.

The contract to supply and construct the Power Plant will be awarded following a commercial tendering process prior to the start of construction. The tendering process will result in a contract for a particular model of electric generation plant. Therefore, the precise size, configuration, performance, and layout of the equipment will be finalized following the award of the contract and a site-specific detailed design process, however this will not affect the design of the buildings or emissions as described in this EIAR. The construction contract will identify a preferred Contractor to construct the Proposed Development, in accordance with the mitigation and monitoring measures set out in this EIAR. The Client (the Applicant) will administer the construction contract and liaise with the Local Authority to discharge planning conditions as appropriate.

Further descriptions of the main features of the Power Plant are outlined in the following sections.

2.4.1.1. Combined Cycle Gas Turbine Power Block Description

The Power Plant will contain three blocks with one CCGT, each block with a nominal capacity of up to 200 MW. The multi-shaft arrangement of each block will provide fast acting response, such as will be required in a system with a low level of stable generation, and is therefore ideally suited to support a high level of intermittent renewable power generation.

Each block will comprise:

- Two gas turbines with generators;
- Two heat recovery steam generators with exhaust stacks;

[16] Million Sm^3/d = Million Standard cubic metres per day of natural gas: cubic metre natural gas at 101,325 Pa and 15°C, dry

- One steam turbine;
- Electricity generator;
- One air-cooled condenser;
- Air-cooled heat exchanger;
- Generator step-up transformer (GSU);
- Natural gas fuel system;
- Turbine Hall;
- Vacuum Pump Building;
- Condenser Polisher Equipment Enclosure;
- Air-cooled condenser (ACC) Air Extraction and Equipment Enclosure; and
- High voltage electrical switchgear and 220 kV substation.

Each proposed power block will use the following process:

- The gas turbine burning natural gas will be connected to a generator for electricity production;
- Exhaust gases from the gas turbine will pass through two heat recovery steam generators to generate steam;
- The steam generated will be routed through a steam turbine, which will also be connected to a generator to produce further electrical power;
- The spent steam exiting the steam turbine will then be directed into the air-cooled steam condenser. The resulting condensate will then be pumped back into the heat recovery steam generator to repeat the steam cycle; and
- Power from the three generators will be combined and the voltage increased to the export voltage by the generator step-up transformer (GSU).

The electricity generated will be fed to a set of transformers where the voltage will be stepped up to the transmission voltage, specified by EirGrid in the, yet to be issued, interconnection offer.

2.4.1.1.1. Gas Turbine Generator (6 m x 15 m)

The gas turbine will consist of an air compressor, a combustion chamber, and a turbine. The air compressor will take in large quantities of filtered air from the atmosphere and compress it. Fuel gas and compressed air will then be injected into the combustion chamber and the fuel/ air mixture ignited. The addition of heat energy and combustion gases in the combustion chamber will raise the temperature of the combined gases to over 1,300°C. The hot gases will expand through the turbine section. The high velocity gas passing through the turbine will spin the main shaft which drives both the air compressor, which will produce the compressed air, and the generator, which will produce the rated electrical power output. The expansion of the hot gases passing through the turbine, and the extraction of mechanical work from them via the turbine will reduce the temperature of the gases to less than 600°C.

The gas turbine will be coupled to a generator for power generation at 50 hertz (Hz).

2.4.1.1.2. Heat Recovery Steam Generator

A gas turbine, as described above, is referred to as operating in open or simple cycle mode. It will be possible to generate approximately 50% more electricity by operating in combined cycle mode. In combined cycle mode the hot exhaust gases leaving the gas turbine will be directed through the Heat Recovery Steam Generator (HRSG), which will extract heat to make steam. The heat recovery steam generator will be multi-pressure type. The temperature of the hot combustion gases will be reduced in this process to less than 100°C.

The HRSG will discharge the exhaust gases to atmosphere through an integral exhaust stack exiting at approximately 35 m above ground.

2.4.1.1.3. Steam Turbine Generator

Water supply for the heat recovery steam generator is discussed below. The water treatment facility will provide demineralized water for steam cycle makeup to each CCGT block.

The high-pressure steam produced by the HRSG will flow through inter-connecting pipework to the steam turbine. The steam turbine will be of a multiple stage type suitable for coupling to a generator for power generation at 50 Hz. The low-pressure exhaust steam will flow out of the steam turbine to the ACC.

2.4.1.1.4. Air Cooled Steam Condenser (48.6 x 42.2 m)

The ACC will be of a standard design. Steam from the steam turbine will enter the ACC and pass through air-cooled fin tubes. The steam will not be in direct contact with the air. The heat is transferred from the steam to the surrounding ambient air, which leads to the steam condensing. This condensate represents boiler quality feed water. The condensate will then be returned to the HSRG in a closed loop. i.e. condensate will not be discharged to the environment. The key advantage of an air-cooled steam condensers is that cooling water and associated systems are not required.

Non-condensable gases (i.e. air ingress into the ACC) will be removed from the ACC by use of vacuum pumps located in an equipment enclosure near the ACC. The condensed steam will be collected in the condensate collection tank located below the ACC where it is pumped by the condensate pumps back to the HRSG through the condensate polisher (whose purpose is to remove impurities and reduce corrosion in the water/ steam cycle). The condensate polisher is located in an equipment enclosure near the condensate pumps.

2.4.1.1.5. Generator Step-up Transformer (GSU) (10 m x 10.4 m)

Power from the gas turbine and steam turbine generators will be collected at the generator voltage level and will be connected to the 220 kV GIS substation through one generator step-up transformer for each block.

2.4.1.1.6. Natural Fuel Gas System

The gas used to fuel the Power Plant will be supplied from the LNG Terminal via the metering and regulating station at a pressure suitable for the specific gas turbine equipment selected. This fuel gas will pass through gas conditioning equipment dedicated to each block/ gas turbine that is anticipated to be comprised of:

- Filter separator;
- Performance heater;
- Final pressure control station; and
- Gas quantity and quality measurement as required for performance management and environmental protection monitoring.

2.4.1.1.7. Buildings Within Each CCGT Block

Each CCGT Block will include the following buildings and enclosures to house the main plant equipment noted above:

- Turbine hall (65m x 93m,);
- Vacuum Pump Building;

- Condenser Polisher Equipment Enclosure (6.3m x 16.3m); and
- ACC Air Extraction and Equipment Enclosure (Power Distribution Centre (PDC)) (8.5m X 12.2m).

These are described in the following sections.

The buildings will be constructed using two main building methods:

- Type 1 will be used for all buildings with the exception of the PDC. These will be steel framed buildings with concrete floor slabs; and
- Type 2 will be used on the PDCs. This building will be a pre-manufactured metal equipment enclosure using a steel base and framing to form an all-weather enclosure. The enclosure will be mounted on steel support legs or concrete piers to elevate the enclosure and allow bottom entry for electrical/ control wiring.

Structural and architectural details have been prepared including particulars of the shallow and deep foundations, lifting equipment, steel structures, and protective coatings. The paint colours of the buildings will be selected to minimise the visual impact of the Power Plant.

Turbine Hall (65.9m x93.7m)

This building will house the combustion turbine generator (CTG), HRSGs, STG and other balance of plant systems required for a complete CCGT Block. The turbine hall will accommodate the selected OEM's recommended component layout, including laydown and maintenance requirements within the building. A bridge crane will be provided for steam turbine maintenance while the gas turbines are each supplied with an overhead crane for maintenance and removal of the gas turbine engine. The building will have internal rooms to house the necessary electrical and control equipment required for each CCGT Block including a stand-by diesel generator. The diesel fuel tank for stand-by diesel generator will be stored in a bunded area, or in a double walled tank.

Vacuum Pump Building

The vacuum pump building will house the liquid ring vacuum pumps associated with the ACC described in **Section 2.4.1.1.4.**

Condenser Polisher Equipment Enclosure (6.3m x 16.3m)

The condenser polisher equipment enclosure will house the condensate polisher associated with the ACC, as described in **Section 2.4.1.1.4**.

Air-Cooled Air Extraction and Equipment Enclosure (Power Distribution Centre)

This enclosure will house the electrical breakers and motor control centres (MCC) associated with the ACC.

2.4.1.2. Battery Energy Storage System

A 120 MW 1-hour (120 megawatt hour (MWh)) BESS is included in the Proposed Development. The BESS will comprise 27 battery containers, approximately 4.5 MWh each, containing lithium ion batteries. Each battery container is paired with two power conversion system (PCS) skids that contain the electrical systems (inverters, etc.) to deliver the power from the batteries to the grid via a 220 kV generator step-up transformer. Due to its fast response, the BESS allows the power Station to provide electricity during 'ramp up' and supports intermittent renewable generation. This was also discussed in **Section 2.4.1.1** above.

Once the Power Plant is operating at the necessary capacity the electrical demand is met, the BESS will be shut down and recharged.

2.4.1.3. High Voltage 220kv Substation (18m x 60.9m)

A high voltage 220 kV substation is included in the Proposed Development. The substation will be gas insulated (GIS) and enclosed in a building. The substation will accept the 220 kV output from each CCGT Block and BESS and connect to the national electricity grid. When the Power Plant is not in operation, power from the national electricity grid will backfeed to the Power Plant via this same grid connection.

This Power Plant GIS substation will in turn route power to the LNG Terminal, even when the Power Plant is shutdown.

2.4.1.4. Auxiliary Boiler (within Auxiliary Boiler Building, 14.3 m x 14.3 m)

An auxiliary boiler will be included in the Proposed Development. The auxiliary boiler will burn natural gas, be of a standard design and be enclosed in a building with a separate 32 m high exhaust stack. Steam from the auxiliary boiler will be used by the Power Plant to keep the equipment warm which allows for faster start up to support intermittent renewable generation.

2.4.1.5. Raw Water Storage Tank (24m x 18m)

Water used by the Power Plant will be supplied from the potable water connection. This raw water will be stored in two raw/ service/ fire water storage tanks. The tanks will supply service water to the Power Plant and raw water to the water treatment facility with reserve storage for fire water. The tanks will be field fabricated welded steel tanks.

2.4.1.6. Buildings

The Power Plant will also include the following buildings, common to the three CCGT Blocks and BESS operations:

- Raw water treatment building;
- Administrative building;
- Central control/ operations building;
- Auxiliary boiler building;
- Workshop/ stores/ canteen building; and
- Firewater pumps enclosure.

Buildings and enclosures common to both the Power Plant and LNG Terminal are described **in Section 2.4.3**.

2.4.1.6.1. Water Treatment Building (18 m x 35 m)

The water treatment facility will make demineralized water for steam cycle makeup to each CCGT Block. The demineralized water will be stored in two demineralized water storage tanks which will be field fabricated welded steel tanks.

2.4.1.6.2. Administrative Building (14 m x 22.7 m)

The administration building will include offices, training rooms and meeting rooms for the administrative personnel stationed at the Power Plant.

2.4.1.6.3. Central Control/ Operation Building (14 m x 22.7 m)

Operation of the Power Plant will be monitored and controlled from the central control/ operations building. This building will include a control room, meeting room and offices for the operations personnel stationed at the Power Plant. The Power Plant will be operated from the main control room (MCR). From the MCR it will be possible to monitor and adjust all of the plant equipment and instrument control systems including all safety control systems.

2.4.1.6.4. Auxiliary Boiler Building (14.3m x 14.3m)

This building will house the auxiliary boiler stack.

2.4.1.6.5. Workshop/ Stores/ Canteen Building (14m x 52.3m)

The workshop/ warehouse/ canteen building will provide storage for equipment and material spares required to maintain an operational facility. The building will also have maintenance offices, a workshop area and canteen.

2.4.1.6.6. Firewater Pumps Enclosure (4.5 m x 10.5 m)

Both the Power Plant and LNG Terminal will house a firewater pumps enclosure.

2.4.1.7. Fuel Storage

A mandate to store defined quantities of fuel onsite is specified in 'Secondary Fuel Obligations on Licensed Generation Capacity in the Republic of Ireland' (CER/09/001), was issued by the CER (now CRU) on 12th January 2009. For power plants, the storage requirement totals one day's worth of fuel consumption, calculated assuming the Power Plant is operating at its maximum capacity. After consultations between the CRU and the Applicant, the CRU has agreed that fuel storage requirements can be met by storing five days' worth of LNG in the FSRU LNG storage tank(s). Avoiding storing large quantities of liquid fuel on site significantly reduces safety and environmental risks as well as increasing the Power Plant's reliability.

2.4.2. The LNG Terminal

The proposed LNG Terminal will comprise:

- An LNG ship in the form of a FSRU, with LNG storage capacity of approximately 170,000 m3 (up to 180,000 m3). This EIAR considers a capacity of up to 180,000 m3. The FSRU is a ship that can store LNG onboard, and which also is fitted with an onboard regasification unit which can return stored LNG into a gaseous state. The ship will be up to 300 m long and up to 50 m wide. The FSRU will be an existing suitably classified marine vessel that will be modified to ensure it operates in accordance with the terms of the Planning Permission, the Industrial Emissions Licence and all the other relevant statutory approvals required for its operation. Further details of the FSRU is provided below;
- A jetty with an access trestle, with the jetty comprising an unloading platform, mooring dolphins and breasting dolphins with capacity to accommodate up to four tugs. They will facilitate safe mooring operations for the FSRU and visiting LNG carriers as required. Further details are provided below;

- Onshore receiving facilities including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator, backup power generators fire water system. Further details are described below; and
- An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, chromatography, gas metering and pressure control equipment. The AGI will facilitate the export of LNG to the national gas transmission network via the already consented 26 km 30” Shannon Pipeline. Further details are described in below.

LNG will be delivered to the LNG Terminal by a visiting LNG Carrier (LNGC) which will be moored to the seaward side of the FSRU.

A detailed description of the main characteristics of the LNG Terminal are outlined in the following sections.

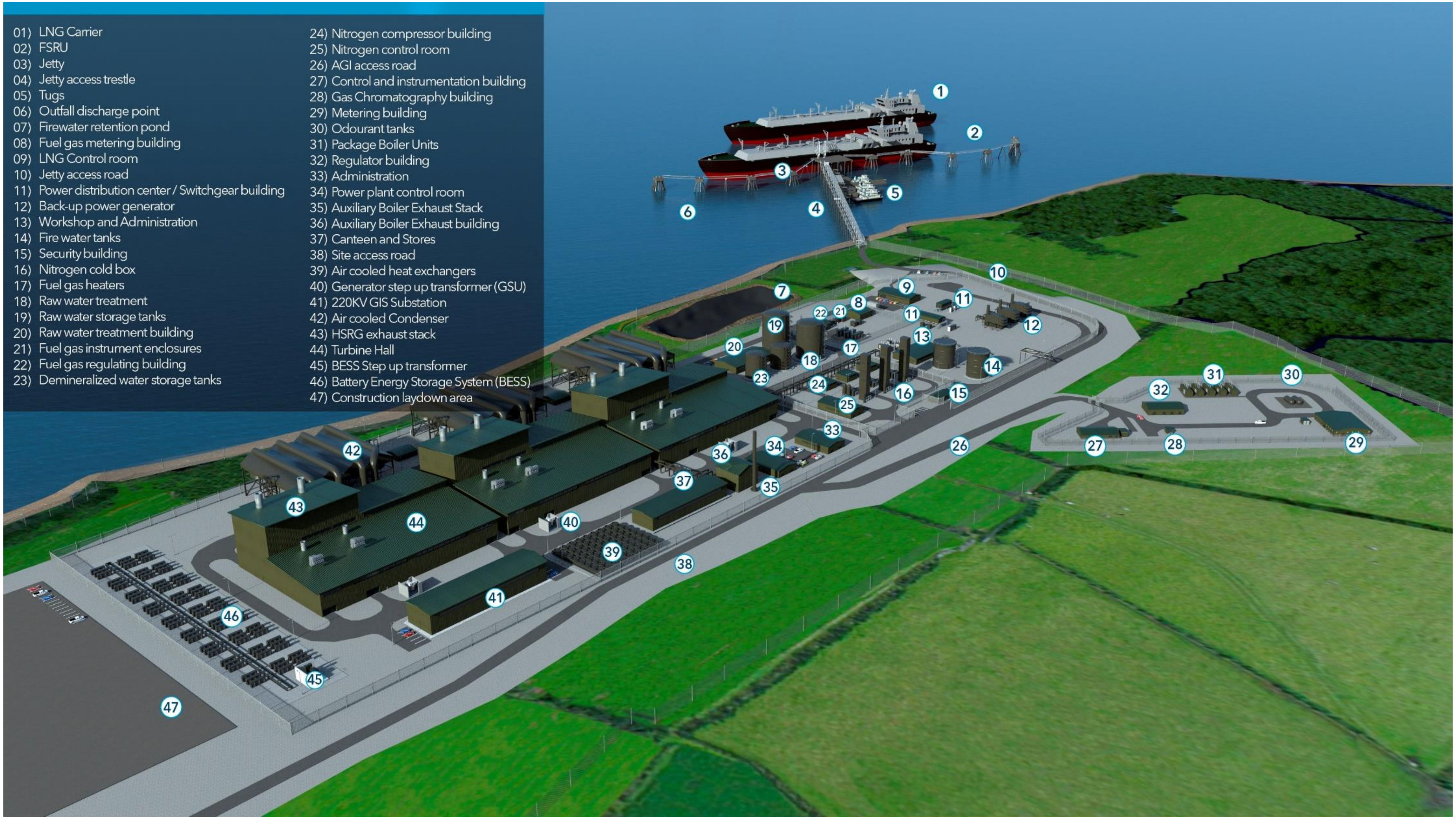


Figure 2-5 Proposed Layout of the Proposed Development

2.4.2.1. Floating Storage Regasification Unit

The FSRU will be berthed at the jetty. Being an oceangoing vessel, the FSRU will have approximately 35 crew members onboard and will be operating under all relevant national and international maritime rules. Further information on the emissions and waste from the FSRU are provided in **Section 2.5**.

The FSRU will be connected to onshore receiving facilities except when disconnected due to adverse weather conditions, during planned yard maintenance and in the event of emergencies (see planning application drawings for details).

LNG vaporisation process equipment to regasify the LNG to natural gas will be onboard the FSRU. Heat energy necessary for regasification of LNG will be derived from locally drawn seawater, supplemented by gas fired heaters for use during periods when the water temperature is inadequate.

At the time of writing this EIAR, the charter agreement for a specific FSRU for the LNG Terminal at Shannon Technology and Energy Park has not been completed. Therefore, the exact characteristics, equipment layout and details of the technical systems which form an integral part of the FSRU are not known. For the purposes of the EIAR, a worst-case scenario in terms of emissions and the potential for environmental impact, has been derived from a review of a range of vessels on the market from various FSRU suppliers.

The FSRU is anticipated to have an LNG storage capacity of approximately 170,000 m3 (up to 180,000 m3), with 180,000 m3 representing the maximum amount of LNG to be stored. The FSRU will be up to 300 m long and up to 50 m wide with a maximum draft of 13 m. In a deep water channel (approximately 20 m) the FSRU will be located at a nominal depth of 12 m. See Figure 2-6.

The height of the FSRU above Ordnance Datum will vary continuously due to tides, the amount of LNG cargo onboard and water ballasting. For example at mid tide, the overall height of the vessel, from the Summer Load Water Line (SLWL) to the top of the highest structure on the FSRU (its communication mast) will be 46.6 m above Ordnance Datum. The height of the FSRU above the water line during Mean High Water Spring (MHWS) tides and with the FSRU unladen (at ballast draft) and will be 54.8 m above Ordnance Datum. Regardless of sea level, Ordnance Datum, tides, cargo and ballasting, the physical height of the FSRU structure from bottom of the hull to the top of the highest structure on the FSRU will be 58.9 m.

The FSRU will be double-hulled and contain LNG cargo tanks designed for storing LNG at very low temperatures, i.e. approximately -163ºC. The tanks will be lined with specialised membranes to allow the storage of chilled LNG. The low temperature and the insulation will keep the LNG cargo in a liquid state until it is required for regasification.

The LNG vaporisation equipment onboard the FSRU will be designed to meet a send-out capacity of up to 22.6 million Sm^3/d (approximately 250 GWh per day) natural gas. Additional information is outlined below.

When the FSRU's LNG tanks are empty,[17] another ship will arrive to fill the FSRU. Visiting ships, known as LNG Carriers, will moor alongside the FSRU and refill the FSRU storage tanks via ship-to-ship

[17] Note that a minimum of 18,500 of LNG will always remain in the FSRU LNG tanks to comply with operational and secondary fuel storage obligations

transfer. The refilling process will take approximately 35 hours, after which the visiting LNG carrier will depart. Further information on this is provided below.

The FSRU will be self-sufficient in terms of producing the necessary electricity and heat to run the ship's systems and the LNG storage and vapourisation process. The vessel will use electricity to power pumps, the regasification equipment, auxiliary systems and for the crew accommodation. Generators will be powered by dual-fuel engines which will use boil-off natural gas from the LNG storage tanks as main fuel. As a pilot fuel, the engines will burn a small amount of marine diesel oil (MDO), estimated at up to 1 m^3/day at maximum.

In the event of an onshore emergency, the FSRU will be disconnected, and its mooring lines automatically released from the jetty, enabling the FSRU to sail quickly to a safe area.

A Process Control System (PCS) and an associated Fire and Gas (F&G) and Emergency Shut-Down (ESD) System will be in place to ensure the integrity of the facility and the safety of personnel. Should a loss of containment of natural gas and/ or a fire occur, the F&G System will detect the incident and trigger the operation of the active fire protection system and the ESD system.

The FSRU will operate in accordance with international conventions on safe navigation, i.e. conditions that have been established by the SOLAS Convention and other international conventions accepted within the International Maritime Organization (IMO).

The FSRU will also meet all the relevant requirements of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), as amended (IMO, 1986).

The specification of the FSRU is presented in **Table 2-1**. The EIAR has considers the maximum values for the purpose of the impact assessments.

Table 2-1 Specification of the Floating Storage Regasification Unit FSRU

	Minimum	Maximum
LNG Storage capacity (m^3)	130,000	180,000
Length (m)	250	300
Width (m)	43	50
Draught (m)	9.0	13
Crew capacity	20	35
LNG storage tank type	Spherical or membrane	
Peak day LNG send out capacity	22.6 million Sm^3/d	

2.4.2.1.1. Liquid Natural Gas Vaporisation Process

When natural gas is needed downstream of the LNG Terminal, i.e. in the gas transmission network, or at the Power Plant, LNG stored onboard the FSRU will be vapourised or regasified onboard the FSRU. The natural gas will then be discharged under pressure via Gas Loading Arms (GLAs) to gas piping on the jetty and onwards to the onshore receiving facilities. From there the gas is routed to the Power Plant, LNG Terminal gas turbine generator and/ or GNI's gas transmission network at the AGI.

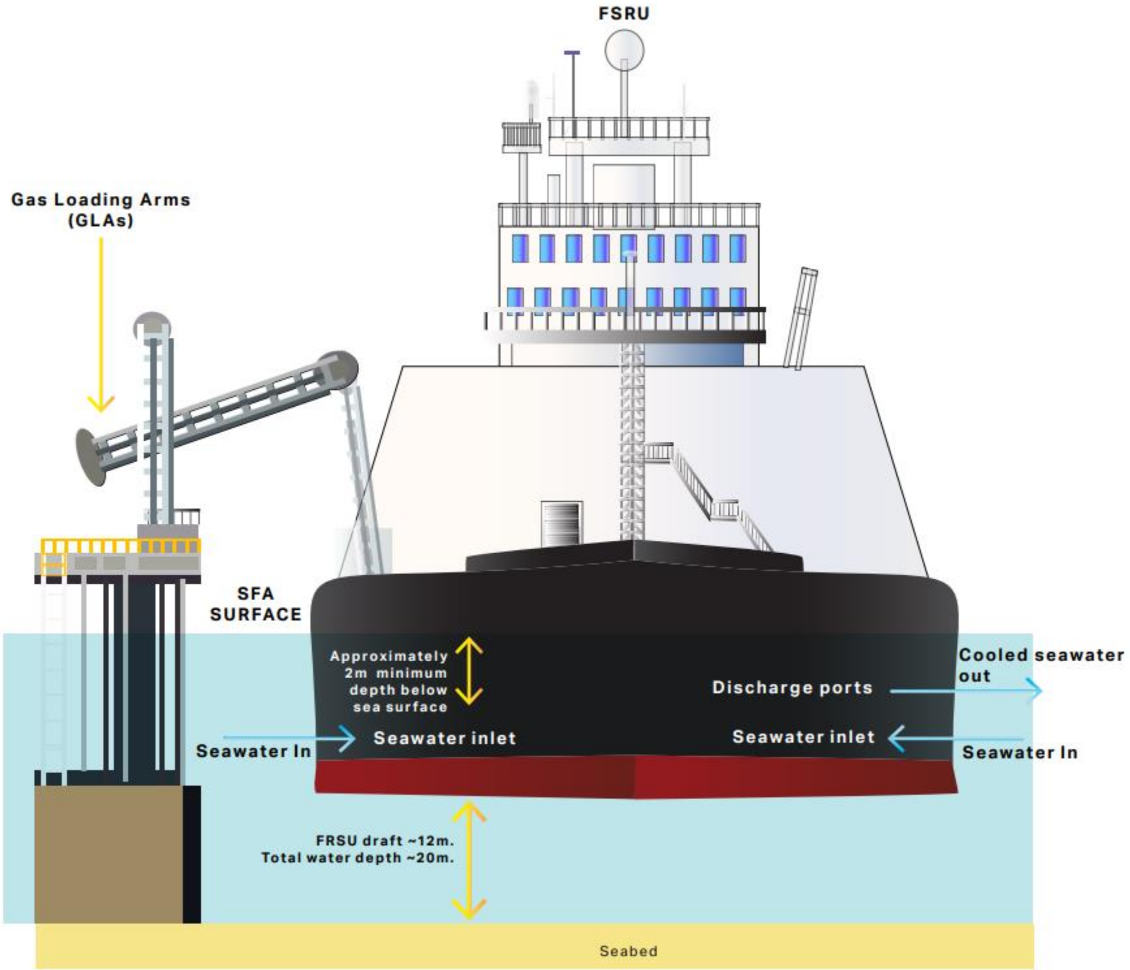


Figure 2-6 FRSU Overview

The onboard regasification unit will have several regasification trains operating in parallel. This enables a degree of turndown, i.e. delivery of varying rates of gas to shore, with the minimum throughput capacity of a single regasification train representing the minimum flowrate and the maximum throughput rate of all of the trains operating simultaneously representing the maximum discharge rate from the FSRU. The number of trains that will be in use at any one time depends on the gas demand. Generally, it is anticipated that the FSRU will be operating with one or two regasification trains running, representing low to medium throughput rates.

The intake and discharge of seawater will be required for the regasification process. Details on the seawater volume, treatment and discharged are presented in below.

Seawater needed for the regasification process will be drawn through a seawater intake in the hull of the FSRU located approximately 2 m below water level. Seawater pumps will circulate the seawater at the required rates through heat exchangers in the FSRU regasification trains. The heat exchangers rely on two phases of heat exchange process:

- Between seawater (as the heat source) and an intermediate fluid (for example propane); and
- Between the intermediate fluid and the LNG.

The pumps will be turned on or off as required based upon the number of regasification trains running.

Two modes of regasification will be employed.

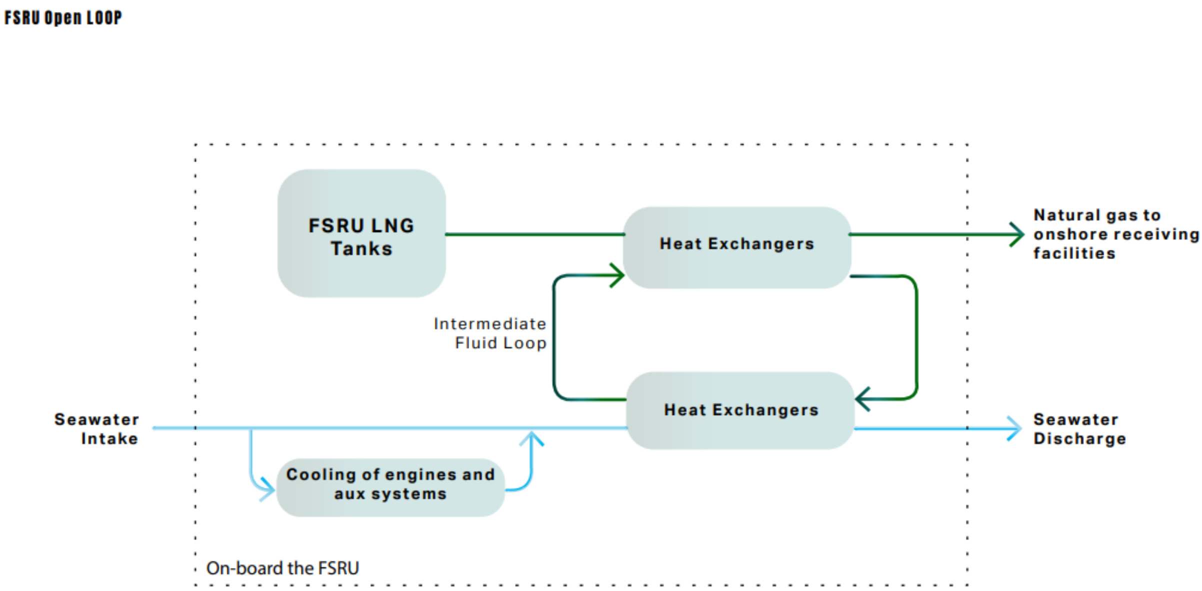


Figure 2-7 Open Loop Regasification

An 'open loop' regasification mode will be used when the seawater intake temperature is approximately 12°C or higher, and a 'Combined loop' regasification mode will be used when the seawater temperature is below 12 °C.

The charter agreement for a specific FSRU has not been completed. Following a review of a range of vessels on the market from various FSRU suppliers, a range of temperatures between 9 °C to 12 °C were identified at which open loop commences and combined loop stops. For the purposes of this EIAR, a temperature of 12 ^{0}C for commencement of open loop mode was selected. 12 °C is a conservative assumption in terms of emissions and to consider the potential environmental impact. It may be the case that the final FSRU will commence open loop at a lower temperature.

In the open loop regasification mode, the heat provided from the seawater, via the heat-exchangers will be sufficient to regasify the LNG. In the combined loop mode seawater will still be used; however, additional supplementary heat will be supplied into the seawater via steam from gas-fired boilers prior to the seawater entering the heat-exchangers in the regasification system. The gas-fired boilers use boil-off gas (BOG) from the LNG storage tanks as fuel gas.

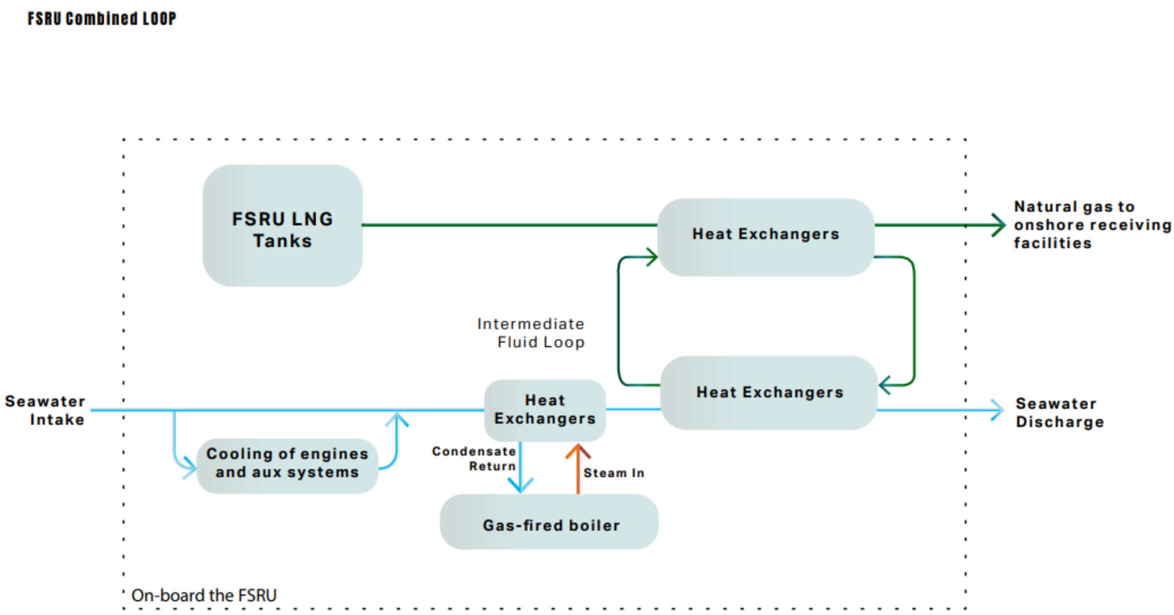


Figure 2-8 Combined Loop Regasification

The seawater that has been used for regasification will be discharged from the FSRU via a subsea pipe. On discharge, this seawater will be up to 8 °C colder than the receiving ambient seawater. In order to optimise mixing and return of the seawater to ambient conditions, the seawater discharge ports will be orientated to deliver a horizontal water jet below the water surface.

When taking into account local seawater temperature data, it is predicted that the combined loop regasification mode will need to be used from the middle of November to early May. During this period supplementary gas fired heaters will be required. The exact temperature of the river Shannon varies from season to season, so the precise timing of the combined loop operation will vary from season to season. The amount of supplementary heat produced will be proportionally increased/ decreased as the water temperature gets colder/ warmer from the 12 °C open loop setpoint, aiming to use heat from the seawater as much as possible.

Boil-off Gas

Despite insulation of the tanks in which the LNG is stored which will limit the admission of external heat, slight evaporation of the LNG will occur during storage, shipping and loading/ unloading operations. This natural evaporation of small amounts of LNG is known as boil-off gas (BOG) and is removed from the tanks to manage tank pressure.

During regasification, BOG is recovered and used as a fuel source in the power generators onboard the FSRU, with any excess BOG being recondensed back into a liquid and stored as LNG. BOG can also be compressed via a minimum send out compressor (MSO) onboard the vessel and discharged via the jetty to downstream users i.e. the gas transmission network via the AGI or the Power Plant.

Table 2-2 presents a summary of the regasification process.

Table 2-2 Regasification Summary

Regasification Summary	
Peak day send out capacity, Max	22.6 million Sm^3/d
Gas Discharge Temperature	Between 1 °C and 4 °C
FSRU Maximum send out pressure	98 Barg
Seawater temperature for 'Open Loop'	> 12°C or 12 °C
Seawater temperatures for 'Combined Loop'	<12 °C
[18] Approximate heat required for LNG regasification	145 MW

2.4.2.1.2. FRSU Water Consumption

The FSRU requires seawater for the following purposes:

Ship systems:

- Main engine cooling;
- Auxiliary machine systems cooling;
- Freshwater generation;
- Ballast; and
- Firewater and service water (intermittent).

LNG Regasification and LNG ship-to-ship transfer:

- Heating/ regasification; and
- Water curtain (during ship to ship transfer from LNG Carrier, intermittent).

The FSRU will manage its draught using untreated ballast water with a maximum capacity of approximately 55,000 m^3. During unloading of LNG i.e. during regasification, the FSRU will take in seawater as ballast to compensate for the reduction of LNG inventory in the cargo tanks as the natural gas is exported to shore. During loading, i.e. ship-to-ship transfer of LNG to the FSRU storage tanks from the LNGC, ballast water will be discharged from the FSRU.

The FSRU will also use seawater for main engine cooling (approximately 1500 m^3/hr), auxiliary systems cooling (approximately 2000 m^3/hr) and onboard freshwater generation (approximately 100 m^3/hr).

There will be intermittent uses of seawater; for example, to test the onboard firefighting systems, intermittent deck washing (approximately 70 m^3/hr), and to create a water curtain when loading LNG from the LNGC (approximately 300 m^3/hr). The water curtain protects the hull from being directly exposed to cryogenic temperatures in the unlikely event that any LNG were to escape during unloading operations. The FSRU firewater system is anticipated to be tested for approximately one hour every 2 weeks.

In addition to the seawater discharge ports for regasification water, several auxiliary discharge ports will be located near the FSRU engine room, including for cooling and ballast as is typical for ocean-going vessels.

[18] The exact amount of heat depends on each LNG cargo delivered

Seawater Intakes

Seawater intakes will be located in the hull of the FSRU, approximately 2 m below water level. Screens will be covering the intakes to prevent fish, crustaceans and debris from entering the seawater system within the FSRU. The design of the water intakes will be such that the approach velocity of the seawater entering the screens will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm. It is anticipated that any silt entering the seawater circulation system will remain in suspension and carry right through the system.

Seawater Discharge

A schedule of FSRU seawater use is presented in **Table 2-3** below.

Table 2-3 FSRU Water Use Summary

Description	Typical (Notes 1, 2)	Maximum	Temperature Difference to Ambient Sea temp.
Seawater for LNG regasification process	11,000 m3/hr	22,000 m^3/hr.	- 8 °C
Seawater for main engine cooling	1,360 m^3/hr	1,500 m^3/hr	+12 °C
Seawater for auxiliary systems cooling	1,040 m^3/hr	2,000 m^3/hr	+5 °C
Seawater for freshwater generation	80 m^3/hr	100 m^3/hr	None
Intermittent use: seawater for onboard firefighting systems and deck washing	70 m^3/hr	70 m^3/hr	None
Intermittent use: Seawater curtain during ship to ship transfer of LNG from the LNGC	300 m^3/hr	300 m^3/hr	None

Note 1 The largest continuous use of seawater is for the LNG regasification process at 22,000 m^3/hr. This flowrate has been calculated for the day peak gas send out of 22.6 million Sm^3/d, which will only happen very infrequently (estimate 1% of the year). On an annual average basis, the FSRU will be send out approximately 14.8 million Sm^3/d of gas. At this annual average rate, the water consumption will be about 11,000 m^3/hr. Refer to **Section 2.4.2.1.1**. for further discussion on the regasification system.

Note 2 The amount of seawater for engine cooling and auxiliary systems is calculated conservatively with all engines running and all the auxiliary pumps running. Typically, only one main engine and one auxiliary cooling pump will be in operation at the nominal send-out capacity of 14.8 million Sm^3/d.

2.4.2.1.3. Seawater Electrochlorination

A small amount of sodium hydrochlorite is injected into the FSRU seawater systems to control microbial growth. The sodium hypochlorite is generated onboard in an electro-chlorination unit. The electro-chlorination unit will consist of cells housing platinised titanium electrodes between which a direct electric current flows. The sodium chloride salts in the sea water passing between the electrodes dissociate to form residual sodium hypochlorite (chlorine) without the addition of any chemicals. As the seawater passes through the system and is discharged back into the estuary, the chlorine will dissipate back into the sea water from which it will have been produced. The concentration of residual chlorine at the seawater discharge will be monitored and will not exceed 0.5 mg/l.

2.4.2.2. Jetty and Access Trestle

The jetty will be capable of receiving and providing secure berthing for the FSRU as specified above. Its main purposes are for the safe berthing of the FSRU, and for accommodating the necessary gas piping and equipment to safely transfer natural gas from the FSRU to the onshore receiving facilities. The jetty head will comprise (**Figure 2-9** and **Figure 2-10**):

- An unloading platform;
- 8 no. mooring dolphins; and
- 2 no. breasting dolphins.

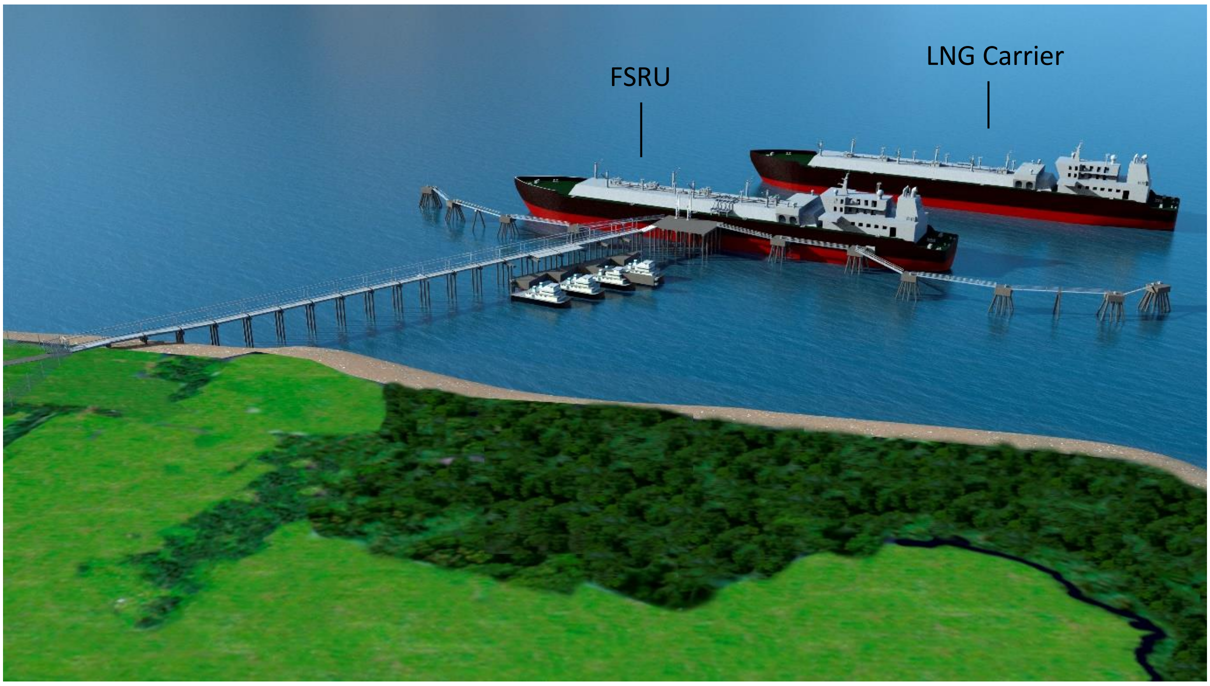


Figure 2-9 Proposed Development Jetty Configuration

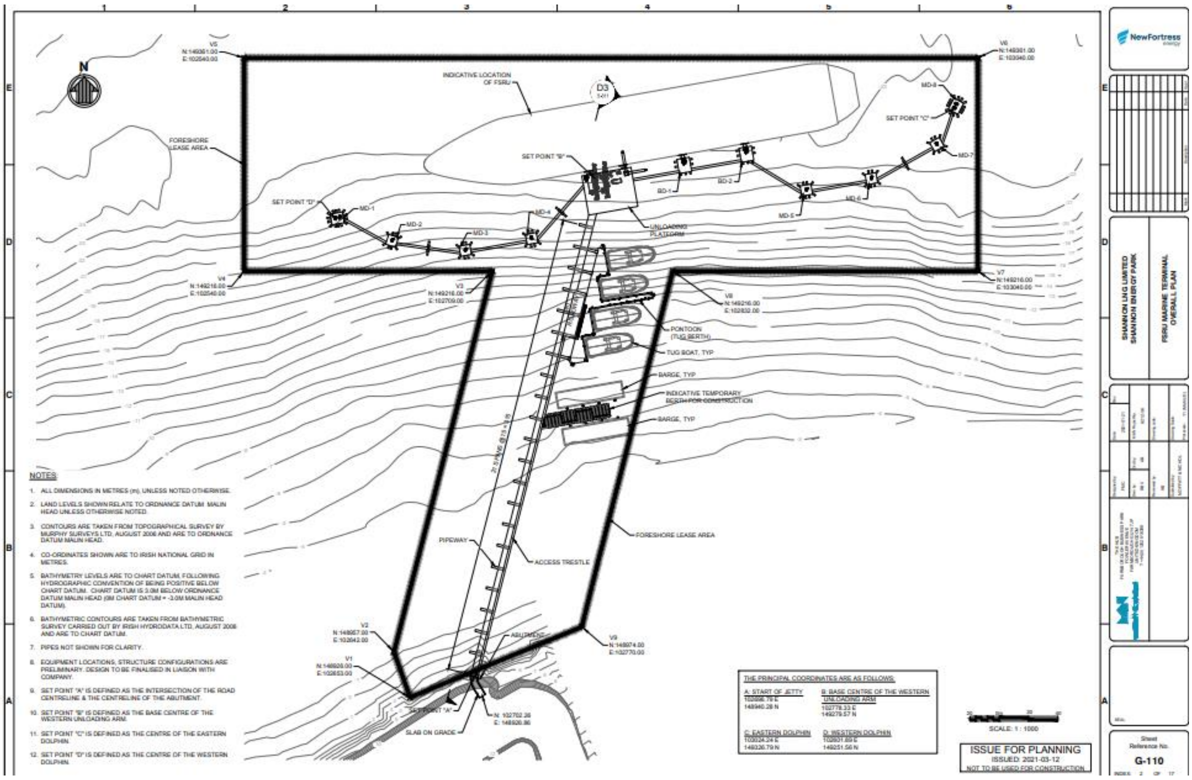


Figure 2-10 FSRU Marine Terminal Layout

The mooring dolphin layout is based on standard industry recommendations for angles of mooring lines (Oil Companies International Marine Forum, 2008). The unloading platform will be supported by steel piles with an additional row of piles along the berthing face to support the weight of the gas unloading arms. The design of the breasting dolphins will take into account the parallel mid-body width of the LNG ships, their various manifold positions forward and aft of mid length, to ensure that ships have adequate fender contact at all times. The unloading platform will also be equipped with fenders. Each of the dolphins will be supported by approximately eight tubular steel piles (see planning application drawings for further detail).

The access trestle, which will connect the jetty head to the shore, will be approximately 315 m in length, and will include a roadway for operational and maintenance access. The trestle will comprise 21 spans of approximately 15 m length with a width of approximately 11 m. The jetty platform elevation will be set at +9 m OD (Malin Head), to be clear of extreme water levels and waves. In total there will be approximately 203 piles inserted into the riverbed for the jetty and the access trestle. Following a constructability review, a temporary loading/ mooring facility has been included in the proposed jetty design which allows a mooring point for the construction of plant. Further details on the construction of the jetty can be found in **Section 2.9.4.1**.

Given the natural water depth at the site, no dredging is required for the Proposed Development.

The infrastructure to be installed on the jetty will include:

- Two GLAs on the unloading platform;
- A 30” (750 mm) gas pipe. The gas piping will run from the unloading arm on the platform to the onshore receiving facilities via a pipe rack which will be installed on the western side of the trestle;

- Hydraulic gangway tower to access the FSRU from the jetty;
- Power Distribution Centre (PDC);
- Compressed air system;
- Fire-fighting systems;
- Spill containment equipment; and
- Lighting and CCTV security system.

The GLAs will facilitate the connection of the 30” gas pipe described above to the FSRU discharge flange/ connector. The arms will be composed of rigid pipe sections which can swivel to allow a flexible connection between the floating (potentially moving) vessel and the rigid gas piping on the jetty. The top of the unloading arms will be approximately 30 m above the platform of the jetty. The 30”gas piping on the jetty will be designed to withstand the maximum discharge pressure from the FSRU. In the event that the FSRU is disconnected from the jetty, the gas inventory within the piping on the jetty will be isolated at the interface with the GLAs. The gas held in the arms will be vented back to the FSRU before disconnecting.

The FSRU will discharge the natural gas into the GLAs at pressures ranging from 48 to 98 barg at flowrates up to 22.6 million Sm^3/d.

It is anticipated the jetty will be operationally available 24 hours a day. Table 2-4 presents a summary of the key specification of the jetty.

Table 2-4 Key Jetty Specification

Description	Quantity
Number of GLAs	2
Jetty gas pipeline nominal diameter	750 millimetres
Jetty gas pipeline length	315 metres
Fire fighting system	Fire pumps, fire monitors, hydrants
Associated infrastructure	Gangway tower, substation, air compressors, transformer, lighting and CCTV system

2.4.2.3. Tugs

Visiting LNGCs delivering LNG to the Proposed Development will require tug support during both arrival and departure as well as for estuary channel navigation. **Figure 2-11** presents the specification of a typical tug, which will be used.

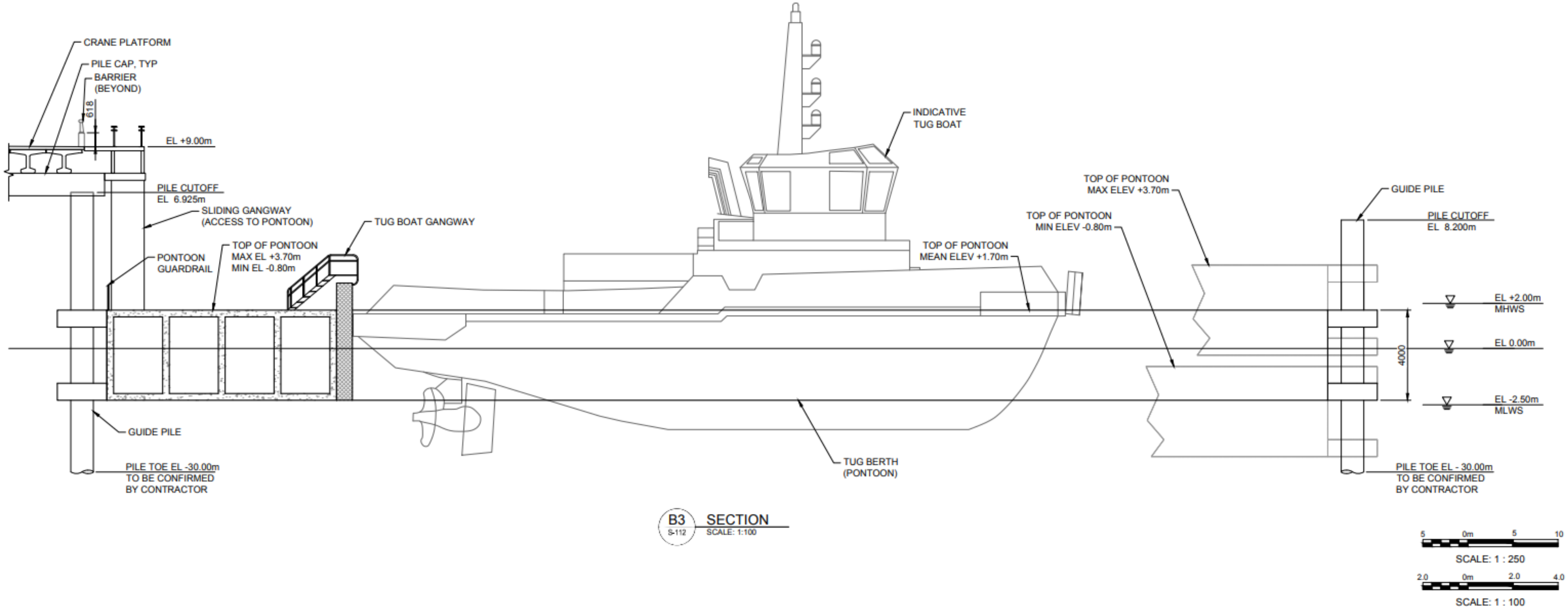


Figure 2-11 Typical Specification of a Tug

The basic functions of the tugs will be for push-pull, escorting, berthing, towing, and in certain circumstances firefighting and pollution control operations. The procedures for towage operations will be developed and written in consultation with and agreed with SFPC.

It is proposed that four new tractor type tugs of about 70 tons bollard pull each are included as part of the LNG Terminal.

The specification of the tug design will be finalised once the FSRU has been selected and contracted. The tugs will be licensed to operate at the Proposed Development by SFPC. The four tugs will be available for FSRU and LNGC mooring operations i.e. typically to safely moor/ unmoor the LNGC alongside the FSRU for LNG transfer. The tugs will be stationed at the jetty in order to meet the necessary service notice requirements, with a minimum of two tugs being moored there. Two fire monitors will be controlled remotely from the wheelhouse of the tug.

When a LNGC is berthed alongside the FSRU, a minimum of one tug will be on standby, underway near the jetty and ready for immediate use. Its primary function will be to provide offshore fire-fighting capabilities during LNG loading operations. A second tug will available at 30 minutes' notice and the third and fourth tugs will be at two hours' notice.

During normal operations when there is no LNGC moored at the jetty, it is anticipated that there will be a minimum of one tug available at the berth, tied alongside but manned and available for immediate use with a second tug at 30 minutes' notice. The third and fourth tugs will be at 2 hours' notice.

The specification of the tugs will be such that at least 2 of the 4 tugs are 'escort notated'. Escort tugs employed in active roles are designed to be capable of operating at speeds of approximately 1.5 times the speed of the approaching LNGC.

2.4.2.4. LNG Supply by LNG Carriers

The LNG in the LNG Terminal will be supplied from visiting LNGCs moored alongside the FSRU in a ship-to-ship transfer configuration. The LNG will then be transferred from the LNG tanks of the LNGC into the LNG storage tanks onboard the FSRU. Once the transfer of LNG is complete, the LNGCs will depart from alongside the FSRU with the assistance of tugs.

Up to 60 LNGC visits per year are anticipated. In addition to the 35 hours required to transfer the LNG, approximately 25 hours in total will be required to moor, berth, unmoor and unberth the LNGC. Ship passage time from the mouth of the Estuary to the Proposed Development is estimated at 4 hours.

The Proposed Development is designed to accommodate LNGCs with a varying capacity ranging from 130,000 m^3 to 265,000 m^3. As of June 2021, 57% of the current world LNGC fleet is between 150,000 and 180,000 m^3 (International Gas Union, 2021). Therefore, it is anticipated that the majority of LNGCs arriving at the Proposed Development will be in the range between 150,000 and 180,000 m^3. See **Figure 2-12** for the LNGC berthing plan.

The LNGCs to be used will comprise double hull construction with the LNG containment systems, equipment and insulation typically installed within the inner hull. LNG will be carried in specially designed cargo tanks onboard the LNGC. The natural gas, which consists predominantly of methane, has a boiling point of approximately -163°C, and LNG is stored at -163°C at atmospheric pressure to remain liquid. The LNG storage tanks are insulated to minimise the thermal flow from the environment to the LNG storage tanks and to minimise the amount of evaporation i.e. BOG produced. The tanks are surrounded completely by two insulation spaces. The insulation spaces will be filled with inert gas, typically nitrogen to provide an inert blanket around the tanks whilst also supporting the gas detection systems installed to continuously monitor the cargo.

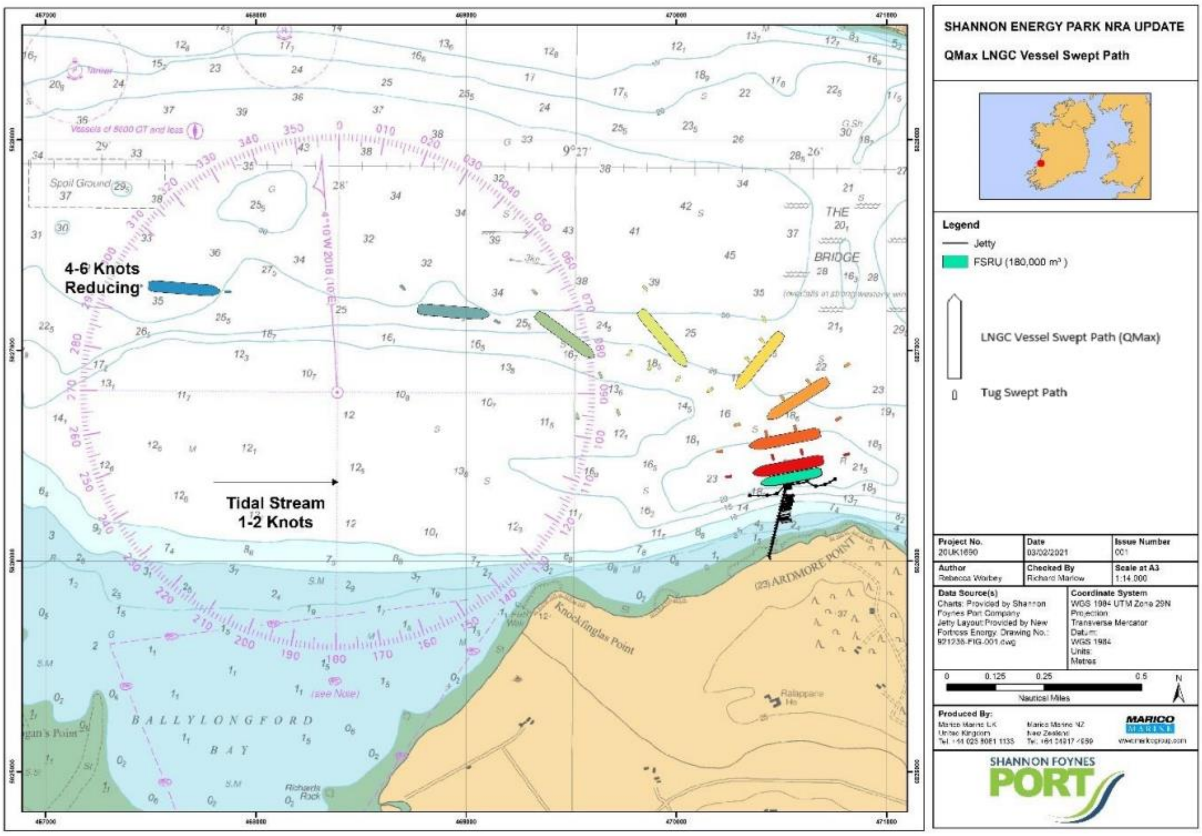


Figure 2-12 LNGC Berthing Plan

The LNGCs will employ either one of two main cargo containment systems:

- Moss spherical tanks system, identified by its large spheres above deck level; or
- Membrane tank system with a more conventional flat deck appearance.

Refer to **Figures 2-13** and **2-14**, for an image of both a Moss type and membrane type ships (respectively).

Figure 2-13 LNG Carrier with Moss Spherical Tank System

Figure 2-14 LNG Carrier with Membrane Tank System

Modern newbuilds have for the most part adopted the membrane type. Specifically, 79% (454) of the LNGC fleet today use membrane tanks, with the remaining 21% (118) being Moss type (International Gas Union, 2021).

The LNGCs that will be employed will be fuelled by natural gas in the form of BOG, diesel, heavy fuel oil, or a combination of BOG with either of the liquid fuels. The current world fleet of LNG ships is predominantly steam turbine powered, having sea service speeds of approximately 19 knots. They are equipped to burn BOG from the cargo in their boilers thus minimizing consumption of fuel oil and avoiding any venting of gas to the atmosphere. Specifically, of the 572 active LNGCs in the world, 92% (526) use either wholly natural gas in form of BOG, or a combination of BOG with either of the liquid fuels. Only 8% (48) exclusively use diesel as fuel. All LNGC engines will comply with the emissions standards set by the MARPOL convention, when using liquid fuel. New generation ships now entering service include dual-fuel natural gas burning diesel electric propulsion systems, which also burn BOG, eliminating any venting of gas.

While the frequency of LNGCs accessing the operational facility is currently estimated at up to 60 visits per year, the LNG containment type, size and propulsion system for each visiting LNGC will vary within the limits set out above.

Pilotage of vessels, including the LNGCs, will be provided by Shannon Estuary Pilots under the direction of the Harbour Master.

For details of the procedures for the arrival and berthing of an LNGC, the unloading operation and for departure, refer to Appendix A2-2 in EIAR Vol. 4 Marine Navigation Risk Assessment (SFPC, 2021).

It is envisaged that the port side of the FSRU will be moored to the jetty, and the LNGC will be berthed by the port side to the FSRU. The main reason for such an arrangement is to point the bow of both vessels to the open sea during the stay on berth so that fast departure of vessels in case of extraordinary circumstances is possible, even without tugs.

Visiting LNGC will arrive full of LNG and there will be no discharge ballast water into the Shannon. The LNGC will take on seawater as ballast as they unload their cargo.

2.4.2.5. Onshore Receiving Facilities

The onshore receiving facilities comprises the following components (**Figure 2-15**):

- Nitrogen generation plant for gas blending (**Section 2.4.2.5.1**);
- Buildings (**Section 2.4.2.5.2**);
- Onsite power generators (**Section 2.4.2.5.3**);
- Black start diesel generator (**Section 2.4.2.5.4);**
- Instrument and plant air package (**Section 2.4.2.5.5**);
- Fire water storage tanks and fire water pumps (**Section 2.4.3.1.4**); and
- Gas metering and regulation area (**Section 2.4.3.1.2** and **Section 2.4.3.1.3**).

Figure 2-15 Proposed Onshore Receiving Facilities

2.4.2.5.1. Nitrogen Generation Plant

The function of the nitrogen generation plant will be to generate nitrogen from air and store it for use at the LNG Terminal. Nitrogen gas will be required for blending in the event that natural gas received from the FSRU to meet the requirements of GNI. Nitrogen will then be injected into the gas stream to achieve the required specification. Nitrogen will also be required for purging of equipment and piping during operation and maintenance activities.

2.4.2.5.2. Buildings

The LNG Terminal will comprise the following buildings:

- Main LNG control building;
- Nitrogen generation package control building;
- Nitrogen compressor building;
- Electrical switchgear enclosures;
- Power Distribution Centre;
- Continuous emissions monitoring (CEMS) enclosures; and
- Workshop/ warehouse building.

Buildings and enclosures common to both the Power Plant and LNG Terminal are described in **Section 2.4.3**.

Main LNG Control Building (22.7m x 14m)

Operation of the LNG Terminal will be monitored and controlled from the Main Control Building. This building will include a control room, electrical and instrumentation room, meeting room and offices for the personnel stationed at the LNG Terminal.

Nitrogen Generation Package Control Building (6.1m x 15m)

The operation of the nitrogen generation plant (see **Section 2.4.2.5.1**) will be monitored and controlled from the Control Room in the Nitrogen generation package control building. This building will also comprise an electrical and instrumentation room, meeting room and offices for the personnel associated with the nitrogen generation plant.

Nitrogen Compressor Building (8.6m X 12m)

Nitrogen gas compressors to pressurise the nitrogen up to 98 barg for injection into the natural gas will be housed in the nitrogen compressor building. These buildings will normally unoccupied.

Electrical Switchgear Enclosures (9m x 26m and 4m x 11m)

Two electrical switchgear enclosures – main and secondary – will house the electrical and control equipment necessary to distribute power and control throughout the LNG Terminal. The enclosures will be pre-manufactured from all-weather steel. The enclosures will be mounted on steel support legs or concrete piers to elevate the enclosures and allow bottom entry for electrical/ control wiring, and will normally be unoccupied.

Power Distribution Centre

Two PDCs will house electrical and control equipment necessary to distribute power and control throughout the LNG Terminal. Each PDC will be a pre-manufactured all-weather steel enclosure. The enclosure will be mounted on steel support legs or concrete piers to elevate the enclosure and allow bottom entry for electrical/ control wiring.

Continuous Emissions Monitoring Enclosures (1.9m x 1.9m)

Three enclosures will house the CEMS.

Workshop/ Warehouse Building (18m X 28m)

The workshop and warehouse building will provide storage for equipment and material spares required to maintain an operational facility. The building will also include a number of maintenance offices and a workshop area. A summary of the proposed architectural colour scheme is provided in **Table 2.5**.

Table 2-5 Summary of Proposed Architectural Colour Scheme

Building Unit	Colour
Fencing, enclosure/ equipment container sides and tops, racks, evaporators, water tanks	RAL 6006 (Grey-Olive)
Building and enclosure façades	RAL 6003 (Olive green)
Building and enclosure roofs	RAL 6020 (Chrome green)
Doors, window frames, auxiliary boiler and fuel gas stacks and cooler pipes	RAL 7043 (Traffic grey B)
Façade for the turbine halls	RAL 6011 (Reseda Green)
Turbine air intakes and diesel generator/ HRSG exhaust stacks	RAL 9023 (Pearl dark grey)

2.4.2.5.3. Onsite Power Generators

It is anticipated that once operational, a small percentage of the electricity generated by the Power Plant will be used to power to the LNG Terminal. Three no 8 MW gas fired electricity generators will be used to provide onsite power generation to the LNG facilities while the 220 kV connection is being constructed in the absence of the 220 kV and medium voltage (10/ 20 kV) grid connections. Fuel gas for these generators will be supplied from gas from the FSRU. However, if there is no gas from the FSRU, the generators will be powered by fuel gas which will be reverse flowed from the consented 26 km 30” Shannon Pipeline.

If the 220 kV and medium voltage (10/ 20 kV) grid connections are consented, these power generators will be used as back up power generation if the grid connections fail, or are unavailable.

Additional information can be found in **Section 2.4.6.1**.

2.4.2.5.4. Black Start Diesel Generator (5m x 9.4m)

A black start diesel generator will be provided to enable start-up of the onsite power generators without a connection to the electricity grid. The diesel fuel for the black start generator will be stored in a bunded or a double-walled tank.

2.4.2.5.5. Instrument and Service Air Package (11.7m x 4.6m)

Compressed air for instrument use and for service and maintenance use will be generated onsite. A combined instrument and service air distribution system will be installed and compressed air will be supplied from a compressed air generation unit. This will include a backpressure regulator to prevent loss of pressure in the instrument air system when pneumatic tools are being used, along with associated equipment such as filters.

2.4.2.6. Above Ground Installation

The AGI will accommodate the valves and control equipment to facilitate the connection to the already consented 26 km 30” Shannon pipeline. It will facilitate the transportation of gas to GNI, and will include odorisation, fiscal metering and pressure control of the gas flow prior to it entering the national gas network. The AGI is located in a separate compound within the Proposed Development. Once commissioned, GNI will operate the AGI. The indicative layout of the AGI is shown in **Figure 2-16**.

Figure 2-16 Proposed Layout of the AGI

The details provided on the AGI are based on information provided by GNI and will be typical of existing GNI AGIs on the national gas transmission network. If required, the AGI will be able to supply the LNG Terminal and/ or Power Plant with a gas. In addition to gas piping and associated valves, the AGI will house the following equipment and buildings (see Figure F2-6, Vol. 3):

- Odorisation package including bulk odorant storage;
- Pig-trap (Bi-directional);
- Filtration;
- Heaters (Package Boiler Units)/ heat exchangers and associated fuel gas skid;
- Metering equipment located in a Metering Building;
- Gas pressure regulation system located in a Regulator Building;
- Gas chromatographs/ Chromatograph Building;
- Generator Building; and
- Control and Instrumentation building.

The AGI compound will be remotely operated and will normally be unmanned.

2.4.2.6.1. Odorisation (21 m x 11.7 m)

Natural gas, which mainly comprises methane, has little or no natural smell. The gas entering the transmission network is therefore injected with small traces of a strongly smelling substance, which is added for the purpose of safety and leak detection for consumers. The odorant is stored in odorisation tanks, a control system and associated pipework will be installed to enable the injection of carefully controlled volumes of odorant into the natural gas (typically 6 milligrams per m^3).

2.4.2.6.2. Pig-Trap (Bi-directional)

A bi-directional pig-trap (and associated equipment) will be installed to launch (or retrieve) the pipeline inspection gauge (pig). Pigs are in-line tools which are propelled through the pipeline for two main purposes: namely initially during the gassing-up/ commissioning to clean and dewater the pipeline, and later, when the pipeline is operational, to inspect the internal condition such as the wall thickness of the pipeline. This inspection pig is also termed an intelligent pig.

2.4.2.6.3. Pressure Reduction/ Flow Control

The pressure reduction/ flow control equipment, which is to be included in a 20.5 m x 12.6 m regulator building, will enable the pressure and flow rate of the natural gas entering the gas transmission network to be controlled as required by the network operator, GNI.

2.4.2.6.4. Heat Exchangers (31.9 m x 40.5 m)

During times when gas pressure is reduced, as described above, the act of reducing the pressure of the gas causes a drop in gas temperature (through the Joule Thompson effect). The gas is therefore passed through a set of heat exchangers to preheat the gas prior to pressure reduction ensuring the gas is 2 ˚C or higher in temperature before it enters the grid. The heating medium to be used for these heat exchangers will be water heaters in boiler units (see below).

2.4.2.6.5. Fuel Gas Heaters

The heating medium (water) combined with Alphi 11 anti-freeze is heated by gas fired boilers planned to be housed in individual package boiler units (PBU) buildings (5 number 13 m x 3.5 m).

2.4.2.6.6. Metering Building (25 m x 20 m)

Fiscal metering of the gas will occur in a metering building (25 m x 20 m).

2.4.2.6.7. Regulator Building (20.5m x 52.7m)

See **Section 2.4.2.6.3**.

2.4.2.6.8. Gas Chromatograph Building (3.5 m x 4.5 m)

The gas chromatography building will house a gas chromatograph where the calorific value of the gas is determined prior to entering the grid.

2.4.2.6.9. Generator Kiosk (4.8 m x 3.5 m)

Generator(s) will be located in the generator building (4.8m x 3.5m).

2.4.2.6.10. Control and Instrumentation Building (20 m x 40 m)

A control room, normally unmanned, will be located in the control and instrumentation building

2.4.2.6.11. Pipework

The majority of valves and pipework within the AGI compound will be located below ground level. A short section of the export pipe will extend above ground level to provide the connection for the pig trap (launcher and receiver), which will be required from time to time to allow internal cleaning or inspection of the pipeline.

2.4.3. Ancillary Buildings

The following buildings will be used by both the Power Plant and LNG Terminal:

- Security building;
- Fuel gas regulating enclosure;
- Fuel gas metering enclosures; and
- Fire water storage tanks and fire water pumps.

The buildings will be steel framed buildings with concrete floor slabs. Structural and architectural details have been prepared including particulars of the shallow and deep foundations, lifting equipment, steel structures, and protective coatings.

2.4.3.1.1. Security Building (11 m x 5.8 m)

The security building will include a reception area to check in visitors, along with a break area and toilets for security staff.

2.4.3.1.2. Fuel Gas Regulating Enclosure (12.6 m x 13.2 m)

The function of the fuel gas regulating enclosure(12.6m x 13.2m) will be to regulate the pressure and temperature of the gas used by the onsite power generators and the Power Plant.

2.4.3.1.3. Fuel Gas Metering Enclosures

There will be several small unoccupied enclosures included in the gas metering area (12.6m x 13.2m) to house instrumentation, such as a gas chromatograph, to measure the calorific value of the gas for onsite use.

These will include:

- Metering and regulating area kiosk enclosure (3 m x 3 m);
- Metering and regulating area analyzer enclosure (3 m x 4.4 m); and
- Metering and regulating area instrument enclosure (3 m x 4.4 m).

2.4.3.1.4. Fire Water Storage Tanks and Fire Water Pumps

Fire water will be supplied from the municipal water supply system and will be stored onsite in two separate tanks (4.5m x 10.5m), which will be field-fabricated welded steel tanks, each with a dedicated capacity representing a minimum of two hours of fire water requirement during firefighting. In addition, One 100% capacity electrically driven fire pump, one 100% capacity diesel engine driven fire pump, and two jockey pumps will be located within the fire water pump enclosure. The pumps will be designed to provide the required volume of firewater needed for any automatic suppression system plus flow for fire hydrants or hose stations. A diesel fuel tank for the diesel driven fire pump will be either located in a bunded area or within a double-walled tank.

In addition to the firewater storage tanks, additional firewater will be stored in the firewater retention pond as described in **Section 2.4.7.3**.

2.4.4. Roads, Site Access and Car Parking

2.4.4.1. Internal Roads

Internal roadways will be constructed to support delivery of equipment, facility operations, and connection between buildings (**Figure 2.21**). Main routes in the Proposed Development site will be reinforced as required to support significant loads and vehicles. All permanent road works will be designed, constructed and specified in accordance with relevant applicable Irish standards and codes of practice. The minimum road width is provided in **Table 2-10**.

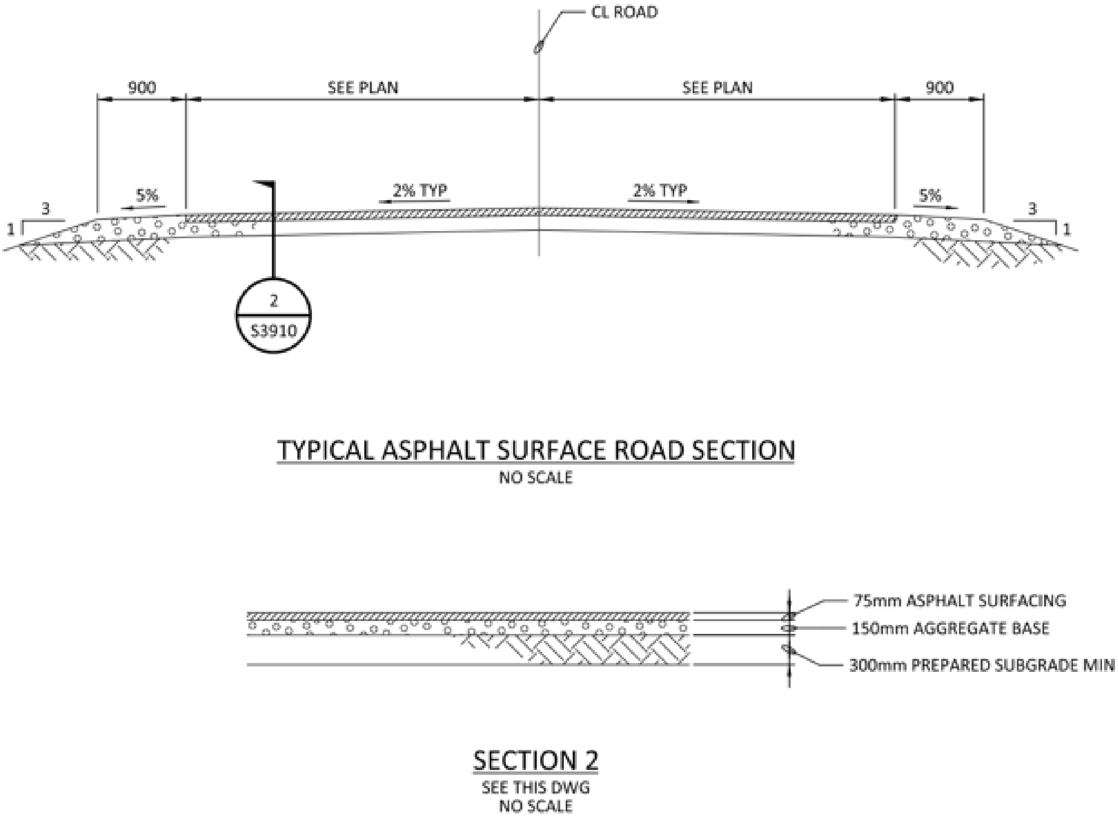


Figure 2-17 Cross Section of Internal Roads

Table 2-6 Internal Road Dimensions

Road	Total Width (m)	Paved Width (m)	Shoulder Width (m)
Paved Interior Roads	7.8	6	0.9

2.4.4.2. Site Access

Site access will be located off the existing L1010 (Coast Road), which is the primary access road to the townlands of Kilcolgan Lower and Ralappane from Tarbert and Ballylongford. Appropriate signage will be installed.

The AGI will be operated remotely by GNI and normally unmanned, but pedestrian access and vehicular access will be required for inspection and maintenance purposes.

See **Section 2.5.6** for details of proposed fencing and security gates.

There will be three watercourse crossings within the boundary of the Proposed Development:

- 600 mm culvert;
- 1200 mm culvert; and
- Pre-cast concrete bridge over the Ralappane Stream.

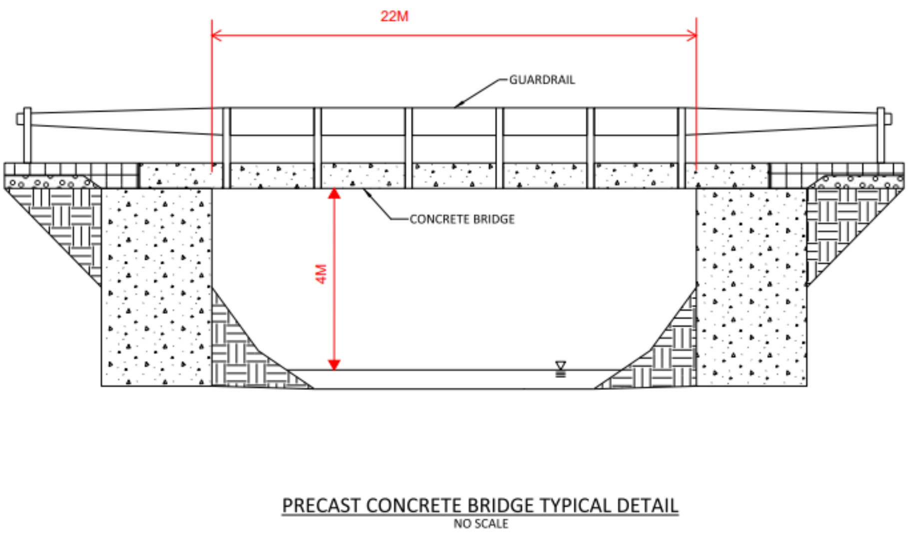


Figure 2-18 Proposed Pre-cast Concrete Bridge over the Ralappane Stream

2.4.4.3. Car parking Site Access

Parking is proposed during the operational phase which will comprise:

- 42 car parking spaces including:
  - A minimum of 2 mobility spaces;
  - A minimum of 2 electric vehicle charging points; and
- A minimum of 40 cycle parking spaces provided throughout the Proposed Development site.

Additional parking is accommodated in the laydown area, which will cover any overflow requirements in the event of maintenance or shutdown.

2.4.5. Security

2.4.5.1. Outer Perimeter Fence

The outer perimeter fence will comprise a 2.4 m high chain link fence, galvanised and PVC coated in evergreen and topped with three layers of barbed wire (see **Figure 2-23**). For visual impact mitigation the outer perimeter fence line will be set back from the L1010 road to avoid crossing watercourses as far as possible. The fencing is not expected to impact surface water flow where two watercourses are crossed, as there will not be a requirement for this fencing to be extended below the water's surface.

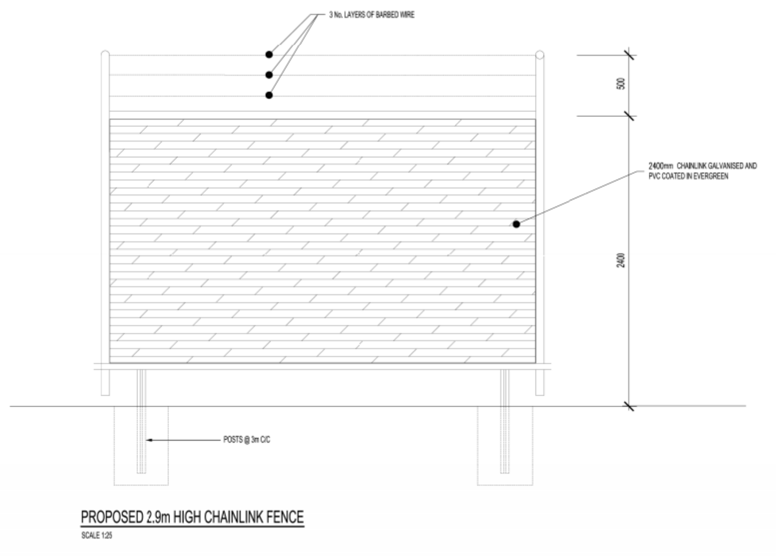


Figure 2-19 Proposed 2.9 m Outer Perimeter Fence

2.4.5.2. Inner Security Fence

A 4 m inner security fence will surround the Power Plant and LNG Terminal (see **Figure 2-24**). This will comprise a fully galvanised and PVC coated palisade fence in evergreen (2.4 m high), topped with an electric wire fence. The LNG Terminal and Power Plant will be manned for round-the-clock service for operations and maintenance purposes, although planned maintenance activities will predominantly be conducted during the daytime. The inner security fence line will not cross any watercourses.

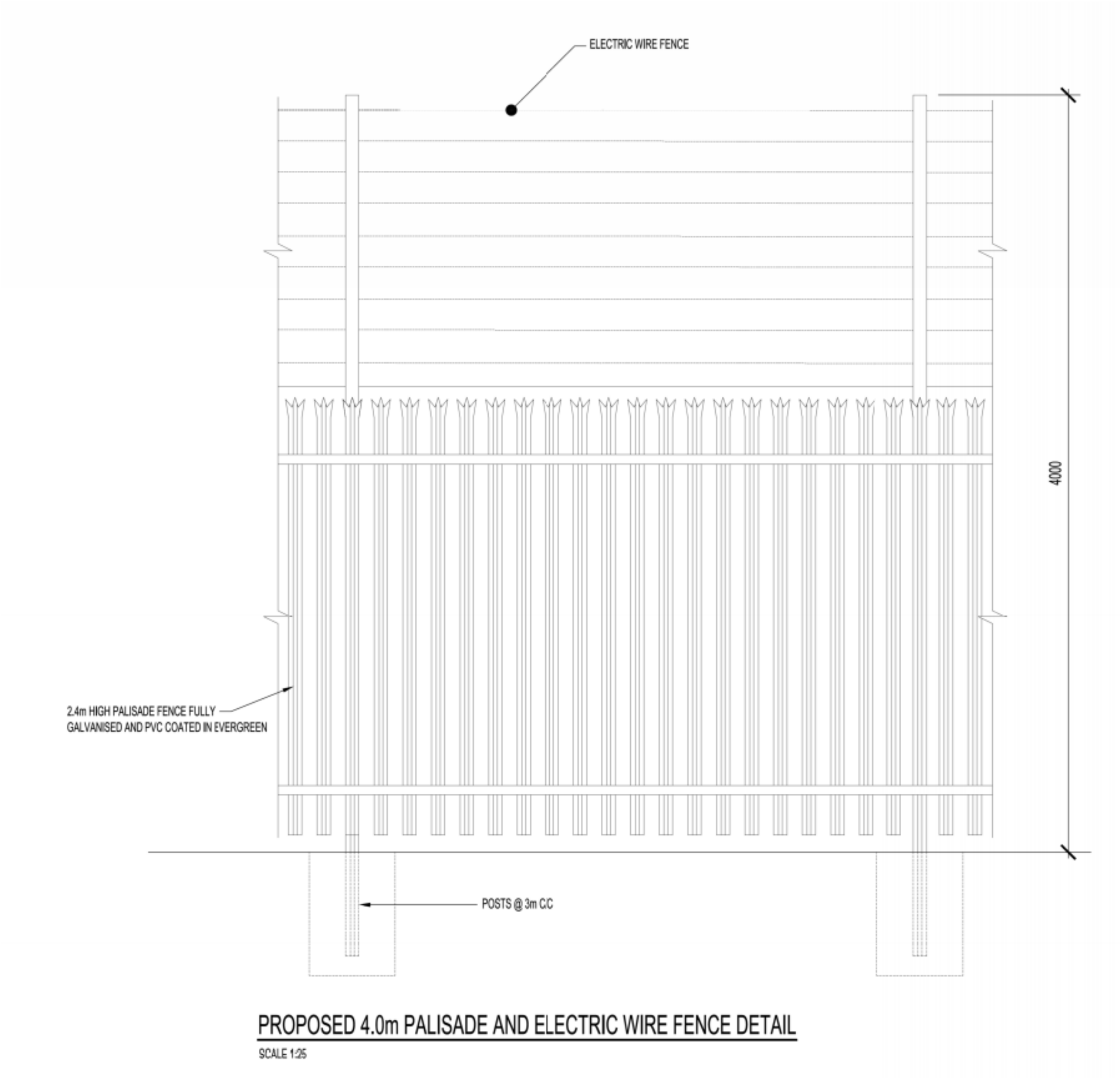


Figure 2-20 Proposed 4 m Inner Security Fence

2.4.5.3. AGI Fenceline

Two layers of fence will surround the AGI. This will comprise a spiked palisade fence, galvanised and PVC coated in dark green, with a weld mesh access security gate and a weld mesh fence in the same colour. The AGI double fenceline will not cross any watercourses.

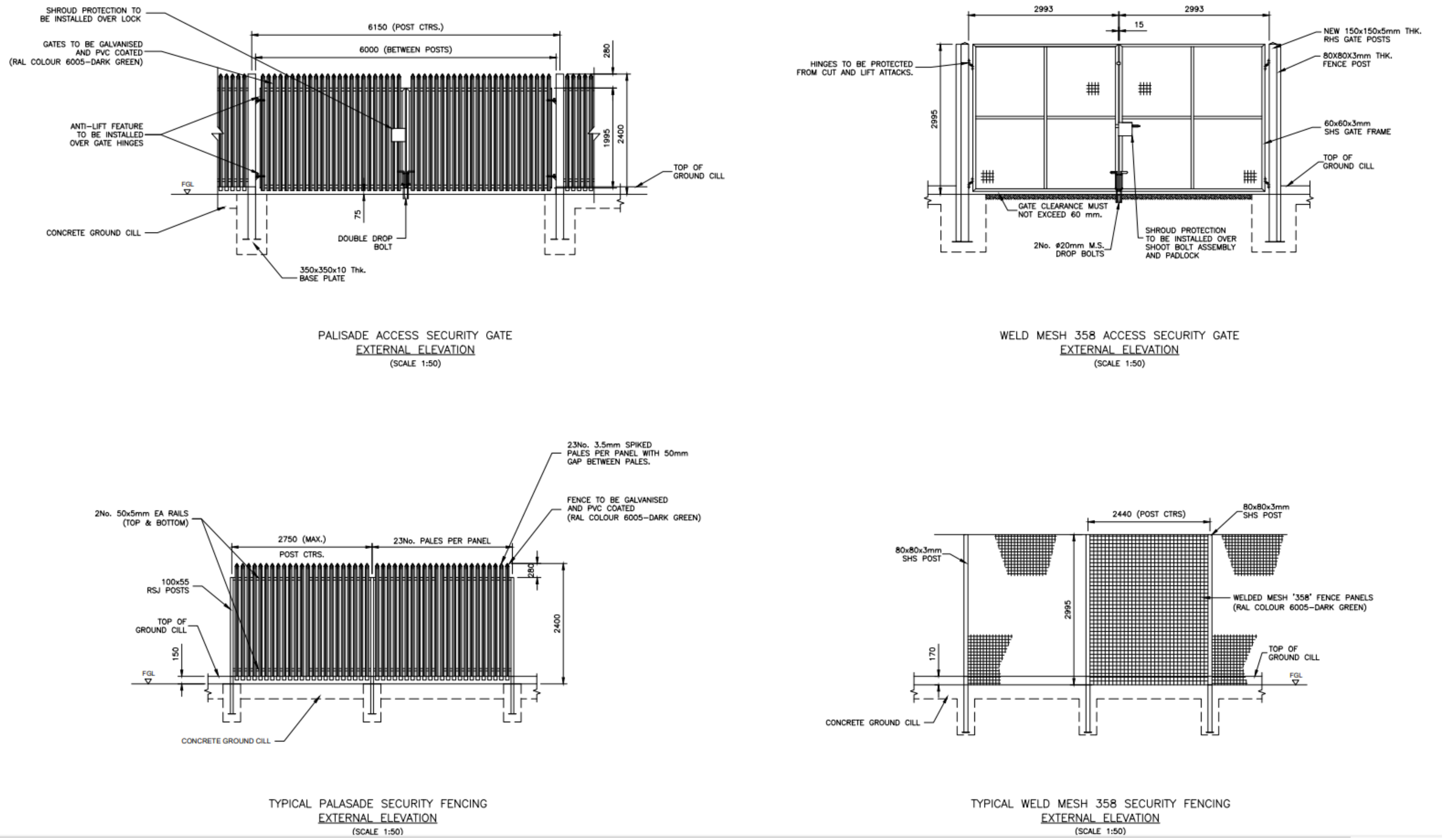


Figure 2-21 Proposed AGI Fenceline

2.4.6. Utilities

The Proposed Development will require connection to the following utilities:

- Electricity;
- Gas;
- Municipal water; and
- Telecommunications.

In addition, the Proposed Development will require stormwater and surface water drainage, sewerage drainage and process effluent drainage infrastructure.

2.4.6.1. Electricity

2.4.6.1.1. Overview

A high voltage (HV) 220 kV grid connection to the national electrical transmission network is required to export power from the Power Plant, when operational. During periods of high wind (renewable) generation it is expected that the Power Plant will be turned off by the system operator (EirGrid) to give priority to renewable power. In this event, the LNG Terminal will require power. At times when the Power Plant is shut down, power may be imported to the Proposed Development site via the proposed future 220 kV high voltage grid connection.

It is currently anticipated that the LNG Terminal will be operational before the Power Plant and the 220 kV grid connection are completed. Therefore, a medium voltage (10/ 20 kV) grid connection will be required to supply power to the LNG Terminal.

Once the Power Plant and/ or future 220 kV grid connection are completed, this medium voltage (10/ 20 kV) grid connection will be reserved as a backup power supply if the Power Plant and 220 kV grid connection are not available. These will be subject to a connection agreement with EirGrid and ESBN. These grid connections will be subject to separate planning applications and do not form part of the Proposed Development.

Additional information on the potential future 220 kV and medium voltage (10/ 20 kV) grid connections are outlined in the following sections.

2.4.6.1.2. The 220 kV High Voltage Connection

An application to connect to the national electrical transmission network was submitted to EirGrid in September 2020 under the Enduring Connection Policy 2 (ECP2) process. An offer has yet to be received so the precise connection details cannot be confirmed at the time of writing. The development of the grid connection will be subject to a separate planning application and associated EIAR by the Applicant once the offer is received, and the precise connection details are known. The aspects and impacts of the construction and operation of the grid connection have been included in the cumulative impact assessments in this EIAR.

It is anticipated that the connection point will be the ESBN / EirGrid Killpaddogue 220 kV substation which is located approximately 5 km east of the Proposed Development site with connection provided via a 220 kV cable(s) under the L1010 road as shown in Figure 2-17. The grid connection will be laid under the L1010 from the Proposed Development to the entrance road to Kilpaddoge 220 kV substation. At the entrance road to Kilpaddoge substation, the grid route will follow the substation access road and connect to the Kilpaddoge substation. No works are anticipated at Kilpaddoge 220 kV substation. The cable route will be approximately 4.6 km in length and is anticipated to be located entirely under private and public roadways. Approximately 3.5 km will be installed under public roadway (L1010). Local access will be maintained throughout the cable installation process.

It is anticipated that the 220 kV grid connection will require an onsite EirGrid 220 kV substation. This is currently proposed to be located onsite and approximately 500 m from the main Proposed Development site entrance. The details of the planned 220 kV substation will be included in the future 220 kV connection planning application.

It is expected that the planned 220 kV substation will comprise lightning protection masts, cable sealing ends, high voltage disconnectors, circuit breaker, current and voltage transformers all contained within a fenced area, approximately 60 m by 50 m. The electrical equipment is not expected exceed 9 m in height with the exception of the lightning protection monopoles which are expected to be between 15 – 18 m in height. A single storey control building of masonry block construction, up to 5 m height, with an estimated footprint of approximately 375 m^2 also is planned within the site boundary.

The planned 220 kV substation will in turn connect to the Power Plant 220 kV GIS substation, as described in **Section 2.4.1.3**.

2.4.6.1.3. The Medium Voltage Connection (10/ 20 kV)

If the LNG Terminal commences operation before the Power Plant and/ or 220 kV high voltage grid connection are completed or operational an alternative electricity supply is required. Therefore, a separate medium voltage (10/ 20 kV) connection to power the LNG Terminal in the absence of the Power Plant and/ or 220 kV high voltage grid connection will be installed. Once the Power Plant and/ or future 220 kV grid connection are completed, this medium voltage (10/ 20 kV) grid connection will be reserved as a backup power supply. However, the connection is subject to a connection agreement with ESBN and will be considered under a separate planning application. This will be included in the cumulative impact assessment within each EIAR chapter.

If consented, the LNG Terminal medium voltage (MV) connection will be via a new onsite substation and underground cable from the existing ESBN / EirGrid Kilpaddoge 220 kV substation. The onsite substation will be adopted by ESBN post commissioning and will form part of the overall medium voltage (10/ 20 kV) distribution system.

The onsite substation will be located within the Proposed Development site redline boundary approximately 800 m from the Proposed Development site entrance. The onsite substation will comprise a single-storey building size of 10 m x 4.5 m approximately and will include separate ESBN and Customer MV switchrooms. The proposed underground cable route will follow the L1010 route in parallel with the 220 kV cables as described above.

The below sections summarise the power requirements and supply for the LNG Terminal and Power Plant considered under this planning application and EIAR.

2.4.6.1.4. LNG Terminal Power Requirements

It is anticipated that once operational approximately 10 MW of electricity generated by the Power Plant will be supplied to the LNG Terminal. However, as outlined above, the LNG Terminal may commence operation prior to the completion of the Power Plant and/ or future 220 kV high voltage grid connection and medium voltage (10/ 20 kV) grid connection. In this case, power to the LNG Terminal will be supplied via onsite gas generators until the Power Plant or the medium voltage (10/ 20 kV) connection are operational.

The onsite power generation will comprise three 8 MW gas fired electricity generators. Fuel gas for these generators will be supplied from gas from the FSRU. However, if there is no gas from the FSRU, the generators will be powered by fuel gas which will be reverse flowed from the 26 km 30" Shannon Pipeline.

Once the medium voltage (10/ 20 kV) grid connection is available, the onsite gas generators will be utilised as backup power supply in the event that the LNG Terminal's grid connection fail.

2.4.6.2. Municipal Water Supply

The Proposed Development will require water supply for the following:

- Domestic site staff – 3.6 m^3/day; and
- Process water – ranging between 10 m^3/hr and 33 m^3/hr.

The Applicant has made a connection request to Irish Water, which will require connection to a mains water system. It is anticipated that this will be provided along the Coast Road from Ballylongford to the Proposed Development site (**Figure 2-22**). The water connection does not form part of the scope of this EIAR.

Figure 2-22 Proposed Electrical and Water Connections

In addition, the fire water supply will come from the potable water supply system and will be stored onsite in two separate firewater tanks.

Water will be supplied to the vessels via portside hose connections and/ or tankers and stored onboard in potable water tanks. Freshwater will be subject to further treatment onboard before is it used for human consumption.

2.4.6.3. Telecommunications

The Proposed Development will require a connection to a broadband network. It is anticipated that it will be serviced by a new fibre cable which will be supplied via a new duct under the widened L1010 road. The installation of telecommunication utilities does not form part of the scope of the EIAR.

2.4.7. Drainage

2.4.7.1. Stormwater and Surface Water Drainage

It is proposed that stormwater from all paved and impermeable areas covering approximately 14 hectares) within the Proposed Development site boundary will be collected and discharged directly to the Shannon Estuary via a discharge pipe with an outfall located 5m beyond the low water mark at a water depth of approximately 2.4 m.

Impermeable areas include the following:

- Heater Building, nitrogen compressor building, regulator building, electrical substations, heat exchangers, administration and security guardhouse buildings;
- Laydown and car parking area;
- Access road, jetty road and footpaths;
- Lined outfall; and
- A percentage of the side slope and landscaping areas.

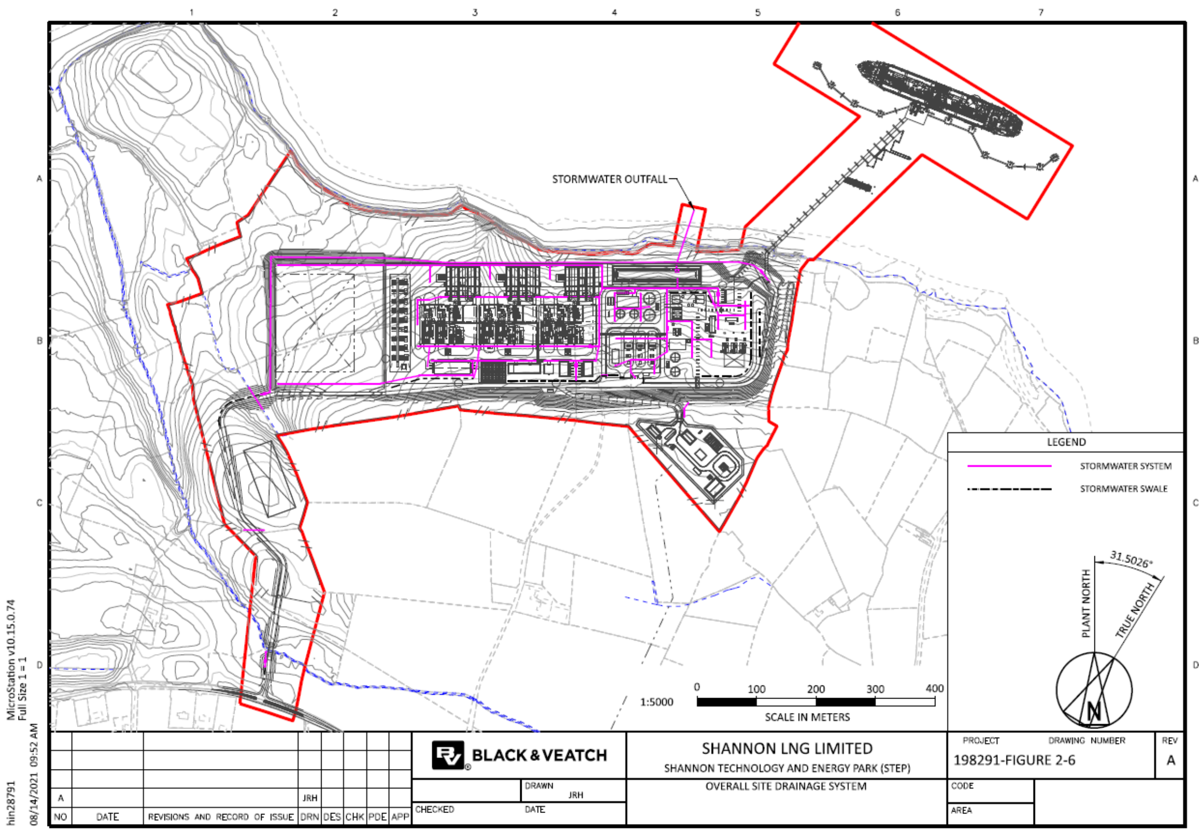


Figure 2-23 Proposed Development Site Drainage

A surface water drainage network comprising piped drainage and swales/ catch basins will be constructed to collect, convey, and attenuate the surface water runoff generated.

All stormwater collected from paved and impermeable areas will pass through an attenuation system including a class 1 hydrocarbon interceptor prior to discharge to the Shannon Estuary via the outfall pipe located 5mm offshore in a water depth of approximately 2.4m. The stormwater discharge rate has been calculated at 162 L/s/ha. Stormwater collected from roof drains and permeable areas will discharge directly to the Shannon Estuary via the final discharge monitoring station. All bunded areas within the Proposed Development site will have valved discharge points as part of their connection to the drainage network.

Groundwater seepages from springs or at the toe of cut slopes will be collected via a groundwater drainage network which will then discharge directly to the Shannon Estuary via the same discharge outfall pipe as the surface water.

Silt traps will be incorporated in all groundwater drainage points prior to discharge.

During the operational phase, all drainage from the Proposed Development site will be controlled and monitored in compliance with the terms of the IE licence.

Details of discharge mitigation measures are presented in the Outline Construction Environmental Management Plan (OCEMP) (Appendix 7 in NIS Vol. 2).

2.4.7.2. Sewerage Drainage System

In the LNG Terminal, sewerage effluent (foul water) will be generated at four locations onsite:

- The workshop/ warehouse building;
- The nitrogen generation package control building;
- The main control building; and
- The AGI Control and Instrumentation Building.

In the Power Plant, sanitary effluent (foul water) will be generated at the following locations on the Proposed Development site:

- The administration building;
- Central control/ operations building;
- Workshop/ stores/ canteen building; and
- Each turbine hall.

All sanitary effluent from the Proposed Development will be transferred to the dedicated onsite waste water treatment plant (WWTP) which will treat the wastewater using a biological Wastewater Treatment System prior to discharge to the Shannon Estuary via the storm water outfall pipe. The WWTP will be designed to treat wastewater for up to 67 personnel, which is the maximum number of staff anticipated to be onsite during normal working hours (excluding the FSRU and tug staff). An average flow of 0.4 L/s (34.5 m^3/day) is expected to be discharged from the WWTP.

Figure 2-24 provides an overview of the treatment process. The treated wastewater will be monitored for compliance with the IE licence limits prior to discharge and will be continuously monitored for pH before discharging to the estuary. The automatic control system associated with the WWTP will sound an alarm if pH falls outside of expected range. This will alert the operator to take corrective action to remedy the problem. If the problem continues to go outside the pre-set range, this will automatically close the discharge valve and effluent will be diverted to a holding tank. **Table 2.6** summarises the characteristics of the WWTP discharge.

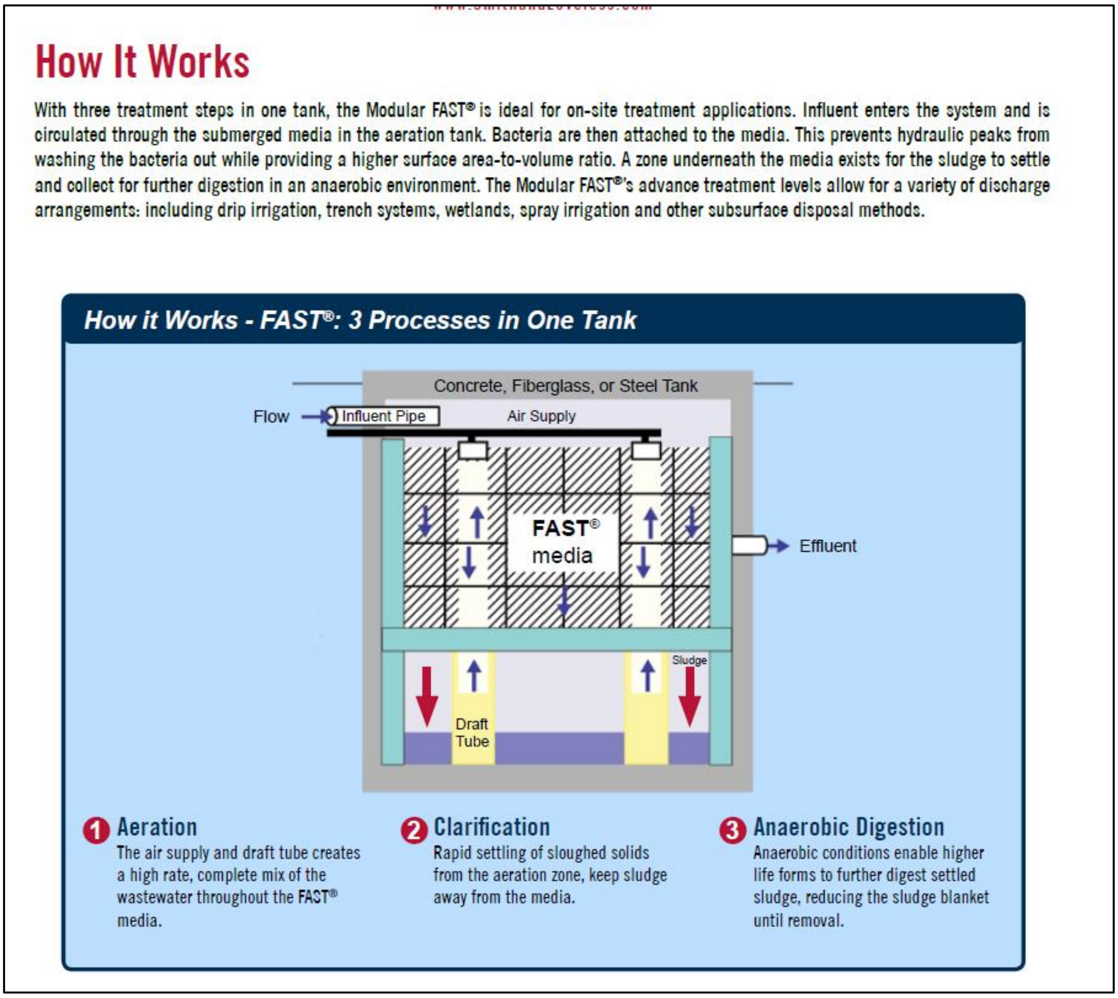


Figure 2-24 Overview of Proposed Wastewater Treatment System

Table 2-7 Characteristic of Waste Water Treatment Plant Discharge

Parameter	**Discharge Limit Value**
Volume	35 m^3/day
pH	6 – 10
BOD	25 mg/l
Suspended Solids	35 mg/l
Ammonia	5 mg/l as N
Total Phosphorous	2 mg/l as N

All sanitary effluent from the FSRU will be retained onboard and pumped to a vacuum lorry for transfer to a licensed waste facility. **Table 2.8** provides estimated of expected operational waste quantities from onshore operations, the FSRU, tugs and potentially from visiting LNGCs.

Table 2-8 Operational waste

Waste Type	Waste Classification	Quantity per Year (m^3)	Potential Waste Management Route
Galley waste (garbage from FSRU, tugs and LNG carriers)	Non-hazardous	240	In accordance with MARPOL Annex V requirements, when in port waste all waste will be stored in suitable containers onboard. Periodically this will be transferred to shore and taken to a licensed waste management site by a licensed waste contractor. Waste from visiting LNG carriers will be managed as International Catering Waste and securely transferred to a designated and licensed disposal site. Source segregation of recyclables (e.g. paper/ card, plastics, metal & glass) for non-ICW
General office waste from onshore activities	Non-hazardous	50	Source segregation of recyclables (e.g. paper/ card, plastics, metal & glass) Residual waste transported to licensed waste treatment facility (landfill or energy-from-waste)
Oily waste (waste from FSRU, tugs and LNG carriers, e.g. sludges from oily water separators)	Hazardous	900	In accordance with MARPOL Annex I the material will be transferred to shore to a licensed waste contractor for management or disposal at a licensed site.
Hazardous materials, e.g. chemicals from FSRU, LNG Terminal and CCGT	Hazardous	10	Export to hazardous waste management facility for recycling/ recovery or high-temperature incineration – delivery to an approved reception facility offshore

Waste Type	Waste Classification	Quantity per Year (m^3)	Potential Waste Management Route
Sanitary waste from site washrooms	Not applicable (not subject to Waste Framework Directive)	Faecal wastewater ('black water'): 270 m^3 Other sanitary wastewater ('grey water'): 2430 m^3	Treated by onsite wastewater treatment plant (WWTP) and discharged, see Chapter 02 – Project Description.

2.4.7.3. Firewater Retention Pond

A firewater retention pond is included in the Proposed Development and sized according to Environmental Protection Agency (EPA) Guidance on Retention Requirements for Firewater Runoff, as the most effective and suitable measure for retaining firewater. The retention pond will be rendered impermeable by use of an appropriate liner, and integrity-tested in line with the requirements of the site's licence. All drainage will pass through the retention pond. An automatic shut-off valve linked to the site's fire detection system will be installed on the drainage outlet point.

2.5. Discharges and Emissions

A Best Available Technology (BAT) Assessment has been undertaken and is summarised in Chapter 01 – Introduction of EIAR Vol. 2.

2.5.1. Power Plant: Process Effluent Collection System and Sump

The Power Plant will generate several process water effluent streams. Some of the effluent streams will be collected and removed offsite transported offsite to a licensed facility and the remaining effluent streams will be pumped or fall by gravity to the effluent sump. Refer to the water flow diagram below (**Figure 2-25**).

The wastewater effluent collection will comprise the following waste streams:

- Water treatment process effluent;
- Steam cycle blowdown/ drains;
- Auxiliary boiler blowdown/ drains;
- Turbine hall drains; and
- Gas turbine wash water effluent.

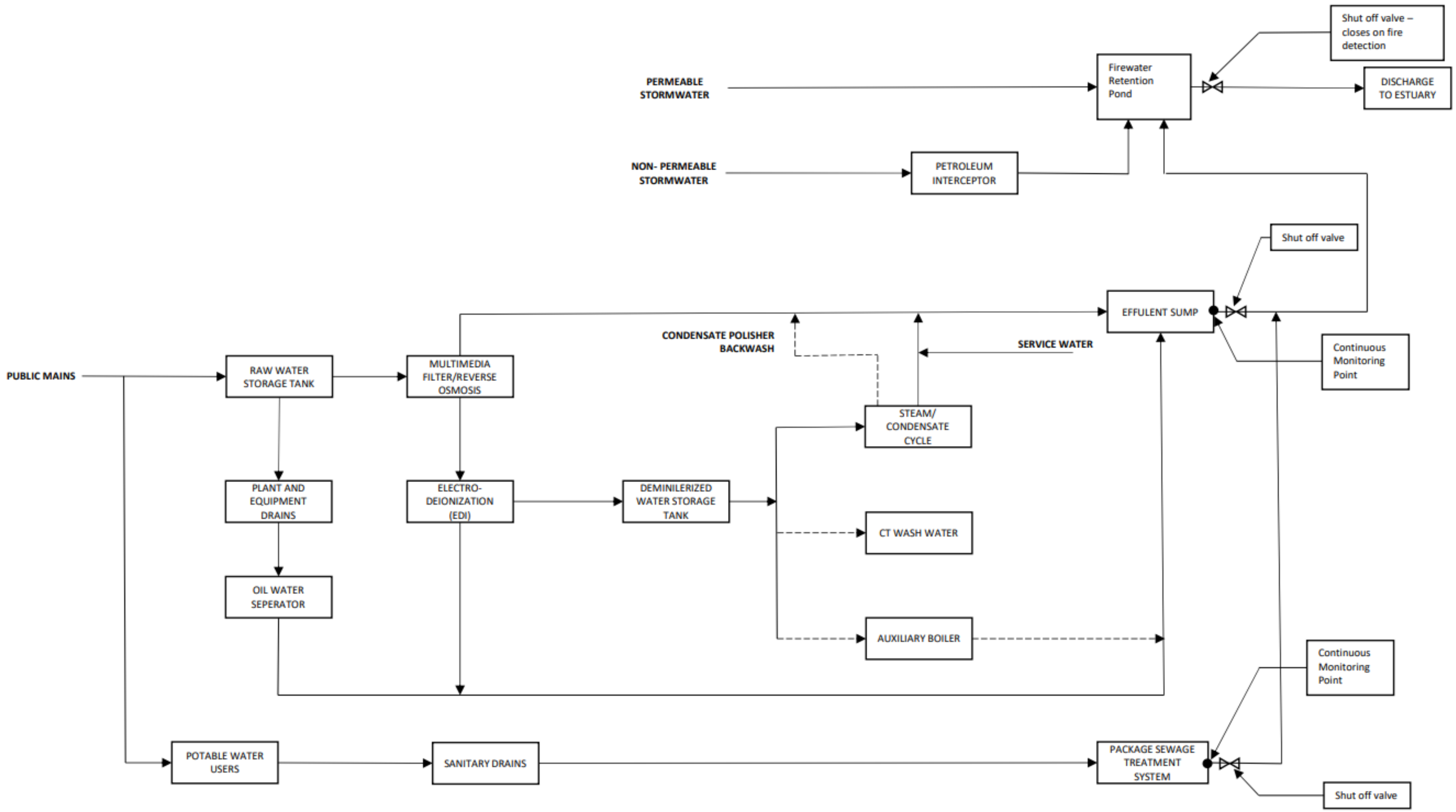


Figure 2-25 Proposed Development Water Flows

2.5.1.1.1. Water Treatment Plant Effluent

A wastewater stream will be produced by the water treatment plant. The effluent streams arising from these activities will contain inorganic dissolved solids as well as negligible traces of dilute solutions of acid, caustic, sodium bisulfite and antiscalant. The water treatment plant effluent will be directed to the effluent sump before discharge into the Shannon Estuary.

2.5.1.1.2. Steam Cycle Blowdown/ Drains

In the case of the Heat Recovery Steam Generator (HRSG), a continuous stream of water approximately 2% of the volume, called blow-down, will be removed from the otherwise closed water systems. It will be necessary to remove this water to maintain the level of dissolved solids in the steam at an acceptable level in order to minimise corrosion and deposition in the boiler water circuits, as well as maintaining steam quality. The boiler water will be dosed to ensure it will stay within the operating limits of the Power Plant. As a result, the blow-down will contain salts and will be alkaline with a pH typically up to 9. The blowdown will be collected in a blowdown tank, cooled with service water to a temperature between 25 °C and 40°C, and then pumped to the effluent sump.

Other intermittent effluent streams from the steam cycle are process steam drains and backwash of the condensate filter. During normal operation, superheated steam from the steam turbine will be sent to the HRSG; however, during start-up and shutdown when the steam piping is heating and cooling the steam will condense and be drained to the process effluent sump via the blowdown tank. There will also be intermittent backwash of the condensate polisher that will be sent to the effluent sump.

2.5.1.1.3. Auxiliary Boiler Blowdown

Similar to the heat recovery steam generator, a continuous stream of water approximately 2% of the volume, called blow-down, will be removed from the auxiliary boiler. It will be necessary to remove this water to maintain the level of dissolved solids in the steam at an acceptable level in order to minimise corrosion and deposition in the boiler water circuits, as well as maintaining steam quality. The boiler water will be dosed to ensure it will stay within the operating limits of the Power Plant. As a result, the blow-down will contain salts with a typical up to 9 (i.e. alkaline). The blowdown will be quenched with service water to a temperature of approximately 60° C and pumped to the effluent sump.

2.5.1.1.4. Drain Down of Feed Water and Heat Recovery Steam Generator System

During maintenance it may be necessary to drain the feed water and HRSG or auxiliary boiler systems and dispose of the water contained within these systems. This water will be sent to the effluent sump.

2.5.1.1.5. Turbine Hall Floor Drains

There will be floor drains in the turbine hall to collect water from floor washing and process equipment. The effluent from the floor drains will be collected and sent through an oily water separator. The water discharged from the separator will be sent to the effluent sump. The oily waste will be collected and removed offsite to an appropriate waste licensed facility.

2.5.1.1.6. Other Process Liquid Wastes

There will be other liquid wastes from the process equipment that will not be sent to the effluent sump but will be collected and removed offsite to an appropriate waste licensed facility. These other waste streams are as noted below:

- Gas turbine water wash – Collected in wash water tanks one per CTG (~2 m^3 each);

- Closed cycle cooling water system drain down – Collected by tanker truck or frac tank; and
- Sludges from petroleum interceptors – Collected in situ

2.5.1.1.7. Outfall Discharge to Estuary

Process water effluent leaving the effluent sump will be continuously monitored for pH before discharging to the estuary. The automatic control system associated with the effluent sump will sound an alarm if the pH goes outside a pre-set range – typically 6 to 10. This will alert the operator to take corrective action to remedy the problem. If the pH continues to go outside the pre-set range, this will automatically close the discharge valve and open the associated re-circulation valve and will then start the re-circulation process during which period the sump will be dosed with either acid or caustic soda to return the pH to between 7 and 8. At this stage the automatic discharge valve will re-open and the re-circulation valve will close.

Regular visual checks will be undertaken for oils and greases in the sump to ensure that the discharge will be free of these contaminants before discharge.

The process effluent in the sump will be monitored for compliance with the IE licence limits and then discharged, via the storm water outfall pipe, to the Shannon Estuary. See Chapter 06 – Water for more details.

Table 2-9 below summarises the process effluents generated from the Power Plant and provides estimated quantities.

Table 2-9 Estimate of Water Discharges from Power Plant

System	Source	Characteristics	Monitoring	Rate
Boiler water treatment plant	Filter effluent. Effluent from treatment plant stages and back wash/ regeneration/ concentrate as appropriate to system installed.	High/ Low pH prior to treatment. Negligible traces of salt, dilute solution acid, caustic, sodium bisulfite and anti scalant. Effluent treated to give a pH at outlet of 6-9.	Effluent sump. Monitoring of pH and visual checks of oil and grease contamination	8.6
HRSG and Auxiliary Boiler blowdown	Outlet from blowdown vessel via a cooler. Water from drain header.	High purity water with traces of ammonia, and phosphate. pH 6 to 9. Temperature about 60°C. Trace salt in the form trisodium phosphate 5-6 ppm and silica 3-5 ppm, BOD 20 mg/l.	Effluent sump	14
Drain down of plant	Occurs during maintenance when necessary to drain feedwater and HRSG system.	High purity water with traces of ammonia, and phosphate.	Effluent sump	Maintenance activity
Turbine hall floor drains	Wash down of floor drains and equipment process drains form turbine hall.	Traces of oil.	Removed offsite for disposal at licensed facility, approximately once per year	0.03

System	Source	Characteristics	Monitoring	Rate
Gas turbine washing	At intervals it is necessary to wash the gas turbine compressor blades.	Traces of oil detergent.	Removed offsite for disposal at licensed facility	N/A
Drain down of closed cooling water system	Occurs during maintenance of these systems (based upon operating hours, typically 2-3 years).	High purity water containing traces of sodium molybdate.	Removed offsite for disposal at licensed facility	N/A
Disposal of Oil	Various (bunds, site interceptors, oil/ water interceptor).	Oil and sludge.	Removed offsite for disposal at licensed facility, approximately once per year	N/A

Table 2-10 summarises the characteristics of the process effluent discharge.

Table 2-10 Characteristic of Process Effluent Discharge

Parameter	Typical Range of Emissions (min to max)
Maximum flow rate	774 m^3/day
pH	6 – 9
Temperature range	40°C
BOD	20 mg/l
Suspended Solids	30 mg/l
Total Dissolved Solids	5000 mg/l
Mineral Oil	20 mg/l
Total Ammonia (as N)	5 mg/l
Total Phosphorous (as P)	5 mg/l

2.5.2. LNG Terminal

Liquid waste from the FSRU, tugs and LNGCs is expected to total 240m^3 per year. When in port all waste will be stored in suitable containers onboard and periodically transferred to shore to be taken to a licensed waste management site by a licensed waste contractor. Waste from visiting LNG carriers will be managed as International Catering Waste and securely transferred to a designated and licensed disposal site.

All sanitary effluent from the FSRU and tugs will be retained onboard and transferred to via vacuum lorry to a licensed facility. Emissions of water from the FSRU are included in the total waste quantities above.

2.5.3. 2.5.3 Air and Noise Emissions

During its operation, the Proposed Development will produce air and noise emissions from a number of different sources.

2.5.3.1. Noise Emissions

The operation of the Proposed Development will include a number of noise emission sources as outlined below:

- Noise generating mechanical plant associated with the Power Plant and LNG Terminal including Air Intake Filter House and Generator Cooling Outlet (air cooled);
- Three CTGs to be installed within the LNG Terminal (two operational and one back up);
- The FSRU and LNGC equipment; and
- Tug engines and generators.

In addition, there are noise sources which will operate intermittently. These intermittent sources are:

- Firewater Pumps;
- Firewater Jockey Pumps; and
- Black Start Diesel Generators.

Noise generating plant associated with the Above Ground Installation (AGI) will comprises the following:

- Odorant New Blend Pump Unit;
- Package Boiler Units;
- Gas Fired Generator; and
- Pressure Regulating Stream.

2.5.3.2. Air Emissions

The operation of the Proposed Development will include a number of sources with emissions to air associated with combustion plant, to generate heat and power for onsite activity. Emissions to air associated with such plant vary with the type of plant and its purpose, the thermal capacity of the plant and the fuel used to enable combustion.

Natural gas will be the primary fuel source for all non-emergency plant at the Proposed Development site. Emissions from natural gas-fired plant predominantly include the pollutants NO_X and CO but may also include other pollutants to a lesser extent for some sources, including THC, some of which will comprise of VOC, including CH_2O.

Liquid fuel will also be utilised. Onshore, this fuel is limited to generators that will only ever be operational in the event of an emergency and for limited periods of testing and maintenance[19]. Offshore, liquid fuel is required as the pilot fuel for the main power engines on the FSRU and the operational facility's tug-boat fleet. Liquid fuel may also be likely as the engine fuel for a small proportion of the LNGCs delivering to the operational facility. Emissions from liquid fuel-fired plant

[19] After consultations between the CRU and the Applicant, the CRU has agreed that the Power Plant does not need to combust liquid fuel to comply with CRU rules on Secondary fuel obligations.

include the same pollutants associated with natural gas, plus PM_{10} and SO_2 (although SO_2 emissions are generally lessened by the use of low and ultra-low sulphur content fuels). The Proposed Development will be operated under the conditions of an Industrial Emissions (IE) Licence, the terms of which will require that any fugitive emissions are controlled at source through appropriate mitigation and monitoring measures, possibly set out as part of an Operational Emissions Management Plan, or a specific Odour Management Plan. Additional information can be found in EIAR Vol. 2 Chapter 08 – Air Quality.

2.5.4. Lighting

Down angle lighting will be installed with the Proposed Development site to illuminate the LNG Terminal, including the vessel / onshore interface areas to ensure activities can be safely conducted during periods of darkness.The Power Plant will have area lighting installed on a down angle to cover the facility and the car parking areas while minimising impact to surrounding neighbours.

The height of the proposed light columns has been kept to a minimum throughout the Proposed Development site, and light temperatures reviewed to minimise the content of blue light. Light columns will be fitted with focused luminaires to avoid glare, sky glow and light spill to the estuary.

An uninterruptible power supply for emergency lighting shall be provided to allow for safe escape of staff from accessible areas of the plant in the event of a power and essential lighting failure or an emergency.

2.6. Site Management

2.6.1. Staffing

Once operational the Proposed Development will employ approximately 101 permanent staff, some of whom will work in shifts as the plant will be operational 24 hours per day for seven days a week. This number excludes the FSRU and tug crews. The maximum number of staff onsite during normal working hours (excluding the FSRU and tug staff) is anticipated to total 67 employees. Additional contract staff and service personnel will be utilised as needed. The LNG Terminal and the Power Plant will be operated with integrated staffing. Personnel will perform the following functions:

- Management and administration;
- Operations;
- Maintenance;
- Marine operations;
- Health, Safety, Security and Environment;
- Finance and accounting; and
- Sales and marketing.

Managerial staff will be experienced personnel from the energy industry. Apart from the FSRU complement of approximately 35 crew members, who will be international marine crew employed by the Ship's operator, operations, maintenance and support personnel employed for the Proposed Development will be recruited locally to the extent possible. Staff will be given extensive training which will include in-plant training or experience in another operating LNG facility or Power Plant. All key personnel to work on the LNG Terminal will be trained in the properties of LNG and natural gas, , proper operation of all equipment, workplace safety and incident response, including leaks, spills, and fires.

The Applicant will operate and maintain the LNG Terminal and the Power Plant to meet or exceed all applicable European Union and Irish employment regulations and requirements. The Applicant will prepare, maintain and update a comprehensive set of operations, maintenance, safety, and emergency response manuals for the combined operations. All operations and maintenance personnel will be trained in accordance with the procedures in these manuals.

Maintenance staff will carry out routine inspections, maintenance, and repairs, as well as major equipment overhauls, where applicable. Certain major overhauls and maintenance will be handled by contract maintenance personnel. Security personnel, pilots, tug and mooring personnel, and catering/ cleaning personnel will be provided by third parties. Warehouse personnel are anticipated to be contract staff.

After the start of operations, operating and maintenance personnel will be involved in ongoing safety, operating, and maintenance training. Operating, maintenance, and emergency response procedures and manuals will be subject to regular review and will be updated to reflect best industry practices, or to reflect the addition of new procedures, equipment or other facilities at the Terminal and Power Plant.

2.6.1.1. Liquid Natural Gas Terminal

The LNG Terminal will be designed to operate 24 hours per day using a rotating shift schedule. The actual shift schedule has yet to be determined; however, it is anticipated that the following manpower levels will be provided.

It is anticipated the FSRU will have up to 35 crew onboard. This will include a Master, 4 deck officers, Cargo engineer, Chief Engineer and 4 engineering officers. The remainder of the crew will be working on deck, in the engine room, LNG process and in catering. The crew typically work on 3- or 6-months rotation, i.e. the officers and supervisory staff work 3 months on and 3 months off, while the remainder of the crew typically work 6 months onboard and 6 months off. When onboard, the crew normally work a 12-hour shift pattern, and they will be stay onboard for the duration for their rotation except when granted shore leave.

The majority of the crew members on the FSRU are anticipated to originate outside of Ireland, and crew changes will be managed by the Ship's Operator, who will make available suitable transport for the crew to travel to and from Shannon or Dublin Airports as required for journeys to and from their homes countries. Appropriate Covid-19 protocols will be in place and adhered to at all times.

The tugs will normally have a working crew of 4 onboard. One of the tugs will be fully mobilised at all times, and a full complement of crew will be onboard for immediate response. A second tug's crew will be on call for immediate callout and must be ready to be onboard within 30 minutes of being called. Crews for tugs 3 and 4 will be available on 2-hours' notice.

The onshore receiving facility and jetty are anticipated to have approximately 20 personnel working during the day (09:00 – 17:30). In addition, there will be 5 shifts of 3 staff working on a 24-hr shift pattern as follows: (08:00 – 16:00), (16:00 – 00:00) and (00:00 – 08:00).

2.6.1.2. Power Plant

The Power Plant is designed to operate 24 hours a day using a rotating shift schedule. It is anticipated that a total of 34 staff will be required for the operation of the Power Plant, as follows:

- 26 day staff (08:30 – 17:00); and

- 40 shift staff – 5 shifts of 8 employees.

Additional contract staff and service personnel will be engaged in the Power Plant as needed.

2.6.1.3. Above Ground Installation

The AGI is a normally unmanned facility, operated by GNI. GNI personnel will visit the AGI as and when required for inspection and maintenance purposes.

2.6.1.4. Training

The Proposed Development, through its training regime, will ensure every employee is aware of his/ her responsibility to work safely, adhere to safety rules and work procedures, use safety equipment provided, is environmentally responsible, and play an active role in the Proposed Development's drive for continual improvement in health, safety and environmental (HSE) performance.

Pre-operational training and regular refresher courses, using simulators, will be undertaken, involving all relevant parties, including SFPA, KCC's Fire Department and the Proposed Development employees.

2.6.1.4.1. LNGC and FSRU Emergency Response and Crew Training

The IMO has developed standards for the design and construction for all classes of ships. These standards, published as specific codes, govern design, materials, construction, equipment, operation and training, and include a code covering 'Ships Carrying Liquefied Gases in Bulk' with specific reference to LNG.

Safety and crew training are addressed in IMO Conventions such as Safety of Life at Sea (SOLAS) and Standards of Training, Certification & Watchkeeping for Seafarers (STCW). These are further supplemented by any additional training provided by the vessel owner/ operator over and above statutory requirements.

The FSRU and arriving LNG Ships will be self-sufficient in their fire detection and fire-fighting capability. All FSRU and LNG ship crew members will have completed extensive training in dealing with shipboard fire response as is required under SOLAS and STCW.

IMO codes covering LNG Ships require them to have fire detection and firefighting equipment in excess of that required by conventional shipping. In addition to the gas detection systems surrounding the LNG cargo containment, there will be gas detectors in compressor rooms, motor rooms, the main engine room and accommodation areas. Heat and/ or fire detectors will be located at cargo tank domes, at the cargo transfer manifolds, in the main engine room and in accommodation spaces.

Conventional firewater mains and hydrants will be supplemented by a self-contained dry chemical powder system covering all cargo areas with a combination of fixed and hand-held monitors. The LNG ships will also be fitted with a water deluge system for fire prevention, or in the rare event of fire, for cooling the LNG ship structure and for crew protection. The deluge system will cover all cargo domes, cargo transfer manifolds and all deck houses and the super structure, accommodation block facing the cargo area. The pumps and valves can be operated remotely, and the system capacity is capable of deluging the accommodation and cargo areas simultaneously.

Sufficient quantities of personal protective equipment (PPE) will be carried in the form of self-contained breathing apparatus, fireman suits and protective suits to permit personnel to enter a cold gas atmosphere. All LNG ship crew members will receive extensive training in fighting shipboard fires as is mandated under IMO codes, flag state requirements and owner's response plans. In addition to monthly drills onboard the vessel, the vessel will also participate in terminal drills covering such areas as gas release, pool fire, electrical fire, confined space extraction.

2.6.1.4.2. Tugs Emergency Response

The firefighting capabilities required of the tugs will be as a minimum that they be equipped to FiFi 1 Class standard. The class notation FiFi 1 means that the tug is equipped with a minimum of 2 fire monitors, which will be able to throw water to a minimum distance of 120 m from the vessel and to a height of minimum 45 m. The monitors will be controlled remotely from the wheelhouse of the tug.

2.7. Process Control and Monitoring

2.7.1. LNG Terminal

The process and utility systems will be automated to support centralised monitoring and operations. Local controls to start, stop, or adjust instrumentation setpoints will be provided where local operations are desired. All actions will be under the supervision of the MCR operations staff. All critical process operations will be monitored and recorded. An integrated control and safety system (ICSS) will be provided. It is anticipated that some process equipment will operate with its own distributed control system hardware and software which will be integrated into the overall ICSS and is discussed in the following section.

2.7.1.1. Integrated Control and Safety System

The ICSS will be a distributed control system that will provide process control, fire and gas detection, event logging, and emergency shutdown (ESD) functions. The functions will be fully integrated and standardised hardware and software will be utilised throughout the system as far as possible. The system is intended to minimise the need for communication gateways or bridges between software systems, thus improving the system reliability and increasing operational flexibility.

The equipment chosen will be well proven but of an up-to-date design.

The primary objective in the design of the ICSS is to provide high reliability and availability. The system will provide safe, efficient and reliable equipment of proven design. The system will use current technology with modern diagnostic capability to increase failure reporting and reduce maintenance requirements.

Dual redundant architecture will be used to avoid common mode failure points and increase availability.

The ICSS should comprise the following sub-systems:

- Process Control System (PCS);
- Process Safety System (PSS);
- ESD; and
- Fire and Gas System (FGS).

The PCS will function to produce on specification product. It will automatically correct disturbances caused by changing process conditions. The safety system is mainly composed of the ESD, FGS and PSS.

Unsafe process and operational conditions in any part of Terminal can be detected and will activate the FGS, PSS and/ or ESD, systems accordingly. The FGS, PSS and/ or ESD, system will provide a controlled shutdown of the facilities. The shutdown system could be initiated manually or automatically. The ESD will provide a reliable response to the process and fire and gas detection systems and will take the necessary executive action to avoid escalation of the event.

2.7.1.2. Alarm Management Overview

The alarm system will form an essential part of the operator interface with the ICSS. Within the alarm management framework determining the roles and responsibilities of facility operations and maintenance support personnel is paramount to ensuring that the alarm system is operated, managed and improved to obtain optimum plant efficiency through the management of abnormal conditions. The alarm system will provide vital support to the operators managing complex systems by warning them of situations that need their attention. The alarm system warns the operator that the process is moving from a Normal to an Abnormal state.

To prevent alarm flooding a robust method of alarm management and rationalisation is required. Each alarm must alert, inform and guide the operator. The information presented to the operator will, where possible, present an indication of what has gone wrong and why it may have occurred. Each configured alarm will be unambiguous and not duplicated by other alarms. Sufficient time should be allowed for the operator to analyse the situation and carry out the defined response. Operator response time includes the time to diagnose the problem and perform the corrective actions (such as shutdown). Alarm documentation and rationalisation is a consistent, logical process used to identify, prioritise and document alarms. The objective of alarm rationalisation is to create an alarm system with the correct number of alarm activations (not necessarily fewer configured alarms) and acceptable alarm rates. All changes to the alarm system must be controlled by management of change procedures. Testing and training of operators will be carried out at the implementation stage of the alarm lifecycle and continue to be performed throughout the life of the asset.

2.7.1.3. Jetty

Active and passive fire protection will be installed on the jetty including a firewater ring main to provide firefighting capability at the jetty. The firewater will have the function of providing protection from incident thermal radiation and for cooling equipment purposes. This will include the following:

- Firewater curtain to enable personnel to escape via gangway tower and/ or trestle;
- Jetty firewater curtain to reduce incident thermal radiation on the FSRU hull;
- Elevated firewater monitor(s) to provide sufficient cooling water coverage to the GLAs and/ or FSRU manifolds;
- Firewater coverage of piping for cooling purposes; and
- Onshore fire pumps with remote and local start/ stop functionality, each capable of delivering full cooling of the pierhead area and the hull of the FSRU.

The firewater system will have a capacity of approximately 800 m^3/hr. Additional information on fire safety policies and procedures can be found in **Section 2.8.1**.

2.7.2. Power Plant

The Power Plant will be monitored and controlled from the central control/ operations building. This building will include a control room, meeting room and offices for the operations personnel stationed at the Power Plant.

2.7.3. Above Ground Installation

The AGI, which is normally unmanned, is operated and controlled from GNI's central control system. Personnel at the LNG Terminal will be in frequent contact with GNI, who through nomination determine the offtake rate of gas from the LNG Terminal.

2.8. Health, Safety and Environmental Aspects

The Applicant recognises and accepts its moral and legal responsibilities for ensuring the health, safety and welfare of its employees, contractors, visitors and members of the public who could be affected by its activities; it is committed to compliance with all applicable Irish health, safety and environmental laws and regulations.

The Directors and Senior Management of the Proposed Development have overall responsibility for the implementation of its HSE policies. These policies will be reviewed periodically to ensure that they remain relevant and appropriate to the Proposed Development's operations and business.

The Applicant will implement a HSE Management System, which will include setting of objectives and targets, measuring progress, reporting results as a commitment for continual improvement, and fostering a culture where incidents are reported and investigated and lessons learned are shared through the organisation. It will use regular audits to ensure its controls are effective. It will provide appropriate health, safety and environment training and guidelines to employees and contractors to enable them to meet the required standards of performance.

The Applicant aims to minimise the health, safety and environmental impacts of its activities and prevent pollution by utilising a structured risk management approach, which includes emergency preparedness and contingency planning. All new activities will be assessed for environmental impact and appropriate health and safety provision, and ongoing activities will be subject to periodic review. Health, safety and environmental protection will be given equal priority to the business objectives of the company.

The Applicant is committed to effective communication and consultation on health, safety and environmental matters with all interested parties and will make its policies available to them subject to appropriate privacy and business confidentiality protections. The Applicant will routinely monitor, assess and report on its health, safety and environmental performance with data on the rate of lost time injuries and occupational injuries.

The Applicant will ensure that operating, maintenance, and emergency response procedures and manuals will be subject to regular review and will be updated to reflect best industry practice, or to reflect the addition of new procedures, equipment or other facilities.

2.8.1. Internal Fire and Rescue Plan

Safety is the main consideration in the Proposed Development design. The main fire hazards on the Proposed Development are identified from the quantitative risk assessment (QRA), which was undertaken by Vysus (previously Lloyds Register) for the Proposed Development on behalf of the Applicant (Appendix A2-5 of EIAR Vol. 4). The QRA includes hydrocarbon flash fires, jet fires and pool fires. To limit the consequences of fire scenarios and to cope with any potential domino effects, the Proposed Development will be partitioned into fire zones, which are areas within the installation where equipment is grouped by nature and/ or homogeneous level of risk attached to them. The partition of an installation into fire zones will result in a significant reduction of the level of risk. The consequences of a fire, flammable gas leak or an explosion corresponding to the credible event likely to occur in the concerned fire zone shall not impact other fire zones.

In order to mitigate or control these hazards, the proposed ESD coupled with the PCS and the FGS, are crucial to ensure the safety of the plant. Should there be a loss of containment and/ or subsequent fire, the FGS will activate. The potential hydrocarbon release to be detected is a clean non-toxic single-phase gas in a well-ventilated area. On confirmed FGS detection, the active fire protection system will operate. A voting logic will be implemented to avoid spurious trips.

The fire hazards associated with the Proposed Development will be mitigated by the use of passive and active fire protection. Passive fire protection (PFP) is aimed to protect personnel and ensure that escape, evacuation and rescue (EER) systems can enable safe evacuation in all scenarios linked to hydrocarbon fire hazards at the Proposed Development site. PFP is mandatory on equipment and structures that could be exposed to a fire that could lead to loss of integrity.

Active fire protection (AFP) aims to control fires and limit escalation, reduce the effects of a fire to enable personnel to undertake emergency response actions or to evacuate, extinguish the fire where it is considered safe to do so, and limit damage to structures and equipment. The AFP equipment at the Proposed Development site will include a combination of:

- Fire water mains network, with hydrants and monitors;
- Water spray systems;
- Water curtains/ hydro shields;
- Portable dry chemical powder systems;
- Firefighting vehicle(s); and
- Portable/ mobile fire extinguishers.

An appropriate firefighting and rescue trained crew will be available/ provided onsite and ready at all times. Employees will be trained in all emergency response actions including natural gas leak and fire situations. Fire safety certificates will be required from the Chief Fire Officer of KCC prior to construction of the facility for each building on the site. The plant shall be operated in a safe and efficient manner compliant with national health and safety legislation.

The activation of firefighting equipment could be manual by push buttons located locally or control room to initiate extinguishing agent, or automatically through the FGS.

The jetty with the FSRU moored will contain primary and secondary escape routes. The primary escape route connects the jetty area via the trestle to the jetty landfall area where a muster point will be located. The jetty primary escape route also interfaces with the FSRU which has its own muster area, temporary refuge (TR), embarkation area or means of escape to the sea.

The primary route will have sufficient lighting along the jetty, floor painted markings (yellow/ black zebra lines), an anti-slip coating, illuminated signs (white with a green background) to identify the muster point which will be located at the jetty landfall, illuminated signs (white with a green background) to identify the escape route(s), a plan of the escape route(s) on the jetty, and life buoys along the escape route(s), etc.

For the onshore installation, the onshore primary escape route will lead to the muster area(s). The onshore secondary escape routes or paths from modules/ locations outside the main fire zones will lead personnel to the primary escape route. An alternative muster point will be provided for should access to the main muster point be impaired. Muster areas are safe places where all personnel normally muster while investigations, emergency response and evacuation pre-planning are undertaken. The main functions of the mustering are to protect personnel, to number and identify personnel, to provide first aid, and to provide information.

An emergency plan will be drawn up in consultation with the port authority, fire brigade, gardai, etc., and shall integrate with any other relevant plans, such as the port emergency plan. The plan will include as a minimum:

- The specific action to be taken by those at the location of the emergency to raise the alarm;
- Initial action to contain and overcome the incident;
- Procedures to be followed in mobilising the resources of the LNG Terminal, as required by the incident;
- Evacuation procedures;
- Assembly points;
- Emergency organisation, including specific roles and responsibilities;
- Communications systems;
- Emergency control centres; and
- Inventory and location of emergency equipment.

The Proposed Development will have an emergency team whose duties include planning, implementing and revising emergency procedures, as well as executing them. The emergency plan, when formulated, will be properly documented in an 'Emergency Procedures Manual', which will be available to all personnel whose work relates to the present facilities.

Both vessels – the FSRU and any visiting LNGC – will be advised of the LNG Terminal's emergency plan, as it relates to the ship, particularly the alarm signals, emergency escape routes, and the procedure for a ship to summon assistance, in the event of an emergency onboard.

The tugs will also be designated as firefighting craft, which enables them to supplement the LNG ships and LNG Terminal's firefighting capabilities and to act as an integral part of the overall response team and equipment at the facility.

Article 13 of the Seveso III Directive requires that: '*the objectives of preventing major accidents and limiting the consequences of such accidents for human health and the environment are taken into account in their land-use policies or other relevant policies*'. As reflected in the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 (S.I. 209 of 2015), this is to be achieved through controls on the siting of new establishments, modifications to existing establishments and new developments in the vicinity of such establishments. The regulations take into account the long term need to maintain appropriate distances between establishments and residential areas, buildings and areas of public use, recreational areas, major transport routes as far as possible, and areas of particular natural sensitivity or interest. Technical advice on the risks from an establishment must be made available to the planning authority. The Planning and Development Regulations 2001 to 2021 specify when planning authorities should seek technical advice in this area and the information that must be supplied to the HSA when seeking the advice.

A quantitative risk assessment (QRA) was undertaken by Vysus (previously Lloyds Register) for the Proposed Development on behalf of the Applicant. The major accident hazards at the establishment were identified. A summary of the major accident scenarios, together with the measures in place to prevent them or mitigate their consequences, is presented in the summary of the QRA.

QRA (Qquantitative Risk Assessment) has been carried out for the purposes of Land Use Planning (LUP) in accordance with draft HSA Technical Land use planning guidance 2021 (HSA, 2021). The land use planning zone boundaries are defined as:

- Zone 1 (inner): within the 1 x 10^{-5} /y individual risk of fatality contour;
- Zone 2 (middle): between the 1 x 10^{-5} /y and 1 x 10^{-6} /y individual risk of fatality contours; and
- Zone 3 (outer): between the 1 x 10^{-6} /y and 1 x 10^{-7} /y individual risk of fatality contours.

The criteria for new establishments are:

- The individual risk of fatality at the nearest residential property should not exceed 1 x 10^{-6} /y; and
- There should be no incompatible land uses existing within any of the three zones.

Details of the QRA study for the establishment will be described in the Predictive Elements section of the Safety Report. QRA provides a quantification of the risks associated with the reasonably foreseeable major accident scenarios identified. The method involves calculating the frequency of a representative range of sizes of releases from equipment using suitable available published data.

The physical consequences of these releases are modelled (e.g. level of thermal radiation), as well as the impact on people, considering a range of weather conditions. This information is combined to give a numerical representation of the risk from the scenarios considered, in terms of 'individual risk' to site workers and members of the public offsite, and also 'societal risk' to the public population as a whole.

The QRA results are compared against tolerability criteria to demonstrate that the risk levels associated with the operations of the LNG Terminal are tolerable. Risk is traditionally defined as the product of a level of harm (severity) and the frequency of that level of harm occurring. Some risks (e.g. personal safety, slips, trips) have a relatively high frequency with low severity; others (e.g. major hydrocarbon fire) have a relatively low frequency with high severity.

Similarly, the level of risk ranges from relatively low to relatively high. At the lower end of the risk spectrum, the risks are comparable with those we are exposed to as part of our everyday activities and, as such, the risk is deemed 'broadly tolerable'. At the opposite end of the risk range, the risk is so high that it cannot be tolerated. Between these two extremes, there is a mid-range of risk values where the risk can be tolerated if it is demonstrated that it has been reduced to a level which is ALARP.

2.8.2. Pollution Mitigation and Response

The risk of marine pollution from the operation of the Proposed Development has been considered and reduced as far as possible. Specifically, the assessment of likelihood and consequences of release events from the Proposed Development are set out in the relevant sections of the following documents:

- Marine Navigation Risk Assessment (see Appendix A2-2 of EIAR Vol. 4);
- OCEMP (see Appendix 7 of NIS Vol 2);
- Quantitative Risk Assessment (QRA) and associated Major Accidents to the Environment (MATTE) (Appendix A2-5 of EIAR Vol. 4); and
- Environmental Impact Assessment Report (EIAR) for the Proposed Development.

The operation of the Proposed Development will be controlled and regulated by the following bodies:

- Environmental Protection Agency;
- Commission for Regulation of Utilities;
- Health and Safety Authority; and
- Local Planning Authority (KCC).

The Shannon Foynes Port Company has statutory jurisdiction over marine activities, as detailed in Chapter 01 – Introduction.

In consultation with Shannon Foynes Port Company and the Shannon Estuary Anti-Pollution Team (SEAPT), Shannon LNG Limited has prepared an Oil and Hazardous and Noxious Substances (HNS) Spill Plan Development Framework for the Proposed Development. This document describes the framework in which Shannon LNG Limited will develop plans to provide a graduated, tiered and coordinated response to release incidents in the unlikely event they should occur. The developed plans will follow international best practice guidelines of the International Maritime Organization (IMO), The Society of International Gas Tanker and Terminal Operators (SIGTTO), and International Petroleum Industry Environmental Conservation Association (IPIECA) while taking into account relevant Irish legislative and regulatory approval requirements. In particular the plans will follow the requirements made within the National Maritime Contingency Plan Oil and HNS Spills 2019 (National Contingency Plan, NCP) and the National Framework for the Management of Major Emergencies. The plans will be developed to cover both In-Land (onshore) and Marine based releases and shall cover the Construction and Operational Phases of the project.

2.8.2.1. The Shannon Estuary Anti-Pollution Team (SEAPT)

The Shannon Estuary Anti-Pollution Team (SEAPT) is a Mutual Aid Group and the primary response organisations for oil and HNS spills within the Shannon Estuary. The SEAPT consists of the Shannon Foynes Port company, Kerry, Limerick and Clare Local Authorities and commercial and industrial entities operating within the Shannon Estuary. SEAPT was initiated to form a unified coordinated response to pollution incidents on the Shannon Estuary. SEAPT is a member's organisation. Members contribute annually to maintain equipment, carry out exercises and training and purchase new and replacement equipment. SEAPT holds a significant stockpile of equipment. This equipment is available to respond to any pollution incident or threat thereof. The Proposed Development will also be able to avail of spill dispersion modelling capability held by SEAPT. SEAPT are also the custodians of the Shannon Estuary Oil/ HNS Contingency Plan developed in accordance with the NCP and approved by the Irish Coast Guard. Shannon LNG Limited has consulted extensively with SEAPT and the intention is to join the SEAPT organisation on successfully receiving development consents and prior to commencement of the construction phase. The Proposed Development has (provisional to project go-ahead) been accepted as a member of the Shannon Estuary Anti-Pollution Team (SEAPT). Membership of SEAPT will enable the Proposed Development to interface directly with the approved Shannon Estuary Oil/ HNS Plan and access additional response equipment to augment that held within the LNG Terminal. Through the membership process, the Proposed Development will additionally be contributing to the ongoing development and strengthening of the SEAPT organisation.

2.8.2.2. Incident Response

In accordance with the requirements of the NCP Standard Operation Procedure 05, and the final STEP Oil and HNS Spill Plan, there will be the five operational phases of an incident response:

- Phase 1 – Discovery and Notification, Evaluation, Identification and Activation;
- Phase 2 – Development of an Action Plan;
- Phase 3 – Action Plan Implementation;
- Phase 4 – Response Termination and Demobilisation; and
- Phase 5 – Post Operations, Documentation of Costs/ Litigation.

The Proposed Development will manage the response to any Tier 1 (Local – within the capability of the operator on site) and Tier 2 (Regional – beyond the in-house capability of the operator) incident for any pollution on the water within their area of jurisdiction with the full cooperation and integration of the response with the Shannon Foynes Port, the Shannon Estuary Anti-Pollution Team (SEAPT) mutual aid group which includes the three local authorities of Kerry, Clare and Limerick and other agencies as appropriate. The developed plans will identify realistic Tier 1 and Tier 2 scenarios and the resources required to effectively response to and mitigate these. The plans will further describe any escalation to Tier 3 (requiring national resources) and as discussed above, interface with the National Marine Oil/ HNS Spill Contingency Plan. A training and exercising program forms part of the plans. The completed plans will be submitted to the Irish Coast Guard and EPA for appropriate approvals. Further detail can be found in the Oil and Hazardous and Noxious Substances (HNS) Spill Plan Development Framework for the Proposed Development (Appendix A2-6 of EIAR Vol. 4). Additional technical guidance can be found in the NCP and annexes.

2.9. Construction Phase

This section describes the construction activities associated with the Proposed Development including the following phases:

- Construction schedule and working hours;
- Enabling, earthworks and site preparation;
- Construction of LNG Terminal, Power Plant and AGI;
- Construction of drainage outfall;
- Utilities;
- Environmental protection measures; and
- OCEMP.

There is no requirement for any additional temporary land take to support the construction phase; all laydown areas will be accommodated within the footprint for the Proposed Development site. The jetty construction will also be within the foreshore lease area.

2.9.1. Construction Schedule

Subject to planning consent and other approvals an arbitrary start date of Jan 2023 is taken as a construction start date (however this is subject to change). The construction programme is anticipated to take 32 months, subject to seasonal and other planning constraints. This is the basis of the impact assessment contained within this EIAR. The whole construction project is broken into 5 sections as per **Table 2 11** which gives the outline of construction period for each section.

The above sections provide more detail on the proposed construction works.

Table 2-11 Indicative Construction Schedule

Area	Start On Site	Duration (months)	Completion	Duration From Start Date (Months)
Enabling, Earthworks and Site Preparation	Jan 23	10	Oct 23	10
LNG Terminal	+6 months	12	Jun 24	18
220 kV and medium voltage (10/ 20 kV) connections[20]	+8 months	14	Sep 24	21
CCGT - 2 Blocks	+9 months	21	Jun 25	30
CCGT - 1 Block	+ 11 months	18	Aug 25	32

Note that the LNG Terminal will be constructed as part of the first phase of construction, followed by the Power Plant. An additional period of up to six months will be required for commissioning prior to operation as described in **Section 2.10**.

2.9.2. Working Hours

Excluding the jetty construction works, it is anticipated that normal working hours during the construction phase will be as follows (**Table 2 12**):

Table 2-12 Working Hours

Start	Finish	Day
07:30	18:00	Monday to Friday
08:00	14:00	Saturday

It is proposed to stagger the various shift starting and ending times within the construction complex (for example civil employees 07:30 – 18:00, or 07:45 – 17:45). This small stagger in shift start and ending times could lessen the impact of traffic peaking.

Construction of the jetty will be undertaken over approximately 15.5 months, on a 24 hour basis, 6 days a week with maintenance works on Sundays. Security arrangements will also be in place full time. Please see Chapter 07 – Biodiversity for further details.

[20] While the 220 kV and medium voltage (10/ 20 kV) connections are outside the Proposed Development, number and traffic from their construction is included in this EIAR. This includes the associated onsite Eirgrid 220 kV and ESBN 20 kV substations.

Other areas of construction may also be required to work outside of these hours to perform certain tasks such as mechanical testing, inspection duties and commissioning. Reasons for working outside the normal hours would include considerations of safety, weather, tides and subcontractor availability. Every effort will be made during the detailed project execution planning to minimise the number and duration of night-time activities. Working outside normal hours will be agreed in advance with KCC.

2.9.3. Enabling, Earthworks and Site Preparation

2.9.3.1. Pre-Construction Environmental Surveys

A pre-construction environmental survey will be undertaken in advance of the enabling works. Following the survey, licences will be sought from the National Parks and Wildlife Service (NPWS), as appropriate. Exclusion works will be carried out in the appropriate season.

An extensive programme of pre-development licensed archaeological testing will be undertaken in the areas of the site which will be subject to development. Refer to EIAR Vol. 2. Chapter 14– Cultural Heritage for more details on archaeological, architectural and cultural heritage. This will include the demolition of a small farm complex and remains associated with a pillbox. It is anticipated that archaeological survey and investigation works will commence in advance of the main enabling works in accordance with the relevant licenses. Enabling works will only be carried out on areas where archaeological survey and investigation works have been completed.

Prior to the start of works onsite areas to be protected (such as ecologically sensitive habitats or notable trees) will be fenced off to protect from accidental damage.

2.9.3.2. Earthworks and Site Preparation

Enabling, site preparation and earthworks activities are common to the LNG Terminal, Power Plant and ancillary facilities will comprise:

- Construction of safe access and temporary site roads;
- Erection of perimeter and environmental protection fencing;
- Installation of pre earthworks drainage;
- Establishment of the laydown construction area; and
- Earthworks to create level platform at +18 m OD for the main footprint of the development excluding AGI and jetty.

2.9.3.3. Site Access

The contractor will begin by setting out the site entrance as early as possible in the programme consistent with seasonal environmental restrictions and constraints. This operation will begin with the clearance of existing hedgerows and vegetation at the site entrance on the L1010 and progress along the route of the access road to the construction laydown area. This will be followed closely by the excavation of vegetation and topsoil for the access road which follows the existing ground levels and then the placement of crushed stone (to create a 6 m wide access road) to create an initial access and roadway to the construction laydown and jetty area. All topsoil will be retained onsite for future use. Topsoil will be placed in temporary stockpiles at various locations throughout the site for re-use on slopes, with any excess material placed in the vicinity of the contractor's compound. Approximately 26,000 tonnes of imported aggregate will be delivered from local quarries along the L1010 from the Tarbert direction. Sources of material could include:

- Ardfert Quarries, Ardfert, Co. Kerry;
- O'Mahoney Quarries, Tralee, Co. Kerry;
- Roadstone, Foynes, Co. Limerick; and
- Liam Lynch, Adare, Co. Limerick.

It is anticipated that the creation of this initial access will take approximately 2 to 3 months. Apart from the delivery of materials, the operation will all take place within the site boundary with personnel using mobile plant.

Traffic management measures approved by KCC and An Garda Siochana will be implemented prior to the commencement of works to ensure the site access is safe for all road users.

Following the construction of the site access, a perimeter fence will be erected around the site boundary. Fencing will be installed to protect the Rallapane stream. Temporary car parking and site office and other facilities will be established to support the early works which will primarily comprise earth moving. Temporary surface water drainage and silt ponds will be constructed to control runoff from the earthworks stages. Areas within the Proposed Development site, which are not to be disturbed during the construction stage, will be fenced off. The environmentally designated areas are outside the site boundary and will therefore be fenced off by the perimeter fence.

Some hedgerows, bushes and trees, and disused buildings, will also be removed during this phase.

2.9.3.4. Fencing

Fencing will be erected along the perimeter of the site as early as possible. Particular care will be taken at the boundary between the development site and the cSAC and SPA so that construction activities do not cause damage to habitats in this area. These habitats will be securely fenced off early in the construction phase. The fencing will be clearly visible to machine operators and include relevant areas in which works are planned, such as utilities. To prevent incidental damage by machinery or by the deposition of spoil during site works, hedgerow, tree and scrub vegetation which are located in close proximity to working areas will be clearly marked and fenced off to avoid accidental damage during excavations and site preparation.

2.9.3.5. Pre Earthworks Drainage

To prevent the risk of contaminating surface water and groundwater, temporary surface water drainage (including dewatering measures) and silt ponds will be constructed to control runoff from the earthworks stages. This will flow through a filtration system (such as hay bales) to slow down flow to an acceptable level. Silt traps will be placed at crossing points to avoid siltation of watercourses. Attention will also be paid to preventing the build-up of dirt on road surfaces, caused by lorries and other plant entering and exiting the Proposed Development site, via wheel washes and road sweepers as required. The layout of the temporary surface water drainage system will incorporate the mitigation and monitoring measures outlined in this EIAR and conform to the requirements of the OCEMP, Waste Management Plan (WMP) and Construction Traffic Management Plan (CTMP), Natura Impact Statement (NIS) and planning conditions.

Rainwater runoff will be diverted away from the construction areas into the Shannon Estuary. Rainwater runoff will passed through an attenuation system including ponds with straw bales or silt bags to prevent sediment from entering the estuary. Discharge water quality targets will be agreed with KCC and included in the OCEMP. Regular water inspection and sampling regimes will be put in place via the OCEMP on the foreshore during construction activity onsite to monitor compliance with the discharge conditions.

2.9.3.6. Laydown Construction Area

A construction compound, or laydown area, for the construction activities will be established to provide for storage of construction equipment and materials, as well as for offices, parking and welfare facilities for staff (for the duration of the construction phase. The locations and extent of the construction compounds are presented in **Figure 2-3**.

The laydown area will be constructed by stripping back the topsoil (which will be used later in the landscaping), and placing a layer of stone over a layer of geotextile membrane as required. The laydown areas will be suitably drained and any areas which will involve the storage of fuel and refuelling will be paved with bunding and hydrocarbon interceptors to ensure that no spillages percolate into the surface water or groundwater systems. During the removal of the topsoil and placement of the stone for the laydown areas precautions will be taken to minimise runoff into ditches, drains or the stream.

Additional mitigation and monitoring measures as required will be implemented in OCEMP including the WMP and CTMP.

The construction compound units will incorporate canteens, offices, medical, changing, and welfare facilities and drying rooms.

Following completion of construction, the laydown area will be cleared and re-instated, temporary buildings and containers, parking areas and material such as stone, aggregates and unused construction materials will be removed as appropriate. As much of this material as possible will be re used onsite as part of landscaping and construction works.

2.9.3.7. Earthworks

The LNG Terminal and Power Plant will be constructed to a finish grade platform with an elevation of 18 m. In order to create this platform, approximately 475,000 m^3 of overburden soils and rock will be excavated and moved within the site (Table 2-13). Some of the rock t will need to be broken up before it can be excavated. This will be done either by percussive rock breaking equipment mounted on tracked excavators or by blasting depending on the hardness and depth of the rock to be removed. The soil and rock will then be excavated using tracked excavators. Excavated material will be stockpiled for use as engineering fill, landscaping and other uses throughout the Proposed Development site. Stockpiles will be no more than 2 – 3 m high and will be seeded with an appropriate seed mix. All excavated material will be reused onsite, within the development area, and no import of soil is expected.

Table 2-13 Estimated Material Volumes

	Excavation (m^3)	**Backfill (m^3)**
Topsoil	35,000*	35,000
Soil excavation	356,054	437,115

	Excavation (m^3)	Backfill (m^3)
Rock excavation	81,062	
Total	472,115	472,115
*Excess topsoil will be placed on the laydown area or spread onsite		

The overburden will be, in places, quite thin, and to create the level platforms for the facilities. It is expected that blasting will be required to excavate some of the rock, which cannot be removed by rock breaking equipment mounted on tracked excavators. The blasting will be carried out in a controlled manner in accordance with a pre-approved plan, and in a controlled manner to minimize the noise and ground vibrations. This is done by designing a blast pattern with a small charge in many holes drilled in to the rock at close spacing; the individual charges are then set off in a sequence using an electronic relay so that the maximum charge going off at any instant (this is referred to as the 'maximum instantaneous charge') is only the small amount of charge in any one of the holes. This causes cracks in the rock which allows the rock to be broken up further using mechanical rock breakers; the rock is then excavated using tracked excavators. No more than three blasts are envisaged to occur in any given day and associated noise and vibration levels will be transient and very short lived.

Excavated material will be stockpiled for use as engineering fill, landscaping and other uses throughout the site.

Earthworks are expected to be completed within four months, with two to three months of blasting. Piling for the construction of the jetty will also commence during this period, initially from onshore (approximately four and a half months) followed by 11 months from the water.

Monitoring of dust, noise and vibration levels will be undertaken during blasting operations at appropriate locations around the boundary in accordance with the OCEMP. Piling activities will also comply with ecological constraints such as breeding mammals (June to September) and wintering birds (October to March). Refer to Chapter 07 – Biodiversity for more information.

The OCEMP will also identify mitigation and monitoring measures required to protect watercourses from pollution associated with the earthworks operations and set out the specific arrangements for the strict control of erosion and generation of sediment or any other pollutants. It will detail appropriate sediment control temporary works and plant, including silt curtains, settlement lagoons, flow control arrangements etc. to ensure no pollutants are discharged to watercourses or the sea.

2.9.3.8. Traffic and Transport

For the impact assessment purposes, a worst-case construction scenario of the LNG Terminal, Power Plant and medium voltage (10/ 20 kV) connection has been assumed. This scenario will result in a maximum site headcount and consequently the highest amount of traffic.

The traffic associated with the earthworks and site preparation phase will be managed such that the impact on public roads will be minimised. This is achieved by the implementation of the CTMP which will be agreed by KCC in advance of the works. The traffic volumes on the public road will largely comprise HGV deliveries and arrival of personnel to the Proposed Development site.

Deliveries will be co-ordinated with the planned L1010 road upgrade works, which is anticipated to overlap with the enabling works phase. These activities will be completed at about the same time to allow the main construction works to proceed.

2.9.4. LNG Terminal Construction

The LNG Terminal construction activities will commence once the main earthworks activities have been completed. The construction of the LNG Terminal will include the following:

- Construction of jetty; and
- Construction of onshore receiving facilities
- Construction of AGI.

Typically, the construction equipment required will include floating plant (for the jetty), compressors, mobile cranes, tower cranes, generators, hoists, gantries, and various types of excavators, loaders, trucks, trailers, vans, etc. Other equipment required will include a rock crusher and screening plant, diesel fuel tanks, gas storage cages, electric power supply, mechanical repair shops, etc. Hard standings will be established for these by pouring concrete in the relevant locations.

Fuel will be required for the diesel generators and equipment. To minimise the numbers of fuel deliveries, one or more double skinned diesel fuel tanks (maximum 20,000 l) will be installed onsite to supply fuel for the diesel generators and construction vehicles and equipment. The diesel fuel tanks will be positioned on a temporary bunded concrete plinth (constructed at the start of the works), away from sensitive watercourses.

2.9.4.1. Jetty Construction

Construction of the jetty will include (over approximately 15.5 months):

- Installation of the jetty trestle supported on steel piles with a concrete deck and access roadway to the jetty head;
- Installation of a jetty head with unloading arms;
- Installation of mooring dolphins;
- Installation of breasting fender dolphins;
- Installation of permanent docking location for four tugs; and
- Installation of topside equipment and facilities.

Topside facilities and equipment construction will include:

- Installation of welded pipework and electric supply and instrument cables along the trestle to the jetty head and berthing facilities; and
- Installation of major equipment such as loading arms, gangway towers, firewater pumps, elevated fire monitors, lighting, safety systems, including the berthing monitoring systems.

Typically, the construction of the jetty will be undertaken from the water using floating barges and self-elevating platforms (jack-ups), manned with teams of specialist marine construction personnel, divers, operators, and labourers plus supervision. Tugs will be on hand for moving the floating equipment around. Other smaller equipment such as compressors, generators, and land-based machines will also be used.

The construction materials for the jetty consist of 203 steel tubular piles, structural steel, precast concrete elements, reinforcing steel and concrete. Up to 163 m^2 of SAC habitat is expected to be lost as a result of the jetty piles. This is discussed further in Section below. It is anticipated that the initial steel piles for the jetty will be delivered by road from Foynes port (within the first 3 months of enabling works) with subsequent pile deliveries supplied directly by barge once the first part of jetty is constructed. The piles will be up to 50 m long x 1067 mm in diameter and will be delivered out of hours as an abnormal load.

The majority of the piles supporting the jetty will be driven, with some piles drilled and socketed into the underlying rock to ensure stability of the jetty. This operation will require a jack-up platform supporting a large crane-mounted drill and a large barge-mounted support crane. Spoils from the drilling operation will be conveyed to the surface via reverse-circulation through the drill stem and contained within designated scows or other vessels. Approximately 1000 m^3 pile arisings are anticipated from the socketed piles (approximately 80 no.), none of which will be from onshore piling operations. The spoils will be placed on a barge, dried, then transferred to shore for drying and reused in general earthworks or in landscaped bunds. Pile installation is anticipated to advance outward from shore. It is anticipated that between 0.5 and 2 piles will be drilled per day during the construction of the jetty.

Once the pile installation is underway, one or two additional floating spreads will follow in sequence to lift and set the precast pile caps, beams, and deck planks. These spreads will comprise one or two large floating cranes and materials barges. All works will be carried out within the foreshore lease area.

The work will also involve in-situ grouting of precast members at the pile tops and other connections. The access roadway to the jetty platform will be constructed of reinforced concrete and will be 5 m wide. This work will advance outward from shore using land-based concrete transit mixers, pre cast concrete, and other paving equipment.

The jetty construction contractor will be required to liaise closely with SFPC Harbour Master and Pilotage Superintendent in relation to scheduling of activities. Support barges will be moored and anchored so as not to interfere with traffic in the navigation channel and in accordance with guidelines established by the Harbour Master and SFPC.

The use of pre-cast concrete will be maximised, while the pouring of wet concrete onsite will be minimised to reduce any potential environmental impacts on the Shannon Estuary. Any in-situ concrete work will be staged in a manner to prevent concrete from entering the water. This will be achieved by installing shuttering to contain the concrete, with all concrete pours supervised by the Environmental Manager. Refer to the OCEMP in Appendix 7 of NIS Vol 2. for further detail. Piles will be pre-fabricated as much as possible to minimize in-water construction.

2.9.4.2. Onshore Receiving Facilities Construction

Onshore, LNG Terminal facilities construction will follow the sequence below, consistent with gas industry practices, over a period of 12 months following the enabling works phase, namely:

- Placement of concrete foundations, drainage system, power and instrumentation conduits;
- Installation and erection of process and utility equipment, piping and instrumentation;
- Construction of buildings; and
- Site landscaping.

Initially, drainage systems and power and instrumentation conduits will be installed along with the placement of concrete foundations, followed by the building superstructures (including metal frames, cladding and additional finishes). Following this the fit out of the major mechanical and electrical equipment, instrumentation and process piping will be completed. The fit out and completion of the buildings, and completion of site access roads with landscaping, using stockpiled topsoil material, will then take place. The facilities will be tested and commissioned, prior to commencing operations.

Where possible, equipment will be modularised for some of the facilities, and components will be standardised and pre-fabricated in order to reduce onsite construction time and to minimise local disruption during the construction phase. Pre-fabricated materials will be delivered to the site via the road network and may require out of hours abnormal load delivery. GI Construction

The construction of the AGI will be undertaken following enabling works over a period of 12 months and will encompass the following activities:

- Placement of concrete foundations, drainage system, power and instrumentation conduits;
- Installation and erection of process and utility equipment, piping and instrumentation;
- Construction of buildings; and
- Site landscaping.

Buildings to house the AGI will mostly be steel framed with infill construction and cladding. Structural steel for buildings is anticipated to be delivered by road and assembled onsite.

The majority of the building materials for the AGI will be purchased as complete units, where practicable, and delivered to the site for installation. Pipe work and ducting will be assembled onsite.

Drainage system power and instrumentation conduits will be installed along with the placement of concrete foundations, followed by the building superstructures (including metal frames, cladding and additional finishes. Later stages of the initial phase will see the installation of the major mechanical and electrical equipment, instrumentation and process piping. Final stages of the initial phase will see the fit out and completion of the buildings, and completion of site access roads, with landscaping. The facilities will be tested and commissioned and the facility will commence operations.

2.9.4.3. AGI Construction

The construction of the AGI will be undertaken following enabling works over a period of 12 months and will encompass the following activities:

- Placement of concrete foundations, drainage system, power and instrumentation conduits;
- Installation and erection of process and utility equipment, piping and instrumentation;
- Construction of buildings; and
- Site landscaping.

Buildings to house the AGI will mostly be steel framed with infill construction and cladding. Structural steel for buildings is anticipated to be delivered by road and assembled onsite.

The majority of the building materials for the AGI will be purchased as complete units, where practicable, and delivered to the site for installation. Pipe work and ducting will be assembled onsite.

Drainage system power and instrumentation conduits will be installed along with the placement of concrete foundations, followed by the building superstructures (including metal frames, cladding and additional finishes. Later stages of the initial phase will see the installation of the major mechanical and electrical equipment, instrumentation and process piping. Final stages of the initial phase will see the fit out and completion of the buildings, and completion of site access roads, with landscaping. The facilities will be tested and commissioned and the facility will commence operations.

2.9.5. Power Plant Construction

Construction of the Power Plant will begin after the platform level has been excavated to 18 m AoD and the surface prepared, as outlined in the enabling works section (2.9.3). Typically, the construction equipment required for the Power Plant includes compressors, mobile cranes, tower cranes, generators, hoists, gantries, and various types of excavators, loaders, trucks, trailers, vans, etc. Other equipment required will include diesel fuel tanks, gas storage cages, electric power supply, mechanical repair shops, etc. A number of tower cranes may be required. Hard standings will be required for these and will be located away from environmentally sensitive sites.

It is currently anticipated that the Power Plant construction will commence shortly after the commencement of the construction of the LNG Terminal.

2.9.5.1. Power Plant Construction Works

The construction works for the Power Plant will be sub-divided into four main packages:

- Civil and structural works;
- Mechanical and electrical installation;
- Gas Infrastructure; and
- Connection to the EirGrid 220 kV substation.

Foundation construction will include excavating to a depth of approximately 2 to 3 m, installation of concrete forms, fixing of steel reinforcing, and the pouring of concrete. Pile foundations could be necessary for parts of the Power Plant, depending upon soil conditions and loading.

Buildings to house the Power Plant are expected to be steel framed with infill construction and cladding. Structural steel for buildings is anticipated to be delivered by road and assembled onsite.

The majority of the building materials for the Power Plant will be purchased as complete units, where practicable, and delivered to the site for installation. Pipe work and ducting will be assembled onsite.

The mechanical activities will include the installation of:

- Gas turbine generators;
- Steam turbine generators;
- Heat recovery steam generator;
- Air cooled condenser;
- Auxiliary cooling water system;
- Feed water/ condensate system;
- Fuel gas supply system;
- Water supply/ treatment system; and
- Fire protection system.

The main electrical activities will include the installation of the following:

- Transformers;
- Distributed control systems;
- Switchgear;
- Low and medium voltage and control and instrument systems;
- Batteries and Uninterruptible Power Supply systems;
- BESS; and
- 220 kV GIS substation.

2.9.6. Drainage Outfall Construction

A drainage outfall into the Shannon Estuary will be constructed. Within the Proposed Development site, surface water from paved and impermeable areas and groundwater will be collected by an underground drainage system and will discharge to either, the existing stream and/ or drainage ditches within the site, or to the Shannon Estuary. via the drainage outfall pipe which will extend across the foreshore to below the low water mark.

All discharges through the drainage outfall will pass through a Class 1 Hydrocarbon Interceptor. Any bunded areas within the site will have valve-controlled discharge points as part of their connection to the outfall drainage network. Drainage runoff from these areas will be tested for contamination prior to release to the outfall drainage network.

The drainage outfall pipe will be buried as it crosses the shoreline and will extend approximately 5 m beyond the low water mark. A check valve will be installed at the end of the outfall drainage pipe to prevent ingress of water from the estuary back into the drainage system.

It is anticipated that the construction of the drainage outfall pipe will be an open cut trench technique as follows:

- Excavate a trench across the foreshore to a maximum depth of approximately 2.4 m;
- Install a 900 mm diameter concrete drainage pipe in trench and backfill with concrete; and
- Reinstate the foreshore and shoreline.

The outfall trench will be excavated above the low water mark using a hydraulic rock breaker mounted on a tracked excavator. This operation will be carried out in the dry at all times working above the tide during a suitable period of spring tides.

Where the outfall extends beyond the low water mark into the estuary, excavation of rock will be undertaken using an expanding grout placed by divers into drilled holes to pre-split the rock to the required levels and facilitate its removal by long reach excavator bucket.. Trenches excavated across the shoreline will be backfilled with concrete suitable for underwater use and the surface will be embedded with cobbles and stone excavated from the trench to minimise the visual impact. The excavated material will be removed from the foreshore and incorporated as part of the earthworks and landscaping for the Proposed Development. Below the low water mark, the trench will remain open, and the sides of the trench will be battered back to avoid creating a pocket for siltation. Additionally, the cliff face will be armoured with rock to prevent erosion and maintain the integrity of the foreshore. Disturbance of the seabed below the low water mark will be small, arising primarily from the excavation of the trench and clearing and levelling of the ground to install the outfall pipe. This will result in temporary habitat loss of approximately 90m^2 of Annex I habitat above the low water mark and 10m2 below the low water. Loss of Annex I habitat Estuaries habitat is estimated to be approximately 100m^2, while the loss of Reef habitat is approximately 65m^2. Installation of the pipe will result in the loss of 0.000041% and 0.000030% of the Annex I habitats 1130 Estuaries and 1170 Reefs respectively. This is discussed further in Section below.

All refuelling of equipment and machinery will take place at designated refuelling areas on the site. No refuelling will take place on the foreshore. Arisings from trenching, or other works, will either be used for reinstatement. Details on this will be outlined in OCEMP.

2.9.7. Construction Utilities

2.9.7.1. Electricity

During the construction phase of the Proposed Development, electricity will be supplied via a series of portable site units prior to the medium voltage electricity connection becoming available.

2.9.7.2. Water Supply

Water will be required for consumption by the construction personnel, for general construction works, hydrotesting of tanks and pipework, for the construction of the concrete elements, and for wheel wash facilities and for dust suppression. It is anticipated that water supply for the construction phase will be obtained from a water main along the L1010. The Applicant has submitted a pre-connection agreement application to Irish Water for this supply. If this supply is not available, water will be delivered by road and stored in a temporary tank onsite.

The maximum potable water demand for construction will be 98 m^3/day. The Proposed Development will incorporate water efficiency measures such as collection of grey water to minimise water consumption as far as possible.

2.9.8. Drainage

2.9.8.1. Sewerage Drainage for Construction

Sewage effluent will arise from the site offices, canteens, toilets and showers. The effluent will be collected in tanks and self-contained toilet units for removal by tanker by a licensed haulier to a licensed facility.

2.9.8.2. Stormwater and Surface Water Drainage during Construction

Surface water and groundwater on or adjacent to the site could become contaminated with silt or debris during the construction phase. Therefore, temporary surface water drainage and silt ponds will be constructed to control runoff from the earthworks stages. Water will be reused onsite where possible, for example grey water will be used for wheel washing activities. Surface water will flow through a filtration system (such as hay bales) to slow down flow to an acceptable level. Silt traps will be placed at crossing points to avoid siltation of watercourses. Attention will also be paid to preventing the build-up of dirt on road surfaces, caused by lorries and other plant entering and exiting the Proposed Development site, via wheel washes and road sweepers as required. The layout of the temporary surface water drainage system will incorporate the mitigation and monitoring measures outlined in this NIS and conform to the requirements outlined in the OCEMP, WMP and CTMP (see Section 2.9.12), EIAR and planning conditions.

2.9.9. Construction Management

A construction management team will be onsite for the duration of the construction phases of both the LNG Terminal and the Power Plant. The team will supervise the construction of the Proposed Development, including monitoring the contractors' performance to ensure that the proposed construction phase mitigation and monitoring measures are implemented, and that construction impacts and nuisance are minimised. KCC will be notified of the identified point of contact onsite for the duration of the construction programme. Further details on the construction management structure, environmental management, site audit system, and community feedback arrangements are contained within the OCEMP (see Appendix 7 or NIS Vol. 2).

2.9.10. Construction Employment

It is envisaged that the initial construction phase will last approximately 32 months, with an additional 6 months commissioning prior to operation. During the initial phase, approximately 975 people will be employed onsite at peak. While some of the construction personnel will be specialists who will travel from outside the area, it is intended that many of the jobs will be filled by personnel recruited locally, with appropriate training provided as necessary. The project will therefore provide both employment opportunities as well as training during this phase. Where required, construction personnel will be accommodated locally in hotels and guesthouses.

The coordination of people and materials onsite will be one of the key activities throughout the construction phase.

2.9.11. Materials Sourcing and Transportation

Construction materials will be sourced locally from authorised quarries, where possible to minimise the environmental impact of transportation. It is intended that this will include all suitable stone recovered on during the enabling works will be reused as hardcore. For this purpose, rock crushing and screening plant will be provided. Additional rock, stone and sand materials could be procured from local quarries as required including the following:

- Ardfert Quarries, Ardfert, Co. Kerry;
- O' Mahoney Quarries, Tralee, Co. Kerry;
- Roadstone, Foynes, Co. Limerick; and
- Liam Lynch, Adare, Co. Limerick.

Most of the materials will be transported to the Proposed Development site by road It is anticipated that up to 26,000 t of imported aggregates will be required for the Proposed Development.

There may be periods in the early stages of construction where onsite haul roads are not surfaced. To reduce dust these routes can be dampened down (including the reuse of water from the wheel washing facilities) and maximum speed limits will be signposted and imposed.

Some of the process equipment and structural elements will arrive onsite as complete units or sub-assemblies, which may be larger than normal construction loads. It is anticipated that all the units will be delivered by ship to Foynes, and from there transported to the Proposed Development site by road. Some of the units could be 'extra-large loads' and a Garda escort may be required when they are on the road network. The timing of their transport to the Proposed Development site will be chosen to minimise disruption to other roads users. For example, the jetty piles will be up to 50 m long x 1067 mm in diameter and will be delivered out of hours as an abnormal load, subject to prior agreement with KCC. This will be managed in accordance with the CTMP, see Appendix A11-1 in EIAR Vol. 4.

2.9.12. Environmental Protection Measures

2.9.12.1. Outline Construction Environmental Management Plan

An CEMP will be produced as part of this planning submission. A detailed CEMP will be produced by the successful Contractor prior to the main construction works. The OCEMP will detail the Contractor's overall management and administration of the works. The CEMP will also include any commitments included within the statutory approvals.

The CEMP will set out the necessary approach to managing the environmental aspects and impacts associated with the construction of the Proposed Development. It will also contain details of the monitoring and reporting system which will be implemented to document compliance with the following:

- Environmental commitments identified in the impact assessment studies; and
- The conditions of the relevant statutory consents including the planning consent and the foreshore licence associated with the Proposed Development.

The Contractor will be required to include the following information:

- Project details and the scope of works (including the locations of construction compounds and information on construction periods and phasing);
- A summary of relevant policy and project and environmental aims;
- The planning and foreshore licence conditions relevant to the construction activities and a summary of how and where they will be addressed within the CEMP;
- Information on the roles and responsibilities of key individuals, including the environmental management and reporting structure (as provided by the contractor or as available at the time of writing the CEMP);
- An outline communication strategy, making recommendations to the contractors, for example such as the implementation of toolbox talks (environmental discussion on issues encountered onsite) by the contractor relating to environmental constraints and procedures to be adhered to onsite;
- Methods to identify non-conformances, details of non-conformances and breaches of environmental limits and reporting measures;
- A summary of the potential environmental effects as identified by the EIAR, the schedule of mitigation and other existing documentation;
- The schedule of identified potential environmental impacts, risks and mitigation and monitoring measures;
- Method statements and work programmes for specific tasks such as the management of concrete washout onsite;
- Requirements for and maintenance of concrete washout areas;
- Requirements for fencing off of any protected environmental sites such as areas of ecological or archaeological importance;
- Protection of vegetation including hedgerows, trees etc.;
- An environmental monitoring programme and details of monitoring locations as required;
- An outline emergency response plan and procedure for environmental incidents including accidental spills;
- Requirements for inspection and auditing; and
- An outline reporting programme and procedure to be updated by the appointed contractor.

The CEMP will be a living document and periodically reviewed and updated as required during the course of construction.

As a minimum, the CEMP will be reviewed every six months. Notwithstanding the above requirements, the CEMP will also be reviewed at least two weeks prior to the construction stages listed below:

- Start of works;
- Start of each succeeding stage of the works;
- Start of any site activity that may potentially have an effect on sensitive habitats/ species; and
- Start of the landscaping works.

2.9.12.2. Construction Traffic Management Plan (CTMP)

An outline CTMP has been prepared (see Appendix A11-1 in EIAR Vol. 4). A detailed CTMP will then be produced by the appointed Contractor as part of the contractual agreements for the construction of the Proposed Development and will be updated as needed during the construction period. This CTMP will be agreed with KCC prior to commencement of works and shall apply to all traffic to and from the Proposed Development site including those works carried out by the Contractor and any subcontractors, as well as have regard to traffic associated with works associated with the construction of the jetty, the AGI and the gas export pipeline, the electricity substations and connections. The plan will include measures to direct construction traffic (including site access), as much as practicable, along the upgraded road from Tarbert to the Proposed Development site rather than along the road from Ballylongford to the Proposed Development site.

2.9.12.3. Waste Management Plan (WMP)

The Contractor will be responsible for developing a WMP and a CTMP related to the construction activities. The WMP will establish a waste recording system to test and track all waste loads going offsite for appropriate disposal. This includes Waste Acceptance Testing (WAC) to determine the appropriate disposal route for the waste.

The WMP will also contain details of waste permits and hauliers who will be authorised to remove waste from the site and it will detail waste audits to be carried out.

2.10. Commissioning Phase

Following completion of construction and installation of equipment, and before the LNG Terminal commences operations, there will be a testing and commissioning phase. This phase will comprise:

- Installation compliance checks;
- Commissioning tests; and
- Performance demonstration tests.

2.10.1.1.1. Installation Compliance Checks

This will be a process of systematically checking that all systems and equipment have been constructed, assembled, aligned and installed correctly, in accordance with the design specifications and drawings, and that all interconnecting pipe work, cabling and wiring has been installed in compliance with the design specifications and drawings.

2.10.1.1.2. Commissioning Tests

The function of each item of equipment and each system will be tested and verified, in a systematic manner, as being in accordance with the design and specifications. All the alarm and control systems and instrumentation will be tested to demonstrate that they are functioning correctly. Following these tests, each system will be checked to ensure that it is ready to be commissioned under operating conditions including using real materials, temperatures, pressure, and voltages.

2.10.1.1.3. Performance Demonstration Tests

In this commissioning phase the individual items of equipment and systems will be tested under operating conditions using the materials, temperatures, pressure, and voltages to which they will be subjected when in operation. Once the operation of all equipment and systems has been tested and verified individually, they will be integrated and the operation of complete systems will be tested.

The Proposed Development's safety and fire prevention systems and the Operational Emissions Management Plan will be subject to the same rigorous testing protocols as the other systems.

2.11. Decommissioning Phase

The Proposed Development is expected to have a design life of 50 years, but this could be extended by maintenance, equipment replacement and upgrades or by the transition of the site to use hydrogen capability (which will be subject to a future planning application). It is expected that it would be a condition of the industrial emissions licence for the Proposed Development that a closure and residuals management plan, including a detailed decommissioning plan, be submitted to the EPA for their approval.

Decommissioning activities will include, as a minimum:

- All wastes at the facility at time of closure will be collected and recycled or disposed of by an authorised waste contractor, as appropriate;
- Utilities will be drained of all potential pollutants such as lubricating oils or sealed to prevent leakage if being moved offsite or recused elsewhere;
- All raw materials, oils, fuels, etc. onsite at the time of closure will be returned to the supplier, or collected and recycled or disposed of by an authorised waste contractor, as appropriate,
- All buildings and equipment will be decontaminated, decommissioned and demolished in accordance with a phased demolition plan, and either sold for reuse or recycled, or disposed of by an authorised waste contractor, as appropriate. In general, specialist equipment, pipelines and storage tanks will be sold for reuse, where possible, or disposed of offsite;
- Roadways to be broken up and removed and security fences dismantled;
- All hazardous and non-hazardous process substances to be removed;
- All roads and hardstanding areas to be removed and recycled or disposed of by an authorised waste contractor, as appropriate;
- Landscaped will be reinstated in accordance with a landscape reinstatement plan; and
- On completion of safe decommissioning of equipment, the potable water, fire water and electrical power supplies could be disconnected, and removed or abandoned in place.

When operations have ceased, and assuming confirmation from the monitoring programme that all emissions have ceased, it is expected that there would be no requirement for long-term aftercare management at the Proposed Development site.

2.12. *Screening Exercise*

Overview

A key factor in the consideration as to whether or not a conservation feature (*i.e.* a QI or a SCI) is likely to be affected by a proposed project is the existence of connectivity (or pathway of interaction or impact) between the conservation feature and the source of impacts (or impact mechanisms) associated with the project. National guidance (DEHLG 2009; OPR 2021) states that screening for AA should be carried out for any European site within the likely 'Zone of Impact' of a plan or project. Guidance outlines that the Zone of Impact must be evaluated on a case-by-case basis. The evaluation of the Zone of Impact must consider the potential for effects to conservation features with reference to the nature, size and location of the project, its location in relation to individual European sites and the Conservation Objectives defined for their conservation features, and with reference to the sensitivities of the receptors, and the potential for in-combination effects.

The Lower River Shannon cSAC and, the River Shannon and River Fergus Estuaries SPA is partly within and adjacent to the site along the northern/ north-western boundary and also along part of the eastern boundary of the Proposed Development site (see **Figure 1-2**). The proposed jetty and outfall will extend into the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA (see **Figure 2-26** and **Figure 2-27** respectively).

Figure 2-26: Proposed jetty, outfall and FRSU relative to the Lower River Shannon cSAC.

Figure 2-27: Proposed jetty, outfall and FRSU relative to the River Shannon and River Fergus SPA.

2.12.1. Methodology

To establish the Zone of Impact of the Proposed Development, the examination of connectivity between impact mechanisms and a conservation feature considers the location of the development and its associated activities relative to habitats and non-mobile species, species foraging distances and migration routes, and the proximity of the development to foraging and breeding areas, and potential changes in species behaviour, effects on prey species resulting in alteration in interactions and associated impacts.

To inform the screening exercise, survey data including nationally available data on protected habitats and species was mapped using a Geographic Information System (GIS) and interrogated to identify for source-pathway-receptor connectivity. The source (potential impact mechanisms), pathways (hydrological, physical or ecological connectivity) and receptors (conservation features) were identified based on a review of ecological surveys undertaken in the area, and through the examination of aerial photography and using GIS software.

The evaluation of impact sources (or mechanisms) considers all relevant aspects of the Proposed Development that have the potential to directly or indirectly effect conservation features. The stepwise approach to the evaluation of effects to conservation features is summarised below:

1. **Identification of impact mechanisms** associated with the development likely to directly or indirectly effect conservation features of SACs and SPAs (see **Section 2.12.2**).
2. **Preliminary assessment** to identify SACs and SPAs relevant to the current assessment (see **Section 2.12.3**). The preliminary screening of conservation features is based on an evaluation

of the potential pathways for significant impact existing between the conservation features and the impact mechanisms.
The preliminary screening considers the nature of the impacts mechanisms and, the distance of the sites and conservation features from the Proposed Development. Any conservation feature of a SAC or a SPA deemed to have no pathway for significant effect was excluded (screened out) from further assessment.

3. Any conservation feature identified to have a potential pathway for significant effect is brought forward to the **Screening exercise** (see **Section 2.12.4**).
Where the risk of a significant effect to a designated conservation feature from an impact mechanism can be excluded on the basis of objective evidence, the designated feature and impact mechanism combination is screened out of further assessment.
In contrast, where it is considered that there is potential for a significant effect to a Qualifying Interest from an impact mechanism, the conservation feature and the impact mechanism combination is brought forward for a detailed consideration of the potential for adverse effects (see **Section 3 Stage 2 AA - NIS**).
4. Potential impacts of the Proposed Development are considered in combination with other relevant plans or projects in **Section 1.1**. Specifically, the assessment of potential **in-combination effects** considers the impact mechanisms associated with the Proposed Development that in combination with other plans and project may result in significant effects to conservation features.

2.12.2. Identification of Potential Impact Mechanisms based on the Nature, Size and Location of the Proposed Development

A detailed description of the STEP development is provided in **Section 2.1 – Section 2.16** above. The development can be split into three phases: operation, construction, and decommissioning. Key activities proposed for the phases of the development relevant to conservation features are summarised in **Section 2.12.2.1** through **Section 2.12.2.3**, while **Section 2.12.2.4** outlines the potential impact mechanisms associated with the phases relevant to conservation features.

2.12.2.1. Summary of Construction Phase Activities

This phase of the development includes the construction of the LNG Terminal and jetty and the Power Plant.

Works required for the construction of the LNG Terminal include the construction of the jetty, the administration and security building, stores, workshops, various other buildings and process equipment associated with the receiving facilities and the AGI. Other construction works include the installation of structural steel piping and supports between the FSRU and the onshore receiving facility and AGI. The FSRU will arrive at the LNG Terminal fully fitted out. Only minor installation works are anticipated to facilitate the connection between the FSRU and the jetty based systems.

Construction of the LNG Terminal, the Power Plant and the AGI will require extensive pre-construction site preparation works including earth moving and rock breaking, installation of temporary surface water drainage and silt ponds, and temporary site access roads. Site preparation works may also require controlled rock blasting. Works at the Power Plant include the installation of gas turbine generators, heat recovery steam generator, a steam turbine generator, and an air cooled condenser.

For the jetty, up to 203 of construction piles for the structures' foundations will be required. The construction piles will support a jetty trestle on steel piles. The trestle will support a concrete deck constructed of reinforced concrete. The jetty trestle and platform will include docking locations alongside for tugs, and berthing facilities and unloading arms at the jetty head for the FRSU. During the construction phase a trenched storm water outfall will be constructed across the shoreline into the Shannon estuary extending approximately 5m beyond the low water mark.

2.12.2.2. Summary of Operation Phase Activities

As part of operational activities the FRSU will be typically, but not permanently, moored at the jetty. LNG will be transferred to the FSRU via a ship to ship transfer from a LNGC berthed alongside. The LNG will be returned to a gaseous state using the FRSU onboard regasification unit. Gas Loading Arms on the jetty connect to the FSRU via a 30" gas pipe, also installed on the jetty, to transfer the gas from the FSRU to the onshore receiving facility. Tugs will typically be used to moor the LNG carrier safely next to the FSRU. The heat required for the LNG vaporisation will be primarily via seawater, supplemented by gas fired heaters when the seawater temperature is inadequate. Up to 60 visits of LNG carriers (LNGC) are expected every year. The passage time for the LNGC from the mouth of the Estuary to Ardmore point is estimated at 4 hours. LNG unloading to the FSRU from the LNGC via ship-to-ship transfer is estimated to take 35 hours with a further 25 hours required to moor, berth, unmoor and unberth.

Seawater intakes will be located in the hull of the FSRU, approximately 2 metres below water level. Screens will be covering the intakes to prevent fish, crustaceans and debris from entering the seawater system within the FSRU. The design of the water intakes will be such that the approach velocity of the seawater entering the screens will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm. It is anticipated that any silt entering the seawater circulation system will remain in suspension and carry right through the system.

A small amount of sodium hypochlorite is injected into the FSRU seawater systems to control microbial growth. The sodium hypochlorite is generated onboard in an electro-chlorination unit. The electro-chlorination unit will consist of cells housing platinised titanium electrodes between which a direct electric current flows. The sodium chloride salts in the sea water passing between the electrodes dissociate to form residual sodium hypochlorite (chlorine) without the addition of any chemicals. As the seawater passes through the system and is discharged back into the estuary, the chlorine will dissipate back into the sea water from which it will have been produced. Other routine activities associated with the operational phase of the development include inspection and maintenance of the facilities at the LNG Terminal and Power Plant buildings including carpark surface, access roadways *etc.* Other operation phase activities include the periodic maintenance of the jetty structure and pipeline infrastructure, and electrical substation and pump station.

2.12.2.3. Summary of Decommissioning Phase Activities

The Proposed Development is expected to have a design life of 50 years, but this could be extended by maintenance, equipment replacement and upgrades or by the transition of the site to use hydrogen capability (which would be subject to a future planning application). The Proposed Development will be maintained in the long term by Shannon LNG. It is expected that it would be a condition for the Proposed Development that a closure and residuals management plan, including a detailed decommissioning plan, be submitted to the EPA for their approval. Strict adherence to the proposed plan will ensure no significant impacts associated with decommissioning will occur.

2.12.2.4. Potential Impact Mechanisms

The potential impact mechanisms associated with the phases of the development relevant to conservation features are briefly described in **Table 2.14**. Impact mechanism 1, 2 and 3 are associated with the construction phase, impact mechanism 4, 5, 6, 12, 13 and 14 are common to both the construction and operation phase, while impact mechanism 7, 8, 9, 10 and 11 are associated with the operation phase.

Table 2.14: Potential Impact Mechanisms.

Potential Impact Mechanisms		**Development Phase**	**Description**
1.	Release of pollutants during construction	Construction Phase	As with any construction project there is a risk that activities proposed for the construction of the LNG Terminal, Power Plant and jetty may result in the accidental release of chemical pollutants or other waste material pollution to nearby habitats, watercourses and waterbodies. Potential chemical pollutants associated with construction plant equipment include fuels, oils, greases, hydraulic fluids (hydrocarbons). There is also risk of the accidental release of construction materials including concrete. Runoff from construction excavated material may result in the release of sediment, potentially impacting habitat and water quality. Given the nature and scale of the proposed works, there is potential that conservation features located adjacent to the works and immediately downstream and upstream of the works may be affected.
2.	Land-based construction noise and vibration disturbance	Construction Phase	During initial site preparation/ clearance works and during construction activities, the presence of construction personnel and the operation of construction equipment (*e.g.* excavators, rock breakers *etc.*) will result in noise, vibration and light disturbance, potentially displacing fauna from the site and immediately surrounding areas. Site preparation works may also require controlled rock blasting on land. Blasting will generate noise and vibration disturbance. There is potential that mobile conservation feature species (*e.g.* bird species, otter) may occur in the area and thereby be affected.
3.	Release of spoil during piling	Construction Phase	The construction of the jetty structure will require piles to be installed. Underwater pile drilling operations will result in the generation and release of spoil (rock particles and sediment) to the water column potentially affecting local water quality (*e.g.* turbidity) and result in the generation of sediment plumes in the water column extending beyond the immediate works area. There is potential that the plume of spoil released may extend a significant distance from the works area. The increase in turbidity could result in a significant reduction of light in the water column. Spoil generated and released by piling operation may be deposited on benthic habitats resulting in smothering effects.
4.	Underwater noise	Construction Phase **and**	Piling operations will result in the generation of underwater noise. Noise emissions could potentially cause

Potential Impact Mechanisms		Development Phase	Description
		Operation Phase	disturbance, physical injury and behavioural changes in fauna. The vessel activity (including the FRSU, tug and LNGC) will result in the generation of noise, potentially affecting local ambient noise levels resulting in disturbance to fauna. There is potential that controlled rock blasting on land will generate underwater noise disturbance.
5.	Seabed habitat loss	Construction Phase **and** Operation Phase	The installation of the jetty requires piles to be installed in the seabed which will result in the direct loss of habitats and associated fauna. During the construction phase a trenched water outfall will be constructed across the shoreline into the Shannon Estuary, which will result in the direct loss of habitats and associated fauna.
6.	Vessel physical disturbance and collision injury	Operation Phase **and** Operation Phase	Additional vessel activity in the estuary (including construction scows and storage vessels, and, the FRSU, tugboats and LNGC) will increase the potential for physical disturbance and collision injury to fauna. There is potential that mobile conservation feature species (*e.g.* marine mammals, bird species) may occur in the area where the vessels are operating and thereby be affected.
7.	Discharge of treated cooled seawater	Operation Phase	Cooled sea water discharged to the estuary close to the head of the jetty will contain sodium hypochlorite, potentially affecting local water conditions in the vicinity of the proposed discharge points. Heated water will be discharged to the estuary via the storm water outfall point, potentially affecting local water conditions in the vicinity of the proposed discharge points.
8.	Entrainment and impingement of fauna by the FSRU seawater system	Operation Phase	Potential that abstracting and pumping of seawater will result in fish and macrocrustaceans being entrained in the FRSU water intake and/ or impinged on the filter screens of the intake.
9.	Discharge of Wastewater and Power Plant Process Heated Water Effluent	Operation Phase	Potential environmental impact associated with the treatment and disposal of secondary treated wastewater from on-site hygiene facilities. Heated water will be discharged to the estuary via the storm water outfall point, potentially affecting local water conditions in the vicinity of the proposed discharge points. Given local water currents, the plume of discharge waters may extend over a large area.
10.	Introduction of invasive species	Operation Phase	Potential increase in the risk of invasive organisms being imported by LNGC and FRSU in ballast water and as ship hull fouling.
11.	Accidental large-scale oil or LNG spill	Operation Phase	Potential habitat loss within cSAC and SPA, changes in water quality and bird mortality from oil spill and/ or fire associated oil/ LNG spill during operation.

Potential Impact Mechanisms		Development Phase	Description
12.	Collision Risk site infrastructure	Construction Phase **and** Operation Phase	Potential bird collision risk during construction due to presence of plant along the shoreline. Potential bird collision risk with jetty during operation.
13.	Barrier to connectivity	Construction Phase **and** Operation Phase	Potential risk that increased noise and visual disturbance (including lighting) during construction could create a barrier to connectivity during construction. Potential risk that the and the presence of the jetty along the shoreline of the Shannon Estuary during operation has the potential to prevent movement of fauna along the shoreline.
14.	Loss of prey biomass	Construction Phase **and** Operation Phase	Potential that release of pollutants, as well as the underwater noise and sediment plumes during piling works could lead to fish mortality. Removal of wet grassland at the Proposed Development site could lead to a reduction in common frog. This could lead to loss of prey biomass for SCI birds and otter during construction. Potential that discharges of treated cooled seawater, wastewater discharges, entrainment and impingement during operation could lead to fish mortality. This could lead to loss of prey biomass for SCI birds and otter during construction.

2.12.3. Preliminary Evaluation of Relevant Conservation Features of SACs and SPAs

Given the nature, size and location of the Proposed Development and adopting a precautionary principle, the identification of conservation features relevant to the impact mechanisms (see **Section 2.12.2.4**) considered European sites within a 15km buffer area of the Proposed Development. There are five European sites within 15km area of the Proposed Development.

The Proposed Development is located within the Lower River Shannon cSAC (Site code: 002165) (see **Figure 2-26**), and within 15km of two other cSACs namely; Moanveanlagh Bog cSAC (002351) (12.4km south of the Proposed Development area) and Tullaher Lough and Bog cSAC (Site code: 002343) (14.0km North West) (see **Figure 2-28**).

The Proposed Development area also overlaps the River Shannon and River Fergus Estuaries SPA (Site code: 004077) (see and **Figure 2-27**), while the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Site code: 004161) is located 10.0km south of the Proposed Development (**Figure 2-29**).

Short descriptions of the SACs and SPA are provided below while detailed site descriptions are included in the site synopsis reports presented in **Appendix 1**.

Lower River Shannon cSAC (Site code: 002165) (overlaps development area) - This very large site stretches along the Shannon valley from Killaloe in Co. Clare to Loop Head/ Kerry Head, some 120km. The site thus encompasses the Shannon, Feale, Mulkear and Fergus estuaries, the freshwater lower reaches of the River Shannon (between Killaloe and Limerick), the freshwater stretches of much of the Feale and Mulkear catchments and the marine area between Loop Head and Kerry Head.

The site is designated for a wide range of Annex I marine, coastal, freshwater aquatic and terrestrial habitats, while Annex II species for which the site is designated include marine mammals, diadromous fish species and freshwater aquatic species.

Moanveanlagh Bog cSAC (002351) (12.4km south of the development area) - Moanveanlagh Bog is situated in Co. Kerry approximately 6km east of Listowel, mainly within the townlands of Carhooeara and Bunagarha. The site comprises a raised bog that includes both areas of high bog and cutover bog.

The site is a designated for Annex I habitats [7110] Raised Bog (Active) (*priority habitat), Degraded raised bogs still capable of natural regeneration [7120] and Depressions on peat substrates of the *Rhynchosporion* [7150].

Tullaher Lough and Bog cSAC (Site code: 002343) (14.0km northwest of the development area) – Tullagher Lough and Bog is located 4km south-east of Doonbeg in the townlands of Carrowmore South, Carrowblough Beg and Tullaher in Co. Clare. This is a diverse site comprising of raised bog (including areas of high bog and cutover bog), wet grassland, improved grassland, scrub woodland, alkaline fen and lake. It is bounded to the east by the Doonbeg to Moyasta road, to the west by a local road, to the north by bog tracks and to the south by a conifer plantation.

The site is a designated for Annex I habitats [7110] Raised Bog (Active) (*priority habitat), Degraded raised bogs still capable of natural regeneration [7120], Transition mires and quaking bogs [7140] and Depressions on peat substrates of the *Rhynchosporion* [7150].

Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Site code: 004161) (10.0km south of the development area) - The Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA is a very large site centred on the borders between the counties of Cork, Kerry and Limerick.

The site is skirted by the towns of Newcastle West, Ballydesmond, Castleisland, Tralee and Abbeyfeale. The SPA is designated for Hen Harrier.

River Shannon and River Fergus Estuaries SPA (Site code: 004077) (overlaps development area) - The estuaries of the River Shannon and River Fergus form the largest estuarine complex in Ireland. The site comprises the entire estuarine habitat from Limerick City westwards as far as Doonaha in Co. Clare and Dooneen Point in Co. Kerry. The site has vast expanses of intertidal flats which contain a diverse macroinvertebrate community which provides a rich food resource for the wintering birds. Salt marsh vegetation frequently fringes the mudflats and provides important high tide roost areas for the wintering birds. Elsewhere in the site the shoreline comprises stony or shingle beaches.

The site is designated for the following species: Cormorant, Whooper Swan, Light bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Scaup, Ringed Plover, Golden Plover, Grey Plover, Lapwing, Knot, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Curlew, Redshank, Greenshank and Black-headed Gull. The site is also designated for wetlands.

Conclusion – Following a detailed review of NPWS reports and spatial data of the protected habitats and species designated of the above cSACs and SPAs it was concluded that, given the spatial extent of the zone of impact of the impact mechanisms, the only conservation features of SACs and SPAs that have potential pathways for significant impact are QIs and SCIs for which the Lower River Shannon cSAC (Site code: 002165), the River Shannon and River Fergus Estuaries SPA (Site code: 004077) and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Site code: 004161) are designated. The conservation features of the Lower River Shannon cSAC, the River Fergus Estuaries

SPA and Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA are brought forward to the screening exercise presented in **Section 2.12.4.**

Given the spatial extent of the zone of impact of the impact mechanisms, it was concluded that there are no potential pathways for significant impact to other conservation features of European sites; potential significant effects on the conservation features of all other European sites have been excluded.

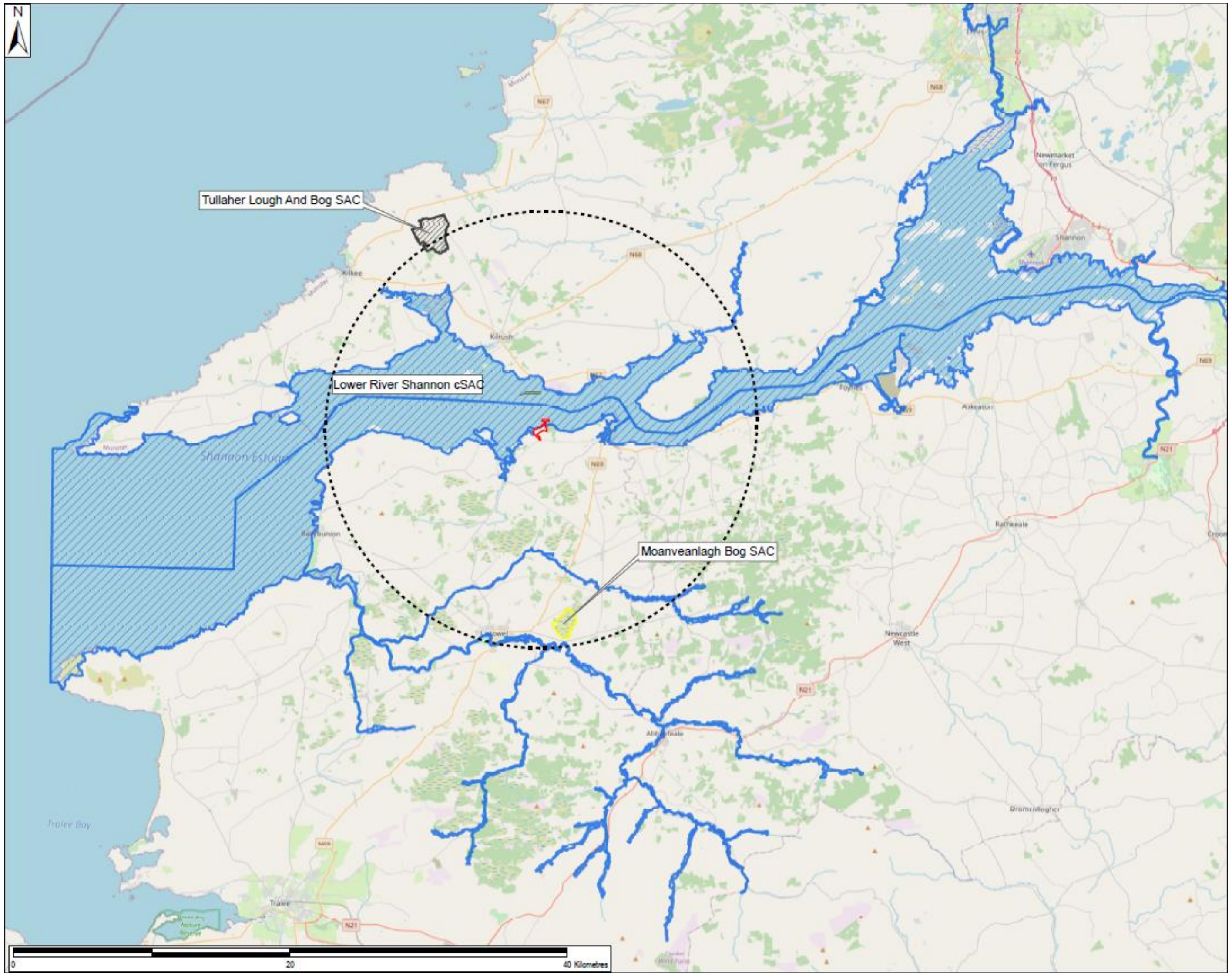


Figure 2-28: SACs within 15km of the Proposed Development line boundary.

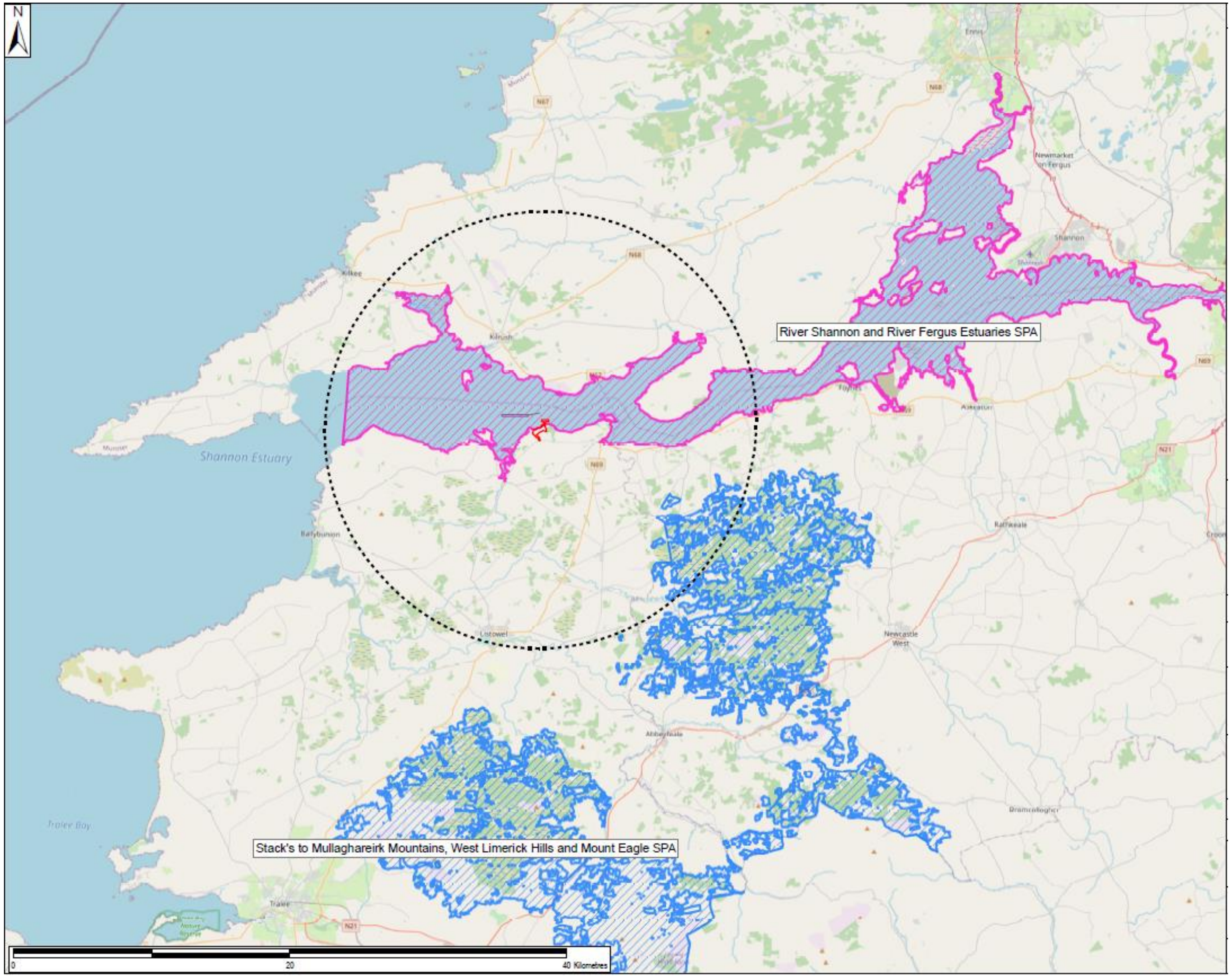


Figure 2-29: SPAs within 15km of the Proposed Development line boundary.

2.12.4. Screening Exercise

2.12.4.1. Introduction

The conservation features (*i.e.* QIs and SCIs) of the Lower River Shannon cSAC and, the River Shannon River Fergus Estuaries SPA, Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA are listed in **Table 2.15**, **Table 2.16** and **Table 2.17** alongside conservation objectives set for the conservation features.

The Natura 2000 Forms for the Lower River Shannon cSAC[21], River Shannon and River Fergus Estuaries SPA[22] Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA[23] list the main habitat characters and outline the most important negative impacting threats and pressures, and positive impacting activities/ management affecting the sites; this information is included in **Table 2.18** and **Table 2.19** respectively.

Table 2.20 and **Table 2.21** present screening exercises of potential for effects of impact mechanisms associated with Proposed Development to the conservation features of the Lower River Shannon cSAC, the River Shannon and River Fergus Estuaries SPA and Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA.

The screening exercise takes into account the negative impacting threats and pressures and positive impacting activities/ management affecting the sites as listed in Natura 2000 Forms. With regard to the Proposed Development the most relevant source of negative impact is Shipping lanes (D03.02) which is listed as a threat/ pressure for the River Shannon and River Fergus Estuaries SPA (see **Table 2.19**).

The screening exercise of potential in-combination effects (see **Section 1.1**) identified the following categories of plans, projects or activities may act in-combination with the Proposed Development:

- energy storage and energy infrastructure (see **Section 2.13.1**)
- data centre (**Section 2.13.2**)
- geophysical survey (see **Section 2.13.3**)
- commercial shipping (see **Section2.13.4**)
- dredging activity (see **Section 2.13.5**)

Table 2.15: Lower River Shannon cSAC.

QI	Conservation Objective	Category
*Coastal lagoons [1150	Restore the favourable conservation condition	Annex I marine/ coastal habitats
Sandbanks which are slightly covered by sea water all the time [1110]	Maintain the favourable conservation condition	
Mudflats and sandflats not covered by seawater at low tide [1140]	Maintain the favourable conservation condition	
Large shallow inlets and bays [1160]	Maintain the favourable conservation condition	

[21] https://www.npws.ie/sites/default/files/protected-sites/natura2000/NF002165.pdf

[22] https://www.npws.ie/sites/default/files/protected-sites/natura2000/NF004077.pdf

[23] https://www.npws.ie/sites/default/files/protected-sites/natura2000/NF004161.pdf

QI	Conservation Objective	Category
Estuaries [1130]	Maintain the favourable conservation condition	
Reefs [1170	Maintain the favourable conservation condition	
Perennial vegetation of stony banks [1220]	Maintain the favourable conservation condition	Annex I coastal habitats
Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]	Maintain the favourable conservation condition	
Salicornia and other annuals colonising mud and sand [1310]	Maintain the favourable conservation condition	
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]	Restore the favourable conservation condition	
Mediterranean salt meadows (*Juncetalia maritimi*) [1410]	Restore the favourable conservation condition	
Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]	Maintain the favourable conservation condition	Annex I freshwater aquatic and terrestrial habitats
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) [6410]	Maintain the favourable conservation condition	
*Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0]	Restore the favourable conservation condition	
Tursiops truncatus (Common Bottlenose Dolphin) [1349]	Maintain the favourable conservation condition	Annex II marine mammal species
Petromyzon marinus (Sea Lamprey) [1095]	Restore the favourable conservation condition	Annex II diadromous fish species
Lampetra fluviatilis (River Lamprey) [1099]	Maintain the favourable conservation condition	
Salmo salar (Atlantic Salmon) [1106]	Restore the favourable conservation condition	
Margaritifera margaritifera (Freshwater Pearl Mussel) [1029]	Restore the favourable conservation condition	Annex II freshwater aquatic species
Lampetra planeri (Brook Lamprey) [1096]	Maintain the favourable conservation condition	
Lutra lutra (Otter) [1355]*	Restore the favourable conservation condition	

Table 2.16: River Shannon and River Fergus Estuaries SPA (NPWS 2012, 2013).

Special Conservation Interest Species	Conservation Objective	Foraging Guild (after Weller 1999 and NPWS 2011)
A017 Cormorant (*Phalacrocorax carbo*)	Maintain the favourable conservation condition	Water column diver (shallow and deeper)
A052 Teal (*Anas crecca*)	Maintain the favourable conservation condition	Surface swimmer
A054 Pintail (*Anas acuta*)	Maintain the favourable conservation condition	
A062 Scaup (*Aythya marila*)	Maintain the favourable conservation condition	
A050 Wigeon (*Anas penelope*)	Maintain the favourable conservation condition	Surface swimmer/ Intertidal walker (out of water),
A056 Shoveler (*Anas clypeata*)	Maintain the favourable conservation condition	
A048 Shelduck (*Tadorna tadorna*)	Maintain the favourable conservation condition	
A137 Ringed Plover (*Charadrius hiaticula*)	Maintain the favourable conservation condition	Intertidal walker (out of water),
A140 Golden Plover (*Pluvialis apricaria*)	Maintain the favourable conservation condition	
A141 Grey Plover (*Pluvialis squatarola*)	Maintain the favourable conservation condition	
A143 Knot (*Calidris canutus*)	Maintain the favourable conservation condition	
A149 Dunlin (*Calidris alpina*)	Maintain the favourable conservation condition	
A156 Black-tailed Godwit (*Limosa limosa*)	Maintain the favourable conservation condition	
A157 Bar-tailed Godwit (*Limosa lapponica*)	Maintain the favourable conservation condition	
A160 Curlew (*Numenius arquata*)	Maintain the favourable conservation condition	
A162 Redshank (*Tringa totanus*)	Maintain the favourable conservation condition	
A164 Greenshank (*Tringa nebularia*)	Maintain the favourable conservation condition	
A142 Lapwing (*Vanellus vanellus*)	Maintain the favourable conservation condition	
A046 Light-bellied Brent Goose (*Branta bernicla hrota*)	Maintain the favourable conservation condition	
A038 Whooper Swan (*Cygnus cygnus*)	Maintain the favourable conservation condition	Surface swimmer/ Terrestrial walker

Special Conservation Interest Species	Conservation Objective	Foraging Guild (after Weller 1999 and NPWS 2011)
A179 Black-headed Gull (*Chroicocephalus ridibundus*)	Maintain the favourable conservation condition	Surface swimmer/ Intertidal walker (out of and in water) / Terrestrial walker
Habitat		**Category**
Wetland and Waterbirds [A999]		Habitat

Table 2.17: Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (NPWS 2015, 2021).

Special Conservation Interest Species	Conservation Objective	Category
A082 Hen Harrier (*Circus cyaneus*)	Maintain or restore the favourable conservation condition	Raptor

Table 2.18: General Site Character of the Lower River Shannon cSAC, the River Shannon and River Fergus Estuaries SPA, and Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Natura 2000 - Standard Data Form).

Lower River Shannon cSAC	
Habitat class	**% Cover**
Tidal rivers, Estuaries, Mud flats, Sand flats, Lagoons (including saltwork basins) (N02)	44.0
Marine areas, Sea inlets (N01)	39.0
Improved grassland (N14)	3.0
Salt marshes, Salt pastures, Salt steppes (N03)	2.0
Inland water bodies (Standing water, Running water) (N06)	2.0
Heath, Scrub, Maquis and Garrigue, Phygrana (N08)	2.0
Humid grassland, Mesophilic grassland (N10)	2.0
Coastal sand dunes, Sand beaches, Machair (N04)	1.0
Shingle, Sea cliffs, Islets (N05)	1.0
Bogs, Marshes, Water fringed vegetation, Fens (N07)	1.0
Dry grassland, Steppes (N09)	1.0
Broad-leaved deciduous woodland (N16)	1.0
Artificial forest monoculture (*e.g.* Plantations of poplar or Exotic trees) (N20)	1.0
River Shannon and River Fergus Estuaries SPA	
Habitat class	**% Cover**
Tidal rivers, Estuaries, Mud flats, Sand flats, Lagoons (including saltwork basins) (N02)	96.0
Salt marshes, Salt pastures, Salt steppes (N03)	1.0
Shingle, Sea cliffs, Islets (N05)	1.0
Bogs, Marshes, Water fringed vegetation, Fens (N07)	1.0
Dry grassland, Steppes (N09)	1.0
Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	
Habitat class	**% Cover**
Inland water bodies (Standing water, Running water) (N06)	10.0
Improved grassland (N14)	16.0
Bogs, Marshes, Water fringed vegetation, Fens (N07)	13.0
Heath, Scrub, Maquis and Garrigue, Phygrana (N08)	15.0
Artificial forest monoculture (*e.g.* Plantations of poplar or Exotic trees) (N20)	44.0
Broad-leaved deciduous woodland (N16)	1.0
Inland water bodies (Standing water, Running water) (N06)	1.0

Table 2.19: Threat, pressures and activities affecting the Lower River Shannon cSAC, the River Shannon and River Fergus Estuaries SPA, and Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Natura 2000 - Standard Data Form). L – low, M – medium, H – High; i = inside, o = outside, b = both.

Lower River Shannon cSAC					
Negative impacts			Positive impacts		
Threats and pressure			Activities, management		
L	invasive non-native species (I01)	i	L	paths, tracks, cycling tracks (D01.01)	i
M	Fertilisation (A08)	o	L	Leisure fishing (F02.03)	i
M	Urbanised areas, human habitation (E01)	o	L	Nautical sports (G01.01)	i
M	Air pollution, air-borne pollutants (H04)	o			
M	Fertilisation (A08)	i			
M	Discharges (E03)	o			
L	Paths, tracks, cycling tracks (D01.01)	i			
M	Eutrophication (natural) (K02.03)	o			
L	Nautical sports (G01.01)	i			
L	Sylviculture, forestry (B)	i			
L	Marine and Freshwater Aquaculture (F01)	i			
L	Hunting (F03.01)	i			
L	Removal of beach materials (C01.01.02)	i			
M	Discharges (E03)	i			
L	Hand cutting of peat (C01.03.01)	i			
M	Grazing (A04)	i			
L	Sea defence or coast protection works, tidal barrages (J02.12.01)	i			
M	Polderisation (J02.01.01)	i			
L	Management of aquatic and bank vegetation for drainage purposes (J02.10)	i			
M	Reclamation of land from sea, estuary or marsh (J02.01.02)	o			

River Shannon and River Fergus Estuaries SPA					
Negative impacts			Positive impacts		
Threats and pressure			Activities, management		
H	Industrial or commercial areas (E02)	o	M	Marine and Freshwater Aquaculture (F01)	i
M	Nautical sports (G01.01)	i	M	Shipping lanes (D03.02)	i
H	Discharges (E03)	i	M	nautical sports (G01.01)	i
M	Shipping lanes (D03.02)	i			
H	Fertilisation (A08)	o			
M	Marine and Freshwater Aquaculture (F01)	o			
H	Urbanised areas, human habitation (E01)	o			

2.12.4.2. Potential for Significant Effects

Table 2.20, **Table 2.21** and **Table 2.22** present screening exercises undertaken to assess the potential for effects (direct or indirect) of project impact mechanisms (identified in **Section 2.12.2.4** above) to the conservation features for which the Lower River Shannon cSAC, the River Shannon and River Fergus Estuaries SPA and Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA are designated.

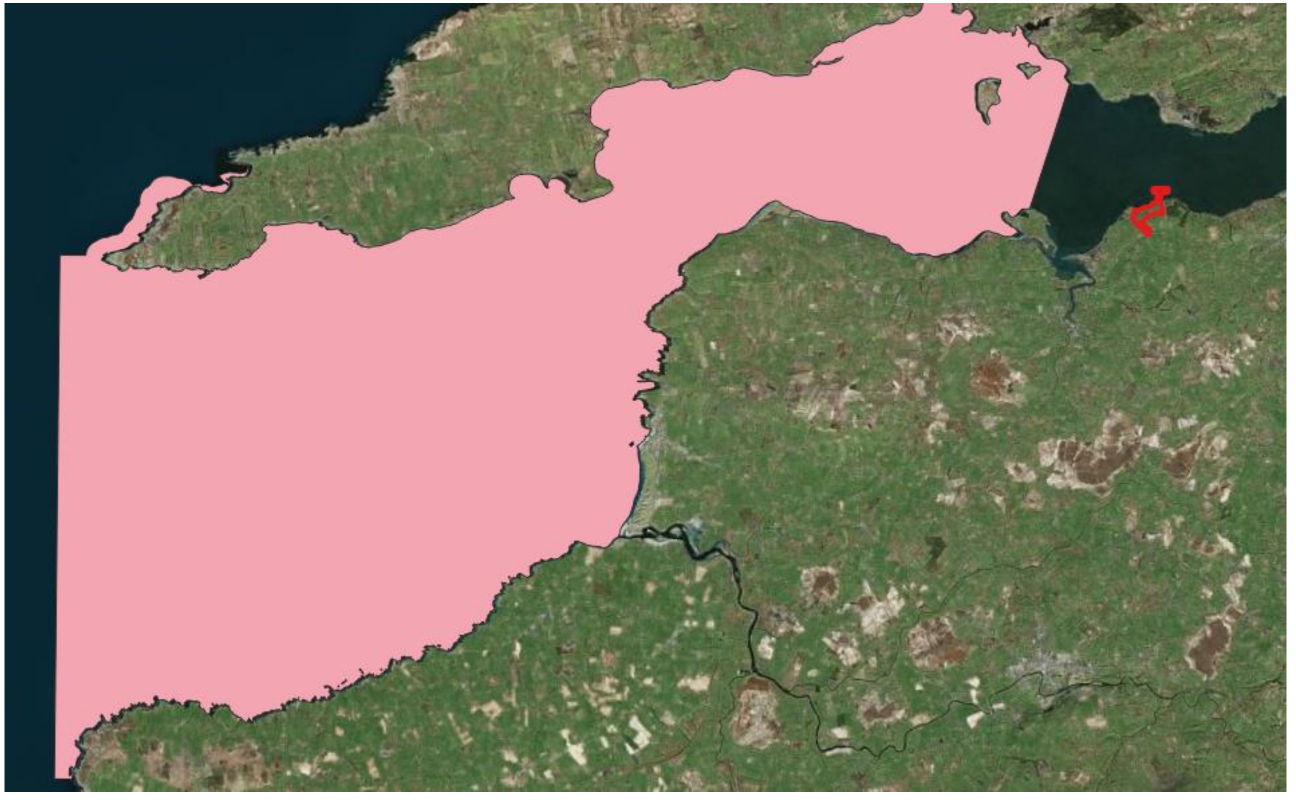
Where there is potential for significant effect to a designated conservation feature from an impact mechanism, the designated feature and the impact mechanism combination is brought forward in the assessment for a detailed consideration of the potential for adverse effects (see **Section 3 Stage 2 AA - NIS**).

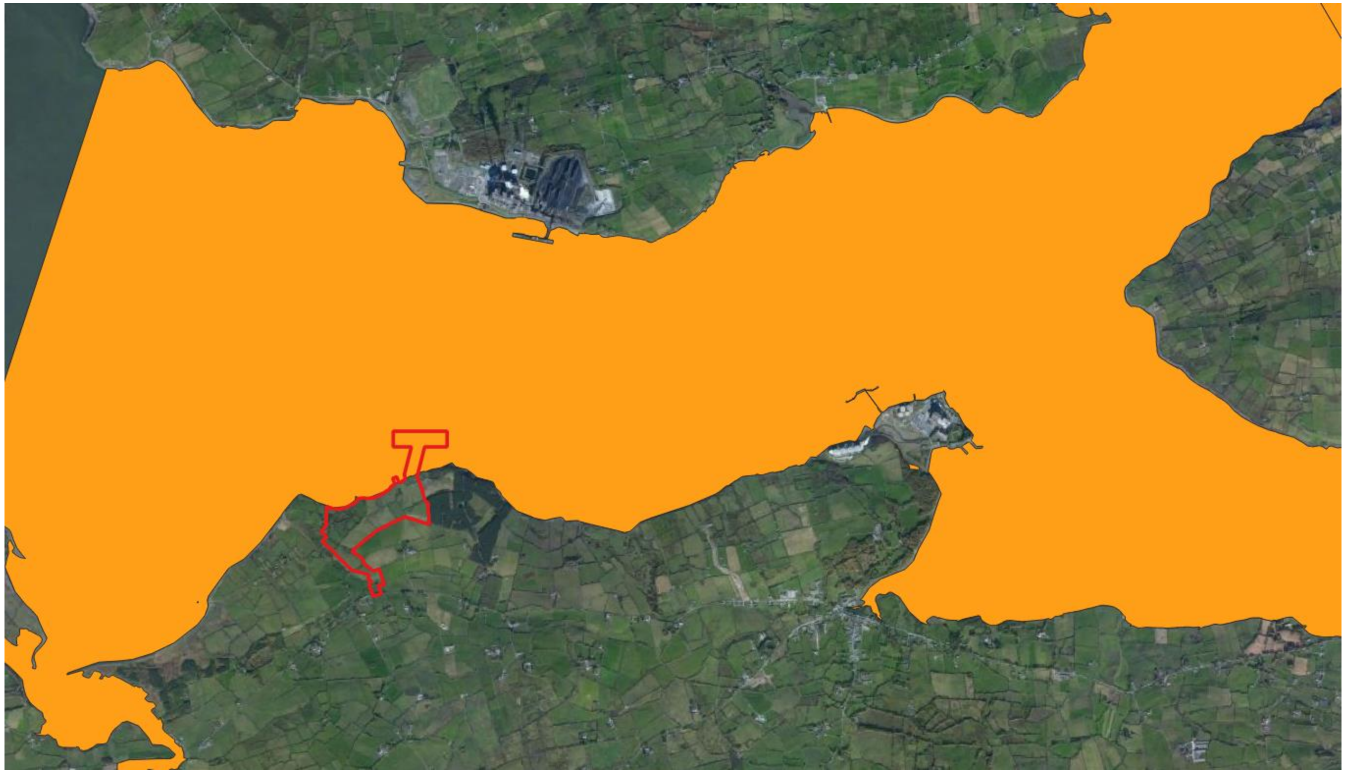
In contrast, where the risk of a significant effect to a designated feature from an impact mechanism can be **excluded** on the basis of objective evidence, the designated feature and impact mechanism combination is **screened out** (excluded) from further assessment.

Table 2.20: Screening Exercises – QIs of the River Shannon cSAC. QIs brought forward to the Stage 2 AA NIS are highlighted in bold.

Annex I marine/ coastal habitats.

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Mudflats and sandflats not covered by seawater at low tide [1140]	**Some tidal areas of the cSAC support extensive areas of 1140 habitat (NPWS 2013). The closest 1140 habitat areas are located 3.5km west and 5km east of the development area. Given the proximity of the habitats to the Proposed Development area, it is not possible to exclude the potential for significant effects. The impact mechanisms of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 7. Discharge of treated cooling waters, 9. Waste water discharge, 11. Accidental large-scale oil or LNG spill. The QI and the listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).** 

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Large shallow inlets and bays [1160]	**NPWS 2013 indicates that within the cSAC habitat 1160 extends from the western most boundary of the site to the middle estuary area approximately 3.2km west of the development area. Given the proximity of the habitat to the Proposed Development area, it is not possible to exclude the potential for significant effects. The impact mechanisms of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 7. Discharge of treated cooled seawater, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and the listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).** 

<table>
<tr><th>Qualifying Interest</th><th>Source-Pathway-Receptor Screening Exercise</th></tr>
<tr><td>Estuaries [1130]</td><td>The Proposed Development overlaps part of the habitat 1130. Given this overlap it is not possible to exclude the potential for significant effects to the QI. The impact mechanisms of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 5. Seabed habitat loss, 7. Discharge of treated cooled seawater, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).
</td></tr>
</table>

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Reefs [1170]	**The Proposed Development overlaps part of the habitat 1170. Given this overlap it is not possible to exclude the potential for significant effects to the QI. The impact mechanisms of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 5. Seabed habitat loss, 7. Discharge of treated cooled seawater, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).** 

<table>
<tr><th>Qualifying Interest</th><th>Source-Pathway-Receptor Screening Exercise</th></tr>
<tr><td>Sandbanks which are slightly covered by sea water all the time [1110]</td><td>The Conservation Objectives report for the cSAC (NPWS 2013) indicates that the site is designated for two areas of 1110 habitat; these habitat areas are in the lower estuary over 19.2km from the Proposed Development area. The QIs are located outside of the zone of impact of the impact mechanisms. The impact mechanisms of concern with respect to potential significant effects to the QI are; 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).
</td></tr>
</table>

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
***Coastal lagoons [1150] (* = Priority Habitat)**	**The Conservation Objectives report for the cSAC (NPWS 2013) indicates that the site is designated for four lagoons. The lagoons are: Scattery Lagoon (5.9km northwest of the development), Clooconeen Pool (18.1km west), Quayfield and Poulaweala Loughs (26.5km east), Shannon Airport Lagoon (35.5km northeast of the development). There is also a small undocumented lagoon located approximately 4.5 south west of Proposed Development. Given the proximity of the habitats to the Proposed Development area, it is not possible to exclude the potential for significant effects. The impact mechanisms of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 7. Discharge of treated cooled seawater, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).** 

Annex I coastal habitats.

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Perennial vegetation of stony banks [1220]	**NPWS 2013 indicates that the site is designated for nine 1220 sites, the closest of which to the Proposed Development is over 3km to the north at Ballymacbrennan Bay. Given the proximity of the habitats to the Proposed Development area, it is not possible to exclude the potential for significant effects. The impact mechanisms of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 7. Discharge of treated cooled seawater, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).**

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]	NPWS 2013 indicates extensive areas of 1230 habitat located on the north and south shore of the outer bay. A small area of habitat is also located on the northern shore approximately 5km northeast of the development. Given that habitats are located above the high water mark there is no potential pathway for impact, and it is possible to exclude the potential for significant effects at the Screening for AA stage. The QI is screened out of further assessment. 

<table>
<tr><th>Qualifying Interest (*=Priority Habitat)</th><th>Source-Pathway-Receptor Screening Exercise</th></tr>
<tr><td>Salicornia and other annuals colonising mud and sand [1310]</td><td rowspan="3">NPWS 2013 indicates extensive areas of 1310, 1330 and 1410 salt marsh habitats within the cSAC, the closest area of habitat is located approximately 1.5km southwest of the development. Given the proximity of the habitats to the Proposed Development area, it is not possible to exclude the potential for significant effects. The impact mechanisms of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 7. Discharge of treated cooled seawater, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS)

</td></tr>
<tr><td>Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330]</td></tr>
<tr><td>Mediterranean salt meadows (Juncetalia maritimi) [1410]</td></tr>
</table>

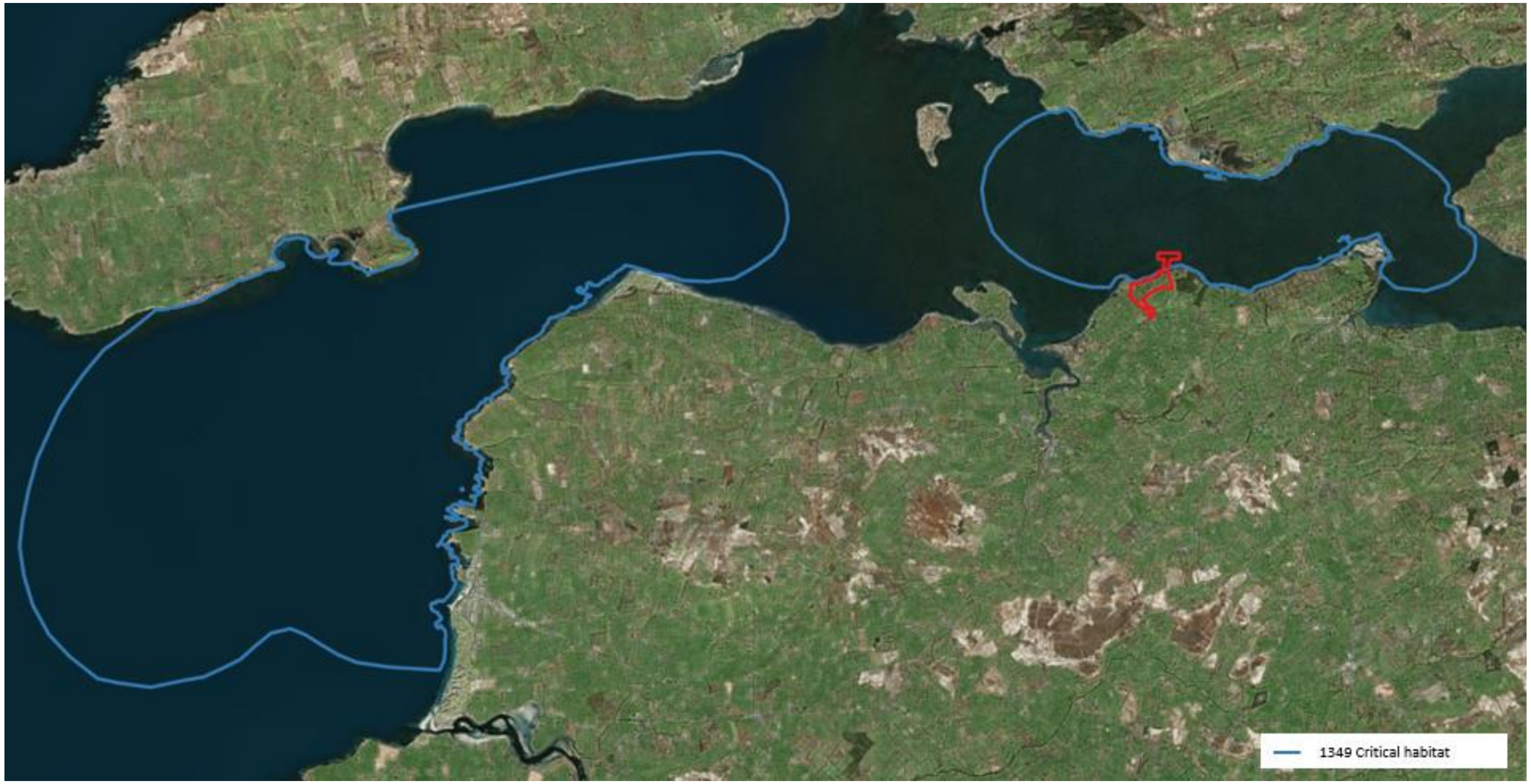
Annex I freshwater aquatic and terrestrial habitats.

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]	NPWS 2013 indicates extensive areas of 32600 habitat approximately 45km upstream of the Proposed Development. Given the distance of the habitats from the Proposed Development area, it is possible to exclude the potential for significant effects. Consequently, it is possible to exclude the potential for significant effects at the Screening for AA stage. This QI is screened out of further assessment. 

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) [6410]	This grassland habitat has been recorded over 60km upstream of the Proposed Development on the eastern bank of the Shannon, just north of Castleconnell, Co. Limerick (NPWS internal files referenced in NPWS 2013). Given the distance of the terrestrial habitat from the Proposed Development it is possible to exclude the potential for significant effects at the Screening for AA stage. The QI is screened out of further assessment.

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
*Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0]	NPWS 2013 indicates areas of 91E0 habitat located upstream of the Proposed Development, east of Limerick City. A small area of habitat is also located on the northern shore approximately 5km northeast of the development. Given the distance of the terrestrial habitat from the Proposed Development it is possible to exclude the potential for significant effects at the Screening for AA stage. The QI is screened out of further assessment.

Annex II marine mammal species.

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Tursiops truncatus **(Common Bottlenose Dolphin) [1349]**	**NPWS 2013 indicates two large critical habitat area for the species. The Proposed Development overlaps part of the critical habitat. Given this overlap it is not possible to exclude the potential for significant effects to the QI. The impact mechanism of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 4. Underwater noise, 6. Vessel physical disturbance and collision injury, 7. Discharge of treated cooled seawater, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).** 

Annex II freshwater aquatic species.

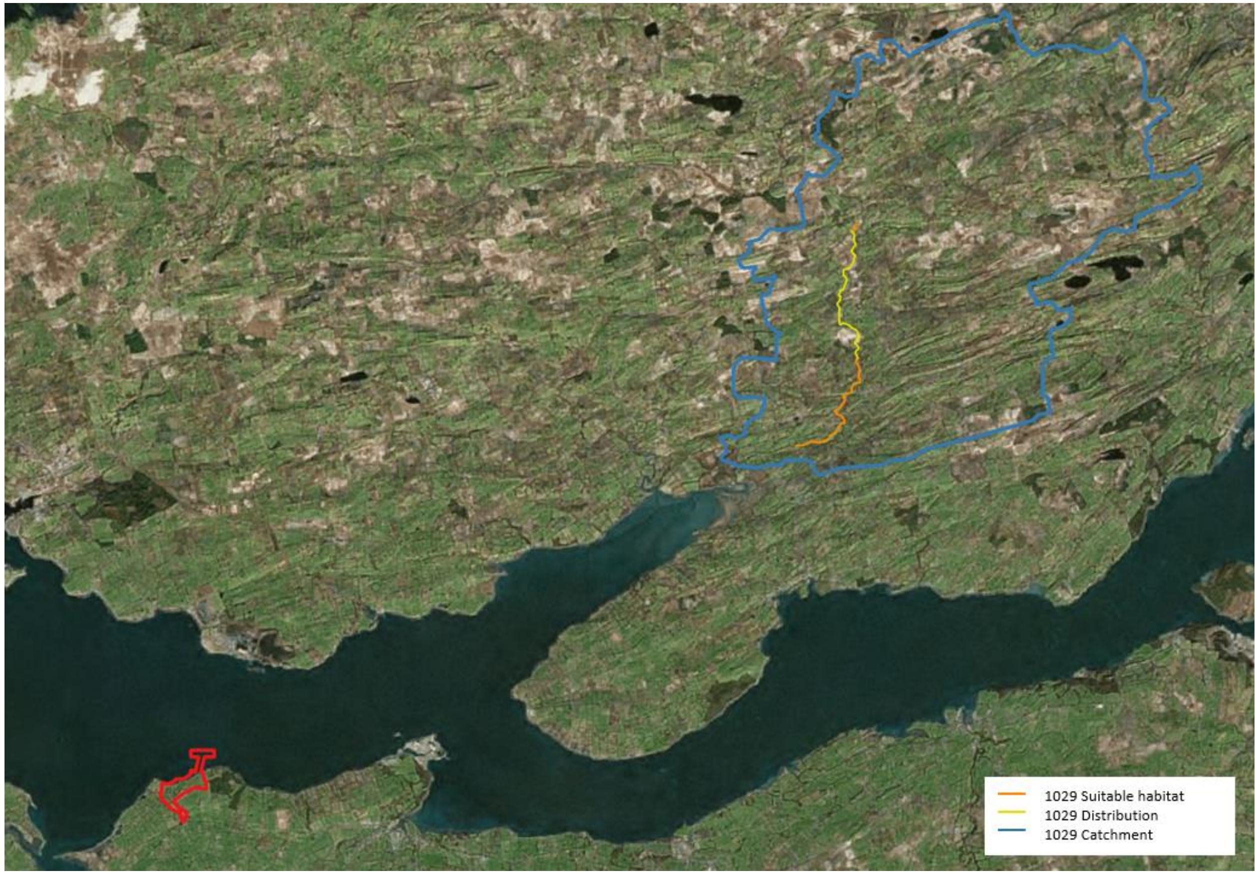
Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Lampetra planeri (Brook Lamprey) [1096]	NPWS 2013 notes that Brook Lamprey (*Lampetra planeri*) have been observed spawning in the lower Shannon or its tributaries. As there is potential that the species may occur in close proximity to the Proposed Development it is not possible to exclude the potential for significant effects. The impact mechanism of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 4. Underwater noise, 7. Discharge of treated cooled seawater, 8. Entrainment and impingement of fauna by the FRSU seawater system, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. This QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).

Annex II diadromous fish species

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Salmo salar (Atlantic Salmon) [1106]	Salmon spend their juvenile phase in rivers before migrating to sea to grow and mature. To complete their life cycle they home to predetermined natal rivers (philopatric behaviour) to spawn. Salmon have all been observed spawning in the lower Shannon or its tributaries (NPWS 2013). The Fergus is important in its lower reaches for spring salmon, while the Mulkear catchment excels as a grilse fishery, though spring fish are caught on the actual Mulkear River. The Feale is important for both types. There is potential that salmon may pass in close proximity to the Proposed Development during migration runs; consequently, it is not possible to exclude the potential for significant effects. The impact mechanism of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 4. Underwater noise, 7. Discharge of treated cooled seawater, 8. Entrainment and impingement of fauna by the FRSU seawater system, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Lampetra fluviatilis **(River Lamprey) [1099]** ***Petromyzon marinus*** **(Sea Lamprey) [1095]**	**NPWS 2013 report that lamprey species have been observed spawning in the lower Shannon or its tributaries. The sea lamprey (*Petromyzon marinus*) is a migratory species which grows to maturity in the sea and migrates to freshwater to spawn. They migrate through the estuary from the sea in April and May (Hardisty, 1969) and spawn in rivers in late May or June and then return to sea. The river lamprey (*Lampetra fluviatilis*) is a migratory species which grows to maturity in estuaries and migrates to freshwater to spawn from October to December (Maitland, 2003). Spawning occurs in the rivers in March and April. Between July and September young adults migrate during darkness to the estuary. As there is potential that the lamprey species may pass in close proximity to the Proposed Development during migration runs it is not possible to exclude the potential for significant effects. The impact mechanism of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 3. Release of spoil during piling, 4. Underwater noise, 7. Discharge of treated cooled seawater, 8. Entrainment and impingement of fauna by the FRSU seawater system, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS)**

Annex II freshwater aquatic species.

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Margaritifera margaritifera (Freshwater Pearl Mussel) [1029]	NPWS 2013 reports a freshwater pearl mussel population is located in the Cloon River, which is a tributary of the River Shannon, Co. Clare. The Cloon population is confined to the main channel and is distributed from Croany Bridge to approximately 1.5km upstream of Clonderalaw Bridge. Given the location of the population and habitat, relative to Proposed Development area, it is possible to exclude the potential for significant effects. The QI is screened out of further assessment. 

Qualifying Interest	Source-Pathway-Receptor Screening Exercise
Lutra lutra **(Otter) [1355]***	**NPWS 2013 maps a commuting buffer of 250m around the boundary of the shoreline of the Shannon Estuary. The Proposed Development overlaps part of the otter habitat. Given this overlap it is not possible to exclude the potential for significant effects to this QI. The impact mechanism of concern with respect to potential significant effects to the QI are; 1. Release of pollutants during construction, 2. Land-based construction noise and vibration disturbance, 3. Release of spoil during piling, 4. Underwater noise, 6. Vessel physical disturbance and collision injury, 7. Discharge of treated cooled seawater, 9. Waste water discharge, 11. Accidental large-scale oil or LNG spill. 13. Barrier to connectivity. 14. Loss of prey biomass. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).** **The conservation attributes for otter habitat within the SAC relate to the extent of terrestrial habitat (596.8ha), marine habitat (4,461.6ha), freshwater habitat (500.1km) as well as the number of couching sites and holts. The target for these habitats is 'no significant decline'. While there will be habitat loss within marine habitat of 162m^2 this will not represent a significant decline in the overall area of habitat available to otter within the SAC. It is noted that no couching or holts will be impacted by the Proposed Development (See in Section 3.3.3). Therefore, this impact mechanism (Habitat loss) is not brought forward to Section 3 (Stage 2 AA-NIS).**

Table 2.21: Screening Exercises – River Shannon and River Fergus Estuaries SPA (Site code 004077). Potential significant effects to conservation features are highlighted in bold.

Habitat

Habitat	Source-Pathway-Receptor Screening Exercise
Wetland [A999]	**Wetland structure and functionality are influenced by hydrological regime and sediment transport. If sediment and water discharge plumes generated by the Proposed Development overlap wetland habitats there is potential for significant direct effects. Consequently, it is not possible to exclude the potential for significant effects to the SCI. The impact mechanism of concern with respect to potential significant effects to the QI are; 3. Release of spoil during piling, 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent, 11. Accidental large-scale oil or LNG spill. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).** **The QI and impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS).** **As detailed mapping and the characteristics of designated wetlands within the SPA are not available on the NPWS website, the assessment of potential adverse effects to wetlands presented in Section 3 (Stage 2 AA – NIS) relies on the detailed assessments of the effects of sediment and water discharge plumes on Annex I habitats designated for the Lower River Shannon cSAC.** **The target for Wetland within the SPA is that the permanent area occupied by the wetland habitat should be stable and not significantly less than the area of 32,261ha, other than that occurring from natural patterns of variation. While this is a broad habitat category given the area of the Shannon Estuary is *ca* 68,300ha (Natura 2000 Standard Data Form cSAC, given the small size of the Proposed Development within this area will not represent a significant change to Wetland [A999] within the SPA. Therefore, this impact mechanism (Habitat loss) is not brought forward to Section 3 (Stage 2 AA-NIS)**

SCI Species – Diving species

Special Conservation Interest Species	Foraging Guild	Source-Pathway-Receptor Screening Exercise
A017 Cormorant (*Phalacrocorax carbo*)	Water column diver (shallow and deeper)	Given the foraging behaviour of the species there is the potential that this SCI may be present in the vicinity of the Proposed Development during construction and operation. As the bird is a diving species underwater noise emissions from piling could potentially cause behavioural changes and/or injury. There is also potential for collision with the vessel and infrastructure. Consequently, it is not possible to exclude the potential for significant direct effects to the QI. The impact mechanism of concern with respect to potential significant effects to the SCI are; 1. Release of pollutants during construction, 2. Land-based construction noise and vibration disturbance, 3. Release of spoil during piling, 4. Underwater noise, 6. Vessel physical disturbance and collision injury, 9. Waste water discharge, 11. Accidental large-scale oil or LNG spill, 12. Collision with Site infrastructure, 13. Barrier to connectivity. 14. Loss of prey biomass. The QI and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS) The assessment of potential adverse effects to cormorants presented in Section 3 (Stage 2 AA – NIS) relies on the detailed assessments of indirect impacts via the impact mechanisms listed above. Specific conservation targets regarding habitat for cormorant relate to breeding colonies and given the distance of breeding colonies (See Section 3.3.4 from the Proposed Development, there is no potential for direct impacts to cormorant via habitat loss. Therefore, this impact mechanism (Habitat loss) is not brought forward to Section 3 (Stage 2 AA-NIS).

SCI Species – Surface swimmer/ Intertidal walker/ Terrestrial walker

Special Conservation Interest Species	Foraging Guild	Source-Pathway-Receptor Screening Exercise
A052 Teal (*Anas crecca*)	Surface swimmer	These bird species use wetland habitats for foraging. The structure and functionality of wetlands are influenced by hydrological regime and sediment transport. If sediment deposition plumes generated during excavation activities overlap wetland habitats there is potential for significant
A054 Pintail (*Anas acuta*)		
A062 Scaup (*Aythya marila*)		
A050 Wigeon (*Anas penelope*)	Surface swimmer/ Intertidal walker (out of water)	
A056 Shoveler (*Anas clypeata*)		
A048 Shelduck (*Tadorna tadorna*)		

A137 Ringed Plover (*Charadrius hiaticula*)	**Intertidal walker (out of water)**	**direct effect to wetlands and indirect effect to bird foraging (*i.e.* connectivity exists).** **The impact mechanism of concern with respect to potential significant effects to these SCIs are; 1. Release of pollutants during construction, 2. Land-based construction noise and vibration disturbance, 3. Release of spoil during piling, 6. Vessel physical disturbance and collision injury, 9. Waste water discharge, 11. Accidental large-scale oil or LNG spill, 12. Collision with site infrastructure. . The bird species and listed impact mechanism combinations are bought forward to Section 3 (Stage 2 AA – NIS). It is noted that habitat area is not a conservation attribute for these SCI species. Therefore, this impact mechanism (Direct habitat loss) is not brought forward to Section 3 (Stage 2 AA-NIS).**
A140 Golden Plover (*Pluvialis apricaria*)		
A141 Grey Plover (*Pluvialis squatarola*)		
A143 Knot (*Calidris canutus*)		
A149 Dunlin (*Calidris alpina*)		
A156 Black-tailed Godwit (*Limosa limosa*)		
A157 Bar-tailed Godwit (*Limosa lapponica*)		
A160 Curlew (*Numenius arquata*)		
A162 Redshank (*Tringa totanus*)		
A164 Greenshank (*Tringa nebularia*)		
A142 Lapwing (*Vanellus vanellus*)		
A046 Light-bellied Brent Goose (*Branta bernicla hrota*)		
A038 Whooper Swan (*Cygnus cygnus*)	**Surface swimmer/ Terrestrial walker**	
A179 Black-headed Gull (*Chroicocephalus ridibundus*)	**Surface swimmer/ Intertidal walker (out of and in water) / Terrestrial walker**	

Table 2.22: Screening Exercises – Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Site code 004161). Potential significant effects to conservation features are highlighted in bold.

Special Conservation Interest Species	Conservation Objective	Source-Pathway-Receptor Screening Exercise
A082 Hen Harrier (*Circus cyaneus*)	Maintain or restore the favourable conservation condition	**Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA is located approximately 10km southeast of the proposed development site. A national survey of breeding Hen Harriers in Ireland in 2016, recorded no evidence of breeding Hen Harriers in the 10km grid square containing the Proposed Development (Ruddock et al. 2016). It is noted that a juvenile (Ringtail) Hen Harrier was recorded over the reed bed habitat to the west of the Site in July 2021 (DixonBrosnan surveys). However, there is no suitable foraging or breeding habitat for this species within the Site boundary, no other records of hen harrier during Site surveys and no records of breeding Hen Harrier within 10km of the Site. It is noted that Hen Harrier disperse widely outside the breeding season (O'Donoghue 2019). The Proposed Development area is of negligible value for Hen Harrier.** **Given the location of the population and habitat relative to Proposed Development area and the habitats within the Proposed Development site, no potential *ex situ* impacts have been identified. Therefore, it is possible to exclude the potential for significant effects. The SCI is screened out of further assessment.**

2.13. Plans or Projects That Might Act In-Combination

Regulation 42 (1) of the 2011 Regulations requires that:

> *A screening for Appropriate Assessment of a plan or project for which an application for consent is received, or which a public authority wishes to undertake or adopt, and which is not directly connected with or necessary to the management of the site as a European Site, shall be carried out by the public authority 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*.

It is therefore required that the potential impacts of the Proposed Development are considered in-combination with other relevant plans or projects.

To inform the assessment of potential in-combination effects a review was undertaken in July 2021 of the planning consent and foreshore licence applications for plans/ projects included on the following web-sites:

- DHPLG (http://www.housing.gov.ie/planning/foreshore/foreshore-consenting and https://www.housing.gov.ie/planning/environmental-assessment/environmental-impact-assessment-eia/eia-portal)
- ABP (http://www.pleanala.ie/lists/2018/sid/index.htm)
- Clare County Council (http://www.eplanning.ie/ClareCC/searchtypes)
- Kerry County Council (http://maps.kerrycoco.ie/flexviewers/kerrymaps/)
- Department of Agriculture, Food and the Marine (https://www.gov.ie/en/collection/94568-aquaculture-licence-decisions/)

The plans/ projects identified that pose a risk of acting in-combination with the Proposed Development can be broadly categorised as **1)** energy storage and energy infrastructure and **2)** geophysical survey which are assessed respectively in **Section 2.13.1** and **Section 2.13.2** below.

The assessment of potential in-combination effects also considered relevant negative impacting activities (threats and pressures) and, positive impacting activities/ management affecting the sites as identified in the Natura 2000 forms published for the sites (and presented in **Table 2.19**). The activities that pose a risk of acting in-combination with the Proposed Development are **1)** commercial shipping and **2)** dredging activity (see **Section2.13.4** and **Section 2.13.5** respectively)**.**

Previous planning applications and foreshore licence applications for projects at the site of the Proposed Development are listed in **Table 2.23** and **Table 2.24**. These projects form part of the Proposed Development and as such have been considered in full in the screening exercise in **Section 2.12.4**.

2.13.1. Energy Storage and Energy Infrastructure

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
220 kV and 20 kV Power Transmission Systems	An application to connect to the national electrical transmission system via a 220 kV high voltage connection was submitted to EirGrid in September 2020. An offer has yet to be received. It is expected that the high voltage connection will run 5 km east under the L-1010 road to the Eirgrid Kilpaddoge 220 kV substation. The LNG Terminal may need to be operational before the Power Plant and/or 220 kV high voltage grid connection are completed or operational. Therefore, the LNG Terminal design will also require an onsite substation and a separate 20 kV medium voltage connection, from the existing Electricity Supply Board Networks (ESBN)/EirGrid Kilpaddoge substation. This will be used as a back-up electricity system when the Power Plant is undergoing maintenance. The 20 kV and 220 kV power connections will be constructed in parallel with the Proposed Development but will be subject to separate planning design and planning applications.

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
Kilpaddoge Battery Energy Storage Project	A 10-year permission for the development of a Battery Energy Storage System (BESS) Facility on a site of *circa* 0.6ha in the townland of Kilpaddoge, Tarbert, Co. Kerry. The BESS facility will provide balancing services to the Irish national grid allowing short term battery energy storage for surplus energy which can be subsequently transferred back into the grid at peak energy demand periods. The facility will contain a series of 26 no. BESS units with associated heating ventilation and air conditioning system and control building, together with associated site works including ESB sub-station installation, transformer, access roadways, footpaths, paving, site security (lighting, CCTV *etc.*), drainage and landscaping. The development area is currently used for agriculture and has low biodiversity value. The development is located 300m from the boundary of the Lower River Shannon cSAC and, the River Shannon and River Fergus Estuaries SPA. An AA Screening report prepared for the BESS development concluded that the development will not have a significant effect on any Natura 2000 site. Findings of the AA Screening report for the development relevant to the assessment of in-combination effects with Proposed Development are summarised below. *Direct and Indirect Habitat Loss or Deterioration of Natura 2000 sites* The AA Screening report for the BESS development outlined that the development *is not located within of the boundaries of Natura 2000 site* and will not result *in any direct of habitat loss*. The AA Screening report also outlined that *indirect loss of habitat or deterioration of Natura 2000 sites… can occur from the effect of run-off or discharge into the marine environment through impact such as increased siltation, nutrient release and/or contamination*. It was concluded that there is no potential impact to Natura sites as there are no hydrological links (impact pathways) between the development and the Lower River Shannon cSAC and the River Shannon and River Fergus Estuary SPA. There are no potential impact pathways between the BESS project and habitat receptors; consequently it is concluded that there is no potential for in-combination effects with Proposed Development to conservation features of the Lower River Shannon cSAC or the River Shannon and River Fergus Estuaries SPA.

	Disturbance/ Displacement of Species The AA Screening report for the BESS development concluded that the construction and operation of the development *would not cause disturbance to the birds using the River Shannon (and hence the SPA)* as the development site is *located 300m from the estuary (and boundary of the SPA)* and is *not suitable for roosting and foraging of the qualifying bird species of the River Shannon and River Fergus Estuary SPA.* There is no potential for significant in-combination disturbance effects; in-combination effects can be screened out. *Impact on Water Quality* With respect to water quality AA Screening report for the BESS development concluded that following adherence to standard construction codes *there will be no significant impacts from the Proposed Development on water quality in the River Shannon.* There is no potential for in-combination effects from the BESS development; in-combination effects can be screened out.

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
LNG Pipeline	Permission was granted in 2009 for a pipeline to connect the Proposed Development to the existing national gas network near Foynes, Co. Limerick. The application was accompanied by a report to support AA Screening and an EIAR. The AA Screening report concluded that the development will not have a significant detrimental impact on features of interests for designated Natura 2000 sites, or the ecological integrity of these sites. Similarly, the EIAR concluded that no significant residual effects were identified to hydrogeology and surface water in the EIAR for the LNG pipeline. The assessments for the development concluded '*that there is no evidence to indicate that the original proposed works or the proposed alterations to the proposed works will cause significant deterioration of important habitats, the habitats of the qualifying species and species of special conservation interest or significant disturbance to these species thus ensuring the integrity of the site is maintained. No significant cumulative impacts are expected to occur. No significant indirect impacts are envisaged'*. Given the above, it can be concluded that there is no potential for effects from the pipeline development in-combination with the Proposed Development; in-combination effects can be screened out.

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
Cross Shannon 400 kV Cable Project	The Cross Shannon 400 kV Cable Project involves the laying of a new 400kV cable across the Shannon Estuary (in the seabed) between the Moneypoint 400kV Electricity Substation in the townland of Carrowdotia South County Clare and Kilpaddoge 220/110 kV Electricity Substation in the townland of Kilpaddoge County Kerry. The connection at Moneypoint will be at the existing substation on ESB lands. The connection at Kilpaddoge requires an extension of 5,500m^2 to the existing substation on ESB lands. It is anticipated that installation operations will commence in 2021. It is expected that the development will become fully operational in 2022. The Screening Statement for AA and NIS report prepared for the cable project. The report concluded that cable project will not have a significant effect on any Natura 2000 site. Findings of the report relevant to the assessment of in-combination effect with Proposed Development are summarised below.

Impact on Water Quality

With respect to water quality the report concluded that following adherence to standard construction codes there will be no impacts from the cable project on water quality in the River Shannon. Consequently, there in-combination effects with the Proposed Development can be screened out.

Noise Disturbance to Species

The report identified potential effect of noise construction noise disturbance associated with excavation and cable laying activities. However, implementation of mitigation measures will ensure negative effects to species are avoided. Consequently, there is no potential likelihood for effects from the cable project in-combination with Proposed Development; in-combination noise effects can be screened out.

Vessel collision risk

Given the ambient level of vessel activity in the area, the temporary presence of the vessels in the area required for the cable project will not significantly increase the levels of overall vessel activity in the area and no significant risk of collision impacts. Consequently, there is no potential likelihood for significant increased collision risk from the cable project in-combination with Proposed Development; in-combination effects can be screened out.

Sedimentation of solids in habitats

For the proposed cable laying project, three-dimensional sediment modelling was undertaken to determine the transport, dispersion and sedimentation of solids resuspended by trench excavation activities. Modelling showed that sediment deposition depths after completion of the cable installation would be well below the threshold for impact to habitats and associated faunal communities. The sediment plume generated by the excavation and cable activity is shown in **Figure 2-30** below.

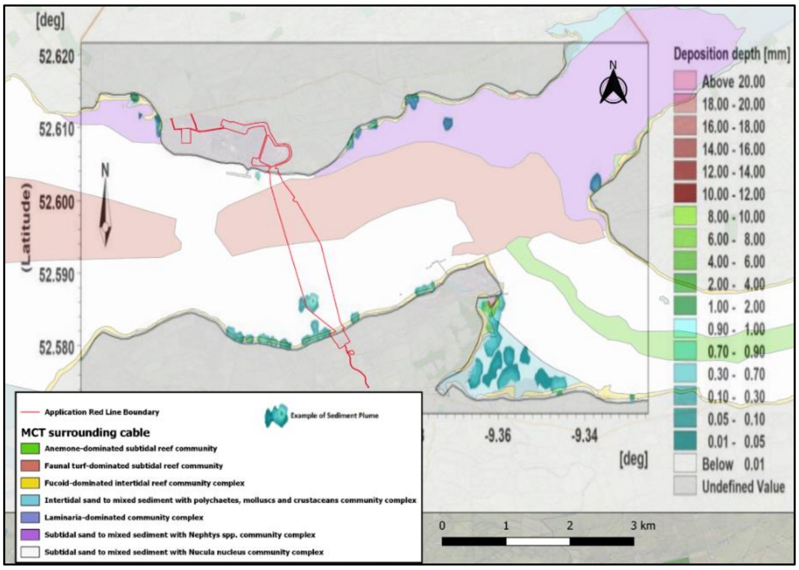


Figure 2-30: Marine community types identified within Annex I Habitats in relation to the modelled sediment plume (Mott McDonald, 2019).

There is potential that the sediment plumes associated with the excavation and cable laying activities, may overlap sediment plumes generated due to the installation of piles. If the combined sediment deposition depths could exceed the threshold for impact to habitats and associated faunal communities, thereby resulting in **significant in-combination effects**; potential in-combination effects are considered in **Section 3 Stage 2: AA – NIS**.

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
Moneypoint Synchronous Condenser	The ESB is proposing to develop a Synchronous Condenser on a plot of land at Moneypoint Power Station, Carrowdotia, Co. Clare. The planning application for this development (Ref: 20/318 Clare County Council) notes that the synchronous condenser compound will be approximately 100m by 40m in total. The Proposed Development will comprise a main building and ancillary equipment such a cooling equipment, electrical and control equipment, transformer, circuit breaker, connections to existing site services networks including electrical, water and wastewater and an underground surface water attenuation tank connecting to existing surface water drains, and fencing. A NIS was prepared for the Synchronous Condenser development. The associated screening assessment noted that piling works during the construction phase of the development may result in elevated underwater noise in the immediate vicinity of the Moneypoint site which could affect bottlenose dolphin. The NIS prescribes a marine mammal observer (MMO) operating in accordance with 'Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters' as mitigation to avoid the potential for adverse effects on the Lower River Shannon cSAC. The report identified potential effect of noise construction noise disturbance associated with excavation and cable laying activities. However, implementation of mitigation measures will ensure negative effects to species are avoided. Consequently, there is no potential likelihood for significant effects from the cable project in-combination with Proposed Development; in-combination noise effects can be screened out.

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
Moneypoint Generating Station, Carrowdotia North and Carrowdotia South, Killimer, Co. Clare.	On 9th April 2021, ESB announced Green Atlantic @ Moneypoint project. Planning applications and foreshore licence applications for project have yet to be made. The project will be subject to AA and EIAR. The project which will see the Power Station site transformed into a green energy hub, including: Renewable Enablement ESB has already commenced work on transforming Moneypoint into a green energy hub, with the installation of a Synchronous Compensator (permitted under application register reference 20/318) to provide a range of electrical services to the electricity grid which would previously have been supplied by thermal fired power stations. Its operation will enable higher volumes of renewables on the system. *Moneypoint Floating Offshore Wind Farm* A floating offshore wind farm of 1,400MW will be developed off the coast of Counties Clare and Kerry in two phases by ESB and joint venture partners, Equinor. Once complete, the wind farm will be capable of powering more than 1.6m homes in Ireland. Subject to the appropriate consents being granted, the wind farm is expected to be in production within the next decade. *A Wind Turbine Construction Hub* Moneypoint will become a centre for the construction and assembly of floating wind turbines. A deep-water port already exists at the site, making it an ideal staging ground for the construction of the wind farm. *Hydrogen Energy* ESB's plans include investment in a green hydrogen production, storage and generation facility at Moneypoint towards the end of the decade. A clean, zero-

	carbon fuel, green hydrogen will be produced from renewable energy and used for power generation, heavy goods vehicles in the transport sector and to help decarbonise a wide range of industries such as pharmaceuticals, electronics and cement manufacturing. The Green Atlantic @ Moneypoint project will be subject to its own planning consent and foreshore licence applications. The project will also be subject to its own AA and EIAR. The AA and EIAR will require that in combination and cumulative effects respectively are considered fully and where necessary mitigations undertaken to avoid significant impacts occurring. Consequently, there is no potential likelihood for significant effects in-combination with Proposed Development; in-combination noise effects can be screened out.

2.13.2. Data Centre

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
Data Centre	A data centre complex is to be constructed to the west of the Proposed Development. This will be subject to its own AA, EIAR and planning application. The AA and EIAR will require that in combination and cumulative effects respectively are considered fully and where necessary mitigations undertaken to avoid significant impacts occurring. Consequently, there is no potential likelihood for significant effects in-combination with Proposed Development; in-combination noise effects can be screened out.

2.13.3. Geophysical Survey

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
Cross Shannon 400kV Cable Project	There are plans to carry out a geophysical survey of the Prospect Tarbert pipelines which extend across the River Shannon estuary from Tarbert Generating Station in Co. Kerry to Kilkerin Point in Co. Clare. The survey project will be carried out under the conditions of its 2005 licence. For the survey project, mitigation measures will be used to avoid negative effects. The mitigation measures include the implementation of NPWS guidelines on underwater noise. Consequently, significant in-combination effected can be screened out.

2.13.4. Commercial Shipping

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
Commercial Shipping	*Shipping lanes (D03.02)* is listed as a negative *threat/ pressure* for the River Shannon and River Fergus Estuaries SPA (see **Table 2.19**). There is potential that the presence of the Proposed Development (*i.e.* LNGC, FRSU, Tugs) may act in-combination with background vessel activity to affect conservation features of the Lower River Shannon cSAC and River Shannon and River Fergus Estuaries SPA. According to the Shannon Foynes Port Company (SFPC) approximately 1,800 vessel movements are made within the estuary, equating to 900 different AIS (automatic identification system) tracked vessels travelling into the estuary annually. Cargo in excess of 12 million tonnes (approximately 20% of goods tonnage handled at national

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
	ports in Ireland) is delivered to the main facilities. The level of commercial shipping in the Shannon has remained relatively stable over the last 10 years (pers. comm[24]). EMODnet[25] vessel density mapping indicates that high levels of shipping activity occur throughout the year along the Shannon estuary and, in particular, in the vicinity of the Proposed Development area. In general, average monthly vessel density in 2017, 2018, 2019 and 2020 in the Shannon estuary ranged between 2 and 10 hours per km^2 and exceeded 100+ hours per km^2 in the vicinity of the Proposed Development area. The presence of the project vessels (*i.e.* the FSRU, LNGC, tugs) will not significantly increase the level of overall vessel activity in the area. Consequently, there will be a non-significant relative change in the risk of disturbance to conservation features due to in-combination activities.

2.13.5. Dredging Activity

Project Category	Summary of Project/ Activity and Assessment of Potential In-Combination Effects
Dredging Activity	The level of maintenance dredging activities in the Shannon has remained relatively stable over the last 10 years. In July 2019 Shannon Foynes Port Company Foynes Port applied for a foreshore licence to undertake maintenance dredging at Foynes Port. The Foynes Port is located almost 30km upstream of the Proposed Development. Given the distance there is no potential for in-combination effects It should be noted that for Proposed Development will be no marine dredging or 'Dumping at Sea'. Consequently, there is no potential likelihood for significant effects in-combination with Proposed Development; in-combination noise effects can be screened out.

[24] Personal communication 18/06/2020 Captain Hugh Conlon – Shannon Foynes Harbour Master

[25] https://www.emodnet-humanactivities.eu/view-data.php

Table 2.23: Planning Applications relating to the Proposed Development.

Planning Reference	Location	Received Date	Decision Date	Decision	Description
PL08B. PA0002	Ralappane and Kilcolgan Lower, Co. Kerry	24.09.2007	31.03.2008	Granted	Proposed LNG regasification terminal.
PL08.PM0002	Ralappane and Kilcolgan Lower, Co. Kerry	01.11.2012	04.12.2013	Granted	Amendment to the phasing of the construction of the permitted LNG Terminal (condition no. 3) and other minor modifications
PL08.PM0014	Ralappane and Kilcolgan Lower, Co. Kerry	22.09.2017	13.07.2018	Granted	Amendment to the length of the permission for the permitted LNG Terminal (condition no. 2) from 10 years to 15 years. This decision was quashed by the High Court in November, 2020 It follows that the 2008 permission (PL08B. PA0002) is now expired as well as PL08.PM0002.
PL08.GA0003	townlands of Ralappane, Carhoonakineely, Carhoonakilla, Cockhill, Carhoona, Dooncaha, Doonard Upper, Tieraclea Upper and Kilmurrily, County Kerry and Ballygoghlan, Ballycullane Upper, Ballynagaul, Kinard, Ballygiltenan Lower, Killeany More, Flean More, Curra More, Lisready (Clare), Ballyroe, Knocknabooly West, Knocknabooly Middle, Knocknabooly East, Mounttrenchard, Ballynash (Bishop), Ballynash (Clare) and Leahys, County Limerick	14.08.2008	17.02.2009	Granted	Permission approved for a gas pipeline to connect Shannon LNG Terminal to the existing natural gas network at Leahy's Co. Limerick.
PL08. DA0003	townlands of Ralappane, Carhoonakineely, Carhoonakilla, Cockhill, Carhoona, Dooncaha, Doonard Upper, Tieraclea Upper and Kilmurrily, County Kerry and Ballygoghlan, Ballycullane Upper, Ballynagaul, Kinard, Ballygiltenan Lower, Killeany More, Flean More, Curra More, Lisready (Clare), Ballyroe, Knocknabooly West, Knocknabooly Middle, Knocknabooly East, Mounttrenchard, Ballynash (Bishop), Ballynash (Clare) and Leahys, County Limerick	01.08.2008	17.02.2009	Make acquisition order without amendments	Application for an acquisition order for the Shannon LNG Terminal at Tarbert, Co. Kerry to the Bord Gáis Eireann Network at Foynes, County Limerick

Planning Reference	Location	Received Date	Decision Date	Decision	Description
PL08. PA0028	Ralappane and Kilcolgan Lower, Co. Kerry	21.12.2012	09.07.2013	Granted	10-year permission for a combined Heat and Power (CHP) Plant

Table 2.24: Foreshore Licence Applications relating to the Proposed Development.

Planning Reference	Location	Received Date	Decision Date	Decision	Description
FS006224	Shannon Estuary near Tarbert and Ballylongford in Co. Kerry	19.03.2008	20.04.2010	Granted	Drainage outfall.
FS006225	Shannon Estuary near Ballylongford and Tarbert, County Kerry	19.03.2008	20.04.2010	Granted	Construction of a LNG jetty.
FS006227	Shannon Estuary near Ballylongford and Tarbert, County Kerry	19.03.2008	20.04.2010	Granted	Construction of a materials jetty.
FS006228	Shannon Estuary near Ballylongford and Tarbert, County Kerry	19.03.2008	20.04.2010	Granted	Construction of a seawater intake and outfall.

2.14. Screening Exercise Outcome

The screening exercise investigates the potential for the proposed project to have significant effects on European Sites within the Natura 2000 network. The exercise has determined, in light of best available scientific data, that there is potential for significant effects on the conservation features of the Lower River Shannon cSAC and, the River Shannon and River Fergus Estuaries SPA from the Proposed Development. The likelihood of significant effects on all other European sites has been ruled out. The assessment also determined that there is the potential likelihood for significant effects from the Proposed Development in-combination with other plans or projects or activities. The findings of the screening exercise are summarised in **Table 2.25**.

Table 2.25: Screening exercise matrix.

Screening Matrix	
Brief description of the project or plan	Detailed description of the Proposed Development is presented in **Section 2.1** through **Section 2.16**. The development can be split into three phases: operation, construction, and decommissioning. Key activities proposed for the phases of the development relevant to conservation features are summarised in **Section 2.17.2.1** through **Section 2.17.2.3**, while **Section 2.17.2.4** outlines the potential impact mechanisms associated with the phases relevant to conservation features. The application line boundary area for the LNG Terminal and Power Plant is shown in red in **Figure 1-1.** The Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA extend along the north-western shoreline boundary of the site of the Proposed Development (see **Figure 1-2**). The proposed jetty extends into the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA (see **Figure 2-26** and **Figure 2-27** respectively).
European Site(s)	
Brief description of the European site(s)	The Proposed Development is located within the Lower River Shannon cSAC (Site code: 002165) (see **Figure 2-26**), and within 15km of two other cSACs namely; Moanveanlagh Bog cSAC (002351) (12.4km south of the Proposed Development area) and Tullaher Lough and Bog cSAC (Site code: 002343) (14.0km North West) (see **Figure 2-28**). The Proposed Development area also overlaps the River Shannon and River Fergus Estuaries SPA (Site code: 004077) (see **Figure 2-27**), while the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Site code: 004161) is located 10.0km south of the Proposed Development (**Figure 2-29**). Site synopsis reports for the SACs and SPAs are included in **Appendix 1**. Given the spatial extent of the zone of impact of the impact mechanisms, the only conservation features of cSACs and SPAs that have potential pathways for significant impact are conservation features for which the Lower River Shannon cSAC (Site code: 002165) and, the River Shannon and River Fergus Estuaries SPA (Site code: 004077) are designated. The conservation features of the Lower River Shannon cSAC and, the River Fergus Estuaries SPA were brought forward to the screening exercise presented in **Section 2.12.4**. Following source-pathway-receptor assessment, the screening exercise in **Section 2.12.4** determined that there is potential for significant effects for the following conservation features: Lower River Shannon cSAC: • Mudflats and sandflats not covered by seawater at low tide [1140] • Large shallow inlets and bays [1160]

	• Estuaries [1130 • Reefs [1170] • *Coastal lagoons [1150] • Perennial vegetation of stony banks [1220] • Vegetated sea cliffs of the Atlantic and Baltic coasts [1230] • Salicornia and other annuals colonising mud and sand [1310] • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] • Mediterranean salt meadows (*Juncetalia maritimi*) [1410] • *Tursiops truncatus* (Common Bottlenose Dolphin) [1349] • *Salmo salar* (Atlantic Salmon) [1103] • *Lampetra planeri* (Brook Lamprey) [1096] • *Lampetra fluviatilis* (River Lamprey) [1099] • *Petromyzon marinus* (Sea Lamprey) [1095] • *Lutra lutra* (Otter)* [1355] River Shannon and River Fergus Estuaries SPA: • *Phalacrocorax carbo* (Cormorant) [A017] • *Anas crecca* (Teal) [A052] • *Anas acuta* (Pintail) [A054] • *Aythya marila* (Scaup) [A062] • *Anas penelope* (Wigeon) [A050] • *Anas clypeata* (Shoveler) [A056] • *Tadorna tadorna* (Shelduck) [A048] • *Charadrius hiaticula* (Ringed Plover) [A137] • *Pluvialis apricaria* (Golden Plover) [A140] • *Pluvialis squatarola* (Grey Plover) [A141] • *Calidris canutus* (Knot) [A143] • *Calidris alpina* (Dunlin) [A149] • *Limosa limosa* (Black-tailed Godwit) [A156] • *Limosa lapponica* (Bar-tailed Godwit) [A157] • *Numenius arquata* (Curlew) [A160] • *Tringa totanus* (Redshank) [A162] • *Tringa nebularia* (Greenshank) [A164] • *Vanellus vanellus* (Lapwing) [A142] • *Branta bernicla hrota* (Light-bellied Brent Goose) [A046] • *Cygnus cygnus* (Whooper Swan) [A038] • *Chroicocephalus ridibundus* (Black-headed Gull) [A179] • Wetland and waterbirds [A999] Given the spatial extent of the zone of impact of the impact mechanisms, it was concluded that there are no potential pathways for significant impact to other conservation features of European sites; potential significant effects on the conservation features of all other European sites have been excluded.
Assessment Criteria	
Describe the individual elements of the project (either alone or in combination with other plans or projects) likely to give rise to impacts on the European site.	The impact mechanisms associated with the Proposed Development that may result in potential direct and indirect effects to the conservation features listed above are: 1. Release of pollutants during construction 2. Land-based construction noise and vibration disturbance 3. Release of spoil during piling 4. Underwater noise 5. Seabed habitat loss 6. Vessel physical disturbance and collision injury 7. Discharge of treated cooled seawater 8. Entrainment and impingement of fauna by the FRSU seawater system

<table>
<tr><td>Brief description of the European site(s)</td><td rowspan="3">9. Discharge of Wastewater and Power Plant Process Heated Water Effluent
10. Introduction of invasive species
11. Accidental largescale oil or LNG spill
12. Collision with site infrastructure
13. Barrier to connectivity
14. Reduction in prey biomass
The Proposed Development is located within the Lower River Shannon cSAC (Site code: 002165) (see Figure 2-26), and within the River Shannon and River Fergus Estuaries SPA (Site code: 004077) (see Figure 2-27). Site synopsis reports for the cSAC and SPA are included in Appendix 1.</td></tr>
<tr><td>Describe any likely direct, indirect or secondary impacts of the project (either alone or in combination with other plans or projects) on the Natura 2000 site by virtue of Size and scale, Land-take.</td></tr>
<tr><td>Distance from the Natura 2000 site or key interests of the site;</td></tr>
<tr><td>Resource requirements (water abstraction etc.);</td><td>During the proposed project, construction equipment and plant (excavators and dump trucks etc.) will be in operation. The fuel used by the construction equipment, dumper trucks and plant and vessels will be petrol/ diesel.
Materials required are detailed in Section 2.2. The main materials required includes concrete, piles, concrete slabs, steel pipes etc.
The FSRU ship will use seawater for different purposes with the largest quantities being used for the regasification process. Seawater will also be used as firefighting water, to create water curtain, ballast water and cooling water for engine cooling and auxiliary systems cooling.</td></tr>
<tr><td>Emissions (disposal to land, water or air);</td><td>Atmospheric and noise emissions from construction equipment, dumper trucks, plant, vessels.
Potential release of sediment, chemicals or other waste material pollution during construction periods
Underwater pile drilling operations will result in the generation and release of drilling rock particles and sediment.
No dredging or dumping at Sea is proposed.</td></tr>
<tr><td>Excavation requirements;
Transportation requirements;</td><td>Excavation/ reprofiling of onshore lands to allow the construction of the LNG Terminal including the construction of administration and security building, stores, workshops, various other buildings and workshop and maintenance buildings.
Excavated material will be reused as backfill on site.</td></tr>
<tr><td>Duration of construction, operation,
Decommissioning Other.</td><td>The commencement of construction for the LNG Terminal is subject to planning consent and other approvals including foreshore licences. Total construction duration for the LNG Terminal is estimated at 18 months. Using an arbitrary start date of January 2022, the LNG Terminal would be operational by June 2023.
On completion of the work at the sites and the installation of the required infrastructure, all equipment will leave the area.
The dates and timeframes for the project may change dependent on the outcome of the consenting process.
The Proposed Development is expected to have a design life of 50 years, but this could be extended by maintenance, equipment replacement and upgrades or by the</td></tr>
</table>

	transition of the site to use hydrogen capability (which would be subject to a future planning application)
Describe any likely changes to the site arising as a result of: Reduction in habitat area; Disturbance to key species; Habitat or species fragmentation; Reduction in species density; Changes in key indicators of conservation value (water quality *etc*.); Climate change	**Reduction in habitat area** *Impact mechanism 5 – Loss of seabed habitat* The proposed jetty extends into the Lower River Shannon cSAC and, the River Shannon and River Fergus Estuaries SPA (see **Figure 2-26** and **Figure 2-27** respectively); the works will result in a reduction of seabed habitat area within the sites. The Annex I conservation features of the Lower River Shannon cSAC of concern with respect to impact mechanism 5 are; • Estuaries [1130] • Reefs [1170] Potential for effects are considered in **Section 3.4** below. The onshore activities are located outside the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA. The site of the works is agricultural and scrub land that is of low conservation value. The onshore works will not involve land take within the cSAC or SPA; the works will not result in a reduction of habitat area.
	Disturbance to key species *Impact mechanism 2 – Land-based construction noise and vibration disturbance* Construction activity will result in noise and vibration disturbance, potentially displacing species from the site and immediately surrounding areas. Increased lighting during the construction and operational phase may also result in disturbance of qualifying species. The conservation features of concern within the River Shannon and River Fergus Estuaries SPA with respect to impact mechanism 2 are: • *Phalacrocorax carbo* (Cormorant) [A017] • *Anas crecca* (Teal) [A052] • *Anas acuta* (Pintail) [A054] • *Aythya marila* (Scaup) [A062] • *Anas penelope* (Wigeon) [A050] • *Anas clypeata* (Shoveler) [A056] • *Tadorna tadorna* (Shelduck) [A048] • *Charadrius hiaticula* (Ringed Plover) [A137] • *Pluvialis apricaria* (Golden Plover) [A140] • *Pluvialis squatarola* (Grey Plover) [A141] • *Calidris canutus* (Knot) [A143] • *Calidris alpina* (Dunlin) [A149] • *Limosa limosa* (Black-tailed Godwit) [A156] • *Limosa lapponica* (Bar-tailed Godwit) [A157] • *Numenius arquata* (Curlew) [A160] • *Tringa totanus* (Redshank) [A162] • *Tringa nebularia* (Greenshank) [A164] • *Vanellus vanellus* (Lapwing) [A142] • *Branta bernicla hrota* (Light-bellied Brent Goose) [A046] • *Cygnus cygnus* (Whooper Swan) [A038] • *Chroicocephalus ridibundus* (Black-headed Gull) [A179] The conservation features of concern within the Lower River Shannon cSAC with respect to impact mechanism 2 are: • Otter (*Lutra lutra*) [1355] Potential for effects are considered in **Section 3.4** below.

	Impact mechanism 3 – Release of spoil during piling Underwater pile drilling operations will result in the generation and release of drilling rock particles and sediment, potentially affecting water quality. There is potential that the plume of released sediment may extend a significant distance from the works area. The conservation features of concern with respect impact mechanism 3 are the following Annex I habitats and Annex II species of the Lower River Shannon cSAC; • Mudflats and sandflats not covered by seawater at low tide [1140] • Large shallow inlets and bays [1160] • Estuaries [1130] • Reefs [1170] • Sandbanks which are slightly covered by sea water all the time [1110] • Coastal lagoons [1150] • Perennial vegetation of stony banks [1220] • Salicornia and other annuals colonising mud and sand [1310] • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] • Mediterranean salt meadows (*Juncetalia maritimi*) [1410] • *Tursiops truncatus* (Common Bottlenose Dolphin) [1349] • *Lampetra planeri* (Brook Lamprey) [1096] • *Salmo salar* (Atlantic Salmon) [1106] • *Lampetra fluviatilis* (River Lamprey) [1099] • *Petromyzon marinus* (Sea Lamprey) [1095] • *Lutra lutra* (Otter) [1355]* • Wetland [A999] The conservation features of concern within the River Shannon and River Fergus Estuaries SPA with respect to impact mechanism 3 are: • *Phalacrocorax carbo* (Cormorant) [A017] • *Anas crecca* (Teal) [A052] • *Anas acuta* (Pintail) [A054] • *Aythya marila* (Scaup) [A062] • *Anas penelope* (Wigeon) [A050] • *Anas clypeata* (Shoveler) [A056] • *Tadorna tadorna* (Shelduck) [A048] • *Charadrius hiaticula* (Ringed Plover) [A137] • *Pluvialis apricaria* (Golden Plover) [A140] • *Pluvialis squatarola* (Grey Plover) [A141] • *Calidris canutus* (Knot) [A143] • *Calidris alpina* (Dunlin) [A149] • *Limosa limosa* (Black-tailed Godwit) [A156] • *Limosa lapponica* (Bar-tailed Godwit) [A157] • *Numenius arquata* (Curlew) [A160] • *Tringa totanus* (Redshank) [A162] • *Tringa nebularia* (Greenshank) [A164] • *Vanellus vanellus* (Lapwing) [A142] • *Branta bernicla hrota* (Light-bellied Brent Goose) [A046] • *Cygnus cygnus* (Whooper Swan) [A038] • *Chroicocephalus ridibundus* (Black-headed Gull) [A179] Potential for effects are considered in **Section 3.4** below.

	<u>*Impact mechanism 4 - Underwater Noise*</u> The generation of underwater noise during piling operations, vessel operations (and possibly during land-based rock blasting) have the potential to cause disturbance, physical injury and behavioural changes in fauna. The conservation features of the Lower River Shannon cSAC of concern with respect to impact mechanism 4 include the following Annex II species; • *Tursiops truncatus* (Common Bottlenose Dolphin) [1349] • *Lampetra planeri* (Brook Lamprey) [1096] • *Salmo salar* (Atlantic Salmon) [1106] • *Lampetra fluviatilis* (River Lamprey) [1099] • *Petromyzon marinus* (Sea Lamprey) [1095] • *Lutra lutra* (Otter) [1355]* Potential for effects are considered in **Section 3.4** below. The conservation features of concern with respect impact mechanism 4 within the River Shannon and River Fergus Estuaries SPA; • *Phalacrocorax carbo* Cormorant [A017] <u>*Impact mechanism 6* - Vessel physical disturbance and collision injury</u> Vessel activity has the potential to cause physical disturbance and collision injury to fauna. The conservation features of the Lower River Shannon cSAC of concern with respect to impact mechanism 6 include the following Annex II species; • *Tursiops truncatus* (Common Bottlenose Dolphin) [1349] • *Lutra lutra* (Otter) [1355]* The conservation features of concern with respect *Impact mechanism 6* within the River Shannon and River Fergus Estuaries SPA; • *Phalacrocorax carbo* Cormorant [A017] <u>*Impact mechanism 13* – Barrier to connectivity</u> Increased noise and visual disturbance (including lighting) during construction and the presence of the jetty along the shoreline of the Shannon Estuary during operation has the potential to create barriers to connectivity for conservation features. The conservation features of the Lower River Shannon cSAC of concern with respect to *Impact mechanism 13* include the following Annex II species; • *Lutra lutra* (Otter) [1355]* The conservation features of concern with respect *Impact mechanism 13* within the River Shannon and River Fergus Estuaries SPA; • *Phalacrocorax carbo* Cormorant [A017] <u>*Impact mechanism 14* – Loss of Prey Biomass</u> Potential that water abstraction, vibrations and sediment plumes from piling, discharges, release of pollutants and changes in water temperature may reduce fish numbers and subsequently prey biomass for piscivorous species. The conservation features of the Lower River Shannon cSAC of concern with respect to *Impact mechanism 14* include the following Annex II species; • *Lutra lutra* (Otter) [1355]* The conservation features of concern with respect *Impact mechanism 14* within the River Shannon and River Fergus Estuaries SPA; • *Phalacrocorax carbo* Cormorant [A017] Potential for effects are considered in **Section 3.4** below.

	Reduction in species density *Impact mechanism 8 - Entrainment and impingement of fauna by the FRSU seawater system* Potential that abstracting and pumping of seawater will result in fish and macrocrustaceans being entrained in the cooling water intake and/or impinged on the filter screens of the intake, impacting species density. The conservation features of the Lower River Shannon cSAC of concern with respect to impact mechanism 8 include the following Annex II species; • *Tursiops truncatus* (Common Bottlenose Dolphin) [1349] • *Lampetra planeri* (Brook Lamprey) [1096] • *Salmo salar* (Atlantic Salmon) [1106] • *Lampetra fluviatilis* (River Lamprey) [1099] • *Petromyzon marinus* (Sea Lamprey) [1095] Potential for effects are considered in **Section 3.4** below. *Impact mechanism 12 – Collision with site infrastructure* Collision with the jetty during operation and machinery at the jetty during construction has the potential to impact on SCI birds within the River Shannon and River Fergus Estuaries SPA. The conservation features of concern with respect to *Impact mechanism 12* include the following SCI species; • *Phalacrocorax carbo* (Cormorant) [A017] • *Anas crecca* (Teal) [A052] • *Anas acuta* (Pintail) [A054] • *Aythya marila* (Scaup) [A062] • *Anas penelope* (Wigeon) [A050] • *Anas clypeata* (Shoveler) [A056] • *Tadorna tadorna* (Shelduck) [A048] • *Charadrius hiaticula* (Ringed Plover) [A137] • *Pluvialis apricaria* (Golden Plover) [A140] • *Pluvialis squatarola* (Grey Plover) [A141] • *Calidris canutus* (Knot) [A143] • *Calidris alpina* (Dunlin) [A149] • *Limosa limosa* (Black-tailed Godwit) [A156] • *Limosa lapponica* (Bar-tailed Godwit) [A157] • *Numenius arquata* (Curlew) [A160] • *Tringa totanus* (Redshank) [A162] • *Tringa nebularia* (Greenshank) [A164] • *Vanellus vanellus* (Lapwing) [A142] • *Branta bernicla hrota* (Light-bellied Brent Goose) [A046] • *Cygnus cygnus* (Whooper Swan) [A038] • *Chroicocephalus ridibundus* (Black-headed Gull) [A179]
	Changes in key indicators of conservation value (water quality *etc.*) *Impact mechanism 1 - Release of pollutants during construction* Given the nature and scale of the proposed works, there is potential that conservation features located adjacent to the works and downstream and upstream of the works may be affected. The conservation features of concern with respect to impact mechanism 1 include;

	• Estuaries [1130] • Reefs [1170] • Coastal lagoons [1150] • Perennial vegetation of stony banks [1220] • Salicornia and other annuals colonising mud and sand [1310] • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] • Mediterranean salt meadows (*Juncetalia maritimi*) [1410] It is also possible that the following mobile conservation feature species may occur in the areas and thereby be affected; • *Tursiops truncatus* (Common Bottlenose Dolphin) [1349] • *Lampetra planeri* (Brook Lamprey) [1096] • *Salmo salar* (Atlantic Salmon) [1106] • *Lampetra fluviatilis* (River Lamprey) [1099] • *Petromyzon marinus* (Sea Lamprey) [1095] • *Lutra lutra* (Otter) [1355]* • *Phalacrocorax carbo* (Cormorant) [A017] • *Anas crecca* (Teal) [A052] • *Anas acuta* (Pintail) [A054] • *Aythya marila* (Scaup) [A062] • *Anas penelope* (Wigeon) [A050] • *Anas clypeata* (Shoveler) [A056] • *Tadorna tadorna* (Shelduck) [A048] • *Charadrius hiaticula* (Ringed Plover) [A137] • *Pluvialis apricaria* (Golden Plover) [A140] • *Pluvialis squatarola* (Grey Plover) [A141] • *Calidris canutus* (Knot) [A143] • *Calidris alpina* (Dunlin) [A149] • *Limosa limosa* (Black-tailed Godwit) [A156] • *Limosa lapponica* (Bar-tailed Godwit) [A157] • *Numenius arquata* (Curlew) [A160] • *Tringa totanus* (Redshank) [A162] • *Tringa nebularia* (Greenshank) [A164] • *Vanellus vanellus* (Lapwing) [A142] • *Branta bernicla hrota* (Light-bellied Brent Goose) [A046] • *Cygnus cygnus* (Whooper Swan) [A038] • *Chroicocephalus ridibundus* (Black-headed Gull) [A179] Potential for effects are considered in **Section 3.4** below. *Impact mechanism 7. Discharge of treated cooled seawater* There is potential that impact mechanism 7 may impact water conditions. Given the scale of discharge system, the plume of treated cooled seawater will be largely confined to the areas adjacent to the discharge point. There is potential that conservation features located adjacent to discharge point may be affected. The conservation features of the Lower River Shannon cSAC of concern with respect to impact mechanism *7* include the following Annex I habitats; • Estuaries [1130] • Reefs [1170] It is also possible that the following mobile conservation feature species may occur in the area and thereby be affected; • *Tursiops truncatus* (Common Bottlenose Dolphin) [1349] • *Lampetra planeri* (Brook Lamprey) [1096] • *Salmo salar* (Atlantic Salmon) [1106]

	• *Lampetra fluviatilis* (River Lamprey) [1099] • *Petromyzon marinus* (Sea Lamprey) [1095] Potential for effects are considered in **Section 3.4** below. *Impact mechanism 9. Waste water discharge* There is potential that impact mechanisms 9 may impact water quality. There is potential that plume discharge waters may extend over a large area. Consequently, the conservation features of concern with respect to impact mechanism 9 include; • Mudflats and sandflats not covered by seawater at low tide [1140] • Large shallow inlets and bays [1160] • Estuaries [1130] • Reefs [1170] • Sandbanks which are slightly covered by sea water all the time [1110] • Coastal lagoons [1150] • Perennial vegetation of stony banks [1220] • Salicornia and other annuals colonising mud and sand [1310] • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] • Mediterranean salt meadows (*Juncetalia maritimi*) [1410] • *Tursiops truncatus* (Common Bottlenose Dolphin) [1349] • *Lampetra planeri* (Brook Lamprey) [1096] • *Salmo salar* (Atlantic Salmon) [1106] • *Lampetra fluviatilis* (River Lamprey) [1099] • *Petromyzon marinus* (Sea Lamprey) [1095] • *Lutra lutra* (Otter) [1355]* • *Phalacrocorax carbo* (Cormorant) [A017] • *Anas crecca* (Teal) [A052] • *Anas acuta* (Pintail) [A054] • *Aythya marila* (Scaup) [A062] • *Anas penelope* (Wigeon) [A050] • *Anas clypeata* (Shoveler) [A056] • *Tadorna tadorna* (Shelduck) [A048] • *Charadrius hiaticula* (Ringed Plover) [A137] • *Pluvialis apricaria* (Golden Plover) [A140] • *Pluvialis squatarola* (Grey Plover) [A141] • *Calidris canutus* (Knot) [A143] • *Calidris alpina* (Dunlin) [A149] • *Limosa limosa* (Black-tailed Godwit) [A156] • *Limosa lapponica* (Bar-tailed Godwit) [A157] • *Numenius arquata* (Curlew) [A160] • *Tringa totanus* (Redshank) [A162] • *Tringa nebularia* (Greenshank) [A164] • *Vanellus vanellus* (Lapwing) [A142] • *Branta bernicla hrota* (Light-bellied Brent Goose) [A046] • *Cygnus cygnus* (Whooper Swan) [A038] • *Chroicocephalus ridibundus* (Black-headed Gull) [A179] • Wetland and waterbirds [A999] Potential for effects are considered in **Section 3.4** below.

	Impact mechanism 11. Accidental large-scale oil or LNG spill It must be emphasised at the outset that accidental large-scale oil or LNG spill are extremely rare. That said, such hazards exist and cannot be ignored given the potential for significant impacts to habitat and water quality. To help ensure that such events do not occur safe working Standard Operating Procedures (SOPs) and Protocols. Potential for effects are considered in **Section 3.4** below.
	Impact mechanism 10. Introduction of invasive species Potential increase in the risk of invasive organisms being imported by LNGC and FRSU in ballast water and as ship hull fouling. Impact mechanism 10 is considered in **Section 3.4** below.
	Climate Change Chapter 15 of the STEP Environmental Impact Assessment Report assesses the likely significant effects of the Proposed Development on climate. The following aspects are particularly relevant to the climate assessment: • Construction, design and operation • The climate impact associated with the use of raw materials for construction, operation and maintenance of the Proposed Development The impact assessment identified no significant adverse effects during the construction or operation of the Proposed Development, no mitigation measures are required.
Describe any likely impacts on the Natura 2000 site as a whole in terms of: Interference with the key relationships that define the structure of the site; Interference with key relationships that define the function of the site.	Behavioural changes and/ or injury to QIs and SCI could have knock on effects to the wider function of the cSAC and SPA in particular predator/ prey relationships and foraging opportunities.
Provide indicators of significance as a result of the identification of effects set out above in terms of: Loss; Fragmentation; Disruption; Disturbance; Change to key elements of the site.	Indicators of significance are loss of SCI and QI species and habitats. Indicators of significance are behavioural changes in SCI and QI species.

Describe from the above those elements of the project or plan, or combination of elements, where the above impacts are likely to be significant or where the scale or magnitude of impacts is not known.	Potential impacts to habitats from change in water quality have the potential to be significant. Mitigation measures required to avoid impacts to water quality occurring are identified in **Section 3 (Stage 2 AA – NIS)**. Potential noise disturbance effects to bird species, mammals and diadromous fish species have the potential to be significant; significance of potential effects is assessed in **Section 3 (Stage 2 AA – NIS)**. Where possible, mitigation measures required to avoid noise impacts occurring are identified in **Section 3 (Stage 2 AA – NIS)**. Potential physical disturbance and sedimentation effects to habitats have the potential to be significant; significance of potential effects is assessed in **Section 3 (Stage 2 AA – NIS)**. Potential loss of prey biomass for Cormorant and Otter due to fish mortality; significance of potential effects is assessed in **Section 3 (Stage 2 AA – NIS)**.

3. Stage 2 Appropriate Assessment - Natura Impact Statement

3.1. Summary of Screening Outcome

The following provides a summary of the findings of the screening exercises presented in **Table 2.20** and **Table 2.21** in **Section 2.3**.

Lower River Shannon cSAC (Site code 002165)

There is potential for significant effects to the following QIs of the Lower River Shannon cSAC:

- Mudflats and sandflats not covered by seawater at low tide [1140]
- Large shallow inlets and bays [1160]
- Estuaries [1130
- Reefs [1170]
- Sandbanks which are slightly covered by sea water all the time [1110]
- *Coastal lagoons [1150]
- Perennial vegetation of stony banks [1220]
- Salicornia and other annuals colonising mud and sand [1310]
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]
- Mediterranean salt meadows (*Juncetalia maritimi*) [1410]
- *Tursiops truncatus* (Common Bottlenose Dolphin) [1349]
- *Salmo salar* (Atlantic Salmon) [1103]
- *Lampetra planeri* (Brook Lamprey) [1096]
- *Lampetra fluviatilis* (River Lamprey) [1099]
- *Petromyzon marinus* (Sea Lamprey) [1095]
- *Lutra lutra* (Otter)* [1355]

The above conservation features are brought forward to the NIS.

In contrast, as there is no viable pathway for effects to the following QIs it can be concluded that there is no likelihood for significant effects:

- Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]
- Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation [3260]
- Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) [6410]
- *Alluvial forests with Alnus glutinosa and Fraxinus excelsior (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0]
- *Margaritifera margaritifera* (Freshwater Pearl Mussel) [1029]

River Shannon and River Fergus Estuaries SPA (Site code 004077)

There is potential that the Proposed Development may directly affect the conservation feature Wetland and waterbirds [A999].

Potential direct and indirect effect to the following SCI species of the SPA were also identified:

- *Phalacrocorax carbo* (Cormorant) [A017]
- *Anas crecca* (Teal) [A052]
- *Anas acuta* (Pintail) [A054]
- *Aythya marila* (Scaup) [A062]
- *Anas penelope* (Wigeon) [A050]

- *Anas clypeata* (Shoveler) [A056]
- *Tadorna tadorna* (Shelduck) [A048]
- *Charadrius hiaticula* (Ringed Plover) [A137]
- *Pluvialis apricaria* (Golden Plover) [A140]
- *Pluvialis squatarola* (Grey Plover) [A141]
- *Calidris canutus* (Knot) [A143]
- *Calidris alpina* (Dunlin) [A149]
- *Limosa limosa* (Black-tailed Godwit) [A156]
- *Limosa lapponica* (Bar-tailed Godwit) [A157]
- *Numenius arquata* (Curlew) [A160]
- *Tringa totanus* (Redshank) [A162]
- *Tringa nebularia* (Greenshank) [A164]
- *Vanellus vanellus* (Lapwing) [A142]
- *Branta bernicla hrota* (Light-bellied Brent Goose) [A046]
- *Cygnus cygnus* (Whooper Swan) [A038]
- *Chroicocephalus ridibundus* (Black-headed Gull) [A179]

This Natura Impact Statement (NIS) has been produced to support the AA of the Proposed Development to be undertaken by the competent authority. The NIS considers in detail the aspects of the proposed project with potential for significant effects and further examines the impacts of the proposed project on the integrity of the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA with respect to the Conservation Objectives established for the conservation features of the sites. Where possible, mitigation measures are identified to prevent adverse effects on the integrity of the sites.

3.2. Proposed Development

A description of the Proposed Development is presented in **Section 1.1** and, in **Section 2.1** through **Section 2.16**, including mapping of the project relative to conservation features of relevant European sites.

3.3. Description of Receiving Environment

3.3.1. Lower River Shannon cSAC

The proposed project is in the Lower River Shannon cSAC (see **Figure 1-2** and **Figure 2-26**). The Natura 2000 Standard Data Form[6] for the cSAC lists the *negative impacting threats and pressures* and *positive impacting activities/management* affecting the site (see **Table 2.19**). The existing pressures, threats or activities that impose negative impact on the sites are:

- Discharges (E03)
- Air pollution, air-borne pollutants (H04)
- Fertilisation (A08)
- Urbanised areas, human habitation (E01)
- Eutrophication (natural) (K02.03)
- Grazing (A04)
- Polderisation (J02.01.01)
- Reclamation of land from sea, estuary or marsh (J02.01.02)

The above pressures, threats or activities impose moderate negative impacts on the site.

The Lower River Shannon cSAC is designated for a total of twenty-one Annex I Habitat and Annex II species. These Annex I Habitat and Annex II species are listed in **Table 2.15**. **Table 3.1** lists the QIs of the Lower River Shannon cSAC for which there is potential for significant effects (as identified in the screening exercise), alongside their Conservation Objective and national status. A detailed description of the site is included in the Site Synopsis report (NPWS, 2013) which is included in **Appendix 1** while a description of conservation features for which potential significant effects could not be ruled out in the screening exercise is presented below.

Table 3.1: Lower River Shannon cSAC.

Qualifying Interest		Site Conservation Objective (NPWS 2012)	National Status (NPWS 2019, 2019)
Annex I marine habitats	**Mudflats and sandflats not covered by seawater at low tide [1140]**	To maintain the favourable conservation condition	Overall Conservation Status is assessed as Inadequate Overall Trend in Conservation Status is assessed as Deteriorating
	Large shallow inlets and bays [1160]	To maintain the favourable conservation condition	Overall Conservation Status is assessed as Inadequate Overall Trend in Conservation Status is assessed as Deteriorating
	Estuaries [1130]	To maintain the favourable conservation condition	Overall Conservation Status is assessed as Inadequate Overall Trend in Conservation Status is assessed as Deteriorating
	Reefs [1170]	To maintain the favourable conservation condition	Overall Conservation Status is assessed as Bad Overall Trend in Conservation Status is assessed as Stable
	Sandbanks which are slightly covered by sea water all the time [1110]	To maintain the favourable conservation condition	Overall Conservation Status is assessed as Favourable Overall Trend in Conservation Status is assessed as Stable
	***Coastal lagoons [1150]**	To restore the favourable conservation condition	Overall Conservation Status is assessed as Bad Overall Trend in Conservation Status is assessed as Deteriorating
	Perennial vegetation of stony banks [1220]	To maintain the favourable conservation condition	Overall Conservation Status is assessed as Inadequate Overall Trend in Conservation Status is assessed as Stable
	Salicornia and other annuals colonising mud and sand [1310]	To maintain the favourable conservation condition	Overall Conservation Status is assessed as Favourable Overall Trend in Conservation Status is assessed as Stable

	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]	To restore the favourable conservation condition	Overall Conservation Status is assessed as Inadequate Overall Trend in Conservation Status is assessed as Deteriorating
	Mediterranean salt meadows (*Juncetalia maritimi*) [1410]	To restore the favourable conservation condition	Overall Conservation Status is assessed as Inadequate Overall Trend in Conservation Status is assessed as Deteriorating
Annex II marine species	***Tursiops truncatus* (Common Bottlenose Dolphin) [1349]**	To maintain the favourable conservation condition	Overall Status is assessed as Favourable Overall Trend in Conservation Status is assessed as Stable
Annex I fish species	***Lampetra planeri* (Brook Lamprey) [1096]**	To maintain the favourable conservation condition	Overall Conservation Status is assessed as Favourable Overall Trend in Conservation Status is assessed as Stable
Annex I diadromous fish species	***Salmo salar* (Salmon) [1106]**	To restore the favourable conservation condition	Overall Status is assessed as Inadequate Overall Trend in Conservation Status is assessed as Stable
	***Lampetra fluviatilis* (River Lamprey) [1099]**	To maintain the favourable conservation condition	Overall Status is Unknown (data deficient species)
	***Petromyzon marinus* (Sea Lamprey) [1095]**	To restore the favourable conservation condition	Overall Conservation Status is assessed as Unknown Overall Trend in Conservation Status is unknown
Annex I Mammal	***Lutra lutra* (Otter)* [1355]**	To restore the favourable conservation condition	Overall Conservation Status is assessed as Favourable Overall Trend in Conservation Status is assessed as Improving

3.3.2. Qualifying Interest Annex I Habitats

3.3.2.1. Overview

Lower River Shannon cSAC is a very large site and stretches along the Shannon valley from Killaloe in Co. Clare to Loop Head/ Kerry Head, a distance of some 120km. The cSAC supports a wide variety of Annex I habitats.

A description of Annex I marine/ coastal habitats of the cSAC for which potential effects from the proposed project could not be excluded in the screening exercise is provided in **Section 3.3.2.2** below. The description below of marine/ coastal Habitats is informed by reports of the cSAC prepared by NPWS. The description is also part informed by ecological surveys undertaken by AQUAFACT in the area in 2006/2007 and 2012.

Section 3.3.2.3 and **Section 3.3.2.4** respectively detail intertidal and subtidal surveys commissioned by Shannon LNG in 2020 for the Proposed Development.

3.3.2.2. *Marine/ Coastal Annex I Habitats*

The cSAC supports examples of the following Annex I habitats for which significant effects could not be screened out in the screening exercise: 1140 Mudflats and sandflats not covered by seawater at low tide, 1160 Large shallow inlets and bays, 1130 Estuaries, 1170 Reefs, 1110 Sandbanks which are slightly covered by sea water all the time, 1150 *Coastal lagoons, 1220 Perennial vegetation of stony banks, 1310 Salicornia and other annuals colonising mud and sand, 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) and 1410 Mediterranean salt meadows (*Juncetalia maritimi*)]. A total of 10 community types have been identified within the Annex I habitat 1110, 1130, 1140, 1160 and 1170 (see **Table 3.2**). **Figure 3-1** and **Figure 3-2** respectively show the extent of Annex I habitats 1130 Estuaries and 1170 Reefs overlapped by the jetty and outfall for the Proposed Development. **Figure 3-3** shows marine communities types overlapped by the jetty and outfall.

The site is an example of a large shallow inlet and bay. The site supports littoral sediment communities in the mouth of the Shannon Estuary occurring in areas that are exposed to wave action and also in areas extremely sheltered from wave action. Characteristically, exposed sediment communities are composed of coarse sand and have a sparse fauna. Species richness increases as conditions become more sheltered. All shores in the site have a zone of sand hoppers at the top, and below this each of the shores has different characteristic species giving a range of different shore types.

The intertidal reefs in the Shannon Estuary are exposed or moderately exposed to wave action and are subject to moderate tidal streams. Known sites are steeply sloping and show a good zonation down the shore. Well-developed lichen zones and littoral reef communities offering a high species richness in the sublittoral fringe and populations of the Purple Sea Urchin *Paracentrotus lividus* are found. The communities found are tolerant to sand scour and tidal streams. The infralittoral reefs range from sloping platforms with some vertical steps, to ridged bedrock with gullies of sand between the ridges, to ridged bedrock with boulders or a mixture of cobbles, gravel and sand. Kelp is very common to about 18m. Below this, it becomes rare, and the community is then characterised by coralline crusts and red foliose algae.

Figure 3-4 shows multibeam data of the seabed in the general area indicating seabed topography and bathymetry. Substrate type between 0-30m towards the southern shore consists of a mix of sand, slightly gravelly sand, gravelly sand, slightly gravelly muddy sand, gravelly muddy sand and sandy gravel (AQUAFACT, 2008; 2009). Slightly gravelly sandy mud is present between 0-10m towards the northern shore and the 30-60m zone consists of a rocky seabed with boulders, cobbles and gravel.

AQUAFACT (2008; 2009) recorded the following species from the ‘subtidal sand to mixed sediment with *Nucula nucleus* community complex’: the polychaetes *Macrochaeta clavicornis, Nephtys hombergii, Paradoneis lyra, Sphaerosyllis bulbosa, Capitella* sp. complex, *Scoloplos armiger* and *Spirobranchus* sp., the bivalves *Nucula nucleus*, *Nucula nitidosa, Nucula tenuis* and *Abra alba,* the amphipods *Unicola crenatipalma, Abludomelita obtusata, Pisidia longicornis* and *Maera othonis,* the mysid shrimp *Gastrosaccus spinifer* and the sea-squirt *Dendrodoa grossularia.* AQUAFACT (2008) recorded the following species from the ‘subtidal sand to mixed sediment with *Nephtys* spp. community complex’: the polychaetes *Terebellides stroemi, Nephtys hombergii* and *Scoloplos armiger* and the amphipods *Metaphoxus pectinatus* and *Ampelisca brevicornis.*

Within the ‘faunal turf dominated subtidal reef community’, AQUAFACT (2008; 2009) recorded a rocky seabed with boulders up to 0.5m in diameter either in tight clumps or more diffuse with some intervening mud, sands and gravel. Species of note included the queen scallop, *Aequipecten opercularis,* the green crab, *Carcinus maenas,* the harbour crab, *Liocarcinus depurator,* the spider crab *Maja squinado,* the dahlia anemone *Urticina feline,* the sea-squirt *Dendrodoa grossularia*, the reef-forming polychaete, *Sabellaria* sp. and other tubeworms and a variety of sponges and hydroids. **Figure 3-5** shows some images from the rocky seabed.

The 'fucoid dominated intertidal reef' is characterised by *Fucus spiralis* on the upper shore, *F. vesiculosus* on the mid shore and *F. serratus* on the lower shore (AQUAFACT, 2008; 2009). The associated fauna included Talitrids, limpets *Patella vulgata,* dogwhelks *Nucella lapillus*, periwinkles *Littorina littorea* and *L. obtusata,* hermit crab *Pagurus bernhardus,* barnacles and the polychaetes *Spirobranchus* sp. and spirorbid spp.

The Conservation Objectives report for the cSAC (NPWS 2012) indicates that the site is designated for four lagoons. The lagoons are: Scattery Lagoon (5.9km northwest of the development), Clooconeen Pool (18.1km west), Quayfield and Poulaweala Loughs (26.5km east), Shannon Airport Lagoon (35.5km northeast of the development). There is also a small undocumented lagoon located approximately 4.5 south west of Proposed Development. A brackish lagoon (CW1) occurs within to the south west of the Knockfinglas Point. A specialist survey of the lagoon was carried out in October 2007. A report on these surveys which was prepared concluded: "Despite the recorded salinity (0.8 – 1.1 parts per thousand) and presence of one plant, the brackish water tassle weed *Ruppia maritima*, none of the faunal taxa can be regarded as indicator species of coastal lagoons. One species, *Sigara concinna* has been listed by some authors as a lagoonal specialist in Britain, but is found at inland sites in Ireland. The lake may have been a brackish water coastal lagoon in the past and still has a barrier typical of lagoons but is at present dominated by characteristically freshwater insects and molluscs with only a few species, *e.g.* Three-spined Stickleback, *Sigara concinna*, *Haliplus rufficollis*) that can tolerate any measure of salinity. In particular, the presence of Common newts indicate that the lake has been dominated by fresh water for some time. This water body is a marginal example of a lagoon as salinity barely exceeds 1 psu. Plants frequently found in lagoons include *Ruppia maritima*, *Ranunculus baudotii* and *Potamogeton pectinatus* (although this species also occurs in freshwater and is not indicative of lagoons). No lagoonal specialist animals were noted. However the pond's morphology-isolated from the sea by a shingle barrier is a typical lagoonal feature. On balance the pond may be regarded as a lagoon based on plants and morphology but with no fauna of note. Its conservation interest lies in its transitional nature between fresh and brackish conditions."

Saltmarsh vegetation also occurs around a number of lagoons within the site, two of which have been surveyed as part of a National Inventory of Lagoons. Cloonconeen Pool (4-5 ha) is a natural sedimentary lagoon impounded by a low cobble barrier. Seawater enters by percolation through the barrier and by overwash. This lagoon represents a type which may be unique to Ireland since the substrate is composed almost entirely of peat. The adjacent shore features one of the best examples of a drowned forest in Ireland. Aquatic vegetation in the lagoon includes typical species such as Beaked Tasselweed (*Ruppia maritima*) and green algae (*Cladophora* sp.). The fauna is not diverse but is typical of a high salinity lagoon and includes six lagoon specialists (*Hydrobia ventrosa*, *Cerastoderma glaucum*, *Lekanesphaera hookeri*, *Palaemonetes varians*, *Sigara stagnalis* and *Enochrus bicolor*). In contrast, Shannon Airport Lagoon (2 ha) is an artificial saline lake with an artificial barrier and sluiced outlet. However, it supports two Red Data Book species of stonewort (*Chara canescens* and *Chara cf*. *connivens*).

In the transition zone between mudflats and saltmarsh, specialised colonisers of mud predominate. For example, swards of Common Cord-grass (*Spartina anglica*) frequently occur in the upper parts of the estuaries. Less common are swards of Glasswort (*Salicornia europaea agg*.). In the innermost parts of the estuaries, the tidal channels or creeks are fringed with species such as Common Reed (*Phragmites australis*) and club-rushes (*Scirpus maritimus*, *S. tabernaemontani* and *S. triquetrus*). In addition to the nationally rare Triangular Club-rush (*S. triqueter*), two scarce species are found in some of these creeks (*e.g. Ballinacurra Creek*): Lesser Bulrush (*Typha angustifolia*) and Summer Snowflake (*Leucojum aestivum).*

Most of the site west of Kilcredaun Point/Kilconly Point is bounded by high rocky sea cliffs. The cliffs in the outer part of the site are sparsely vegetated with lichens, Red Fescue, Sea Beet (*Beta vulgaris* *subsp. maritima*), Sea Campion (*Silene vulgaris subsp. maritima*), Thrift and plantains (*Plantago* spp.). A rare endemic type of sea lavender, *Limonium recurvum subsp. pseudotranswallianum*, occurs on cliffs near Loop Head. Cliff-top vegetation usually consists of either grassland or maritime heath. The boulder clay cliffs further up the estuary tend to be more densely vegetated, with swards of Red Fescue and species such as Kidney Vetch (*Anthyllis vulneraria*) and Common Bird's-foot-trefoil (*Lotus corniculatus*).

Other coastal habitats that occur within the site include stony beaches and bedrock shores (these support a typical zonation of seaweeds such as *Fucus spp*., *Ascophyllum nodosum* and kelps), shingle beaches (with species such as Sea Beet, Sea Mayweed - *Matricaria maritima*, Sea Campion and Curled Dock - *Rumex crispus*), sandbanks which are slightly covered by sea water at all times (*e.g.* in the area from Kerry Head to Beal Head).

Potential for impact to the Annex I habitats are discussed in **Section 3.4** below.

An assessment of the potential impacts of the project on the integrity of the cSAC is undertaken in **Section 3.5** in relation to the attributes and targets identified for the habitats in the site Conservation Objectives (NPWS, 2012).

Table 3.2: Community types within Annex I habitat of the Lower River Shannon cSAC.

Community type	1110	1130	1140	1160	1170
Intertidal sand with *Scolelepis squamata* and *Pontocrates* spp. Community			✓	✓	
Intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex		✓	✓	✓	
Estuarine subtidal muddy sand to mixed sediment with gammarids community complex		✓			
Subtidal sand to mixed sediment with *Nucula nucleus* community complex		✓		✓	
Subtidal sand to mixed sediment with *Nephtys* spp. community complex	✓	✓		✓	
Fucoid-dominated intertidal reef community complex				✓	✓
Mixed subtidal reef community complex				✓	✓
Faunal turf-dominated subtidal reef community		✓		✓	✓
Anemone-dominated subtidal reef community		✓		✓	✓
Laminaria-dominated community complex		✓		✓	✓

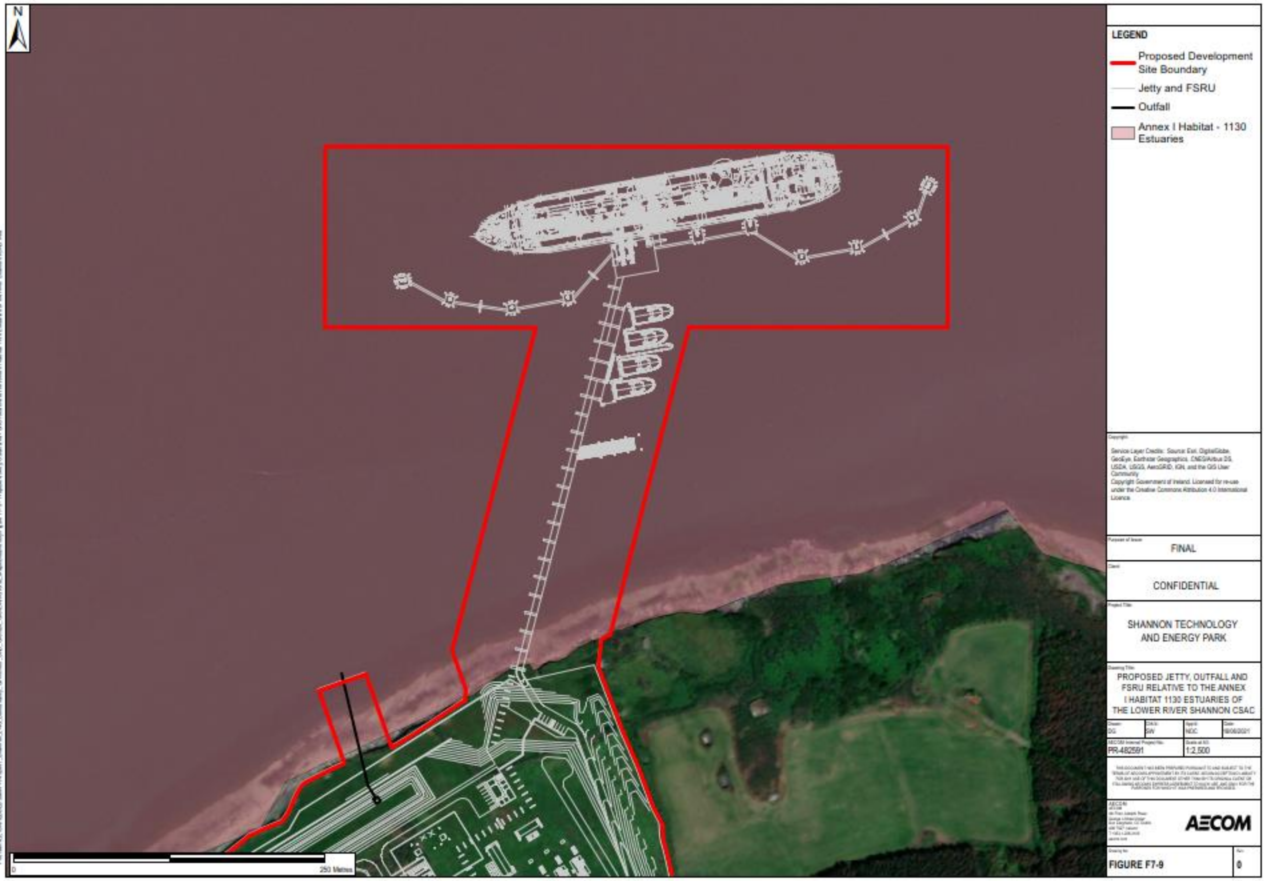


Figure 3-1: Proposed jetty, outfall and FRSU relative to the Annex I Habitat 1130 Estuaries of the Lower River Shannon cSAC.

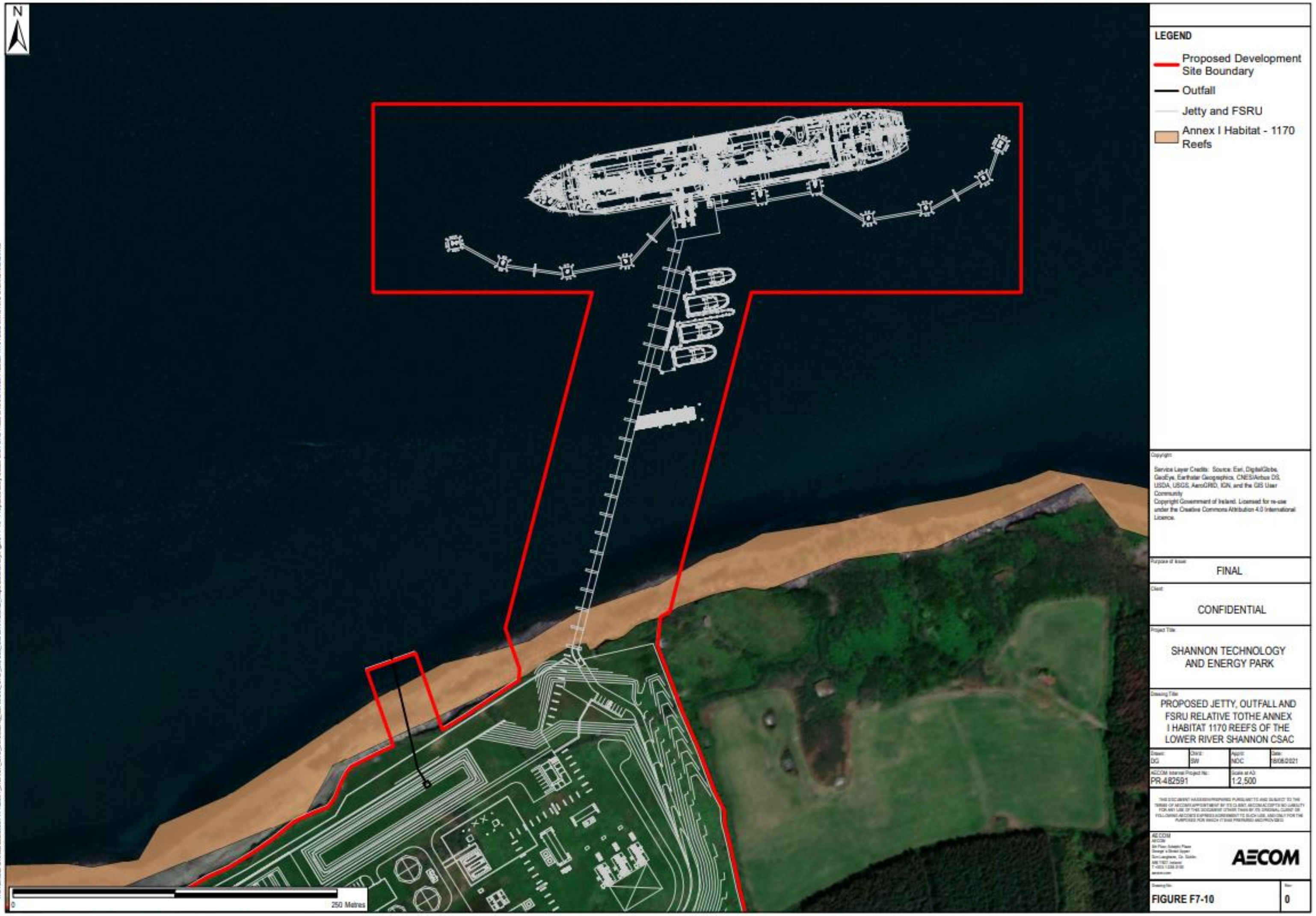


Figure 3-2: Proposed jetty, outfall and FRSU relative to the Annex I Habitat 1170 Reefs of the Lower River Shannon cSAC.

Figure 3-3: Proposed jetty, outfall and FRSU relative to marine community types within Annex I Habitats of the Lower River Shannon cSAC.

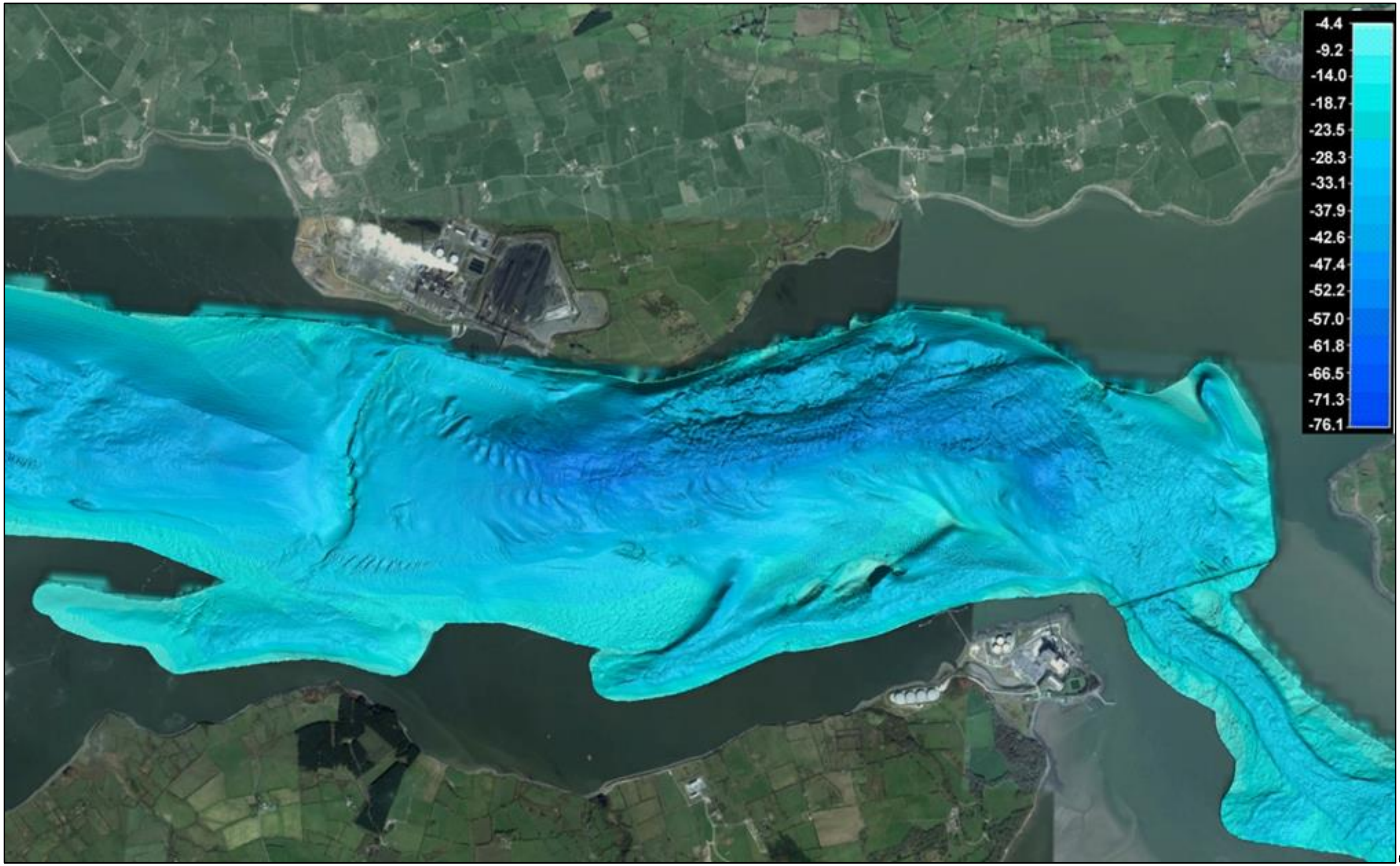


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Figure 3-4: Multibeam bathymetry of the seabed.

Figure 3-5: Representative images from rocky seabed within the general area (AQUAFACT, 2008).

3.3.2.3. Intertidal Survey

AQUAFACT carried out 2 intertidal transects (T1 and T7) on the 8th April 2020 and a further 2 (T3 and T8) on the 9th April 2020. Transects T3, T7 and T8 had surveyed in 2012 and in 2006/2006 T1, T3, T7 and T8 were surveyed along with another 4 transects (see **Figure 3-6**). The weather on both days was dry and sunny, with no cloud cover and there was a force 3 south-westerly wind blowing on the 8th and a force 3 south-easterly wind on the 9th. Low water was at 11:49pm (-0.1m) at Tarbert Island on the 8th and at 12.25pm, (-0.1m) on the 9th.

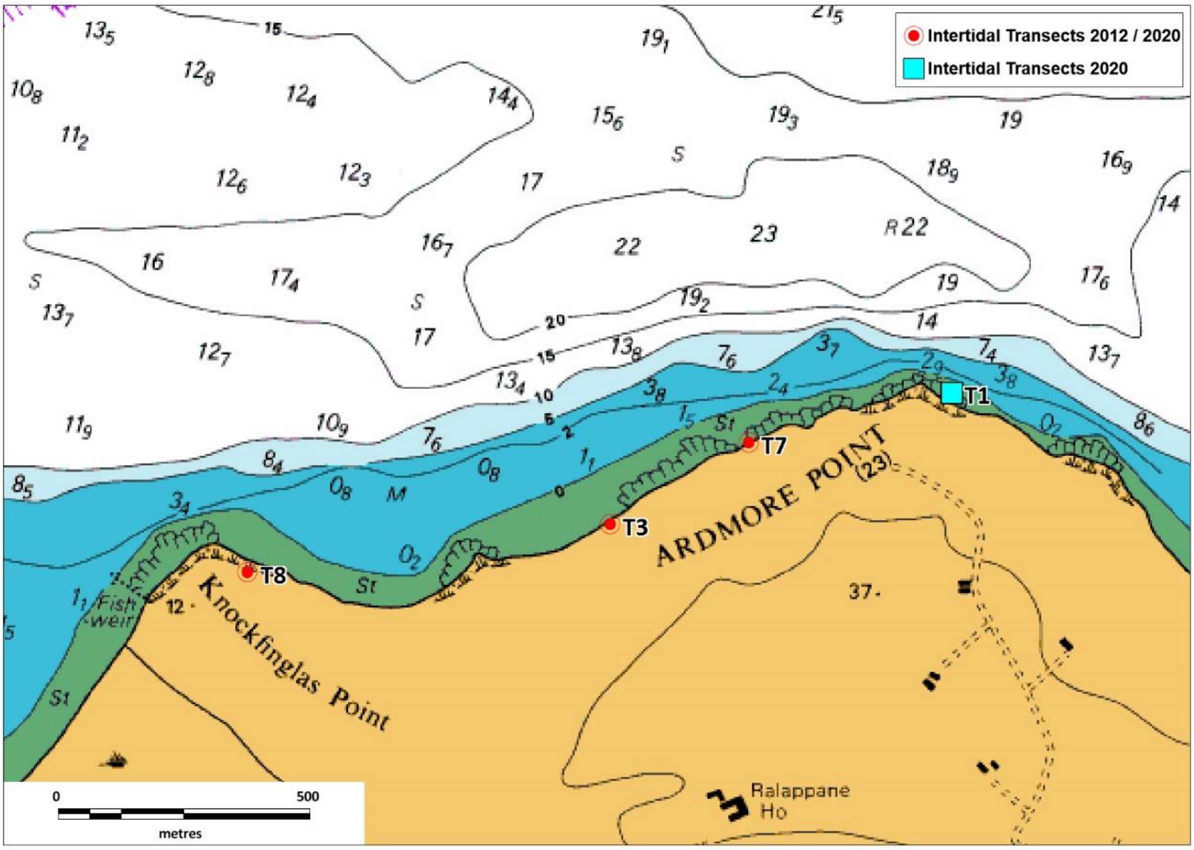


Figure 3-6: Location of the intertidal transects surveyed on the 8th and 9th April 2020.

Along each transect, a 0.25m^2 quadrat was surveyed at three stations (Upper Shore, Mid Shore and Lower Shore). Salient features were noted as they were encountered along each transect and additional notes, supplemental photographs and level readings made where appropriate.

Numerous rocks and stones were overturned and algal canopy cover partially removed at each station (where applicable) to investigate for the presence of any faunal species.

Photographs were taken to record the position of transects and any fixed and conspicuous landmarks which would aid returns to these locations in the future, while each of the 3 stations was marked using global positioning system.

The physical features of the intertidal zone were described and photographed in detail. General physical features which were recorded included:

- surface relief (even–uneven)
- firmness (firm–soft)
- stability (stable–mobile)
- sorting (well–poor)

- black layer (1 = not visible., 2 = >20cm, 3 = 5–20cm, 4 = 1–5cm, 5 = <1cm)

Station-specific physical features which were recorded included:

- mounds/casts
- burrows/holes
- tubes
- algal mat
- waves/dunes (>10cm high)
- ripples (<10cm high)
- drainage channels/creeks
- standing water
- subsurface coarse layer
- subsurface clay/mud
- surface silt/flocculent

<u>Results:</u>

Transect 1

This transect was located 140m southeast of Ardmore Point. (Starting Point: 52.583921°N, 9.428811°W). The start and end points and the quadrat locations can be seen in **Figure 3-7**. The total length of the transect from upper to lower shore was 56.8m. The view along the transect from the upper to lower shore and from lower to upper shore can be seen in **Figure 3-8**. This transect was backed by forestry plantation. At the top of this transect, a hill topped with grass, bramble, fern and gorse sloped directly onto the cobble shore (see **Figure 3-9**). The cobble shore continued to the lower shore before giving way to a substrate of cobbles and muddy sand at the extreme lower shore. The geology of the region is predominately a mix of Namurian shales, flags and sandstones.

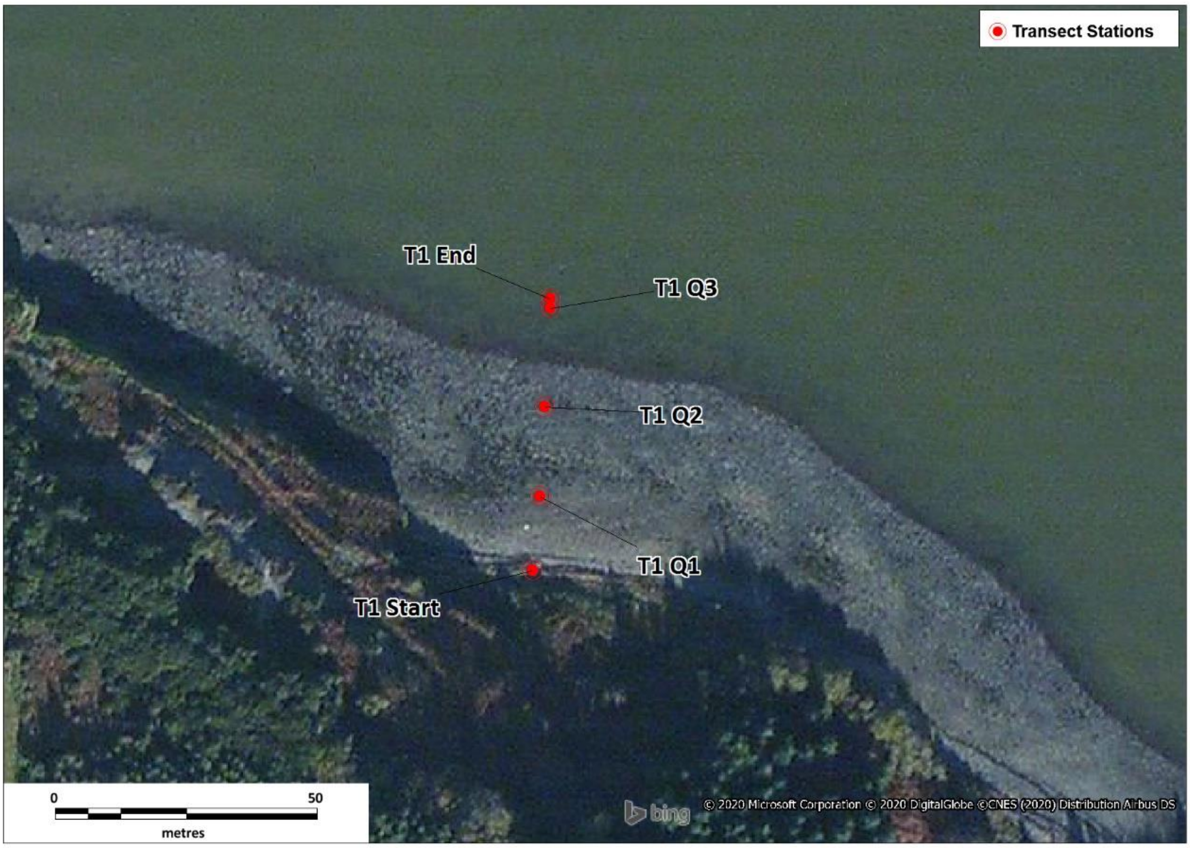


Figure 3-7: Start and end points and Quadrat locations along Transect 1.

Figure 3-8: Intertidal Transect 1. View from upper and lower shores.

Figure 3-9: Strandline above Transect 1.

Upper Shore

The upper shore consisted of a boulder-cobble mix with very sparse coverage of channel wrack (*Pelvetia canaliculata*). The *Pelvetia* algal zone extended from 8.7m to 13.6m along the transect and the sparse spiral wrack (*Fucus spiralis*) algal band extended from 11.4m to 28.1m along the transect. Within the upper shore quadrat, there was 10% coverage of *P. canaliculata.*

Figure 3-10 shows the quadrat surveyed in the upper shore. Talitrid amphipods (2 individuals/0.025m²) and rough periwinkle, *Littorina saxatilis,* (7 individuals/0.025m²) were also recorded.

This biotope corresponds with JNCC biotope ‘LS.LCS.Sh.BarSh Barren littoral shingle’(EUNIS A2.111).

Figure 3-10: Transect 1. Upper Shore Quadrat.

Mid Shore

The mid shore consisted of boulders and shale cobbles with sparse algal cover. The sparse *Fucus vesiculosus* algal band extended from 28.2m to 45.3m along the transect. Within the mid shore quadrat, *Fucus vesiculosus* accounted for approximately 7% cover.

Littorina saxatilis (14 individuals/0.025m²), common periwinkle, *Littorina littorea,* (8 individuals/0.025m²), grey topshell, *Steromphala cineraria,* (approx. 5 individuals/0.025m²), flat topshell, *Steromphala umbilicalis*[26] (approx. 2 individuals/0.025m²) and common limpet, *Patella vulgata, (*2 individuals/0.025m²) were recorded.

Figure 3-11 shows the mid shore quadrat. This biotope corresponds with JNCC biotope 'LS.LCS.Sh.BarSh Barren littoral shingle' (EUNIS A2.111).

Figure 3-11: Transect 1. Mid Shore Quadrat.

[26] *Steromphala cineraria* and *S. umbilicalis* were previously known as *Gibbula cineraria* and *G. umbilicalis.*

Lower Shore

The lower shore substrate consisted of fine sand and shale cobbles. Algal band within the lower shore included serrated wrack, *Fucus serratus,* (43.7m to subtidal) and *Chondrus crispus* (50.3m into subtidal). The quadrat contained *Fucus serratus* (approx. 80% coverage) with encrusting spirorbids, encrusting red algae (10% coverage), *Chondrus crispus* (<10% coverage), *Dilsea carnosa* (<1% coverage), *Delesseria sanguinea* (<1% coverage), *Ceramium* spp. (<1% coverage), *Apoglossum ruscifolium* (<1% coverage), *Palmaria palmata* (<1% coverage), *Polysiphonia* spp. (<1% coverage) and other filamentous red algae (<1% coverage).

Fauna observed included *Littorina littorea* (2 individuals/0.025m²), *Lanice conchilega* (1 individual/0.025m²) and *Ostrea edulis* (1 individual/0.025m²).

Figure 3-12 shows the quadrat surveyed on the lower shore. This biotope corresponds with JNCC biotope 'LR.MLR.BF.Fser.R *Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock' (EUNIS A1.2141).

Figure 3-12: Transect 1. Lower Shore Quadrat.

Transect 3

This transect was located approximately 650m southwest of Ardmore Point and approximately 800m east of Knockfinglas Point. (Starting Point: 52.58227°N, 9.43939°W). The start and end points and the quadrat locations can be seen in **Figure 3-13**. The total length of the transect from upper to lower shore was 53.4m. The view along the transect from the upper to lower shore and from lower to upper shore can be seen in **Figure 3-14**.

This transect was backed by a mixed soil cliff (*ca* 3-4m high). This cliff was backed by improved agricultural land. The strandline (see **Figure 3-15**) consisted of a gravel track (c. 2-3m wide) with outcropping boulders, which consisted of washed up *Ascophyllum nodosum* and *Fucus vesiculosus.* The boulders were covered with lichens (*Verrucaria, Caloplaca thallinicola, Tephromela atra* and *Ramalina cuspidata*).

The biotope located in the supralittoral level corresponds with the 'LR.FLR.Lic.YG Yellow and grey lichens on supralittoral rock' according to the Marine Habitat Classification for Britain and Ireland (Connor et al., 2004). The gravel and boulder mix merges into a boulder field towards the mid and lower shore.

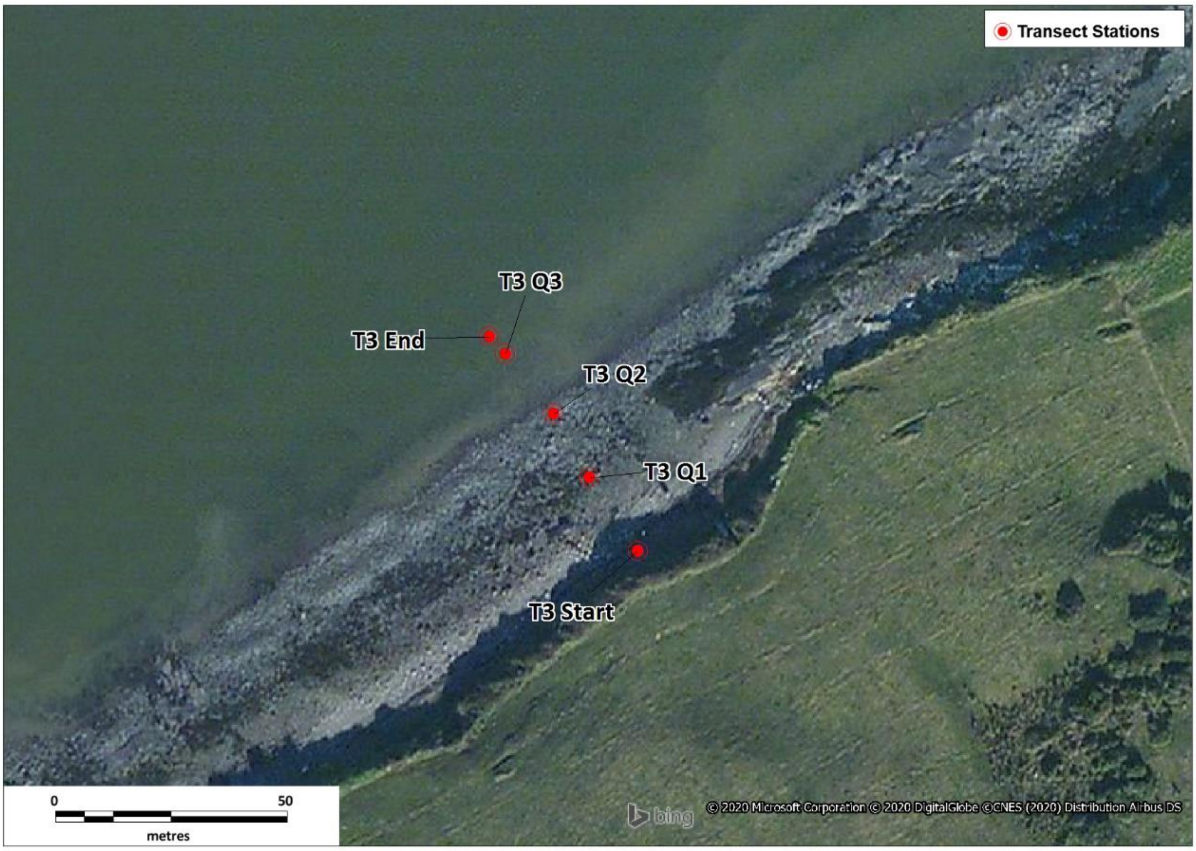


Figure 3-13: Start and end points and Quadrat locations along Transect 3.

Figure 3-14: Intertidal Transect 3. View upper and lower shore.

Figure 3-15: Strandline above Transect 3.

Upper Shore

The upper shore consisted of a gravel-boulder mix. The *Pelvetia canaliculata* algal band extended from 10.9m to 15.6m down the transect; the *Fucus spiralis* algal band from 13.2m to 17.8m; the *Ascophyllum nodosum* algal band from 16.4 to 28.4m. The *Fucus vesiculosus* algal band from 17.4m to 47.5m.

The quadrat (**Figure 3-16**) contained 30% coverage of *Ascophyllum nodosum,* 30% *Fucus vesiculosus, Patella vulgata* (16 individuals), *Carcinus maenas* (1), Talitrid amphipods (>100 individuals), *Melaraphe neritoides* (5), *Littorina littorea* (1) and *Littorina obtusata* (2).

The upper shore at this location displays elements of both the 'LS.LCS.Sh.BarSh Barren littoral shingle' biotope (EUNIS code A2.111) and the 'LR.LLR.FVS.AscVS *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock' (EUNIS code A1.324).

Figure 3-16: Upper Shore Quadrat, Transect 3

Mid Shore

The mid shore consisted of a boulder field with patches of *Fucus vesiculosus*. *Polysiphonia* spp. recorded at 20m.

Figure 3-17 shows the quadrat surveyed in the mid shore. It contained no macroalgae, *Patella vulgata* (11 individuals), *Littorina littorea* (7), *Steromphala cineraria* (2), *Semibalanus balanoides* (5% cover) and *Austrominius modestus* (<1%).

This biotope corresponds to the 'LR.HLR.MusB.Sem.LitX *Semibalanus balanoides* and *Littorina* spp. on exposed to moderately exposed eulittoral boulders and cobbles' (EUNIS code A1.1133).

Figure 3-17: Mid Shore Quadrat, Transect 3.

Lower Shore

The lower shore consisted of a boulder field with patches of *Fucus serratus* and *Chondrus crispus*. The *Fucus spiralis* algal band extended from 41.3m to 52m; the *Chondrus crispus* algal band from 51.1m into the subtidal; *Laminaria digitata* extended from 53.4m into the subtidal.

Within the 0.25m^2 quadrat the following flora and fauna were found – *Chondrus crispus* (55% coverage), *Fucus serratus* (25%), *Steromphala cineraria* (1 individual) and *Littorina littorea* (6).

Figure 3-18 shows the lower shore quadrat. These biotopes correspond to the LR.MLR.BF.Fser.R *Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock' (EUNIS code A1.2141).

Figure 3-18: Lower Shore Quadrat, Transect 3.

Transect 7

This transect was located approximately 335m southwest of Ardmore Point (Starting Point: 52.58375°N, 9.43536°W). The start and end points and the quadrat locations can be seen in **Figure 3-19**.

The view along the transect from the upper to lower shore and from lower to upper shore can be seen in **Figure 3-20**. This transect was backed by improved agricultural land. At the top of this transect a 3m high vertical cliff topped with grass, ivy and gorse dropped directly onto bedrock (see **Figure 3-21**).

The flat bedrock was covered with lichens (*Caloplaca* spp., *Tephromela atra* and *Ramalina* spp.). The biotope located in the supralittoral level corresponds with the JNCC 'LR.FLR.Lic.YG Yellow and grey lichens on supralittoral rock' (EUNIS code B3.111) The bedrock continued to the end of the mid shore before giving way to a substrate of stones, cobbles and pebbles with some muddy sand at the extreme lower shore.

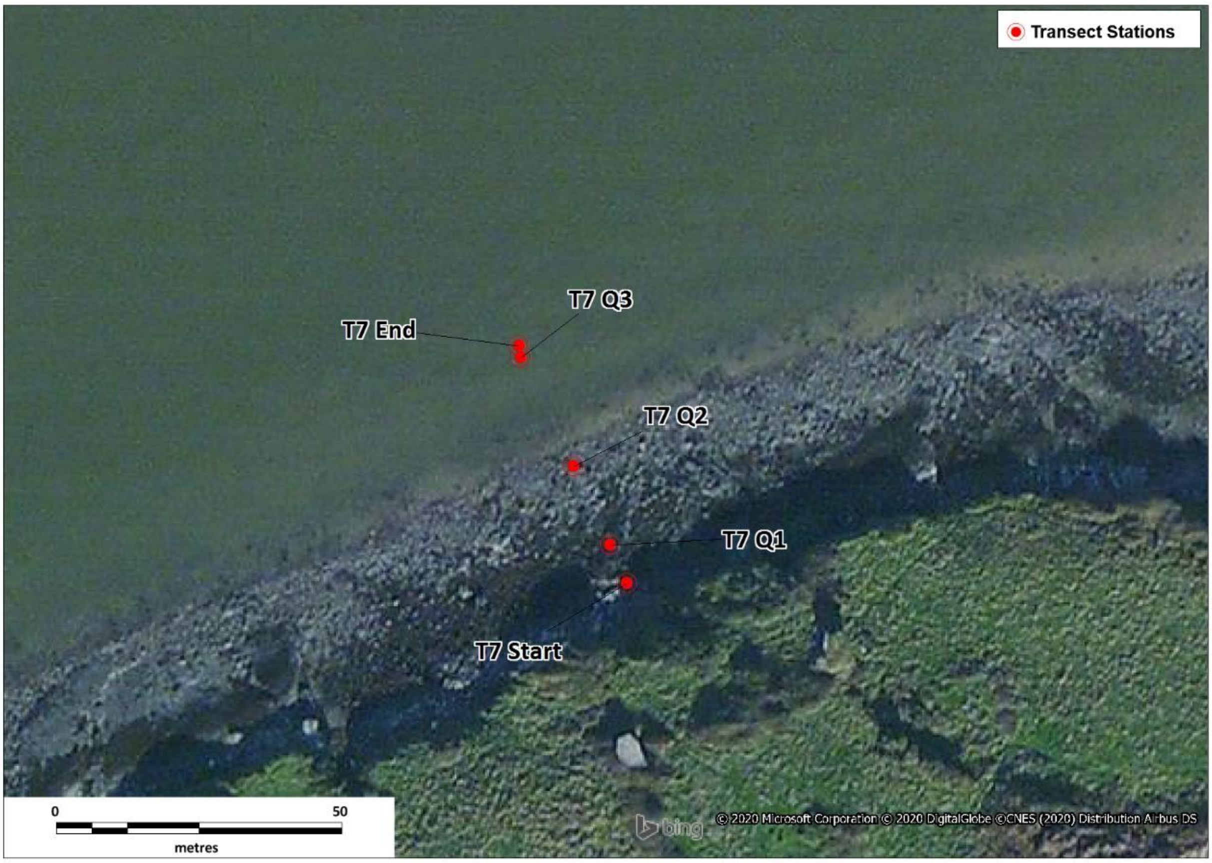


Figure 3-19: Start and end points and Quadrat locations along Transect 7.

Figure 3-20: Intertidal Transect 7. View from upper and lower shore.

Figure 3-21: Strandline above Transect 7.

Upper Shore

The upper shore consisted of broken bedrock with *Pelvetia canaliculata* present in a band extending from 1.2m to 5.8m covering between 80 – 100% of the bedrock substrate in the upper eulittoral. The *Fucus spiralis* algal band extended from 4m to 6.9m; the *Ascophyllum nodosum* algal band from 4.8m to 9.6m and the *Fucus vesiculosus* algal band extended from 9.2m into the midshore to 31.1m.

Figure 3-22 shows the quadrat from the upper shore. Flora and fauna from the quadrat included *Ascophyllum nodosum* (100% coverage), *Vertebrata lanosa* (10%), *Patella vulgata* (17 individuals), *Littorina obtusata* (2), Talitrid amphipods (3), *Ligia oceanica* (1) and *Semibalanus balanoides* (<1%).

The biotopes found in the upper eulittoral correspond to the JNCC biotopes 'LR.LLR.FVS.PelVS *Pelvetia canaliculata* on sheltered, variable salinity littoral fringe rock' (EUNIS code A1.311) above 'LR.LLR.F.Fspi *Fucus spiralis* on moderately exposed to very sheltered upper eulittoral rock' (EUNIS code A1.3122) which was above 'LR.LLR.FVS.AscVS *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock' (EUNIS code A1.3141).

Figure 3-22: Upper Shore Quadrat, Transect.

Mid Shore

The flat broken bedrock with small boulders continued down into the mid shore region. Patches of *Fucus vesiculosus* were present (*ca* 20% cover).

Figure 3-23 shows the quadrat from the mid shore. Flora and fauna within the quadrat included *Fucus vesiculosus* (10% coverage), *Littorina littorea* (9 individuals), *Littorina saxatilis* (2), *Littorina obtusata* (1), *Steromphala cineraria* (1), *Patella vulgata* (3), *Semibalanus balanoides* (<1%) and *Austrominius modestus* (<1%).

This biotope corresponds to the JNCC biotope 'LR.LLR.FVS.FvesVS *Fucus vesiculosus* on variable salinity mid eulittoral boulders and stable mixed substrata' (EUNIS code A1.323).

Figure 3-23: Mid Shore Quadrat, Transect 7.

Lower Shore

The substrate in the lower shore was composed of small boulders on bedrock with silt deposits. The *Fucus serratus* algal band began at 30.9m and extended into the lower shore to 39m. Other macroalgae in the lower shore included *Laminaria digitata* (at 40.1m), *Delesseria sanguinea* and *Ceramium* spp. (at 42m) and encrusting red algae (at 41.2m).

Figure 3-24 shows the quadrat from the lower shore. The flora and fauna recorded within the quadrat include *Laminaria digitata* (4 holdfasts, 20% coverage), *Chondrus crispus* (10%) *Delesseria sanguinea* (<5%), *Ceramium* spp. (<5%), *Phycodrys rubens* (<5%) and Gracilariacea (<5%), encrusting polychaetes *Spirorbis* spp. (5%) and saddle oyster *Anomia ephippium* (5 individuals).

These biotopes correspond to the JNCC biotope 'IR.MIR.KR.Ldig.Ldig *Laminaria digitata* on moderately exposed sublittoral fringe bedrock' (EUNIS code A3.2111).

Figure 3-24: Lower Shore Quadrat, Transect 7.

Transect 8

This transect was located east of the tip of Knockfinglas Point (Starting Point: 52.58114°N, 9.44946°W). The start and end points and the quadrat locations can be seen in **Figure 3-25**.

The view along the transect from the upper to lower shore and from lower to upper shore can be seen in **Figure 3-26**.

The strandline/splash zone consisted of a gravel shore merging onto a mixed sediment cliff (approximately 4m high), the top of which was banking onto a grass field which contained bramble, gorse and ivy (see **Figure 3-27**). Some of the rocks and cobbles in the strandline were sparsely covered with lichens (*Tephromela atra*).

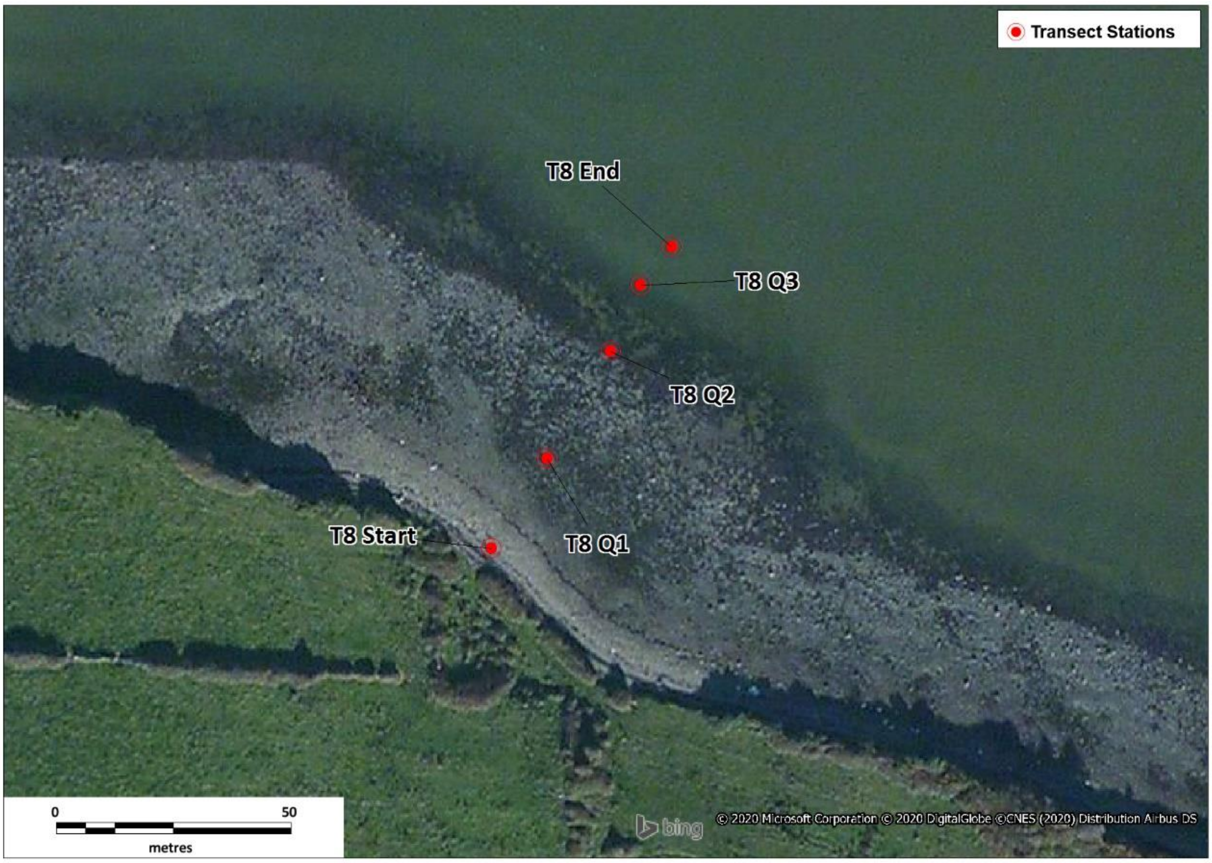


Figure 3-25: Start and end points and Quadrat locations along Transect 8.

Figure 3-26: Intertidal Transect 8. View from upper and lower shores.

Figure 3-27: Strandline above Transect 8.

Upper Shore

The upper shore consisted of cobbles, dominated by a band of *Pelvetia canaliculata* (from 9.6m to 18.4m) above a band of *Fucus spiralis* (14.4m to 19.9m). The *Ascophyllum nodosum* algal band extended from 19.5m into the mid-shore to 33.2m. Barnacles (*Austrominius modestus* and *Semibalanus* balanoides) were noted on the cobbles.

Figure 3-28 shows the quadrat from the upper shore. Flora and fauna within the quadrat include *Ascophyllum nodosum* (40% coverage), *Vertebrata lanosa* (5%), *Fucus spiralis* (5%), *Patella vulgata* (3), *Littorina littorea* (6), *Littorina saxatilis* (15), *Littorina obtusata* (2), Talitrid amphipods (>100 individuals), *Austrominius modestus* (5%) and *Semibalanus balanoides* (5%).

The biotopes in the upper shore resembled the 'LR.LLR.F.Pel *Pelvetia canaliculata* on sheltered littoral fringe rock' (EUNIS code A1.311), 'LR.LLR.F.Fspi *Fucus spiralis* on moderately exposed to very sheltered upper eulittoral rock biotopes' (EUNIS code A1.3122) and 'LR.LLR.FVS.AscVS *Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock' (EUNIS code A1.3141).

Figure 3-28: Upper Shore Quadrat, Transect 8.

Mid Shore

The mid shore consisted of boulders, cobbles and gravel. A *Fucus vesiculosus* algal band extended from 19.2m to 60.2m. **Figure 3-29** shows the mid shore transect.

Flora and fauna within the quadrat include *Fucus vesiculosus* (5% coverage), *Littorina littorea* (6 individuals), *Littorina saxatilis* (15), *Patella vulgata* (3), *Steromphala cineraria* (1), Talitrid amphipods (20), *Austrominius modestus* (<1%) and *Semibalanus balanoides* (<1%).

This biotope corresponds to the JNCC biotope 'LR.LLR.FVS.FvesVS *Fucus vesiculosus* on variable salinity mid eulittoral boulders and stable mixed substrata' (EUNIS code A1.323).

Figure 3-29: Mid Shore Quadrat, Transect 8.

Lower Shore

The lower shore substrate consisted of fine sand and cobbles. The *Fucus serratus* algal band extended from 42.6m to 67.7m and a band of *Chondrus crispus* extended from 65.8m into the subtidal.

Figure 3-30 shows the quadrat surveyed on the lower shore. The flora and fauna recorded in the quadrat included *Fucus serratus* (75% coverage), with encrusting spirorbids on the algae, *Littorina saxatilis* (3 individuals), there was also a small patch of reef building polychaete *Sabellaria* present (15%). Elsewhere on the sandy lower shore there were numerous sand mason tubes (*Lanice conchilega,* approx. 160/m^2).

This biotope corresponds to the JNCC biotopes 'LR.MLR.BF.Fser.R *Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock' (EUNIS code A1.2141) and 'SS.SCS.ICS.SLan Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand' (EUNIS A5.137).

Figure 3-30: Lower Shore Quadrat, Transect 8.

3.3.2.4. Subtidal Survey

To carry out the subtidal benthic assessment of the area, AQUAFACT sampled a total of 10 stations. Sampling took place on the 17th April 2020 from AQUAFACT's 6.8m Lencraft RIB. The weather on the day was dry and mild with a force 3 easterly wind. All stations sampled can be seen in **Figure 3-31** and their locations were selected in order to be representative of the previous survey sites. Station coordinates are presented in **Table 3.3**.

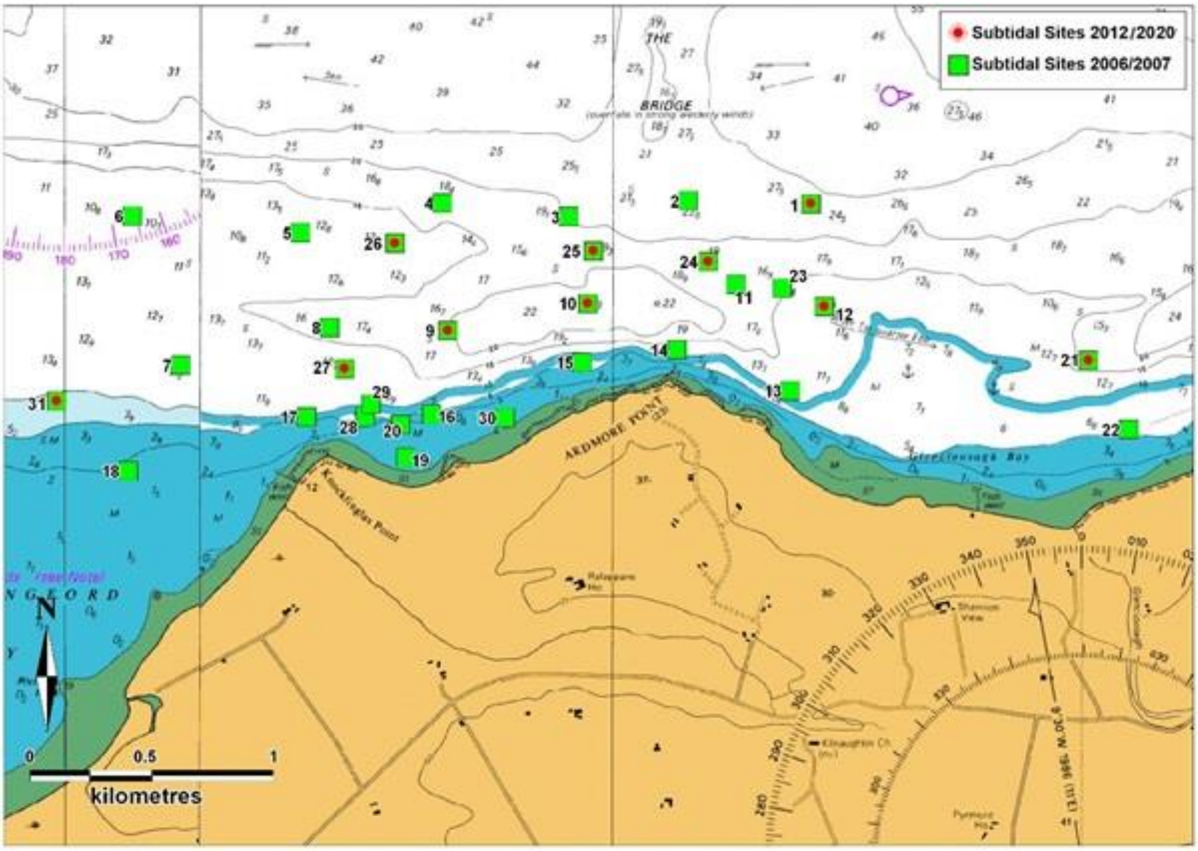


Figure 3-31: Location of all 10 stations sampled on the 17th April 2020 (and October 2012) and the 31 stations sampled in 2006/2007.

Table 3.3: Coordinates

Station	Longitude	Latitude	Longitude	Easting	Northing
S1	-9.42206	52.59132	-9.42206	103676.3	149798.2
S9	-9.44401	52.58662	-9.44401	102178.6	149304.8
S10	-9.43554	52.58762	-9.43554	102754.8	149404.6
S12	-9.42125	52.58752	-9.42125	103722.9	149374.3
S21	-9.40523	52.58555	-9.40523	104804.4	149134.3
S24	-9.42828	52.58917	-9.42828	103250.1	149567.5
S25	-9.43522	52.58955	-9.43522	102781.1	149619.4

Station	Longitude	Latitude	Longitude	Easting	Northing
S26	-9.44723	52.58982	-9.44723	101967.3	149665.4
S27	-9.45025	52.5852	-9.45025	101752.5	149155.8
S31	-9.4677	52.58398	-9.4677	100567.1	149044.3

AQUAFACT has in-house standard operational procedures for benthic sampling, and these were followed for this project. Additionally, the recently published MESH report on "Recommended Standard methods and procedures" was adhered to.

A 0.025m^2 van Veen grab was used to sample each station and 3 replicate grab samples were collected at each site. On arrival at each sampling station, the vessel location was recorded using DGPS (Lat/Long & ING). The grab deployment and recovery rates did not exceed 1 metre/sec and were <0.5 m/sec for the last 5 metres for water depths up to 30m and for the last 10m for depths greater than 30m.

A digital image of each sample (including sample label) was taken, and its reference number entered in the sample data sheet. The grab sampler was cleaned between stations to prevent cross contamination.

Each grab sample was carefully and gently sieved on a 1mm mesh sieve as a sediment water suspension for the retention of fauna. Great care was taken during the sieving process in order to minimise damage to taxa such as spionids, scale worms, phyllodocids and amphipods. The sample residue was carefully flushed into a pre-labelled (internally and externally) container from below. Each label contained the sample code and date. The samples were stained immediately with Eosin-briebrich scarlet and fixed immediately in with 4% w/v buffered formaldehyde solution (10% w/v buffered formaldehyde solution for very organic mud).

An addition grab sample was collected at each station for sediment analysis (organic carbon and granulometry). Each sediment sample was placed in plastic sampling bags and labelled internally and externally. These samples were frozen (<-18°C) as soon as possible after acquisition.

Sample Processing

All faunal samples were placed in an illuminated shallow white tray and sorted first by eye to remove large specimens and then sorted under a stereo microscope (x10 magnification). Following the removal of larger specimens, the samples were placed into Petri dishes, approximately one half teaspoon at a time and sorted using a binocular microscope at x25 magnification.

The fauna was sorted into four main groups: Polychaeta, Mollusca, Crustacea and others. The 'others' group consisted of echinoderms, nematodes, nemerteans, cnidarians and other lesser phyla. The fauna were maintained in stabilised 70% industrial methylated spirit (IMS) following retrieval and identified to species level where practical using a binocular microscope, a compound microscope and all relevant taxonomic keys. After identification and enumeration, specimens were separated and stored to species level.

The sediment granulometric analysis was carried out by AQUAFACT using the traditional granulometric approach. Traditional analysis involved the dry sieving of approximately 100g of sediment using a series of Wentworth graded sieves. The process involved the separation of the sediment fractions by passing them through a series of sieves. Each sieve retained a fraction of the sediment, which were later weighed, and a percentage of the total was calculated. **Table 3.4** shows the classification of sediment particle size ranges into size classes. Organic carbon analysis was carried out using the Loss on Ignition technique.

Table 3.4: The classification of sediment particle size ranges into size classes (adapted from Buchanan, 1984).

Range of Particle Size	Classification	Phi Unit
<63µm	Silt/Clay	>4 Ø
63-125 µm	Very Fine Sand	4 Ø, 3.5 Ø
125-250 µm	Fine Sand	3 Ø, 2.5 Ø
250-500 µm	Medium Sand	2 Ø, 1.5 Ø
500-1000 µm	Coarse Sand	1 Ø, 1.5 Ø
1000-2000 µm (1 – 2mm)	Very Coarse Sand	0 Ø, -0.5 Ø
>2000 µm (> 2mm)	Gravel	< -1 Ø

Data Analysis

Sediment Data

Organic content of sediment samples was determined for each sample by expressing as a percentage the sediment weight loss following combustion over the initial weight of the sediment. In general, LOI correlates with sediment particle size with fine-grained sediments typically containing higher levels of organic matter than coarse sediments.

For the granulometric analysis of sediment samples, the <63 µm (Silt-Clay) fraction was determined by weight loss following wet sieving. Coarser fractions comprising the sediment samples were determined by mechanical dry sieving through a series of Wentworth sieves; >4mm (Fine Gravel), 2-4mm (Very Fine Gravel), 1-2mm (Very Coarse Sand), 0.5-1mm (Coarse Sand), 0.25-0.5mm (Medium Sand), 125-250mm (Fine Sand), 62.5-125mm (Very Fine Sand). For each station, the weight of each fraction of the sediment retained on the sieve was expressed as a percentage of the total sample. The relative proportion of sediments in each fraction was used to classify sediments at the station *sensu* Folk (1954).

Additionally, a drop-down video survey of the seabed was carried out using a drop-down camera (manufactured by LH-Camera). This is an upgraded version of their standard unit. Its specification includes a high resolution, 560-line colour PAL camera with 0.1 lux sensitivity. A video overlay unit allowed position (GPS) to be inserted and recorded continually on screen, streamlining the incorporation of footage into GIS for ground truthing and mapping purposes. The video photography data will be reviewed, and the locations of habitats and/or associated flora and faunal communities will be noted.

Faunal Data

Uni- and multi-variate statistical analysis of the faunal data was undertaken using PRIMER v.6 (Plymouth Routines in Ecological Research).

Univariate Indices

Using PRIMER the faunal data was used to produce a range of univariate indices. Univariate indices are designed to condense species data in a sample into a single coefficient that provides quantitative estimates of biological variability (Heip *et al.,* 1998; Clarke and Warwick, 2001). Univariate indices can be categorised as primary or derived indices.

Primary biological indices used in the current study include:

1. Number of taxa (S) in the samples and
2. Number of individuals (N) in the samples.

Derived biological indices, which are calculated based on the relative abundance of species in samples, used in the study include:

3. Margalef's species richness index (d) (Margalef, 1958),

$$D = \frac{S-1}{\log_2 N}$$

where: N is the number of individuals and S is the number of species.

Margalef's species richness is a measure of the total number of species present for a given number of individuals.

4. Pielou's Evenness index (J) (Pielou, 1977)

$$J = \frac{H^{'}(\text{observed})}{H^{'}_{max}}$$

where: $H^{'}_{max}$ is the maximum possible diversity, which could be achieved if all species were equally abundant (= $\log_2 S$)

Pielou's evenness is a measure of how evenly the individuals are distributed among different species.

5. Shannon-Wiener diversity index (H') (Pielou, 1977)

$$H^{'} = -\sum_{i=1}^{S} p_i(\log_2 p_i)$$

where: p_I is the proportion of the total count accounted for by the i^{th} taxa.

Shannon-Wiener diversity index takes both species abundance and species richness into account quantify diversity (Shannon & Wiener, 1949).

6. The Shannon-Wiener based Effective Number of Species (ENS) (Hill, 1973; Jost, 2006)

$H = \exp(H')$

where H' is the Shannon-Weiner diversity index.

The Shannon-Wiener index diversity index is converted to ENS to reflect 'true diversities' (Hill, 1973, Jost, 2006) that can then be compared across communities (MacArthur, 1965; Jost, 2006). The ENS is equivalent to the number of equally abundant species that would be needed in each sample to give the same value of a diversity index, *i.e.* Shannon-Weiner Diversity index. The ENS behaves as one would intuitively expect when diversity is doubled or halved, while other standard indices of diversity do not (Jost, 2006). If the ENS of one community is twice that of another then it can be said that that community is twice as diverse as the other.

Multivariate Analysis

The PRIMER programme (Clarke & Warwick, 2001) was used to carry out multivariate analyses on the station-by-station faunal data. All species abundance data from the grab surveys was square root transformed and used to prepare a Bray-Curtis similarity matrix in PRIMER. The square root transformation allows the intermediate abundant species to play a part in the similarity calculation. Various ordination and clustering techniques can then be applied to the similarity matrix to determine the relationship between the samples.

Multidimensional scaling (MDS) is a technique that ordinates samples as points in 2D or 3D space based on similarity in species distribution data. MDS performed on the Bray-Curtis similarity matrix produce ordination maps whereby the placement of samples reflects the similarity of their biological communities, rather than their simple geographical location (Clarke & Warwick, 2001).

An indication of how well the similarity matrix is represented by the ordination is given by stress values calculated by comparing the interpoint distances in the similarity matrix with the corresponding interpoint distances on the ordinations. Perfect or near perfect matches are rare in field data, especially in the absence of a single overriding forcing factor such as an organic enrichment gradient. Stress values increase, not only with the reducing dimensionality (lack of clear forcing structure), but also with increasing quantity of data (it is a sum of the squares type regression coefficient). Clarke & Warwick (2001) have provided a classification of the reliability of MDS plots based on stress values, having compiled simulation studies of stress value behaviour and archived empirical data. This classification generally holds well for ordinations of the type used in this study. Their classification is given below:

Stress value < 0.05: Excellent representation of the data with no prospect of misinterpretation.

- Stress value < 0.10: Good representation, no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups.
- Stress value < 0.20: This provides a useful picture, but detail may be misinterpreted particularly nearing 0.20.
- Stress value 0.20 to 0.30: This should be viewed with scepticism, particularly in the upper part of the range, and discarded for a small to moderate number of points such as < 50.
- Stress values > 0.30: The data points are close to being randomly distributed in the ordination and not representative of the underlying similarity matrix.

Each stress value must be interpreted both in terms of its absolute value and the number of data points. In the case of this study, the moderate number of data points indicates that the stress value can be interpreted more or less directly. While the above classification is arbitrary, it does provide a framework that has proved effective in this type of analysis.

Hierarchical Agglomerative Clustering (HAC) is used to cluster samples based on between-sample similarities into groups in dendrograms. Similarity Profiling (SIMPROF) is used to test if differences between HAC derived similarity-based clusters are significant. Similarity Percentages (SIMPER) analysis can be used to determine the characterising species of each cluster of stations identified either arbitrarily (by eye) from HAC dendrograms or statistically using SIMPROF testing (Clarke and Warwick, 2001; Clarke and Gorley, 2006; Anderson *et al.,* 2008).

The species, which are responsible for the grouping of samples in CLUSTER analyses, were identified using the PRIMER programme SIMPER (Clarke & Warwick, 1994). This programme determined the percentage contribution of each species to the dissimilarity/similarity within and between each sample group.

AZTI Marine Biotic Index

To assess the benthic ecological quality of the community, the AZTI Marine Biotic Index (AMBI) was calculated. AMBI offers a 'pollution or disturbance classification' which represents the benthic community health (*sensu* Grall & Glémarec, 1997).

In the AMBI tool, species are allocated to one of five ecological groups depending on their sensitivity to pollution:

- Group I - very sensitive to disturbance/pollution;
- Group II - indifferent to disturbance/pollution;
- Group III - tolerant to disturbance/pollution;
- Group IV - second-order opportunists; and,
- Group V - first order opportunists).

The AMBI score is calculated as a weighted average of the sensitivity scores of each replicate sample. Assemblages with high proportions of sensitive taxa are indicative of areas with low levels of disturbance and stations dominated by opportunistic taxa reflect impacted areas.

Results

Fauna

The taxonomic identification of the benthic infauna across all 10 stations sampled in the Shannon Estuary yielded a total count of 82 taxa ascribed to 9 phyla. Of the 82 taxa, 2 could not be enumerated due to their colonial nature and the remaining 80 taxa consisted of 1,740 individuals. Of the 82 taxa identified, 58 were identified to species level. The remaining 24 could not be identified to species level due to the fact that they were juveniles, damaged or indeterminate.

Of the 82 taxa recorded, 34 were annelids (segmented worms), 20 were arthropods (crabs, shrimps, sea spiders), 18 were molluscs (mussels, cockles, snails *etc*.), 2 were bryozoans (moss animals), 2 were sipunculids (peanut worms), 2 were echinoderms (brittlestars, sea cucumbers), 1 was a tunicate (sea squirts), 1 was a nemertean (ribbon worm) and 1 was a nematode (round worm).

Univariate Analysis

The univariate analyses were carried out using the same methodology as was used in the previous 2012 study (AQUAFACT, 2012), for ease of comparison.

All replicate data was combined to give a total for each station prior to statistical analysis. The following taxa were removed prior to statistical analyses: nematodes, nemerteans, all epifaunal species and all taxa not identified to species level. Univariate statistical analyses were carried out on the station-by-station faunal data. The following parameters were calculated and can be seen in **Table 3.5**: species numbers, number of individuals, richness, evenness, Shannon-Weiner diversity, and Effective Species Number (ENS).

Species numbers ranged from 3 (LS1) to 31 (LS31). Number of individuals ranged from 3 (LS1) to 466 (LS10). Richness ranged from 1.82 (LS1) to 5.72 (LS31). Evenness ranged from 0.22 (LS21) to 1.0 (LS1). Shannon-Weiner diversity ranged from 0.61 (LS21) to 2.35 (S31). Effective species number ranged from 1.85 (LS21) to 10.53 (LS31) indicating that station LS31 is over 6.6 times more diverse than station LS21. **Figure 3-32** shows these community indices in graphical form.

Table 3.5: Community indices

Station	No. Taxa	No. Individuals	Richness	Evenness	Shannon-Weiner Diversity	Effective Species Number
	S	N	d	J'	H'(loge)	EXP(H')
LS1	3	3	1.82	1.00	1.10	3.00
LS9	21	272	3.57	0.39	1.19	3.28
LS10	16	466	2.44	0.17	0.46	1.58
LS12	9	16	2.89	0.91	1.99	7.34
LS21	17	273	2.85	0.22	0.61	1.85
LS24	8	15	2.58	0.77	1.60	4.95
LS25	6	14	1.89	0.91	1.63	5.11
LS26	10	26	2.76	0.77	1.76	5.83
LS27	11	67	2.38	0.59	1.41	4.09
LS31	31	190	5.72	0.69	2.35	10.53

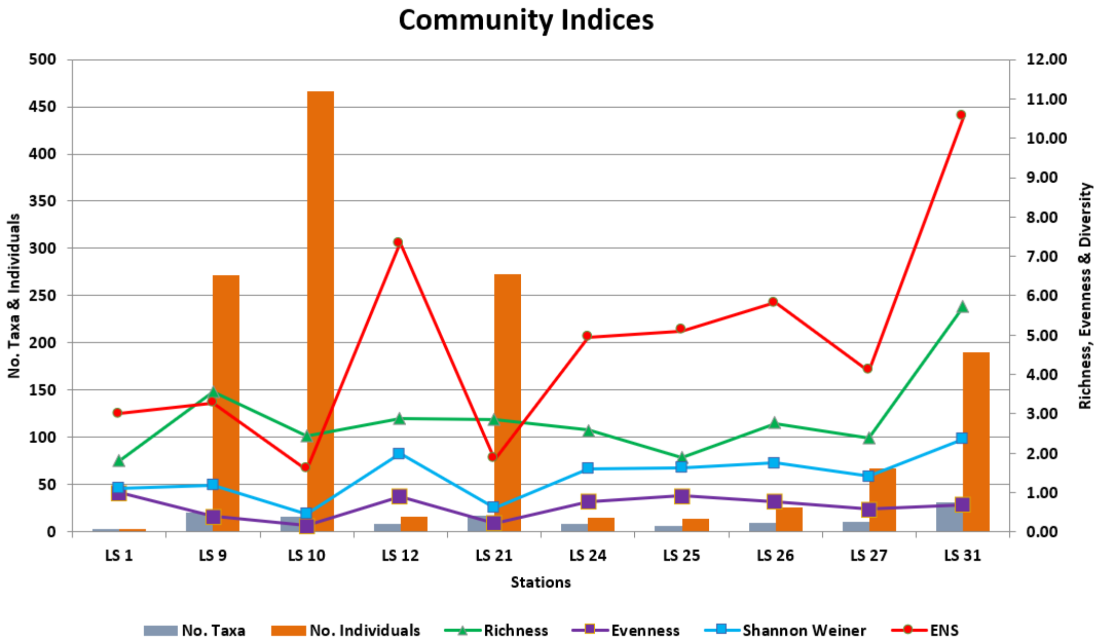


Figure 3-32: Community diversity indices. Diversity is expressed in Shannon-Weiner Diversity and Effective Species Number (ENS).

Multivariate Analysis

The same data set used above for the univariate analyses was also used for the multivariate analyses. The dendrogram and the MDS plot can be seen in **Figure 3-33** and **Figure 3-34** respectively. SIMPROF analysis revealed 3 statistically significant groupings between the 10 stations (the samples connected by red lines cannot be significantly differentiated). The stress level on the MDS plot indicates a good representation of the data with no real prospect of misinterpretation of overall structure.

A clear divide (9.24% similarity) can be seen between **Group a** and **Groups b** and **c**.

Group a consisted of Station LS1. This group separated from all other groups at a 9.24% similarity level. Station S1 contained 3 species comprising 3 individuals. The polychaetes *Scoloplos armiger*, the gastropod *Peringia ulvae* and the hermit crab *Pagurus bernhardus* were all recorded only once. This station had the highest evenness value given the identical numbers of species and individuals recorded. This station was also species poor when sampled in 2012 and 2006. No epifaunal species were recorded at this station.

Group b consisted of Stations LS9, LS10, LS21, LS26 and LS31. Group b had a within group similarity of 41.82% and was most similar to Group c, but only at a level of 17.82%. This group contained 51 taxa comprising 1,294 individuals. Of the 51 taxa, 27 were present twice or less. Four species accounted for almost 87% of the faunal abundance: the bivalve *Nucula nucleus* (951 individuals, 73.49% abundance), the polychaetes *Paradoneis lyra* (105 individuals, 8.11% abundance) and *Pholoe inornata* (37 individuals, 2.86% abundance) and the amphipod *Metaphoxus simplex* (31 individuals, 2.4% abundance). SIMPER analysis revealed that *Nucula nucleus* and *Pholoe inornata* are the characterising species of this group. *Nucula nucleus* is very sensitive to organic enrichment and present under unpolluted conditions *P. inornata* are indifferent to disturbance, typically present in low densities with non-significant variations over time.

Individually, Station LS9 contained 21 species comprising 272 individuals. Thirteen of the 21 species were present twice or less. The bivalve *Nucula nucleus* accounted for 76% of the faunal abundance at this station and *Paradoneis lyra* accounted for 3.6% of it. Two epifaunal bryozoan species were present at this station as well as a large number of the tunicate *Dendrodoa grossularia* (114 individuals). Diversity was below average at this station. The number of species and individuals and richness were above average. Evenness was below average due to the high numbers of *Nucula nucleus* at this station. When sampled in 2012 and 2006 this station was dominated by *Nucula* spp. (*Nucula sulcata* and *Nucula nucleus*). This station can be ascribed to the habitat 'Subtidal sand to mixed sediment with *Nucula nucleus* community complex'. This is one of ten benthic community habitat types occurring in the Lower River Shannon cSAC (NPWS, 2012) and has previously been recorded in this vicinity as illustrated in **Figure 3-35.**

Station LS10 contained 16 species comprising 466 individuals. Eleven of the 16 species recorded were present twice or less. The bivalve mollusc *Nucula nucleus* accounted for approximately 92% of the faunal abundance at this station. The epifaunal tunicate *Dendrodoa grossularia* (14 individuals) was recorded at this station. Richness was below average, and diversity and evenness were lowest at this station given the superabundance of one species. This station had above average species numbers and the highest species abundance. When sampled in 2012 and 2006 this station was also dominated by *Nucula* spp. (*Nucula sulcata* and *Nucula nucleus*). This station can also be ascribed to the habitat 'Subtidal sand to mixed sediment with *Nucula nucleus* community complex'.

Station S21 contained 17 species comprising 273 individuals. Thirteen of the 17 species recorded were present twice or less. The bivalve *Nucula nucleus* accounted for 89.4% of the faunal abundance at this station. No epifaunal species were present at this station. Evenness and diversity were below average;

richness was average and species numbers and abundance were above average. In 2006 and 2012, *Nucula* spp. were also the dominant at this station. This station can also be ascribed to the habitat 'Subtidal sand to mixed sediment with *Nucula nucleus* community complex'.

S26 contained 10 species comprising 26 individuals. Nine of the 10 species recorded were present twice or less. One species accounted for 50% of the faunal abundance at this station: the bivalve mollusc *Nucula nucleus.* No epifaunal species were present at this station. Moderate levels of richness and diversity were found at this station. Species abundance was low at this station. Surveys in 2006 and 2012 produced similar findings with the station dominated by *Nucula* spp. but species and abundance poor. This station can also be ascribed to the habitat 'Subtidal sand to mixed sediment with *Nucula nucleus* community complex'.

Station S27 contained 11 species comprising 67 individuals. Eight of the 11 species recorded were present twice or less. Two species accounted for just under 63% of the faunal abundance at this station: the bivalve mollusc *Nucula nucleus* (34.3%) and the polychaete *Paradoneis lyra* (28.35%). Three epifaunal species were present at this station including two colonial bryozoans and high numbers of the tunicate *Dendrodoa grossularia* (194 individuals). This station had average richness, evenness and diversity. In 2012 this was the second most diverse of the stations sampled with *P. lyra, Nucula* and *Metaphoxus simplex* (then known as *Metaphoxus pectinatus*) the most dominant. In 2007, this station was the most diverse sampled and *Nucula* and *M. simplex* were also the dominant. This station can also be ascribed to the habitat 'Subtidal sand to mixed sediment with *Nucula nucleus* community complex'.

Station S31 contained 31 species comprising 190 individuals. Eighteen of the 31 species recorded were present twice or less. Three species accounted for just under 62% of the faunal abundance at this station: the polychaete *Paradoneis lyra* (37.9%), the bivalve mollusc *Nucula nucleus* (12.1%), and the amphipod *Metaphoxus simplex* (11.58%). Two epifaunal species were present at this station including a colonial bryozoan and the tunicate *Dendrodoa grossularia* (20 individuals). This station was the most diverse and had the highest richness and diversity values of all stations sampled. Its effective species number (ENS 10.53) indicated that it was 6.6 times more diverse than the least diverse station (LS10). This station was also the most diverse in 2012, when it was dominated by *Nucula, P. lyra* and *Harpinia antennaria. Nucula* and *Harpinia* were also the dominants back in 2007 but overall diversity was lower. This station can also be ascribed to the habitat 'Subtidal sand to mixed sediment with *Nucula nucleus* community complex'.

Group c consisted of Stations LS12, LS24 and LS25. Group c had a within group similarity of 34.83% and was most similar to Group c, but only at a level of 17.82%. This group contained 16 taxa comprising 45 individuals. Of the 16 taxa, 11 were present twice or less. Four species accounted for almost 67% of the faunal abundance: the polychaetes *Scoloplos armiger* (10 individuals, 22.22% abundance), the polychaetes *Travisia forbesii* (10 individuals, 22.22% abundance), *Nephtys cirrosa* (5 individuals, 11.11% abundance) and *Paradoneis lyra* (5 individuals, 11.11% abundance). SIMPER analysis revealed that *Nephtys cirrosa* and *Scoloplos armiger* are the characterising species of this group. *N. cirrosa* are indifferent to disturbance, typically present in low densities with non-significant variations over time. *S. armiger* are tolerant of disturbance, they occur under normal conditions, but their populations are stimulated by organic enrichment.

Individually, the station assemblages were as follows:

Station S12 contained 9 species comprising 16 individuals. Seven of the 9 species recorded were present twice or less. Three species accounted for 62.5% of the faunal abundance at this station: the polychaetes *Scoloplos armiger* (25%) and *Paradoneis lyra* (25%) and the bivalve *Nucula nucleus* (12.5%). No epifaunal species were present at this station. This was the second most diverse station sampled. Richness was average and evenness was above average at this station. In 2006 and 2012 *Nucula* was the dominant taxon at this station. This station exhibits elements of two of the ten common benthic community habitat types occurring in the Lower River Shannon cSAC (**Figure 3-35** below) namely the habitats 'Subtidal sand to mixed sediment with *Nephtys* spp. community complex' and 'Subtidal sand to mixed sediment with *Nucula nucleus* community complex'.

Stations LS24 contained 8 species comprising 15 individuals. Seven of the eight species recorded were present twice or less. The polychaete *Travisia forbesii* accounted for 53.33% of the faunal abundance at this station with the remaining species all accounting for 6.66% each. No epifaunal species were recorded form this station. Diversity was above average while richness, species numbers and species abundance were below average. In 2012 this station was dominated by the polychaetes *Spio goniocephala* and was similarly species poor. This station was just as impoverished when sampled in 2007. This station can also be said to exhibit elements of the habitats 'Subtidal sand to mixed sediment with *Nephtys* spp. community complex' and 'Subtidal sand to mixed sediment with *Nucula nucleus* community complex'.

Stations S25 contained 6 species comprising 14 individuals. Four of the 6 species recorded were present twice or less. The polychaete *Scoloplos armiger* accounted for 35.7% of the faunal abundance at this station and *Nephtys cirrosa* accounted for 21.4% of it. No epifaunal species were recorded from this station. Diversity was above average while richness, species numbers and species abundance were below average. This station similarly impoverished when sampled in 2012 and 2007. This station can also be ascribed to the habitat 'Subtidal sand to mixed sediment with *Nephtys* spp. community complex'.

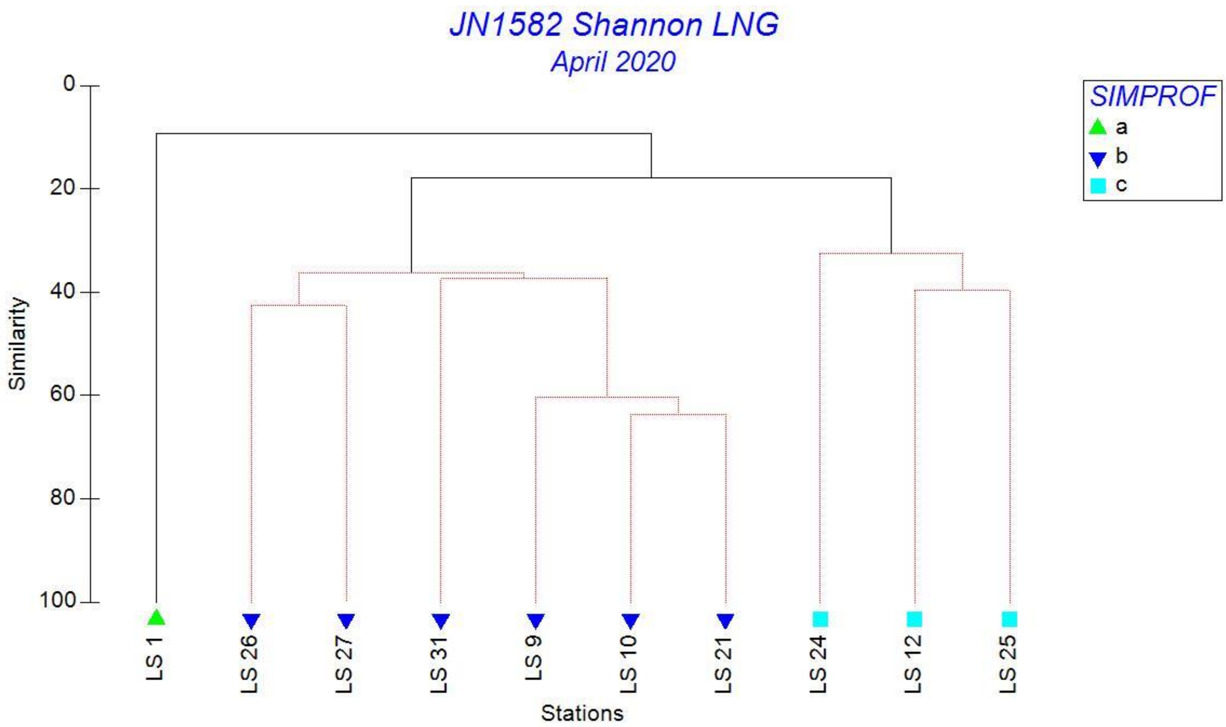


Figure 3-33: Dendrogram produced from Cluster analysis.

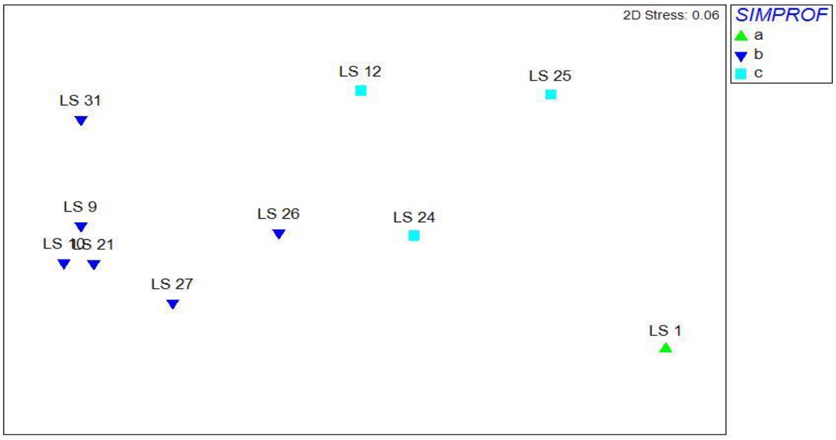


Figure 3-34: MDS plot.

Table 3.6: SIMPER Results

Group a					
Less than 2 samples in group					
Group b					
Average similarity: 41.82%					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Nucula nucleus	10.84	18.22	1.85	43.57	43.57
Pholoe inornata	2.39	5.48	4.81	13.1	56.67
Paradoneis lyra	3.12	3.3	0.97	7.9	64.56
Euclymene oerstedii	1.68	2.97	1.19	7.09	71.66
Sabellaria spinulosa	1.12	2.33	1.25	5.57	77.22
Scoloplos armiger	0.87	1.37	0.72	3.27	80.49
Achelia echinata	0.9	1.15	0.75	2.76	83.25
Metaphoxus simplex	1.56	1.08	0.71	2.59	85.84
Dipolydora flava	0.91	0.98	0.76	2.35	88.19
Golfingia (Golfingia) vulgaris vulgaris	0.83	0.88	0.78	2.09	90.28
Group c					
Average similarity: 34.83%					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Scoloplos armiger	1.75	13.31	2.36	38.23	38.23
Nephtys cirrosa	1.24	10.02	14.95	28.76	66.99
Travisia forbesii	1.41	5.06	0.58	14.53	81.52
Paradoneis lyra	1	3.3	0.58	9.47	90.99

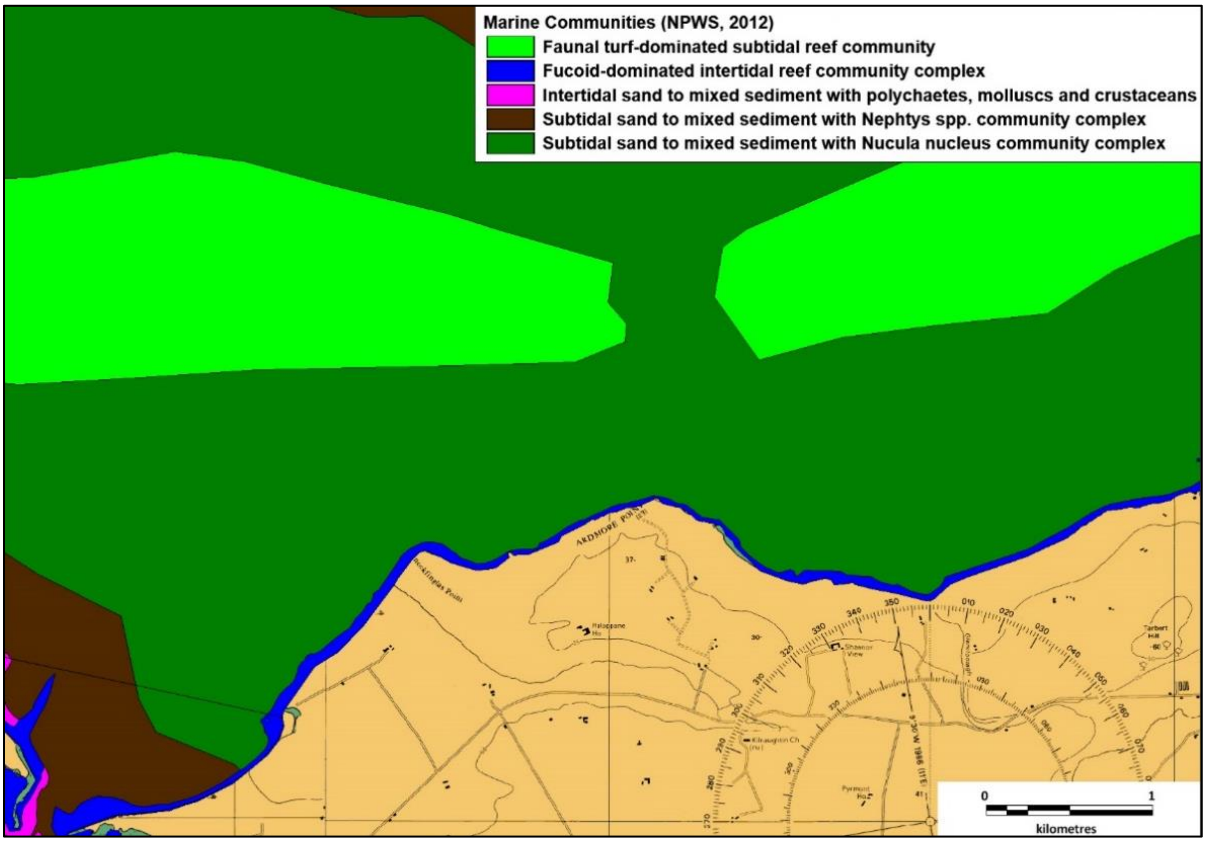


Figure 3-35: Marine biotopes in survey area of Shannon Estuary (NPWS, 2012).

AMBI Results

Table 3.7 shows the mean AMBI results from the analysis of the replicate samples and these results are presented in a histogram in Figure 3-36 Four stations were described as slightly disturbed (Stns LS1, LS12, LS25 and LS31), while 6 were classified as undisturbed (Stns LS9, LS10, LS21, LS24, LS26 and LS27). The slightly disturbed stations had a fairly even split between the abundance of species indifferent to disturbance/pollution and those tolerant of polluted/disturbed sediments. The undisturbed stations had a higher abundance of sensitive species that cannot survive in polluted/disturbed sediments.

Table 3.7: AMBI results.

Stations	I(%)	II(%)	III(%)	IV(%)	V(%)	Not assigned (%)	Mean AMBI	BI from Mean AMBI	Disturbance Classification
LS1	0.0	33.3	66.7	0.0	0.0	0.0	2.5	2	Slightly disturbed
LS9	86.4	6.5	4.3	2.8	0.0	0.3	0.351	1	Undisturbed
LS10	94.8	3.5	1.4	0.2	0.0	0.2	0.105	0	Undisturbed
LS12	18.8	25.0	56.3	0.0	0.0	0.0	2.063	2	Slightly disturbed
LS21	93.1	4.0	2.9	0.0	0.0	0.0	0.146	0	Undisturbed
LS24	70.6	17.6	11.8	0.0	0.0	0.0	0.618	1	Undisturbed
LS25	33.3	16.7	38.9	11.1	0.0	0.0	1.917	2	Slightly disturbed
LS26	76.7	13.3	10.0	0.0	0.0	0.0	0.500	1	Undisturbed
LS27	89.8	1.9	7.9	0.4	0.0	2.2	0.282	1	Undisturbed
LS31	48.9	4.1	45.7	0.9	0.5	0.0	1.500	2	Slightly disturbed

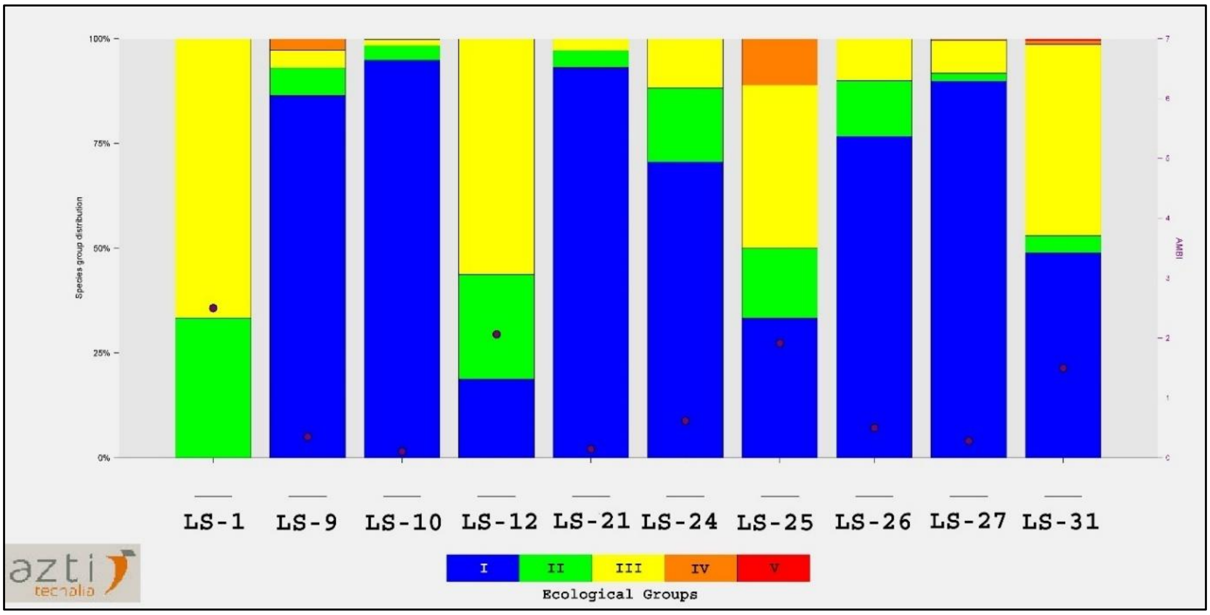


Figure 3-36: Histogram of AMBI results.

Sediment

Table 3.8 shows the sediment characteristics of the subtidal stations surveyed including the granulometry and the percentage organic carbon.

The sediment sampled within the study area was classified as sand, sandy gravel, gravelly muddy sand and slightly gravelly muddy sand according to Folk (1954). No medium gravel-boulders were recorded. Highest levels of fine gravel and very fine gravel were observed at LS10 (43.2% and 19.8% respectively). Highest levels of very coarse sand were found at LS27 (8.8%). Highest levels of coarse sand and medium sand were found at LS1 (7.1% and 65.9% respectively). Highest levels of fine sand were found at LS24 (65.7%). Highest levels of and very fine sand and silt-clay were found at LS31 (33.9% and 28.3% respectively).

Figure 3-37shows the breakdown of sediment composition at each station and **Figure 3-38** illustrates the sediment type according to Folk (1954). Organic matter values ranged from 1.66% (LS1) to 4.22% (LS10).

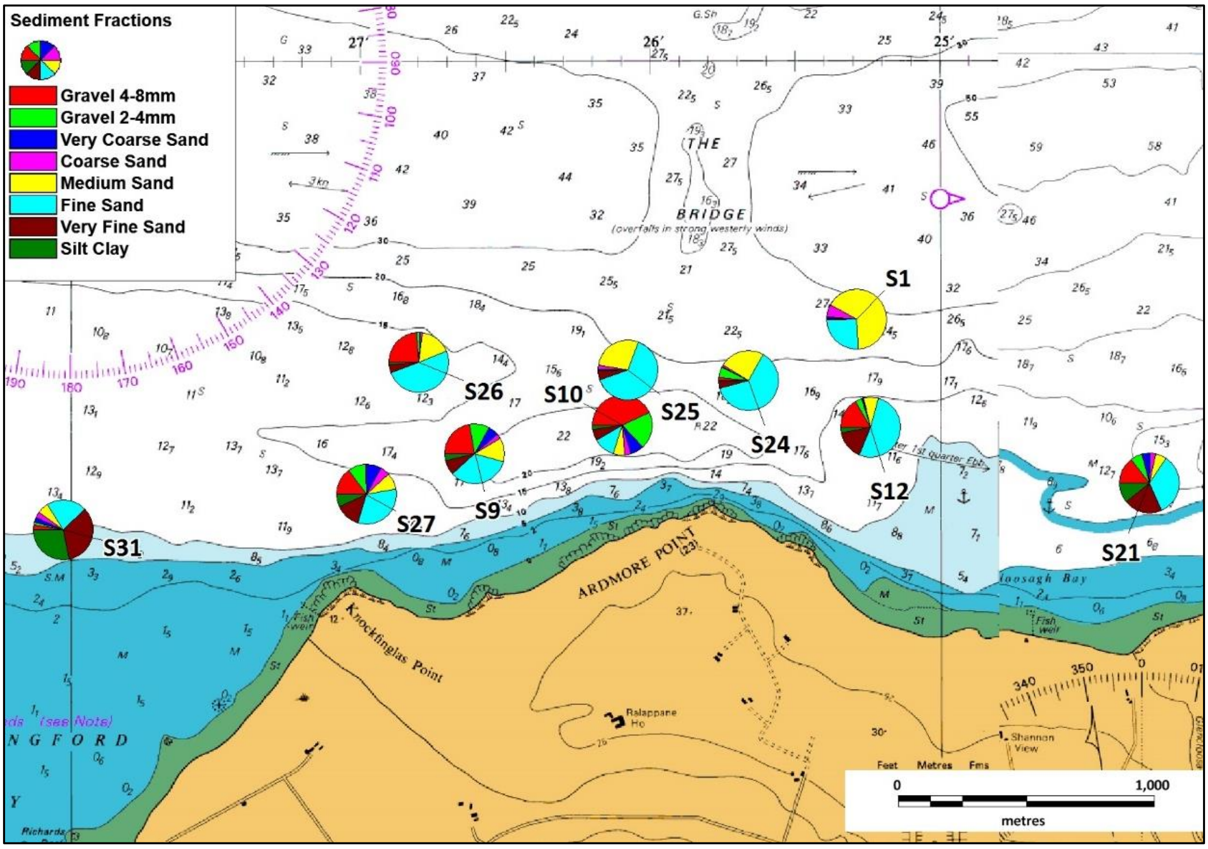


Figure 3-37: A breakdown of sediment type at each subtidal station.

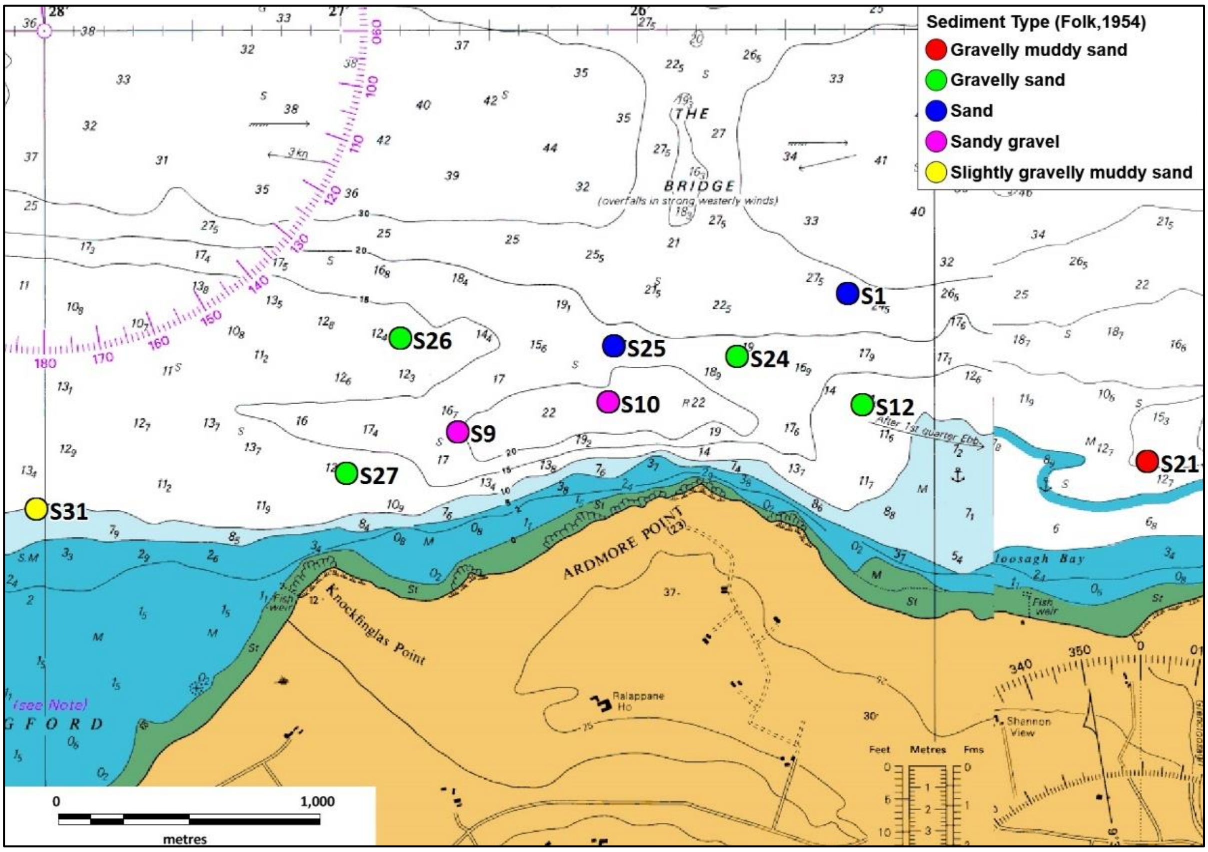


Figure 3-38: Sediment type (Folk, 1954) at subtidal station surveyed in April 2020.

Table 3.8: Sediment characteristics of the benthic faunal stations sampled. LOI refers to the % organic carbon loss on ignition.

Station	>8mm	Fine Gravel (4-8mm)	Very Fine Gravel (2-4mm)	Very Coarse Sand (1-2mm)	Coarse Sand (0.5-1mm)	Medium Sand (0.25-0.5mm)	Fine Sand (125-250mm)	Very Fine Sand (62.5-125mm)	Silt-Clay (<63mm)	Folk (1954)	LOI
LS1	0	0.1	0.2	0.6	7.1	65.9	25.3	0.5	0.2	Sand	1.66
LS9	0	22.4	11	5.5	2.9	12.5	33.6	8.1	4	Sandy Gravel	3.38
LS10	0	43.2	19.8	7.1	3.3	6.2	11.8	6.1	2.5	Sandy Gravel	4.22
LS12	0	16.6	3.6	0.7	0.5	8	51.6	15.8	3.1	Gravelly Sand	1.94
LS21	0	14.5	6.6	4.6	3.1	6	33.6	20.7	11	Gravelly Muddy Sand	3.78
LS24	0	1.7	6	0.2	1.3	26	65.7	4	0.6	Gravelly Sand	1.96
LS25	0	0.3	0	0.2	1.9	28.5	63.7	4.6	0.8	Sand	1.75
LS26	0	24	1.7	0.5	0.9	16.9	50.1	4.5	1.3	Gravelly Sand	1.87
LS27	0	14.8	9.7	8.8	5.1	9	31.9	13.4	7.2	Gravelly Sand	3.84
LS31	0	2.4	1.5	2.7	3.3	6.3	21.7	33.9	28.3	Slightly Gravelly Muddy Sand	4.21

Figure 3-39 indicates the locations of the drop-down video transects surveyed and the sediment type observed on the video footage.

Figure 3-40 illustrates still images from the drop-down video survey indicating the substrate types encountered throughout the survey area.

Stations DV1 and DV4 consisted of cobble substrate; stations DV2, DV6, DV7, DV8, DV9, DV10 and DV12 were sandy substrates with the sand frequently in ripples; stations DV3 and DV5 had boulders that were encrusted with the tunicate *Dendrodoa grossularia* and bryozoans; station DV11 consisted of a sand and shell substrate.

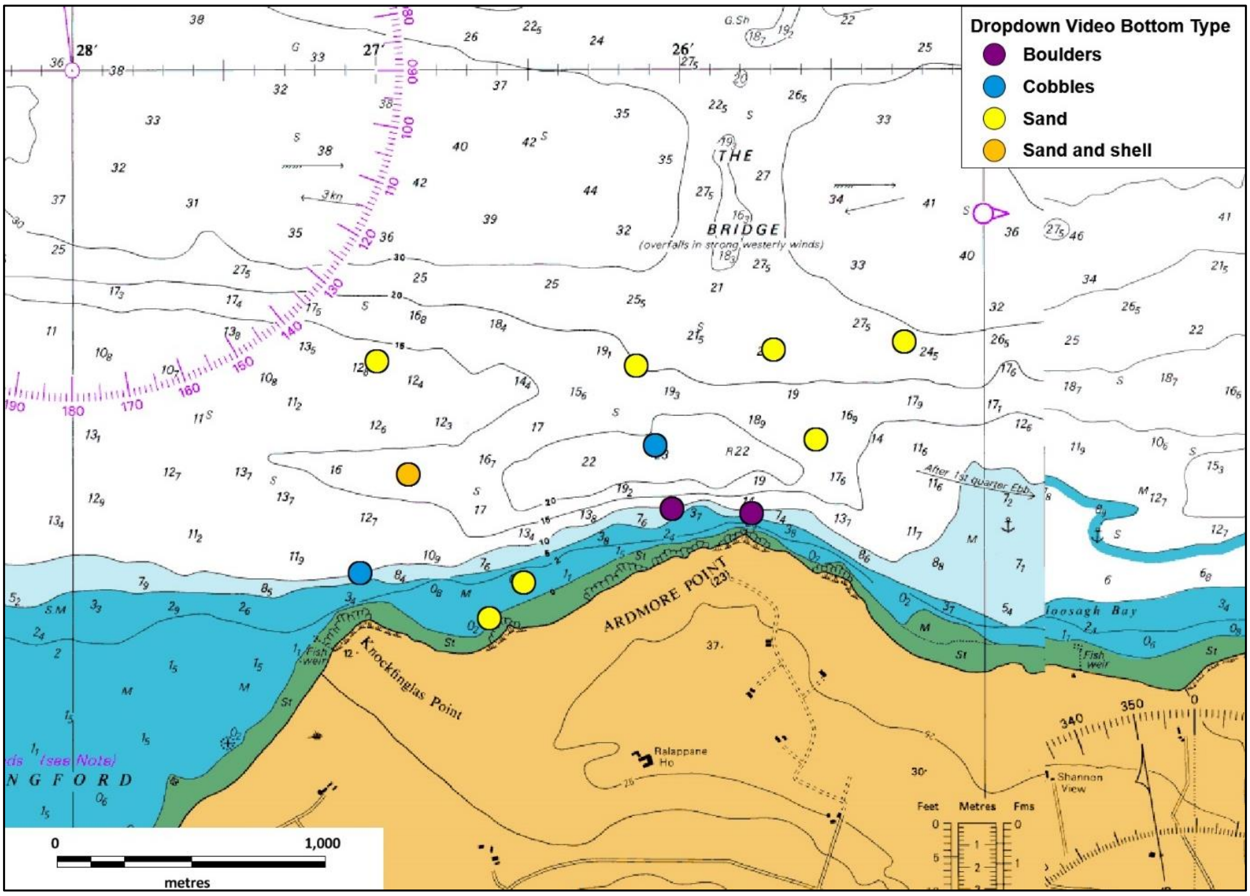


Figure 3-39: Location of drop-down video transects, and sediment type observed.

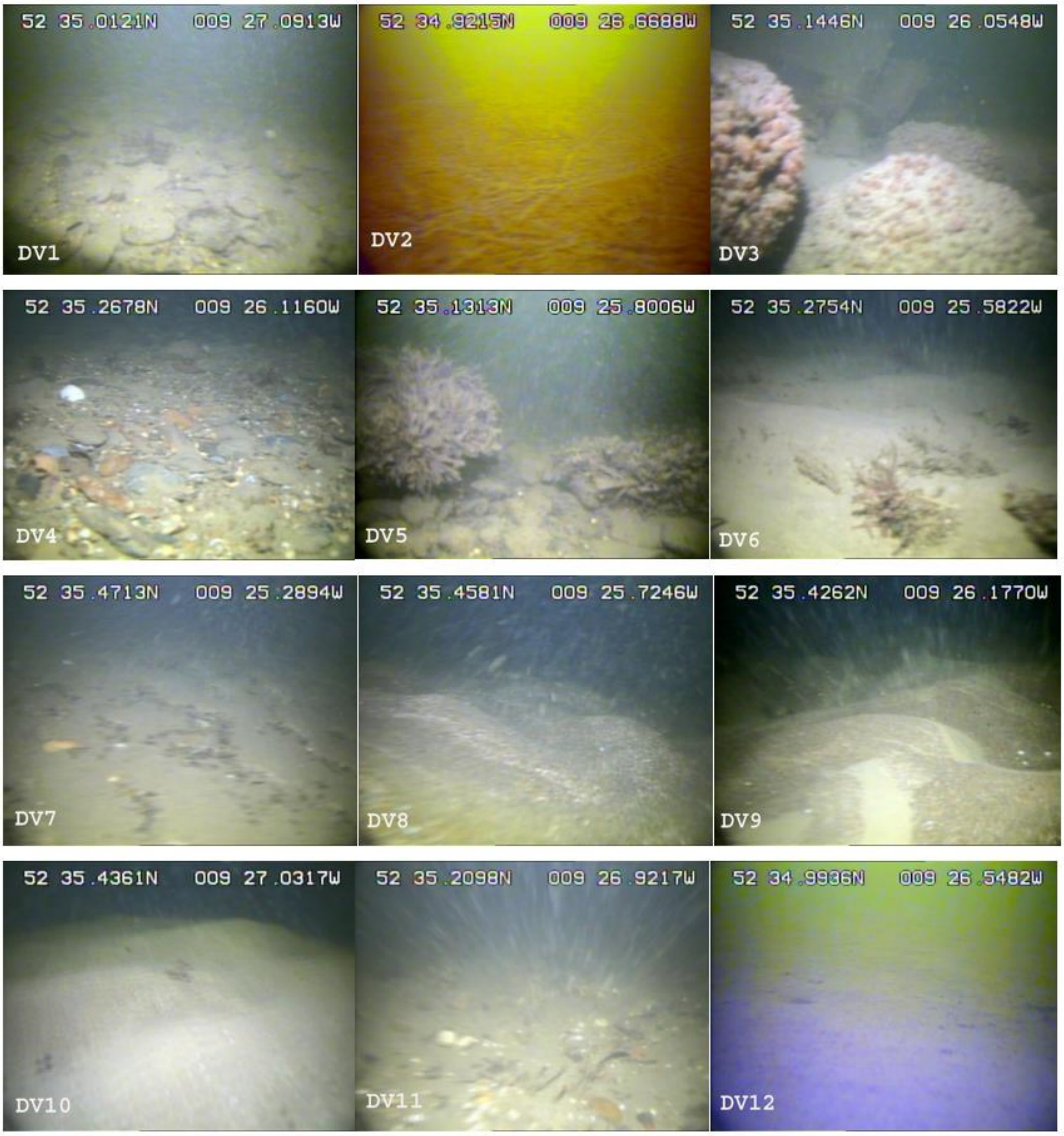


Figure 3-40: Drop-Down video images of substrate type in the survey area.

Discussion

The intertidal habitats encountered are typical of cobbly rocky shores in Ireland being dominated by *Pelvetia canaliculata*, *Fucus* sp. and *Ascophyllum nodosum*. No rare, protected or unusual species were observed, and no changes were observed compared to previous survey undertaken in 2012.

The subtidal fauna was dominated by species typical of fine sandy habitats *e.g.* the polychaetes *Nephtys cirrosa*, *Paradoneis lyra*, *Travisia forbesii*, *Pholoe inornata* and *Scoloplos armiger*, the bivalve *Nucula* spp. and the amphipods *Metaphoxus simplex* and *Harpinia antennaria*.

In areas with boulders or cobbles there were abundant populations of the tunicate *Dendrodoa grossularia*. No rare, protected or unusual species were observed. One-way ANOVA shows a significant difference between the Shannon-Weiner Diversity and the Effective Number of Species between the 2020 and 2012 results. Whether this is a seasonal variation due to the difference in time of surveys (October in 2012 and April in 2020) is unknown. Despite the significant decreases in these indices from 2012 to 2020, the dominant taxa present are similar in both surveys and indicate similar community types between surveys. All species observed are typical of this area of the Lower River Shannon Estuary cSAC.

AMBI analysis indicated that all sites were either undisturbed or slightly disturbed due to the high proportion of sensitive species at each station. Slight variations in the substrate type were observed between this survey and the previous one. Given the strong current speeds and mobile sediments in the area, this is not unusual.

3.3.3. Qualifying Interest Annex II Species

3.3.3.1. Bottlenose Dolphin

The Lower River Shannon cSAC is one of five sites designated for bottlenose dolphins in Irish waters. Studies on the resident bottlenose dolphin population in Shannon Estuary have been occurring since 1993 by the Irish Whale and Dolphin Group (IWDG) and by the National Parks and Wildlife Service (NPWS) of Ireland as part of the EU's obligation to ensure conservation of this species (Blázquez *et al.,* 2020).

Data collected over 20 years show that the Shannon Estuary dolphin population is genetically and demographically isolated from other coastal dolphins (Mirimin *et al.,* 2011; O'Brien *et al.,* 2016; Rogan *et al.,* 2018). Mark-recapture photo-identification studies indicate that bottlenose dolphins in the Shannon Estuary exhibit long-term site fidelity and seasonal residency (*e.g.*, Ingram 2000; Ingram and Rogan 2002; Ingram and Rogan 2003; Englund *et al.,* 2007, 2008; Berrow 2009; Rogan *et al.,* 2018). The most recent photo-identification study occurred during June–October 2018, resulting in a mark-recapture abundance estimate of 139 individuals (CV=0.11, 95% CI=121–160) (Rogan *et al.,* 2018). Baker *et al.,* (2018a) provided an estimate of 145 individuals for 2015, based on direct counts. The median group size based on boat surveys throughout the estuary is 6 (*e.g.*, Englund *et al.,* 2007, 2008; Rogan *et al.,* 2018), and the average group size has been reported as 9.71 (Barker and Berrow 2016). The mean group size (±SD) at the proposed LNG site at Ardmore Point was estimated at 6.2 ± 3.1 dolphins, based on watches from shore (Berrow *et al.,* 2020).

Although the dolphins inhabit the Shannon Estuary year-round, the greatest number appear to occur there between June and August (Garagouni *et al.,* 2019), with decreasing numbers during the winter (Ingram 2000; Englund *et al.,* 2007; Rogan *et al.,* 2018). The lower numbers during winter may be due to animals dispersing over a wider region in pursuit of prey affected by the seasonal changes (Garagouni *et al.,* 2019); however, data on the distribution of the population during winter is generally lacking. However, dolphin sightings were made off Ardmore Point each month during monitoring from October 2020 to March 2021 (Berrow 2020 a,b,c, 2021 a,b,c). One photo-identification study found that at least 62% of individuals from the Shannon bottlenose dolphin population also use waters outside of the Shannon Estuary during the summer (May–August), including Brandon Bay and Tralee Bay located adjacent to estuary (Levesque *et al.,* 2016).

Bottlenose dolphins in the Shannon Estuary prefer areas with the greatest slope and depth (Ingram and Rogan 2002). Two critical habitat areas occur within Shannon Estuary that at least part of the population migrates between throughout the year; the larger of the two areas is located near the mouth of the estuary closest to Kilcredaun, and the smaller is located off Moneypoint (see **Figure 3-41**; NPWS 2012, Ingram and Rogan 2002; Rogan *et al.,* 2018). In general, a smaller proportion of the population is found in the eastern part of the estuary compared to the western part (Baker *et al.,* 2018b). The distribution of sightings in 2018 showed that dolphin presence throughout the estuary was similar to past studies, but noted greater activity within the inner estuary where it constricts near Tarbert/Killimer and farther upriver (see **Figure 3-41**) (Ingram and Rogan 2002; Rogan *et al.,* 2018). Baker *et al.,* (2018b) found that only 25% of the population regularly uses the inner estuary; those dolphins were also seen in the outer estuary. Within the critical habitat areas, the dolphins appear to most commonly be found near northern-facing slopes (Garagouni *et al.,* 2019). Dolphin distribution in the estuary is also correlated with tide level, with higher presence in bottleneck areas during ebb and slack low tides (Garagouni *et al.,* 2019).

The area around the proposed LNG site at Ardmore Point has not been identified as a hot spot for bottlenose dolphin occurrence based on commercial dolphin-watching activities (see Berrow *et al.,* 2020). However, sightings have been made in the area during several vessel-based surveys (*e.g.*, Ingram and Rogan 2003; Englund *et al.,* 2007, 2008; Berrow *et al.,* 2012). Visual observations from shore at Ardmore Point show that the site is regularly used by the dolphins, which pass by the area but rarely stop and socialize or forage there; it is more likely used as a transition corridor to move between the outer and inner estuary (Berrow *et al.,* 2020). During 23 days of observations from April through September 2020, 21 sightings of dolphins were made on 13 separate watch days. Most sightings were made off Moneypoint, near the ferry, near Scattery Island, and mid-channel; six sightings were made within 500 m of Ardmore Point, and a total of 22 individual dolphins were identified. During 23 observation days from October 2020 to March 2021, 20 dolphin sightings were made on 15 different watch days (Berrow 2020 a,b,c, 2021 a,b,c). Thus, the encounter rates of bottlenose dolphin groups were similar during spring/ summer and fall/winter, at 0.2 groups/hour of observation.

Passive acoustic monitoring with C-POD porpoise detectors was also conducted at two sites off Ardmore Point from August 2019 through May 2020; dolphin clicks were detected on 62% of monitoring days at each of the two sites (Berrow *et al.,* 2020). The C-POD located closest to the LNG site (LNG1) had a mean detection positive minutes (DPM) per day of 4.4, whereas LNG2 had a DPM of 3.6; DPM was lower at LNG1 during the winter than during other seasons. The low DPM per day at these two sites supports evidence from visual monitoring that the area around Ardmore Point is primarily a transit corridor (Berrow *et al.,* 2020). There were significantly more detections during the evening than during the day at LNG1, and significantly more detections in the evening and at night than during the day at LNG2 (Berrow *et al.,* 2020).

The Shannon Estuary also acts as a calving area for the species, with neonates most frequently observed from July to September (Ingram 2000; Baker *et al.,* 2018a). An average of seven calves are born each year, with weaning taking place at a mean age of 2.9 years (Baker *et al.,* 2018a). During watches from Ardmore Point, 10 calves were recorded, including four that were born in 2018 and 2019 (Berrow *et al.,* 2020).

Potential for noise disturbance impacts to bottlenose dolphin is considered in **Section 3.4** below. An assessment of the potential impacts of the project on the integrity of the cSAC is undertaken in **Section 3.4.4** in relation to the attributes and targets identified for the species in the site Conservation Objectives (NPWS, 2012) while mitigation measures are identified in **Section 3.6** to prevent adverse effects on the integrity of the cSAC.

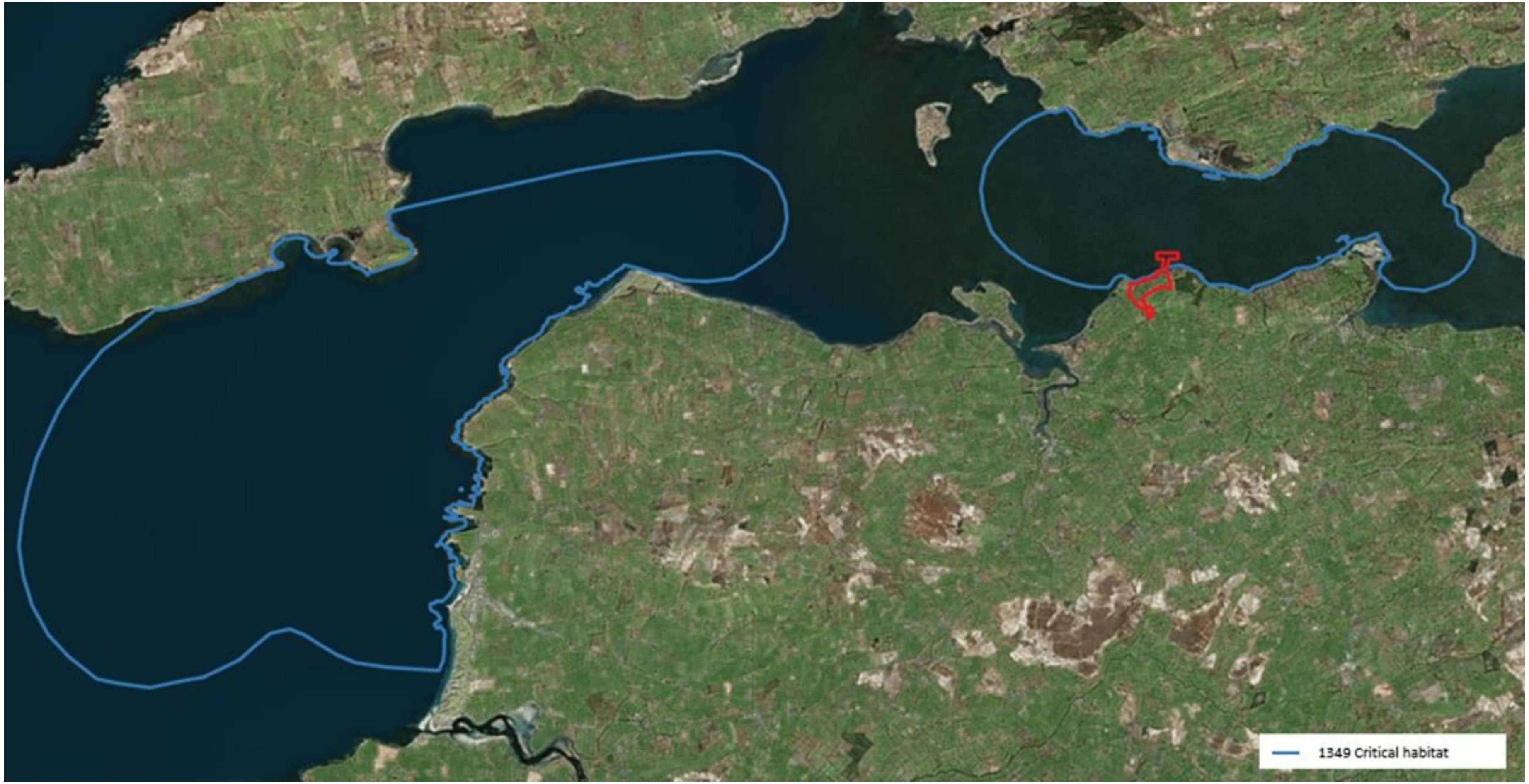


Figure 3-41: Bottlenose dolphin critical areas, representing habitat used preferentially by the species (adapted from NPWS 2012, Ingram and Rogan 2002; Rogan *et al.* 2018).

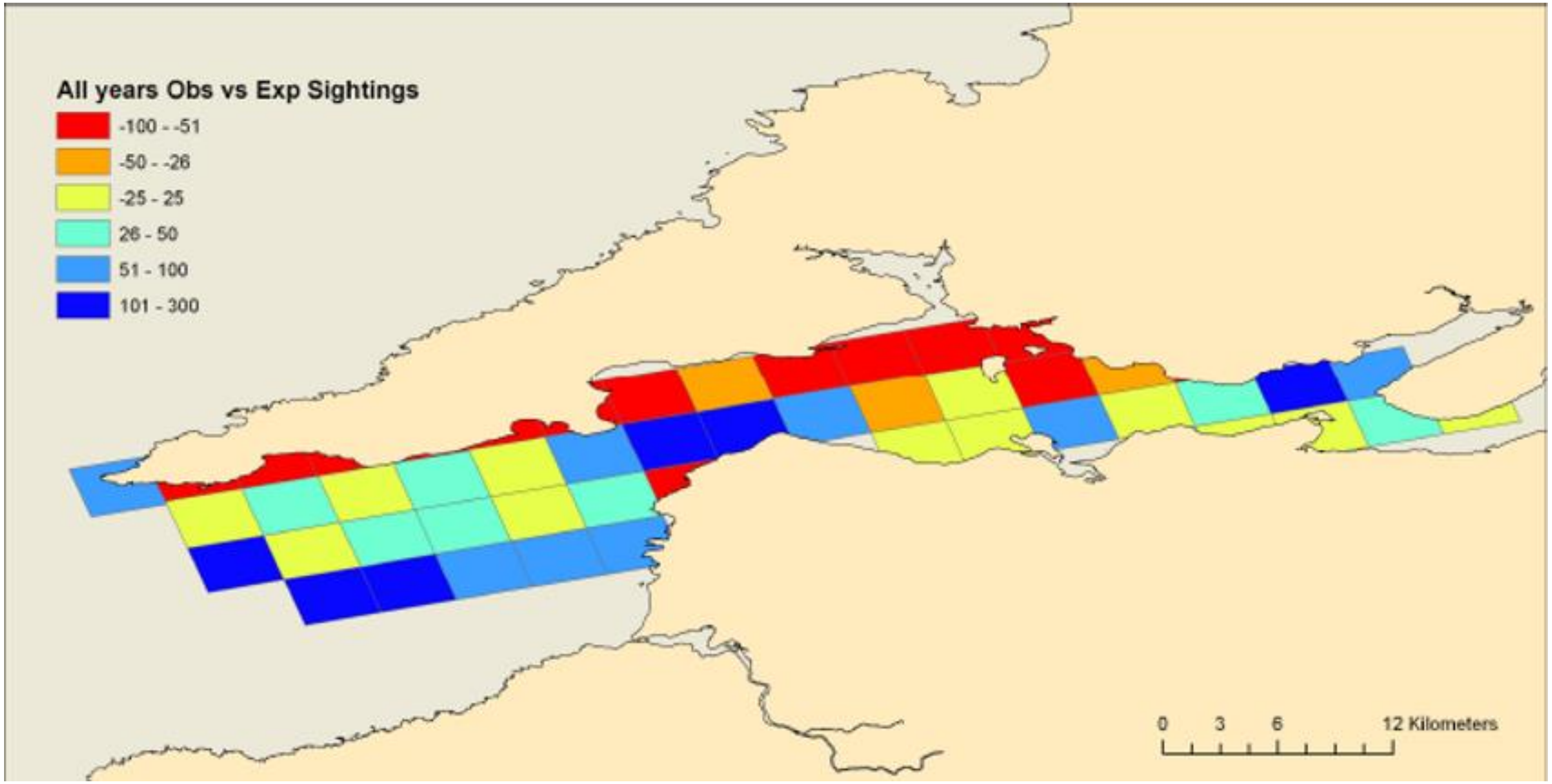


Figure 3-42: Scoring assessment for habitat suitability for bottlenose dolphins in the Shannon Estuary (adapted from Berrow *et al*., 2012).

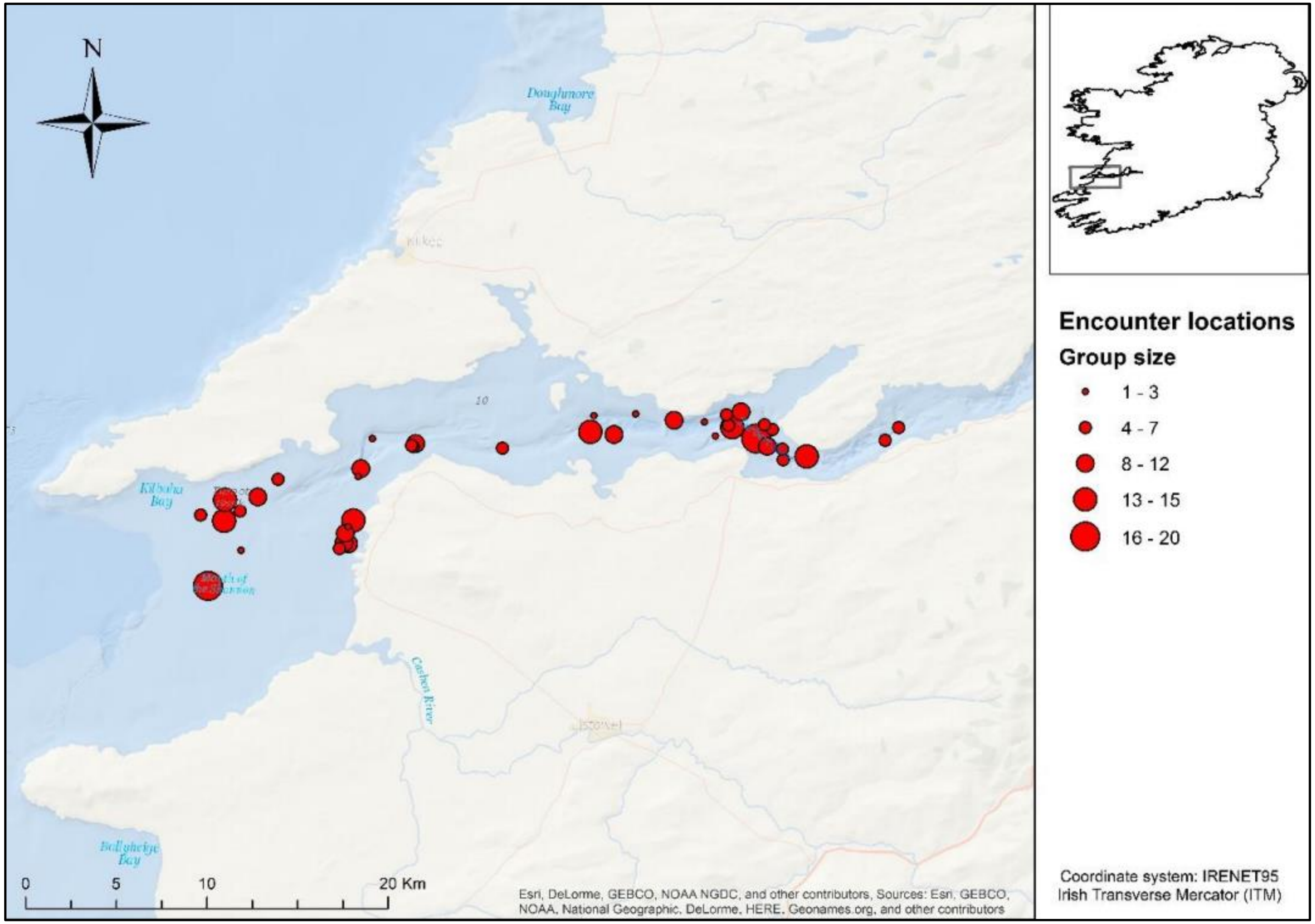


Figure 3-43: Locations of bottlenose dolphin schools encountered during surveys of the lower Shannon Estuary, 2018. Estimated group sizes are denoted by symbol diameters (adapted from Rogan *et al*., 2018).

3.3.3.2. Fish Species

Atlantic Salmon *Salmo salar*

Salmon spend their juvenile phase in rivers before migrating to sea to grow and mature. To complete their life cycle they home to predetermined natal rivers (philopatric behaviour) to spawn. Smolts typically head out to sea between March and June and adults return to the river between March and August. There are no spawning sites at the project area; however, adult fish will pass through the site when travelling up the river to spawn or on return to the sea or as smolts on their first migration to the sea. A number of rivers that flow into the Shannon Estuary are fished for salmon. These include the River Fergus, Castleconnell Salmon Fishery, River Mulchair, River Maigue and the River Deel.

Sea Lamprey *Petromyzon marinus,* River Lamprey *Lampetra fluviatilis* and Brook Lamprey *Lampetra planeri*

Both sea lamprey (*Petromyzon marinus*) and river lamprey (*Lampetra fluviatilis*) are QIs of the Lower River Shannon cSAC and have the potential to occur within the project area. Unlike salmon, spawning sea lamprey and river lamprey do not home to predetermined natal rivers (philopatric behaviour) (Tuunainen *et al.,* 1980; Bergstedt and Seelye, 1995; Waldman *et al.,* 2008; Meckley, *et al*., 2020). As adults in the marine environment, sea lamprey and river lamprey parasitise various species of marine and anadromous fish (Kelly and King, 2001). After the parasitic phase, which lasts between 2 – 3 years, river lamprey and sea lamprey migrate upstream to spawn, selecting rivers and streams through positive rheotaxis (swimming into an oncoming current) and attraction to pheromonal cues (bile acids) from larval conspecifics located upstream (Tuunainen *et al*., 1980; Bergstedt and Seelye, 1995; Waldman *et al*., 2008; Meckley *et al*., 2020). Lamprey spawning habitat requires a gravel bottom with swift-running water and nearby sheltered areas with muddy bottoms for the larvae (Wheeler, 1969). Once in the vicinity of spawning gravels, they hide under stones or among vegetation (Hardisty and Potter 1971), with sea lamprey congregating at spawning gravels to spawn in May and June, and river lamprey spawning in March and April (Kelly and King, 2001). Hatching occurs two weeks after egg deposition and within a further one to three weeks the ammocoete larvae emerge from the spawning substrate and burrow into muddy beds in sheltered areas. Ammocoetes (larvae) are relatively immobile and remain in the muddy beds for between 3 – 8 years (Kelly and King, 2001; Dawson *et al*., 2015). The population of larvae present in the muddy beds, which comprise multiple age classes, filter feed on organic matter until the onset of metamorphosis (Dawson *et al*., 2015). Larvae metamorphose into non-feeding adults that migrate downstream to the marine environment. The Brook Lamprey (*Lampetra planeri)* are a freshwater species occurring in streams and occasionally in lakes in northwest Europe, particularly in basins associated with the North and Baltic seas. Spawning occurs in the rivers in March and April.

Potential for impact to the fish species is discussed in **Section 3.4** below.

3.3.3.3. Otter

Otters, along with their breeding and resting places, are protected under the provisions of the Wildlife Act 1976, as amended. Otters have additional protection because of their inclusion in Annex II and Annex IV of the Habitats Directive which is transposed into Irish law in the European Communities (Birds and Natural Habitats) Regulations 2011, as amended. Otters are also listed as requiring strict protection in Appendix II of the Berne Convention on the Conservation of European Wildlife and Natural Habitats and are included in the Convention on International Trade of Endangered species (CITES).

Otters are widespread in Ireland and found in a variety of aquatic habitats, both freshwater and marine, but always requiring access to fresh water. Their territorial nature results in frequent marking of territories with droppings (‘spraints’), which can usually be readily identified and are often placed in conspicuous locations. Otters breed in burrows, called 'holts', and also use safe places to rest above ground during the day ('couches'). Holts are often found under tree root systems near water, but can be located some distance from water. Otters feed on a variety of prey, usually fish and crustaceans, but occasionally also taking birds and small mammals. It is noted that otters are largely nocturnal, particularly in areas subject to high levels of disturbance as evidenced by the presence of otters in the centre of Irish cities. Thus, they are able to adapt to increased noise and activity levels; however, breeding holts are generally located in areas where disturbance is lower.

Otters are a conservation feature of the Lower River Shannon cSAC (site code 002165). The range of Otter in the areas surveyed within the Lower River Shannon is 73.53% over an area of 684 km^2. This has fallen from 100% occurrence in 1980/1981. Otter's main source of prey within the Shannon are frogs (42.9%), followed by stickleback (35.7%) and salmonids (21.4%) (Bailey and Rochford 2006). Coastal otters feed predominately on marine species but may also travel inland via estuaries to feed on brackish or freshwater food resources (Weir & Bannister, 1977). Reid *et al.* (2013) found otters living along coasts have a greatest niche breath than those in freshwater systems which encompasses a wide variety of intertidal prey though pelagic fish are rarely taken.

Each adult otter has its own home range, which it marks with its faeces (spraints) at prominent locations. When groups of otters are evident, they usually consist of a female and her young. Range sizes vary widely according to the quality of the foraging habitat and other resources, such as suitable sites for otter dens (holts). Their ranges may alter seasonally to include sites of abundant prey. The average distribution density of otters is approximately one otter per 10 km on many Irish watercourses, but this will vary from as little as one otter per 50 km of river to, perhaps, as much as one otter per 2 km of river or coastline (NRA 2008).

Otter surveys were carried out within and in the vicinity of the Proposed Development site in 2007, 2011-2012 and 2018-2021. These surveys found otter activity was centred outside the western boundary of the site. Otter were recorded along the Ralappane Stream and Shannon Estuary by general observation/survey and trail camera surveys (**Figure 3-44**).

An otter sprainting site was recorded along the tidal section of the stream within the site in October 2019. An otter was recorded foraging along the shoreline near Knockfinglas Point and to the west of the site on the October 2019. An otter was recorded in October 2019 foraging close to the lagoon to the west of the Proposed Development site. In December 2018 a dead female otter was noted floating within the coastal waters to the east of the site. An otter was also recorded in January 2020 moving along the upper shoreline approximately 900m southwest of the proposed development site, in a field above the upper shoreline.

Two Bushnell Trophy Cam HD Aggressor were used for camera surveys from June to October 2019. The cameras recorded two otters close to the confluence of the Ralappane Stream and the Shannon Estuary shoreline, outside the Proposed Development site boundary. Two otters, both adult, were recorded together by trail cameras in June 2019. Otters are generally solitary and therefore the presence of two adults may be indicative of breeding behaviour. However, no holts were recorded within 150m of the Proposed Development site. A trail camera which was put in place in the eastern section of the site, near the proposed jetty location from January to March 2021 recorded no signs of otter.

While a holt/resting area was recorded to the west of the Ralappane Stream in 2007, no resting areas or natal holts were recorded within the Proposed Development site boundary or the study area (see **Figure 3-44**). Further details on otter surveys are included in Appendix 7B.1 of EIAR Vol. 4).

Predicted impact on otter is discussed in **Section 3.4** below.

Figure 3-44: Location of Otter surveys area and Otter records in the vicinity of the Proposed Development site.

3.3.4. River Shannon and River Fergus SPA

The proposed project is in the River Shannon and River Fergus Estuaries SPA (see **Figure 1-2** and **Figure 2-26**). The Natura 2000 Standard Data Form for the SPA lists the *negative impacting threats and pressures* and *positive impacting activities/*management affecting the site (see **Table 2.19**). The existing pressures, threats or activities that impose moderate negative impact on the site are:

- Shipping lanes (D03.02)
- Nautical sports (G01.01)
- Marine and Freshwater Aquaculture (F01)

The above pressures, threats or activities impose moderate negative impacts on the site.

The estuaries of the River Shannon and River Fergus form the largest estuarine complex in Ireland. The site comprises the entire estuarine habitat from Limerick City westwards as far as Doonaha in Co. Clare and Dooneen Point in Co. Kerry. The site has vast expanses of intertidal flats which contain a diverse macroinvertebrate community which provides a rich food resource for the wintering birds. Salt marsh vegetation frequently fringes the mudflats and provides important high tide roost areas for the wintering birds. Elsewhere in the site the shoreline comprises stony or shingle beaches.

3.3.4.1. Bird Species and Wetlands

The SPA is designated for a total of twenty-one bird species. The site is also designated for the habitat Wetland. **Table 3.9** lists conservation features for which there is potential for significant effects (as identified in the screening assessment). The E.U. Birds Directive pays particular attention to wetlands and, as these form part of this SPA. A detailed description of the site is included in the Site Synopsis report (NPWS, 2015) which is included in **Appendix 1.**

Table 3.9: Special Conservation Interests the River Shannon and River Fergus Estuaries SPA (NPWS, 2012[3]).

Special Conservation Interest	Conservation Objective
Cormorant (*Phalacrocorax carbo*) [A017]	To maintain the favourable conservation condition
Whooper Swan (*Cygnus cygnus*) [A038]	To maintain the favourable conservation condition
Shelduck (*Tadorna tadorna*) [A048]	To maintain the favourable conservation condition
Wigeon (*Anas penelope*) [A050]	To maintain the favourable conservation condition
Teal (*Anas crecca*) [A052]	To maintain the favourable conservation condition
Pintail (*Anas acuta*) [A054]	To maintain the favourable conservation condition
Shoveler (*Anas clypeata*) [A056]	To maintain the favourable conservation condition
Scaup (*Aythya marila*) [A062]	To maintain the favourable conservation condition
Ringed Plover (*Charadrius hiaticula*) [A137]	To maintain the favourable conservation condition
Golden Plover (*Pluvialis apricaria*) [A140]	To maintain the favourable conservation condition
Grey Plover (*Pluvialis squatarola*) [A141]	To maintain the favourable conservation condition
Lapwing (*Vanellus vanellus*) [A142]	To maintain the favourable conservation condition
Knot (*Calidris canutus*) [A143]	To maintain the favourable conservation condition
Dunlin (*Calidris alpina*) [A149]	To maintain the favourable conservation condition
Black-tailed Godwit (*Limosa limosa*) [A156]	To maintain the favourable conservation condition

Special Conservation Interest	Conservation Objective
Bar-tailed Godwit (*Limosa lapponica*) [A157]	To maintain the favourable conservation condition
Curlew (*Numenius arquata*) [A160]	To maintain the favourable conservation condition
Redshank (*Tringa totanus*) [A162]	To maintain the favourable conservation condition
Greenshank (*Tringa nebularia*) [A164]	To maintain the favourable conservation condition
Black-headed Gull (*Chroicocephalus ridibundus*) [A179]	To maintain the favourable conservation condition
Wetlands [A999]	To maintain the favourable conservation condition

The conservation objectives for the breeding and wintering population of cormorant is defined and measured by eight attributes and targets. The conservation objectives for each of the remaining 20 wintering populations (non-breeding) of qualifying interest species are defined and measured by the same two attributes and targets. The conservation objective for wetland habitat is to maintain its favourable conservation condition in the SPA as a resource for the regularly-occurring migratory waterbirds that utilise it, defined and measured by 1 no. attribute and target (NPWS, 2012).

The Shannon estuary has been the focus of systematic waterbird monitoring since the early 1980s (Sheppard 1993) and more regularly since the mid-1990s (Crowe, 2005). However, regular counts of this site are limited because of the extensive efforts required to undertake coordinated counts of such a large site, which has many areas of limited access. Nonetheless, counts have shown that the Shannon Estuary has held the largest numbers of waterbirds in Ireland (*e.g.* Colhoun, 2001). However, surveys in more recent years show that, for many species, there have been substantial declines in usage by waterbirds (NPWS, 2012).

The most detailed survey of the Shannon Estuary was carried out by MKO in 2017/2018 (MKO 2019). This survey covered 87 subsites within the Shannon Estuary, including the Proposed Development site. This survey found that the total number of SCI species recorded across all subsites ranged from 20 species in October to 10 species in June.

Most of the 21 conservation feature species were present in all the winter months (October-March) with pintail and scaup being the only species absent during these months. Over half of the conservation feature species remained present during the summer. The mean species richness per subsite varied from 1.7-18.3, and species richness was amongst the lowest for all subsites in the subsite overlapping with the Proposed Development site (**Figure 3-45**). One of the highest species richness occurred in the Ballylongford area to the west of the project site. The narrow section of the Lower Shannon between Foynes and Tarbert had generally low species richness, although the small size of the subsites in these areas will have affected the analyses. Subsite species richness was generally correlated with the subsite intertidal area, although this was mainly due to low species richness in subsites with less than 50 ha of intertidal habitat.

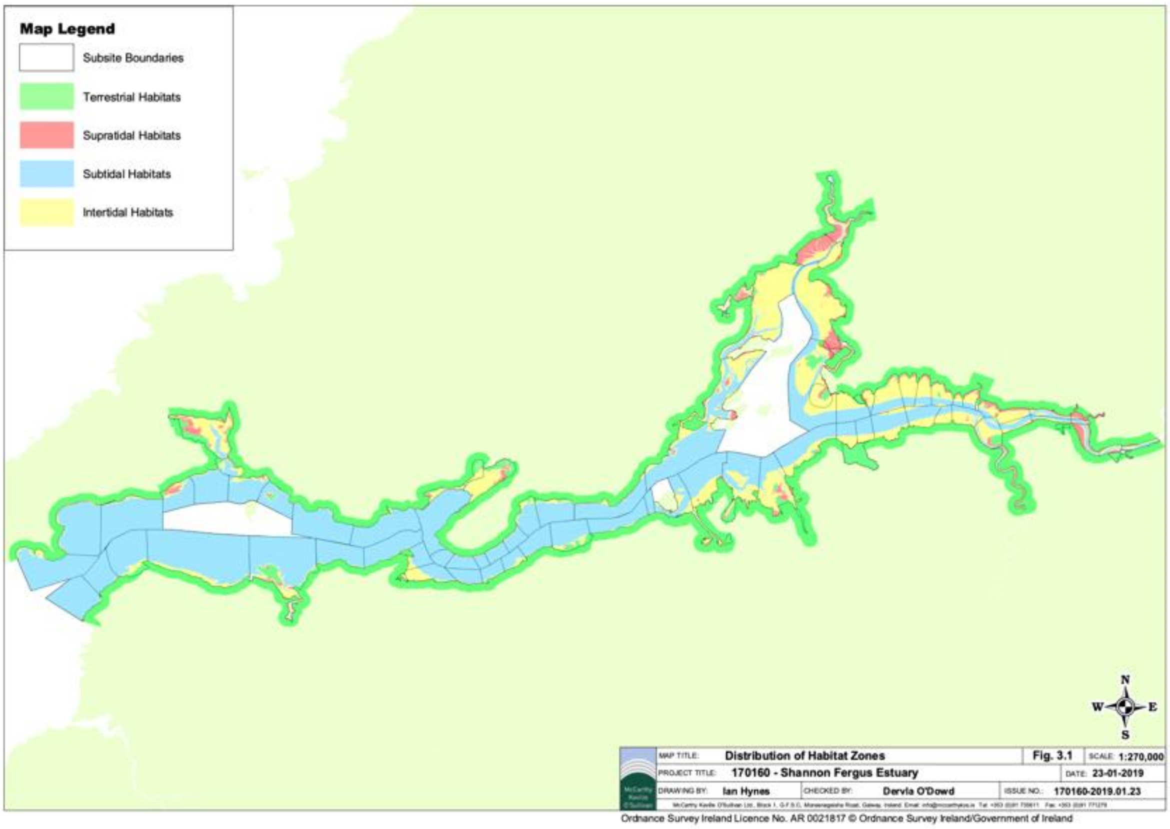


Figure 3-45: Distribution of habitat zones within the Shannon Estuary (MKO 2019).

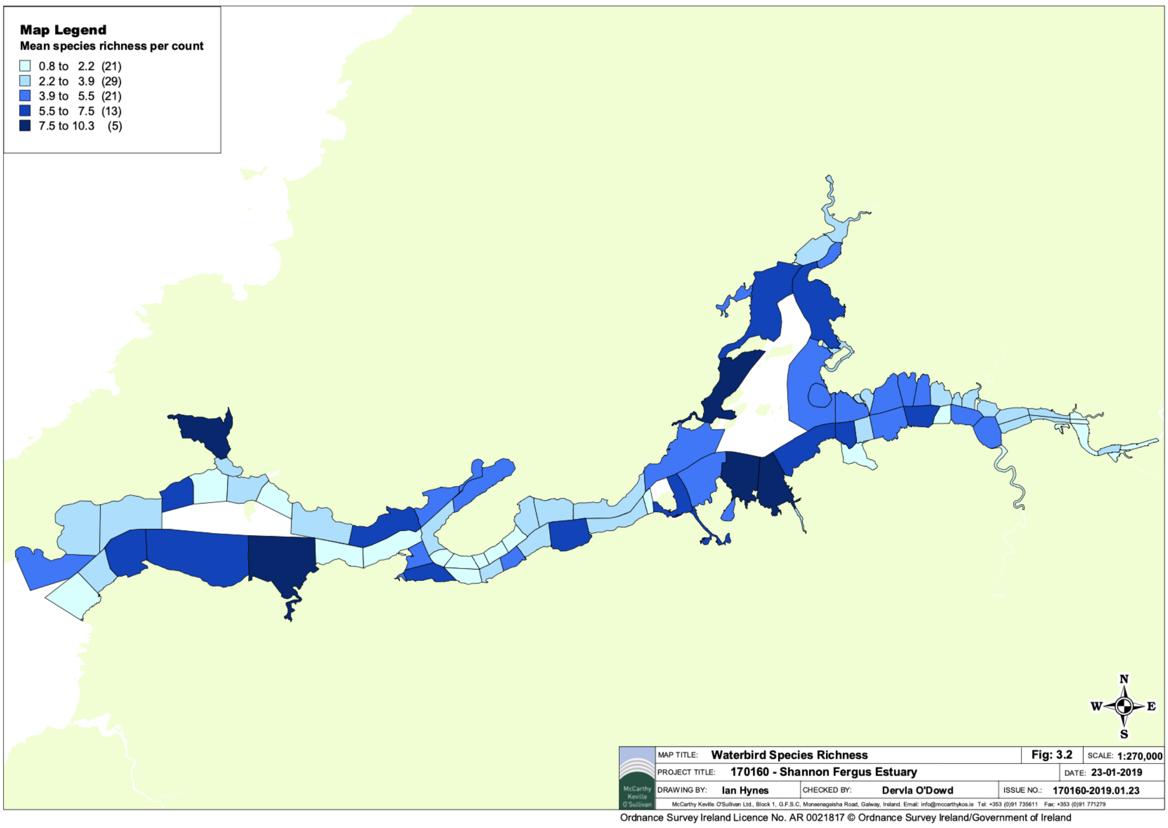


Figure 3-46: Mean species richness per count (MKO 2019).

As part of the current project application DixonBrosnan carried out winter bird surveys from 2018-2020 and summer bird surveys in 2021 at the Proposed Development site as well as along the Shannon Estuary to the east and west of the Proposed Development site (**Figure 3.47**). Surveys were carried out from six vantage points on the southern shores of the Shannon Estuary between Richard's Rock and 1.8km east of Ardmore Point. Initially the survey focused on three points (**Figure 3.47** Points A, B and C). A fourth survey site, (**Figure 3.47** Point D) was added in February of 2019. Two additional survey sites were added to the east of the proposed development site in May 2021 (**Figure 3.47** Point E and F). Fourteen of the 21 SCI species for the River Shannon and River Fergus Estuaries SPA were recorded during estuarine bird surveys *i.e.* cormorant, wigeon, shelduck, light-bellied brent goose, teal, ringed plover, golden plover, grey plover, lapwing, dunlin, curlew, redshank, greenshank and black-headed gull. Full details on survey methodology and results are included in Appendix 7B.3 in EIAR Vol. 4.

Figure 3.47: Estuarine bird survey locations along the Shannon Estuary.

Table 3.10. Summary of peak low tide counts by area.

Species*	POINT A	Beach & Lagoon	POINT B	Bay	POINT C	POINT D	POINT E	POINT F	1% National[a]	1% International[a]
Black Guillemot	8	0	1	0	0	3	1	0	-	-
Black-headed Gull	2	2	6	2	0	94	1	0	-	31,000
Common Guillemot	0	0	1	0	0	0	0	0	-	-
Common Gull	8	1	8	2	2	3	0	3	-	16,400
Cormorant	2	1	3	0	4	1	0	0	110	1200
Curlew	12	12	5	5	0	45	0	0	350	7600
Dunlin	0	0	0	0	0	260	0	0	450	13,300
Great Black-backed Gull	0	0	0	0	0	2	0	1	-	3,600
Great Crested Grebe	11	0	1	0	1	4	0	0	30	6300
Great Northern Diver	4	0	2	0	1	2	0	0	20	50
Greenshank	0	0	0	0	0	1	0	0	20	3300
Grey Heron	1	1	1	1	0	1	0	1	25	5000
Grey Plover	0	0	0	0	0	0	0	0	30	2000
Herring Gull	0	0	9	9	0	5	0	0	-	14,400
Lapwing	11	11	0	0	0	0	0	0	850	72,300
Lesser Black-backed Gull	1	0	1	0	0	0	1	7	-	5,500
Light-bellied Brent Geese	11	11	0	0	0	100	0	0	350	400
Little Egret	1	0	0	0	0	2	1	0	20	1,100
Mallard	2	2	2	2	0	0	0	0	280	53,000
Moorhen	2	2	0	0	0	0	0	0	-	37,100

Mute Swan	0	0	0	0	0	2	0	0	90	100
Oystercatcher	8	8	9	9	3	8	0	1	610	8,200
Razorbill	0	0	0	0	0	0	0	0	-	-
Red-throated Diver	1	0	2	2	1	2	0	0	20	3,000
Redshank	1	1	0	0	0	4	0	0	240	2,400
Ringed Plover	0	0	0	0	0	22	0	0	120	540
Sandwich Tern	2	0	4	0	0	3	0	3	-	-
Shag	5	0	0	0	0	0	0	0	-	2,000
Shelduck	0	0	0	0	0	0	2	0	100	2,500
Snipe	5	5	1	0	0	2	0	0	-	100,000
Teal	10	10	0	0	0	0	0	0	360	5000
Turnstone	0	0	6	6	0	2	2	0	95	1,400
Water Rail	0	0	0	0	0	0	0	0	-	-
Whimbrel	0	0	0	0	1	0	0	1	-	-
Wigeon	25	25	10	0	12	0	0	0	560	1400

*SCI Species for the River Shannon and River Fergus Estuaries SPA in Bold font; a. Burke *et al* (2018)

Table 3.11. Summary of peak high tide counts by area.

Species*	POINT A	Beach & Lagoon	POINT B	Bay	POINT C	POINT D	POINT E	POINT F	1% National[a]	1% International[a]
Black Guillemot	2	0	1	2	1	5	1	-	-	-
Black-headed Gull	46	4	64	64	123	30	1	-	-	31,000
Common Guillemot	3	0	1	2	1	0	0	-	-	-
Common Gull	8	2	14	14	7	1	0	-	-	16,400
Cormorant	3	0	3	3	2	1	0	-	110	1200
Curlew	45	45	10	10	2	30	0	-	350	7600
Dunlin	0	0	0	0	0	1	0	-	450	13,300
Golden Plover	0	0	0	0	0	24	0	-	920	9,300
Great Black-backed Gull	3	0	3	3	4	0	0	-	-	3,600
Great Crested Grebe	11	0	2	2	1	4	0	-	30	6300
Great Northern Diver	3	0	3	3	2	1	0	-	20	50
Greenshank	4	4	1	1	1	0	0	-	20	3300
Grey Heron	1	1	1	1	0	0	0	-	25	5000
Grey Plover	12	12	0	0	0	15	0	-	30	2000
Herring Gull	0	0	1	9	0	10	1	-	-	14,400
Lapwing	3	3	0	0	0	0	0	-	850	72,300
Lesser Black-backed Gull	0	0	1	1	0	14	0	-	-	5,500
Light-bellied Brent Geese	0	0	0	0	0	20	0	-	350	400
Little Egret	1	1	1	1	0	2	1	-	20	1,100
Mallard	0	0	0	2	2	0	0	-	280	53,000

Moorhen	2	2	0	0	0	0	0	-	-	37,100
Mute Swan	0	0	0	0	0	0	0	-	90	100
Oystercatcher	7	7	4	9	5	12	0	-	610	8,200
Razorbill	1	0	0	0	1	0	0	-	-	-
Red-throated Diver	2	0	1	1	2	0	0	-	20	3,000
Redshank	1	1	1	1	1	5	0	-	240	2,400
Ringed Plover	24	24	0	0	0	0	0	-	120	540
Sandwich Tern	2	0	0	0	0	3	0	-		
Shag	2	0	0	0	0	0	0	-	-	2,000
Shelduck	0	0	0	0	0	4	2	-	100	2,500
Snipe	17	17	8	8	0	1	0	-	-	100,000
Teal	1	0	2	2	0	0	0	-	360	5000
Turnstone	27	27	23	23	7	0	2	-	95	1,400
Whimbrel	6	0	0	0	0	0	0	-	-	-
Water Rail	3	0	0	0	0	0	0	-	-	-
Wigeon	8	8	4	10	0	20	0	-	560	1400

*SCI Species for the River Shannon and River Fergus Estuaries SPA in Bold font; a. Burke *et al* (2018)

Point A is located on the beach to the west of the Proposed Development site boundary. Several divers were recorded foraging in the deeper waters here, largely non-SCI species as well as small numbers of cormorant (peak number 3). The deeper waters bordering the Proposed Development site meant that diving birds were recorded during low and high tide counts. Wading birds were occasionally recorded here foraging along the shoreline or roosting on the upper shore *i.e.,* ringed plover (peak number 24), grey plover (peak number 12), greenshank (peak number 4), lapwing (peak number 11) and curlew (peak number 45). Duck species were also recorded here *i.e.,* wigeon (peak number 28), generally roosting near the small stream on the southern boundary of the shoreline. The agricultural fields to the south and west of Point A, (also near Point D), appear to be used regularly by terrestrial foraging curlew.

Point B (and Bay) is located at Knockfinglas Point within the planning boundary for the Proposed Development to the west of the proposed jetty. The limited area of intertidal habitat is reflected by the low numbers of roosting and foraging birds using this area. Low numbers of gulls, diving birds, and waders were recorded here during both low and high tide surveys. A flock of 64 black-headed gull were recorded loafing on the water at high tide. Similarly, low numbers of birds were recorded in the Bay area adjacent to Point B. Few SCI species was recorded in this area (Point B and Bay) i.e. cormorant (peak number 3), curlew (peak number 10), redshank (peak number 1), greenshank (peak number 1), teal (peak number 2), wigeon (peak number 10).

Point C is located at Ardmore Point to the east of the planning boundary and the proposed jetty site. This overlooks slightly deeper waters than the other survey points and limited intertidal habitats are limited in extent. Gull and diving bird species were regularly recorded at this site, albeit in small numbers. A mixed flock of gulls including 123 black-headed gull was recorded in December 2018. Cormorant also forage in this area (peak number 4). Few waders were recorded here, and this is probably due to the limited foraging habitat present; curlew (peak number 2), greenshank (peak number 1) and redshank (peak number 1). Small numbers of duck species *i.e.* wigeon (peak number 12), were recorded here at low tide.

Point D is located at Robert's Rock, approximately 1km southwest of the planning boundary. The largest numbers and diversity of birds were recorded at Point D, reflecting the diversity of habitats visible from this vantage, which overlooks the boundary between Ballylongford Creek and the Shannon Estuary. Here there is a larger area of intertidal foraging habitat, including a small area of mudflat exposed at low tide and saltmarsh habitat. Wading birds, gulls, ducks and diving birds were recorded at this site. There was a notable difference in bird numbers and diversity recorded here between low and high tide. During low tide a range of wading bird species were recorded from point d including black-headed gull (peak number 94), curlew (peak number 45), dunlin (peak number 260), greenshank (peak number 1), light-bellied brent goose (peak number 100), redshank (peak number 4) and ringed plover (peak number 22). Small numbers of cormorant forage in subtidal waters at low tide (peak number 1). While smaller numbers of birds were recorded here during high tide, bird diversity was still relatively high at Point D during high tide counts.

With the exception of one black headed gull (peak number 1), no conservation feature species were recorded at Point E and Point F. It is noted that no winter counts were carried out from these points and a small number of surveys were carried out prior to submission of the planning application and this may be reflected in the low numbers of birds recorded in this area. However, as with other areas along this part of the Shannon Estuary, there is minimal areas of intertidal foraging habitat present.

Figure 3-48 shows the numbers of conservation feature birds foraging within 500m of the jetty works area *i.e.* recorded from Point B (Bay) and Point C. With the exception of black-headed gull, bird numbers foraging in the vicinity of jetty are low. This reflects the lack of suitable intertidal foraging habitat in this area, which is largely confined to a small stretch of gravel/shingle shore and subtidal waters (**Figure 3-48**). Very small numbers of conservation feature bird species were recorded within

500m of the jetty during winter and summer bird counts. Curlew were recorded foraging on wet grassland habitat near Knockfinglas Point (Point A, Beach and Lagoon), to the west of the Proposed Development site. No terrestrial foraging conservation feature bird species were recorded within the Proposed Development site boundary. While there are small areas of wet grassland within the western section of the Proposed Development site, no terrestrial foraging waders were recorded in this area.

There are no cormorant roosts or breeding sites in the vicinity of the Proposed Development site boundary or in this part of the Shannon Estuary (NPWS 2012). No signs of breeding cormorant were recorded at the Proposed Development site and no trees suitable for use as cormorant roosts or suitable potential nesting sites were recorded within the Proposed Development site. The subtidal waters of the estuary provide foraging grounds for cormorant. Cormorant numbers foraging in the vicinity of the jetty site were low (peak number 4).

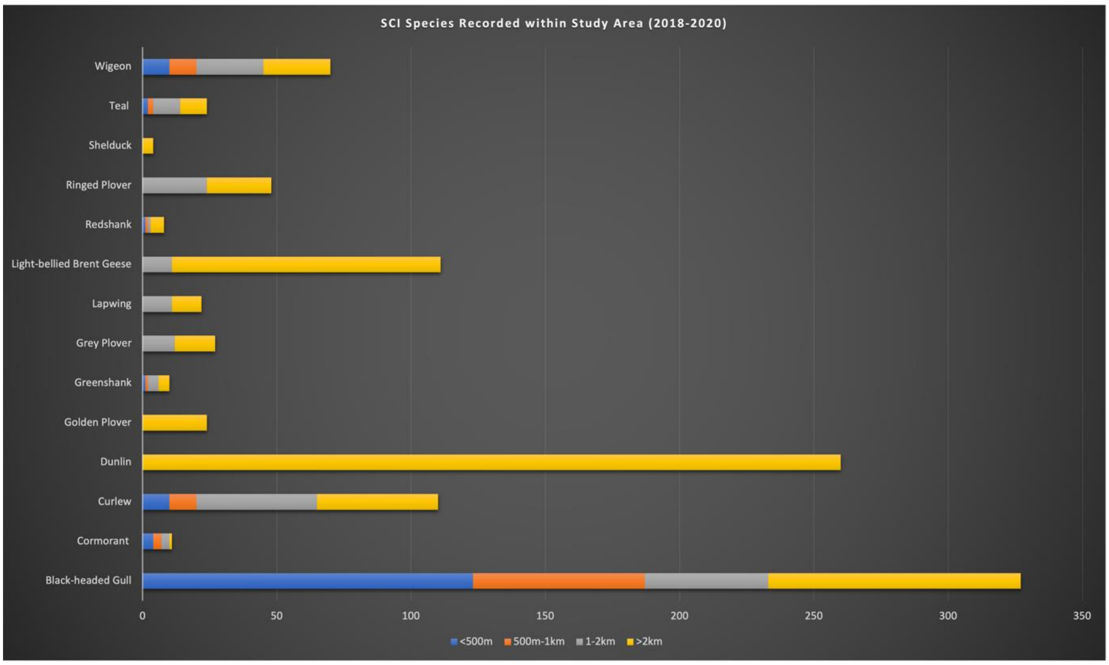


Figure 3-48: Peak numbers of conservation feature birds recorded within study area relative to jetty location.

3.4. Impact Prediction

As described in **Section 2.12.2** above, the impact mechanisms associated with the proposed project that may result in effects to conservation feature marine habitats, marine mammals and diadromous fish species of the Lower River Shannon cSAC, and to the conservation feature bird species and habitats of River Shannon and River Fergus SPA are:

1. Release of pollutants during construction
2. Land-based construction noise and vibration disturbance
3. Release of spoil during piling
4. Underwater noise
5. Seabed habitat loss
6. Vessel physical disturbance and collision injury
7. Discharge of treated cooled seawater
8. Entrainment and impingement of fauna by the FRSU seawater system
9. Discharge of Wastewater and Power Plant Process Heated Water Effluent

10. Introduction of invasive species
11. Accidental large-scale oil or LNG spill
12. Collision with site infrastructure
13. Barrier to connectivity
14. Reduction in prey biomass

3.4.1. Impact Mechanism 1. Release of pollutants during construction

3.4.1.1. Relevant Conservation Features

- Estuaries [1130]
- Reefs [1170]
- Coastal lagoons [1150]
- Perennial vegetation of stony banks [1220]
- Salicornia and other annuals colonising mud and sand [1310]
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]
- Mediterranean salt meadows (*Juncetalia maritimi*) [1410]
- *Tursiops truncatus* (Common Bottlenose Dolphin) [1349]
- *Lampetra planeri* (Brook Lamprey) [1096]
- *Salmo salar* (Atlantic Salmon) [1106]
- *Lampetra fluviatilis* (River Lamprey) [1099]
- *Petromyzon marinus* (Sea Lamprey) [1095]
- *Lutra lutra* (Otter) [1355]*
- *Phalacrocorax carbo* (Cormorant) [A017]
- *Anas crecca* (Teal) [A052]
- *Anas acuta* (Pintail) [A054]
- *Aythya marila* (Scaup) [A062]
- *Anas penelope* (Wigeon) [A050]
- *Anas clypeata* (Shoveler) [A056]
- *Tadorna tadorna* (Shelduck) [A048]
- *Charadrius hiaticula* (Ringed Plover) [A137]
- *Pluvialis apricaria* (Golden Plover) [A140]
- *Pluvialis squatarola* (Grey Plover) [A141]
- *Calidris canutus* (Knot) [A143]
- *Calidris alpina* (Dunlin) [A149]
- *Limosa limosa* (Black-tailed Godwit) [A156]
- *Limosa lapponica* (Bar-tailed Godwit) [A157]
- *Numenius arquata* (Curlew) [A160]
- *Tringa totanus* (Redshank) [A162]
- *Tringa nebularia* (Greenshank) [A164]
- *Vanellus vanellus* (Lapwing) [A142]
- *Branta bernicla hrota* (Light-bellied Brent Goose) [A046]
- *Cygnus cygnus* (Whooper Swan) [A038]
- *Chroicocephalus ridibundus* (Black-headed Gull) [A179]
- Wetland and waterbirds [A999]

3.4.1.2. Assessment

Impact mechanism 1 is associated with the construction phase.

Potential effects associated with construction activity includes accidental release of sediment and chemical pollutants to the Shannon Estuary immediately adjacent to and upstream and downstream of the Proposed Development.

Sediments

The Shannon Estuary is naturally turbid with background level suspended solids ranging from 1 mg/l up to 86 mg/l (McMahon and Quirke, 1992). Excessive suspended sediments can cause stress and affecting the gills of fish, resulting in injury or mortality and the loss of suitable fish spawning habitat and declines in egg and early life stage success rates. Increased turbidity can reduce feeding rates and affect prey abundance and predation efficacy in visual feeders such as salmon. Resident fish species in the Shannon Estuary including Lamprey, Salmon, Seatrout have evolved over geological time to migrate through estuaries on their way to spawning grounds and as many estuaries are naturally high in turbidity, these species evolved mechanisms to deal with high suspended sediment loads.

Bottlenose dolphin use echolocation as their principal means of navigation, communication, foraging and predator avoidance. In murky waters, the use of echolocation means that objects are often "heard" before they are seen (Ansmann, 2005). As dolphin are accustomed to the naturally turbid nature of the Shannon Estuary impacts due to short-lived changes in turbidity are unlikely to impact the species.

Should sediments be released to the Shannon Estuary, the effect of increased turbidity, if realised, will be short lived with the local currents in the immediate area resulting in sediment being rapidly removed from the system and significant sediment deposition in the area will not occur. In the event of significant release of sediment from the construction works, local current are such that any localised deposition of sediment will be short lived with sediments rapidly dispersed seaward.

In addition, any effects are not likely to be significant for local habitats and fauna, as the area is naturally turbid (see above) and hydrodynamically active and experiences a high degree of natural suspended solids. Consequently, there is no risk of significant effects to benthic habitats.

Through the implementation of construction best practice and mitigation and monitoring measures, the risk of activities during the construction resulting in the uncontrolled release of sediment material to the nearby river and habitat types is extremely unlikely to occur. Mitigation and monitoring measures and the general construction practices to be implemented are detailed in **Section 3.6** and the Outline Construction Environmental Management Plan (OCEMP) provided in Appendix 7 of NIS Vol. 2.

Chemical Pollutants

Accidental release of hydrocarbons from plant machinery and fuel stocks, and organic polymers or heavy metals associated with cementing/ concreting materials used for construction activities. These materials are toxic to organisms in sufficient quantities and will potentially contaminate the seabed sediments adjacent to the project, inhibiting recolonisation of the area.

Chemical contamination of the river and river sediments could also occur from accidental spillages, such as oil and other chemicals through poor operational management, the non-removal of spillages, poor storage, handling and transfer of oil and chemicals. Hydrocarbon spills from poorly secured or non-bunded fuel storage areas, leaks from vehicles or plant or spills during re-fuelling can all give rise to the escape of hydrocarbons from construction sites.

Wash off from poorly cured cement can also be highly alkaline and potentially dangerous to fish. Spills of hydrocarbons and chemicals can give rise to tainting of fish or, if large enough, fish kills and invertebrate kills. Accidental release of chemicals and pollutants must be controlled to ensure risk of impacts are minimised.

If suitable precautions are taken and best practice for the storage, handling and disposal of such material are followed, impacts should be minimal.

Mitigation measures specifically designed to avoid the introduction of runoff and contaminants to the river channel are detailed in **Section 3.6** and the OCEMP provided in Appendix 7 of NIS Vol. 2.

Accidental spillages will be contained and cleaned up immediately. Remediation measures will be carried out in the unlikely event of pollution of the marine environment. Accidental spillages are also considered in **Section 3.4.11**.

3.4.1.3. Conclusion

Based on the above and subject to implementation of mitigation, it can be concluded there will be no significant adverse effects to the conservation features from impact mechanism 1.

3.4.2. Impact Mechanism 2. Land-based construction noise and vibration disturbance

3.4.2.1. Relevant Conservation Features

- *Phalacrocorax carbo* (Cormorant) [A017]
- *Anas crecca* (Teal) [A052]
- *Anas acuta* (Pintail) [A054]
- *Aythya marila* (Scaup) [A062]
- *Anas penelope* (Wigeon) [A050]
- *Anas clypeata* (Shoveler) [A056]
- *Tadorna tadorna* (Shelduck) [A048]
- *Charadrius hiaticula* (Ringed Plover) [A137]
- *Pluvialis apricaria* (Golden Plover) [A140]
- *Pluvialis squatarola* (Grey Plover) [A141]
- *Calidris canutus* (Knot) [A143]
- *Calidris alpina* (Dunlin) [A149]
- *Limosa limosa* (Black-tailed Godwit) [A156]
- *Limosa lapponica* (Bar-tailed Godwit) [A157]
- *Numenius arquata* (Curlew) [A160]
- *Tringa totanus* (Redshank) [A162]
- *Tringa nebularia* (Greenshank) [A164]
- *Vanellus vanellus* (Lapwing) [A142]
- *Branta bernicla hrota* (Light-bellied Brent Goose) [A046]
- *Cygnus cygnus* (Whooper Swan) [A038]
- *Chroicocephalus ridibundus* (Black-headed Gull) [A179]
- *Lutra lutra* (Otter) [1355]*

3.4.2.2. Assessment

Impact mechanism 2 is associated with the construction phase.

During initial site preparation/ clearance works and during construction activities, the presence of construction personnel and the operation of construction equipment (*e.g.* excavators, rock breakers *etc*.) will result in noise and vibration disturbance as well as increased lighting, potentially displacing SCI bird species and otter from the site and surrounding areas. During construction the most significant sources of noise will be underwater piling for the jetty and controlled rock blasting on land. It is noted that the impact of underwater noise on conservation feature species is discussed in **Section 3.4.4.** Increased shipping, human activity and lighting in the vicinity of jetty during the operational phase also have the potential to create disturbance impacts. Increased noise and disturbance during construction and operation could cause disturbance/displacement of conservation feature bird species and otter. Bridging works along the Ralappane Stream near the site entrance could cause disturbance to otter during the construction phase.

Blasting

All blasting locations are confined to the onshore habitats and significant noise will dissipate quickly outside the immediate works area. Proposed blasting locations are located at the east of the Proposed Development site (see **Figure 3-49**). It is understood that no more than three blasts per day are envisaged and blasting vibration limits will be achieved by limiting the Maximum Instantaneous Charge (MIC) used in the blasting process. There are no blasting locations located within the cSAC or SPA and the blasting areas at the east of the site are a considerable distance from areas used by conservation feature birds and otter. According to Cutts et al. (2013), a single sudden sound such as blasting will generally cause more disturbance than a constant or regular noise regardless of noise level. The typical response would be for birds to move away from affected areas to less disturbed areas. Birds that remain in the affected area may not forage effectively and this may impact on survival and foraging rates. It is noted that a range of measures will be adopted during the blasting stage of the construction phase to minimise the impact of air overpressure as far as practicable. Given the distance from sensitive receptors, overpressure and vibration impacts from blasting will not be significant. While blasting noise during construction may lead to significant noise in some areas of the Proposed Development site and temporarily displace small numbers of birds from the adjacent lands, given the temporary nature of blasting and the distribution of conservation feature species in the vicinity of the site, no significant impact on the distribution or numbers of conservation interest species within the Lower River Shannon cSAC or River Shannon and River Fergus Estuaries SPA will occur.

SCI Birds

As noted in **Section 3.3.4**, very small numbers of conservation feature birds were recorded foraging along the shoreline within 500m of the jetty. Noise contour modelling has been carried out for peak construction noise, *i.e.*, when site clearance, enabling works, piling and heavy civil engineering operations related to the terminal are expected to occur concurrently (Appendix 7B-3 of EIAR Vol. 4). This noise contour model illustrates that during construction, noise levels will attenuate quickly outside the immediate piling works area.

Noise levels of 70 dB and above are regularly cited within the literature as being the threshold beyond which disturbance to estuarine bird species can be predicted to occur (Cutts *et al.* 2013). During construction significant noise levels *i.e.,* >70dB will be confined to a small area of subtidal waters and shoreline in the immediate vicinity of the jetty. Based on disturbance distances calculated by Cutts *et al.* (2013), visual disturbance impacts for wading birds will be confined to the shoreline within 300m of the jetty works and given the small numbers of birds foraging in this area, the impacts of visual disturbance will not be significant. While estuarine birds may temporarily avoid habitat in the immediate vicinity of construction, these species are likely to readily forage in other areas within the estuary during peak construction works. Therefore, during peak construction works, where high-level noise levels and visual disturbance will occur in the vicinity of the jetty works area, a very small number of conservation feature birds would be temporarily displaced and this would not have a significant impact on overall numbers of birds foraging within the estuary.

Noise contour modelling was carried out for two operational scenarios where peak noise levels are predicted (EIAR Appendix 7B-3 of EIAR Vol. 4). These models illustrate that following mitigation, peak noise levels are predicted to be below 65dB(A) LAeq even at the FRSU. Outside this area noise levels will attenuate quickly with all areas outside the immediate FRSU to between <55 dB(A) near within 500m of the Site and 35dB(A) west of Knockfinglas Point. This represents a low to moderate level of noise disturbance during peak operation, to which birds are likely to become habituated to over time (Cutts *et al*. 2013). Wading birds and waterfowl foraging along the shoreline are likely to habituate to the regular nature of the noise and disturbance associated with the jetty and shipping activity and continue to forage here, albeit in small numbers, as previously. Operational noise level will represent at worst a moderate noise disturbance to which the majority of birds are likely to habituate. Outside subtidal/intertidal habitats in the immediate vicinity of the Site, noise levels within the estuary will be below 55dB(A) throughout the operational phase and will not cause significant disturbance impacts to conservation feature species.

Conservation feature birds which forage in intertidal waters*, i.e.* cormorant and black-headed gull, are relatively flexible with respect to habitat use (Garthe and Hüppop 2004; Furness and Wade 2012) and studies on disturbance distances show they will forage within proximity to human activity such as shipping, *i.e.* cormorant (258m ± 215m), and black-headed gull (84m ± 70m) (Fliessbach *et al.,* 2019).

Cormorant are considerably more tolerant to shipping disturbance than other diving bird species (*e.g. Gavia* spp.) (Garthe and Hüppop, 2004; Furness and Wade 2012; Fliessbach *et al.,* 2019). Evidence from Burbo Bank (CMACS 2008) and Robin Rigg (E.ON/Natural Power 2012) offshore wind farms has shown that densities of cormorant increased during their construction phases.

Higher numbers of conservation feature birds were recorded to the west/southwest of Knockfinglas Point, over 1 km from the onshore construction area, although none in nationally or internationally important numbers. During construction and operation the Proposed Development will be visible from the Shannon Estuary (and SPA), but the topography of the coastline largely hides works from shoreline habitats to the west of the Knockfinglas Point (Appendix 9 in NIS Vol. 2 Photomontages). Noise levels west of Knockfinglas Point will be <40dB (A) during peak construction works (Appendix 7B-3 of EIAR Vol. 4). Given the distance involved, the topography of the shoreline and predicted noise levels, there will be no disturbance impacts to birds west of Knockfinglas Point during construction works.

Artificial lighting used during the construction and operational phases could potentially cause disruption to SCI species within the SPA. Mitigation measures during construction will limit spillover of artificial light into the SPA from the jetty area (Refer to lighting drawing in Appendix 10 in NIS Vol. 2). While the jetty location is within an area which is currently unlit at night, lighting levels will meet national and international engineering standards as a minimum. However, light spillage onto the waters/habitats for the SPA will be minimal. It is noted that artificial light is likely to have positive impacts on waterbirds in intertidal habitats by enhancing the efficiency of nocturnal foraging (Dwyer *et al*. 2013) and may also reduce predation risk to roosting birds (*c.f.* Gorenzel and Salmon, 1995). Therefore, while lighting in the immediate vicinity of the jetty will increase, this will not have a significant on bird numbers or distribution of birds within the SPA.

Mitigation measures to reduce noise, vibration and lighting levels during construction and operation are detailed in **Section 3.6**. Overall, the area of the SPA which adjoin the proposed development site do not support high numbers of waders or waterfowl and therefore construction works are likely to result in temporary to short-term displacement of a small number of foraging birds. Given the ability of birds to habituate to predictable disturbance such as traffic, shipping and boats associated with the jetty, no significant visual disturbance is predicted to occur during operation. No significant impacts on SCI birds are predicted to occur due to visual (and lighting) or noises disturbance during the construction or operational phase of the proposed development.

Based on the above and subject to implementation of mitigation, it can be concluded there will be **no significant adverse effects to the SCI birds within the River Shannon and River Fergus Estuaries SPA from impact mechanism 2**.

Otter

As detailed in **Section 3.3.3** and illustrated in **Figure 3-44** no signs of otter were recorded within the Proposed Development site, although they use lands to the west of the site along the lower reaches of the Ralappane Stream where it meets the Shannon Estuary. No otter holts/couches were recorded within 150m of the Proposed Development site.

During construction otter are likely to avoid bridge works on the Ralappane Stream due to increased disturbance. However, there is no evidence of otter usage upstream of the tidal section of the Ralappane Stream and given its limited size and small numbers of fish recorded here (EIAR Appendix 7B-4) this small watercourse is unlikely to be a critical foraging resource for this species. It is noted that drainage ditches at the Proposed Development site do not support fish species and no signs of common frog were recorded along these drainage ditches. Therefore, any construction works within the stream or drainage ditches will not have a significant impact on otter due to disturbance or impacts on prey availability.

Onshore construction works will primarily take place during daytime hours and will avoid the largely nocturnal foraging habits of otter. Jetty works will take place over 24 hours. However, it is noted that all records of otter were over 1km from the jetty works area and, following mitigation, peak construction noise at the closest known otter areas will be 58.3 dB(A) (Appendix 7B-3 of EIAR Vol. 4 receptor R9). Operational mitigation measures will ensure that noise levels at known areas for otter are less than 36 dB(A) (Appendix 7B-3 of EIAR Vol. 4 location R9).

Outdoor lighting during construction and operation will be designed to minimise the potential for light spill. While the LNG terminal will be manned round-the-clock for operations and maintenance purposes, planned maintenance activities will predominantly be conducted during daytime. Lighting levels will meet national and international engineering standards as a minimum, including a lighted area around the dock to detect spillage and unauthorised craft. It is noted that there will no lighting during construction or operation along the lower reaches of the Ralappane Stream or along the shoreline of the Shannon Estuary to the west of the site where otter were recorded.

While otter activity is centred to the west of the site away from the proposed buildings and jetty locations, given the importance of the Shannon Estuary for otter, it cannot be ruled out that otter forage in the vicinity of the proposed jetty location. If otter were excluded from this area during operation due to disturbance and/or lighting, this could potentially impact on otter foraging range and numbers within the Shannon Estuary. Otter are largely nocturnal and can habituate to human disturbance (Chanin, 2003). It is known that otters use man-made structures for holting in addition to excavations (Natural England, 2006). Examples include locations beneath bridges or jetties, where secluded areas are created. Such areas can be prominent resting areas and thus fall under the 'couch' category. There are several examples of Otter usage around busy industrial structures in Ireland including at the IOWR facility in Corkbeg Island where Otter regularly forage and rest in the vicinity of the oil tanker docks (Macklin 2018) and at the jetty in the Ringaskiddy Port in Cork (RPS 2015). Reid *et al.* (2013) also found that Otter regular use bridges as sprainting sites. Manmade structures in nearshore areas e.g., ports, docks, jetties, canals, coastal protection can also create additional habitat for a range of marine species including fish, invertebrates and algae. Brandl *et al.* (2017) found that artificial marine habitats, including dock pilings and jetties, can harbour diverse, regionally characteristic assemblages of vertebrates that follow macroecological patterns that are well documented for natural habitats. Toft *et al.* (2004) found significantly higher density of juvenile salmonid species around overwater structures in comparison to the surrounding natural habitat. The location of the new jetty along the Shannon Estuary is likely to create additional couch and sprainting sites for Otter, as well as additional foraging habitat during the operational phase.

During construction, blasting and piling works will be centred to the east of the site, a significant distance from the areas of otter activity. While there may be some short-term displacement of otters foraging along the Shannon Estuary shoreline, this increased noise and disturbance during the construction phase is unlikely to significantly impact on otter due to their ability to move away from and/or adapt to short-term disturbance. During the operational phase otters in the area are likely to adapt successfully to increased disturbance and forage along the artificial reef habitat created by the jetty.

Mitigation measures to reduce noise, vibration and lighting levels during construction and operation are detailed in **Section 3.6**.

3.4.2.3. Conclusion

Based on the above and subject to implementation of mitigation, it can be concluded there will be no significant adverse effects to the conservation features of the River Shannon and River Fergus Estuaries from impact mechanism 2.

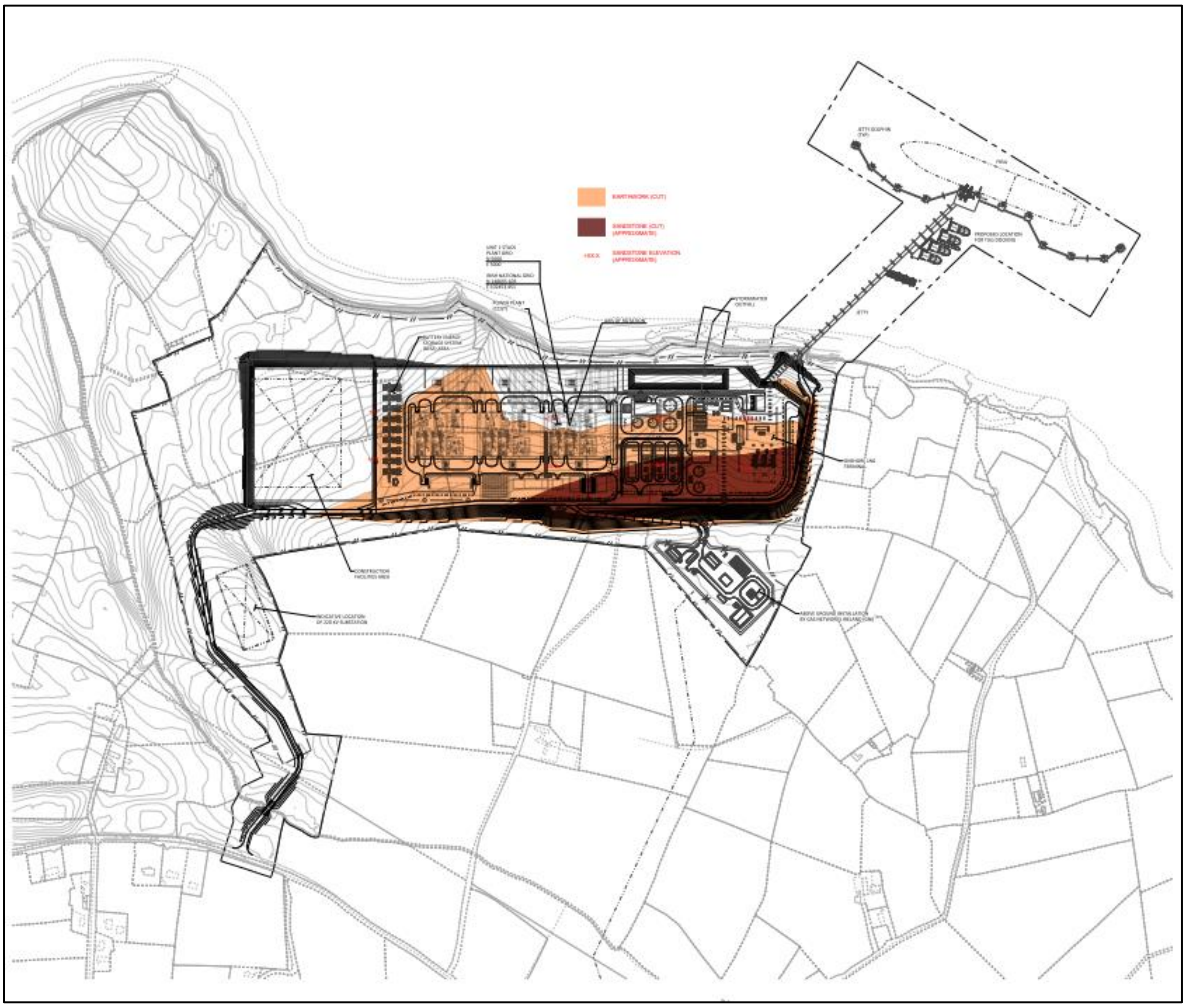


Figure 3-49: Blasting locations.

3.4.3. Impact Mechanism 3. Release of spoil during piling

3.4.3.1. Relevant Conservation Features

- Mudflats and sandflats not covered by seawater at low tide [1140]
- Large shallow inlets and bays [1160]
- Estuaries [1130]
- Reefs [1170]
- Sandbanks which are slightly covered by sea water all the time [1110]
- Coastal lagoons [1150]
- Perennial vegetation of stony banks [1220]
- Salicornia and other annuals colonising mud and sand [1310]
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]
- Mediterranean salt meadows (*Juncetalia maritimi*) [1410]
- *Tursiops truncatus* (Common Bottlenose Dolphin) [1349]
- *Lampetra planeri* (Brook Lamprey) [1096]
- *Salmo salar* (Atlantic Salmon) [1106]
- *Lampetra fluviatilis* (River Lamprey) [1099]
- *Petromyzon marinus* (Sea Lamprey) [1095]
- *Lutra lutra* (Otter) [1355]*
- *Phalacrocorax carbo* (Cormorant) [A017]
- *Anas crecca* (Teal) [A052]
- *Anas acuta* (Pintail) [A054]
- *Aythya marila* (Scaup) [A062]
- *Anas penelope* (Wigeon) [A050]
- *Anas clypeata* (Shoveler) [A056]
- *Tadorna tadorna* (Shelduck) [A048]
- *Charadrius hiaticula* (Ringed Plover) [A137]
- *Pluvialis apricaria* (Golden Plover) [A140]
- *Pluvialis squatarola* (Grey Plover) [A141]
- *Calidris canutus* (Knot) [A143]
- *Calidris alpina* (Dunlin) [A149]
- *Limosa limosa* (Black-tailed Godwit) [A156]
- *Limosa lapponica* (Bar-tailed Godwit) [A157]
- *Numenius arquata* (Curlew) [A160]
- *Tringa totanus* (Redshank) [A162]
- *Tringa nebularia* (Greenshank) [A164]
- *Vanellus vanellus* (Lapwing) [A142]
- *Branta bernicla hrota* (Light-bellied Brent Goose) [A046]
- *Cygnus cygnus* (Whooper Swan) [A038]
- *Chroicocephalus ridibundus* (Black-headed Gull) [A179]
- Wetland [A999]

3.4.3.2. Overview

Impact mechanism 3 is associated with the construction phase.

The construction of the 345-m jetty and access trestle will require the installation of approximately 203 piles.

Piling for the construction of the jetty will commence, initially from onshore (approximately four and half months) followed by approximately eleven months from the water. The jetty construction works will operate on a 24 hour basis, 6 days a week with maintenance works on Sundays and over approximately 12 ½ as months.

The majority of the piles supporting the jetty would be driven, with some piles drilled and socketed into the underlying rock to ensure stability of the jetty. This operation would require a jack-up platform supporting a large crane-mounted drill and a large barge-mounted support crane.

There is potential that spoil (drilling rock particles and sediment) generated and released to the water column may increase turbidity resulting in a significant reduction of light for phytoplankton. There is also the potential that the deposition of solids on benthic habitats will result in the smothering of organisms. High levels of suspended solids settling on the seabed can alter habitats resulting in a potential loss of feeding and spawning grounds. Mobile species may move away from unfavourable conditions; however, sessile, benthic fauna may be smothered and lost. Solid generated and released by piling may be deposited on benthic habitats.

Shannon LNG commissioned AQUAFACT to carry out a hydrodynamic and dispersion modelling study to determine the fate of sediment generated during piling operations required for the installation of the jetty for the Proposed Development. The full modelling report is included Appendix 3 of NIS Vol. 2.

3.4.3.3. Assessment

The average pile length will be approximately 20m resulting in total pile volume of 1,980m^3. At a porosity of 20% the total mass of sediment spoil removed by the piling operation is estimated conservatively to be 5,500 tonnes. Spoil from the drilling operation will be conveyed to the surface using a reverse-circulation drilling rig (*e.g.* LD408 drilling rig (see Appendix 8 of NIS Vol. 2 for details) or similar drilling rig) and collected in designated scows or other storage vessels.

Approximately 1000m^3 pile arisings are anticipated from the socketed piles (approximately 80 no.), none of which will be from onshore piling operations. The spoils would be placed on a barge, dried, then transferred to shore for drying and reused in general earthworks or in landscaped bunds. To allow for disturbance of sediments by the piling process and potential spillage of solids via reverse circulation drilling, a conservative factor of 25% of the sediment removed is used as a spillage rate of sediment. Sediment transport simulations are carried out based on a fine to very fine sand as identified in the geotechnical investigations. An 18-day simulation was performed with 0.9kg/s of sediment releases continuously from the site of the pilling operations. The full details of the model are included in the modelling report included in Appendix 3 of NIS Vol. 2.

3.4.3.3.1. Habitats Directive and Birds Directive Habitats

Modelling shows that while the predicted plumes of spoil extend significant distances from the operations deposition is largely spatially limited to areas along the south and north coasts of the estuary, and the islands to the north west of the jetty (see **Figure 3-50**). This to be expected because, as noted above in **Section 3.4.1**, the Shannon Estuary is naturally turbid (background suspended solids ranging from 1 mg/l up to 86 mg/l; McMahon and Quirke 1992) and hydrodynamically active and any release of sediment to the river will, at most, result in short lived and localised elevated turbidity levels with local water currents rapidly dispersing sediments seaward. On the south coast, sediment deposition rate in the majority of areas ranges is predicted to be between 0.01 and 0.001 mm/m^2 (see **Figure 3-50**). In small discrete areas approximately 400 to 800 m downstream of the piling operations predicted sediment disposition rate ranged between 2 to 5 mm/m^2 while further west at Ballylongford Bay and southwest of Carrig Island the deposition rate is predicted to be 2 mm/m^2 (see **Figure 3-51**). Moving northward from the south coast and the piling operations, sedimentation rate drops below

0.001 mm/m^2 on account of fast moving currents resulting in all generated sediment being rapidly removed from the system. On the north coast, and around the islands to the north west of the jetty, the predicted rate of sediment deposition is low ranging from 0.01 to 0.001 mm/m^2.

The OSPAR Commission (OSPAR 2008, 2009) note that benthic fauna can survive rapid sediment deposition up to depths of 100mm, 20 times the maximum depth predicted by the model (see Appendix 3 of NIS Vol. 2). Further, OSPAR (2008, 2009) also state that negative impacts to marine life are only expected when sediment deposition depths exceed 150mm.

Adverse impacts to habitats will not occur.

3.4.3.3.2. Habitats Directive and Birds Directive Species

As discussed in **Section 3.4.1** sediment loads can give rise to increased bottom sedimentation, which, in turn, can adversely impact macroinvertebrates and aquatic habitat quality. Elevated suspended solids levels within the water column can damage the gills of fish, and benthic macroinvertebrate when deposited.

Increased turbidity can reduce feeding rates and affect prey abundance and predation efficacy in visual feeders. Otter and cormorant are visual hunters with good eyesight both above and below the water. The release of spoil in the water column during piling and the resuspension of sediments during construction has the potential to significantly affect turbidity levels. Otter and cormorant are highly mobile species and while their eyes are adapted for seeing food item in murky or dark water, they will avoid areas of excessive turbidity. While significant increases in turbidity may result in the temporary displacement of the species, there are extensive alterative areas of otter and cormorant habitat available to the species away from the project area. Consequently, there is no risk of significant effects.

Prolonged suspension of sediments may also lead to reduced primary productivity in waters, in turn depressing oxygen levels. However, given the temporary nature of the work and the action of local water current removing suspended solids from the works area, there is no risk of significant effects.

Given the scale and temporary nature of piling works any significant elevated turbidity would be limited spatially and temporally to the immediate project area; consequently there is no risk of significant effects.

Diadromous fish species have evolved over geological time to migrate through estuaries on their way to spawning grounds and as many estuaries are naturally high in turbidity, these species evolved mechanisms to deal with high suspended sediment loads.

Bird species use wetland habitats for foraging. The structure and functionality of wetlands are influenced by hydrological regime and sediment transport. As described above the deposition rate of sediment generated due to piling activities is low and below the threshold of impact to benthic communities. Consequently, significant indirect effects to bird foraging can be excluded.

3.4.3.4. Conclusion

Based on the above it can be concluded there will be no significant adverse effects to the conservation features species from impact mechanism 3.

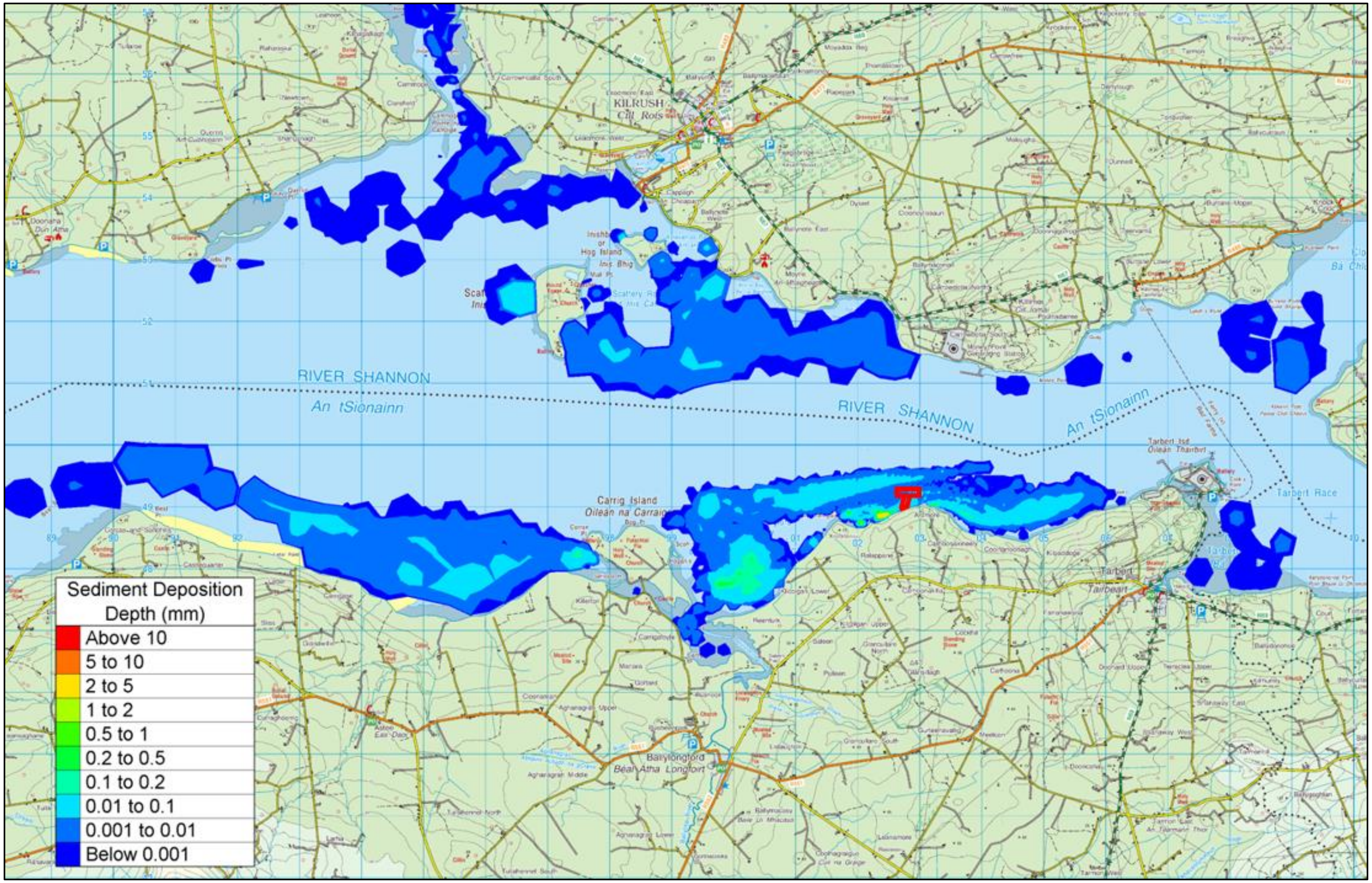


Figure 3-50: Maximum sediment deposition rate. Approximate location of jetty shown in red.

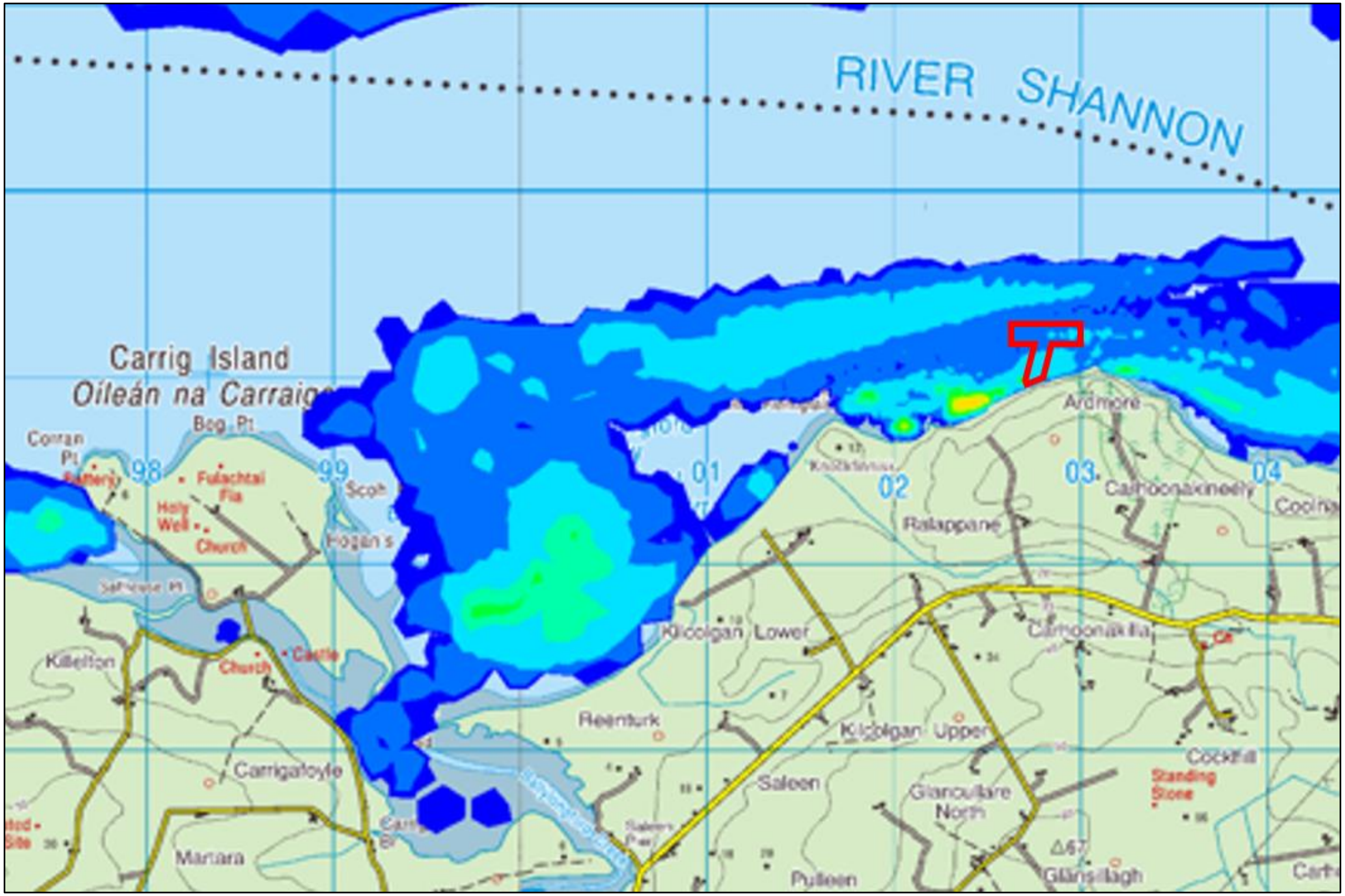


Figure 3-51: Maximum sediment deposition rate. Approximate location of jetty shown in red.

3.4.4. Impact Mechanism 4. Underwater noise

3.4.4.1. Relevant Conservation Features

- *Tursiops truncatus* (Common Bottlenose Dolphin) [1349]
- *Lampetra planeri* (Brook Lamprey) [1096]
- *Salmo salar* (Atlantic Salmon) [1106]
- *Lampetra fluviatilis* (River Lamprey) [1099]
- *Petromyzon marinus* (Sea Lamprey) [1095]
- *Lutra lutra* (Otter) [1355]*
- *Phalacrocorax carbo* Cormorant [A017]

3.4.4.2. Assessment

3.4.4.2.1. Overview

Impact mechanism 4 is associated with the construction and operation phase.

Activities associated with the construction and operation of the LNG Terminal (*e.g.* pile driving, vessel noise) have the potential to impact marine mammals, fish and diving birds by introducing sound into the marine environment.

To assess potential effects of project activities on bottlenose dolphins, the number of acoustic exposures that may occur during the planned activities was calculated based on the occurrence of dolphins in the area and the extent of the potentially affected area which was determined by underwater acoustic modelling and available sound threshold criteria.

In addition, the potential impact on other marine mammals and fish was also assessed, based on modelled distances to available sound threshold criteria. The results are discussed within the context of the Proposed Development and in light of the mitigation and monitoring measures that are anticipated to be implemented.

A 345-m jetty with a central loading platform, six mooring dolphins, and four breasting dolphins would be constructed to access the deeper waters of the estuary (Brown and Worbey, 2020). Approximately 203 piles would be installed using a combination of techniques including a hydraulic impact hammer, vibratory hammer, and/or continuous flight auger (CFA) techniques. The exact number of piles is subject to the final design. Piling for the construction of the jetty will commence initially from onshore (approximately four and half months) followed by approximately eleven months from the water. The jetty construction works will operate on a 24 hour basis, 6 days a week with maintenance works on Sundays and over approximately 15 ½ months. Note that impact piling activities will not commence during night-time hours. The pile diameter would be ~1.067 m, and a 150 kJ impact hammer would be used. Noise from onshore blasting could also enter the water.

The FSRU would not be permanently moored at the jetty and would depart the jetty when necessary. Loading of LNG onto the FSRU would be via a ship-to-ship transfer from an LNG carrier berthed alongside. The FSRU would have an LNG storage capacity of up to 180,000 m^3. Up to one LNG carrier ship (LNGC) per week is expected to deliver its cargo to the FSRU (Brown and Worbey 2020).

3.4.4.2.2. Receptors

Common Bottlenose Dolphin

Bottlenose dolphin use echolocation as their principal means of navigation, communication, foraging and predator avoidance. The individual monitors its surroundings by emitting sound waves and waiting for them to reflect off different objects (Weilgart, 2007; Ansmann, 2005; Potter and Delroy, 1998). The time taken for these pulses to return to the animal, as well as the characteristics of the reflected pulse, gives an indication of the distance and nature of the object. Light propagates poorly in the viscous and opaque marine environment and is absorbed within a few tens of metres (Potter and Delroy, 1998; Nowacek *et al*., 2007). Low frequency underwater sound may travel for hundreds of kilometres without losing intensity (Nowacek *et al.,* 2007). In murky waters, the use of echolocation means that objects are often “heard” before they are seen (Ansmann, 2005). This ability is extremely effective; bottlenose dolphin, can differentiate between two aluminium plates varying by just 0.23 mm and can detect objects up to 113m away (Au, 2002). This level of precision is indicative of the importance of echolocation for foraging and navigation by some species of cetaceans.

The potential impacts of noise on marine mammals have been the subject of considerable research; reviews are provided by), Nowacek *et al*. (2007), Southall *et al.* (2007), Weilgart (2007) and Wright *et al*. (2007). If the frequency of anthropogenic noise overlaps with the frequencies used by marine mammals, this may reduce the animal’s ability to detect important sounds for navigation, communication and prey detection (Weilgart, 2007). This is termed acoustic masking, which may occur anywhere within an organism’s auditory range (Wright *et al.,* 2007; Richardson *et al.,* 1995). Masking of important vocalisations will result in increasing information ambiguity and, in extreme circumstances, may result in cetaceans being unable to orientate themselves or hunt/ evade predation in the marine environment (Wright *et al.,* 2007).

Exposure to high energy noise emissions (piling, drilling, seismic noise) can result in non-recoverable auditory injury (termed Permanent Threshold Shift (PTS). Behavioural reactions to acoustic exposure are generally more variable, context-dependent, and less predictable than the effects of noise exposure on hearing or physiology. This is because behavioural responses to anthropogenic sound are dependent upon operational and environmental variables, and on the physiological, sensory, and psychological characteristics of exposed animals. It is important to note that the variables may differ (greatly in some cases) among individuals, of a species and even within individuals depending on various factors (*e.g.* sex, age, previous history of exposure, season, and animal activity). NOAA (2013) outline that noise can affect cetacean behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Fish Species

Sound is perceived by fish through the ears and the lateral line (the acoustico-lateralis system) which is sensitive to vibration. Some species of fish such as salmon have a structure linking the gas filled swim bladder to the ear. The swim bladder is sensitive to the pressure component of a sound wave, which resonates as a signal that stimulates the ears. These species, therefore, usually have increased hearing sensitivity. Such species are considered to be more sensitive to anthropogenic underwater noise sources than species, such as lamprey that do not possess a structure linking the swim bladder and inner ear.

It should be noted that the potential impact of noise on juvenile and adult fish in open water are considered to be minimal as they can readily move away from the noise source. Experiments on fry demonstrated balance problems resulting from exposure to an energy source, however, the effects were temporary with full recovery observed after a few minutes upon cessation of the noise (Kostyuchenko, 1971). Some studies of high energy seismic noise sources have also demonstrated fish’s ability to acclimatise to noise associated with an energy source over time (*e.g.* Chapman and Hawkins, 1969).

Hearing in salmon is poor, responding only to low frequency tones (below 0.38 kHz). While there are no data available for hearing in lamprey, it is highly unlikely that they detect sound close to 10 kHz (Popper, 2005). The lamprey ear is relatively simple and there is nothing within the structure of the ear or associated structures to suggest any specialisations that would make them into anything but a hearing generalist, with maximum hearing to no more than several hundred Hz.

Cormorant

Generally, noise produced from activities associated with underwater works such as piling have been shown to impact only those offshore species of birds that spend large quantities of time underwater, either swimming or plunge diving while foraging for food. Several studies on the impact of underwater noise from seismic surveys or underwater explosions, which have higher noise and vibration levels than piling works, found no evidence of impact from underwater noise or vibration on birds in the marine environment (Yelverton *et al.* 1973; Turnpenny and Nedwell, 1994, U.S. Department of the Interior, 2004, Aguilar de Soto 2015).

Yelverton *et al.* 1973, examining birds in proximity to underwater explosions, determined that the onset of injury for diving birds was 190dB (Sound Energy Level (SEL) unweighted). Above these levels impacts included mortality, physical injury and permanent hearing damage.

A study which reviewed the underwater hearing of Cormorants suggested they have a narrower band of hearing but have a lower threshold to noise energy levels (Johansen *et al.* 2016). Cormorant's hearing range sits between >1 kHz and 6 kHz. This study suggests that while these birds can hear the pile being driven, their range of most hearing sensitivity (> 1 kHz) is above the frequency range containing the greatest energy from pile driving (< 1 kHz).

Otter

There are no criteria to assess the significant of underwear noise on the Eurasian otter. The only available thresholds for mustelids is for sea otters (*Enhydra lutris*) (PTS 220 dB re 1µPa2s) (Finneran and Jenkins, 2012).

3.4.4.2.3. Assessment of Potential Noise Impacts

Common Bottlenose Dolphin and Fish Species

The Irish Whale and Dolphin Group (IWDG) was contracted by Shannon LNG to monitor the use of the site by bottlenose dolphins (Berrow et al., 2020). A combination of land-based Vantage Point (VP) watches and static acoustic monitoring (SAM) was used to describe the use of the site by bottlenose dolphins and any other marine mammals (seals) present, and their distribution and relative abundance at the site. The survey work built upon data obtained from 2006 and 2007 and other recent publicly available information. The report concluded that:

In conclusion, we have shown that bottlenose dolphins regularly use the waters off Ardmore Point, which is the site of the proposed Shannon LNG terminal. The results from monitoring during 2019-2020 are broadly consistent with results obtained during monitoring at the same site during 2006-2007. Although dolphins were regularly recorded at the site there use seems largely transitory, passing through the site. There was no evidence dolphins are present for long periods or that it is used for foraging. However, the site is an important part of the range of the bottlenose dolphins in the Shannon estuary.

LGL was commissioned by Shannon LNG to carry out an ecological assessment of noise generated by the construction and operational phases of the project on fish and marine mammal species (LGL, 2021) (see Appendix A7A-4). The findings of the LGL assessment are presented below.

The ecological assessment of the potential impacts of noise on marine mammals is based on estimates of how many marine mammals are likely to be present within a particular distance of activities and/or exposed to a particular level of sound. This approach is an accepted common practice, that in most cases, likely overestimates the numbers of marine mammals that would be affected in some biologically important manner, as animals tend to move away from loud sound sources before the sound level is at or above the threshold.

The assessment considered potential impacts associated with different scenarios/project activities at various positions: (1) a stationary FSRU which emits hull-radiated sound continuously, including noise from seawater cooling pumps, (2) an FSRU with an offloading LNGC tied to it and one idling tug, (3) impact pile driving, (4) vibratory pile driving with support vessels (5) socket drilling with support vessels, and (6) blasting were all modelled at the marine terminal, while (7) an approaching LNGC assisted by four transiting tugs was modelled at a location 1,150 m northwest of the terminal, along with the FSRU at the marine terminal; and (8) the FSRU together with a berthing LNGC and four sailing tugs were modelled at the marine terminal together with a general cargo ship sailing in the middle of the estuary and a ship moored at Moneypoint. Scenario 8 is referred to as the cumulative sound scenario. This multi-sequence scenario is based on the offloading scenario, with the addition of the cargo ship and moored ship. For this scenario, the following were assumed: FSRU operating continuously for 24 h, LNGC and idling tug performing offloading for 6 h, LNGC and 4 sailing/engaged tugs transiting for 15 min, cargo ship sailing for 15 min, and moored ship at Moneypoint continuously for 24 h.

Although two potential PTS exposures have been estimated for bottlenose dolphins from impact pile driving over the course of all pile driving activity, no PTS or other injuries would be expected because of the relatively short distance (94 m) to the threshold criteria and the monitoring and mitigation measures that would be implemented. Monitoring and mitigation measures would follow those in the NPWS 2014 guidance (**Section 3.6.2** for details) and would lower the likelihood of impacts from construction activities. Although PTS was modelled to be a possibility relatively far from impact pile driving (up to 3163 m) for harbour porpoise, these cetaceans rarely occur within the Shannon Estuary.

Monitoring and mitigation measures during project construction would include the use of qualified marine mammal observers to monitor during sub-tidal piling operations and the commencement of piling would be delayed if the observers sight any marine mammals within 1,000 m of the site for 30 minutes prior to the planned start of piling. Since impact piling cannot always be stopped immediately if a marine mammal approaches once piling has commenced, some potential for impacts would remain, including potential for TTS. Nonetheless, the 1,000-m mitigation zone is overly precautionary given that the MF-weighted PTS threshold was modelled to occur out to a maximum distance of 94 m.

During operations, the PTS and TTS thresholds that could be exceeded by the activities are all based on accumulated sound over a period of time (sound exposure levels). This means that individuals would have to remain within the predicted distances for the entire duration of the activity, or for at least 24 hrs if the activity lasts longer than a day, in order to experience TTS or PTS. Additionally, the operational scenarios often involved multiple sources operating in different locations. This means that the distances calculated are not continuous in all directions and any one of the sources, resulting in gaps where received sound levels would be below the threshold levels. These factors, along with the highly mobile nature of marine mammals means the it is very unlikely that any marine mammals will experience PTS or even TTS from the planned activities.

Using the available information on dolphin abundance and distribution within the Shannon Estuary, we have estimated that there are likely to be very few daily instances of bottlenose dolphins (or other marine mammals) being affected via disturbance during either construction or operational activities associated with the Shannon LNG project. For all construction activities, and most of the operational scenarios, distances to disturbance thresholds would be less than 140 m. Since the location where the in-water structures will be installed and the immediate vicinity around that are not known to be important feeding or calving areas, temporary avoidance at these distances is not likely to have significant impacts. In addition, strong impulsive sounds from impact pile driving would occur over relatively short periods of time (1 hr per day, or 4% of the time), leaving most of the time available for undisturbed movements through the area. Similarly, the two operational scenarios with disturbance threshold distances of almost 1 km, Scenarios D and E, would only occur for relatively short periods of time (less than 1 hr per day) and infrequently (up to 3 times per week). The temporal aspects (limited duration and infrequent occurrence) of these most potentially behaviourally disruptive activities mean they are unlikely to substantially disrupt important marine mammal behaviours that might occur in this region of the estuary. Since dolphins are highly mobile within the estuary and operations will occur over many years, it is likely that all individuals in the population could be exposed at some point in time to noise from the project. Nonetheless, the potential disturbance exposures likely would have no more than a minor effect, such as localized short-term avoidance of the area around the activities by individual animals and no effect on the population.

Our analysis method used MF-weighting for estimating potential disturbance exposures since it emphasizes the frequencies that are of most relevance to bottlenose dolphins. However, Kastelein et al. (2015, 2016) reported that harbour porpoise (high-frequency cetacean) hearing sensitivity was reduced when exposed to multiple impulsive pile-driving sounds with most energy at low frequencies. These findings suggest that there could be potentially greater impacts of low-frequency sounds on bottlenose dolphins than expected, but the exposure estimates for the development are almost certainly overestimates, and there is no indication that the project activities would be likely to cause significant harm to individuals or the population.

The population of bottlenose dolphins in the Shannon Estuary has remained stable for the past 20 years and has demonstrated evidence of long-term fidelity and seasonal residency despite inhabiting a busy and noisy region with various industrial activities, ferry traffic, and shipping (Ingram 2000; Ingram and Rogan 2002; Englund et al. 2007, 2008; Rogan et al. 2018). Thus, it is anticipated that the dolphins in the vicinity of the project would likely habituate to the sounds produced during project activities as they have to other similar noise and vessel traffic in the estuary. Habituation of bottlenose dolphins to noise has been shown to occur elsewhere. For example, in Aberdeen Harbour, Scotland, an area with high vessel activity, bottlenose dolphins showed a change in normal behaviour around boats, but rarely left the area; this type of response suggested habituation and tolerance, especially due to the estuary's importance for prey availability (Sini et al. 2005).

Although there is some indication that fish (especially those with swim bladders used in hearing) within hundreds of metres of impact pile driving could be at high risk of disturbance or even potentially experience injury or TTS, impact piling would occur for a relatively short duration (60 min) for each pile, once per day. Thus, impact pile driving is unlikely to hinder fish migration, and for most fish, the distances within which mortality and/or mortal injuries could occur are relatively small and should not impact the overall populations if these types of effects were to take place. Although continuous sounds during project construction and operation have little likelihood of causing injury or TTS in fish, fish that use their swim bladder for hearing could potentially be at high risk of disturbance near those sound sources. It is possible that the continuous noise emission from the FSRU during project operation could cause fish to avoid the immediate area around the FSRU, but avoidance behaviour would likely be restricted within tens of metres from the FSRU.

In summary, the proposed construction and operational activities associated with Shannon LNG are similar to other activities that currently occur routinely within the estuary and are unlikely to have adverse effects that could impact populations of marine mammals or fish in the long-term. The most potentially impactful activity on marine mammals and fish during construction would be impact pile driving because of the potential for PTS in marine mammals and injury or mortality in fish, but this would be of limited duration and impacts will be mitigated in multiple ways. Additionally, there is no evidence to suggest that the project site provides critical habitat for bottlenose dolphins (Berrow et al 2020) so avoidance of these activities would be unlikely to have significant impacts. During operations, underwater sounds would be created by vessel traffic and contribute to the pre-existing ambient noise within the estuary. The cumulative sound scenario and approaching/departing LNGC have the largest distances to behavioural disturbance thresholds during operations, but both scenarios would occur only briefly up to 3 times per week, and only if other vessels are located within the vicinity of the project site. Once the other power stations located in the Shannon Estuary shut down, there would be even less potential for cumulative effects from the proposed activities and existing shipping activities occurring in the estuary. In addition, harbour porpoise and grey seals rarely occur in the Shannon Estuary, and harbour seals are uncommon. Thus, any effects from project activities are expected to be minor, temporary, and localized to the area immediately around the terminal, with no long-term effects on marine mammal or fish populations.

Otter

As noted above there are no published criteria for underwater noise disturbance to Eurasian otters. In the context of underwater noise generated during construction and operation, it should be noted that otters, unlike dolphins, are not fully aquatic, and are not confined to the waters of the Shannon Estuary. However, taking a conservative approach and using the 120dB threshold applied to marine mammals, the zone of influence of disturbance to otter is likely to be 0.094 km from piling works during construction. No significant impacts from operational underwater noise have been identified. Therefore, the potential zone of impact will be confined to the immediate piling works. No signs of otter were recorded in this part of the estuary, either within the water or along the shoreline.

Given that there are no records of otter near the proposed jetty works area, no PTS or other injuries would be expected because of the relatively short distance (0.094 km) to the threshold criteria and the monitoring and mitigation measures that will be implemented. There will be no significant adverse impact on otter distribution and there will be no significant impact on otter within the Lower River Shannon cSAC from underwater noise.

SCI Bird Species

Based on noise predictions modelled by Lloyd's Register (2020), underwater noise during piling works, which is the most significant underwater noise/vibration expected during construction and operation, would be significantly below the threshold for mortality or injury in diving birds. All other activity during construction and operation will be significantly below noise thresholds. It is noted that the presence of the large construction machinery is likely to make the waters in the immediate vicinity unattractive to seabirds during the construction phase and that birds are unlikely to forage in the immediate vicinity of construction works (Refer to **Section 3.4.2.2**). It is also noted that the numbers of cormorant recorded in vicinity of the works area are very low. Mitigation measures will be implemented during construction to avoid significant impacts to sensitive bird species. Given that potential disturbance exposures would have no more than a minor impact, such as localised short-term avoidance of the area around the activities by individual animals, there will be no effect on the population of qualifying species.

3.4.4.3. Conclusion

The ecological assessment (LGL, 2021) summarises by stating that as the proposed construction and operation activities associated with the LNG project are similar to other activities that currently occur in the estuary, they are unlikely to have adverse effects on populations of marine fish and mammals in the long-term. Based on the above, it can be concluded there will be no significant adverse effects on the conservation features of the Lower River Shannon cSAC or the River Shannon and River Fergus Estuaries from impact mechanism 4.

3.4.5. Impact Mechanism 5. Seabed habitat loss

3.4.5.1. Relevant Conservation Features

- Estuaries [1130]
- Reefs [1170]

3.4.5.2. Assessment

Impact mechanism 5 is associated with the construction and operation phase.

There are two distinct sources of habitat loss due to the Proposed Development; one being the installation of construction piles for the jetty structures foundations and, the other being the installation of a trenched water outfall across the shoreline into the Shannon estuary.

The assessment of the potential impact of seabed habitat loss is undertaken here with respect to the Annex I habitats for which the Lower River Shannon cSAC is designated. Specifically, the assessment considers the area of Annex I habitat lost relative to the full areal extent of the Annex I habitat within the cSAC.

The construction of the proposed jetty requires the installation of approximately 203 piles. As shown in **Figure 3-52** and **Figure 3-53**, the proposed jetty overlaps the Annex I habitats 1130 Estuaries and 1170 Reefs of the Lower River Shannon cSAC. The majority of the piles supporting the jetty would be driven, with some piles will be drilled and socketed into the underlying rock to ensure stability of the jetty.

The proposed outfall overlaps Annex I habitats 1130 Estuaries and 1170 Reefs (see **Figure 3-52** and **Figure 3-53** respectively). The width of the trench will be approximately 2 m while its total length through Annex I habitats is approximately 50 m. Once the outflow pipe is set position the trench will be infilled using concrete to approximately 30mm below the surface of the level of the adjoining substrate. In areas of reef substrate, the surface concrete of the trench will be embedded with reef cobbles and stone excavated from the trench, while in areas of soft sediment the void to will left to infill naturally by sedimentation and sediment movement processes.

Figure 3-54 shows the constituent marine communities types of the Annex I habitats overlapped by the proposed jetty and outfall.

The Conservation Objectives[27], attributes and targets relating to the area of Annex I habitat 1130 Estuaries and 1170 Reefs within the cSAC are presented respectively in **Table 3.12** and **Table 3.13** (NPWS, 2012).

[27] NPWS (2012) Conservation Objectives Series. Lower River Shannon SAC Site Code: 002165. https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO002165.pdf

Table 3.12. Annex I habitat 1130 Estuaries.

To maintain the favourable conservation condition of Estuaries in the Lower River Shannon SAC, which is defined by the following list of attributes and targets:			
Annex I habitat	**Measure**	**Target**	**Notes**
1130 Estuaries	Habitat area	The permanent habitat area is stable or increasing, subject to natural processes.	Habitat area was estimated as **24,273ha** using OSi data and the Transitional Water Body area as defined under the Water Framework Directive

Table 3.13. Annex I habitat 1170 Reefs.

To maintain the favourable conservation condition of Reefs in the Lower River Shannon SAC, which is defined by the following list of attributes and targets:			
Annex I habitat	**Measure**	**Target**	**Notes**
1170 Reefs	Habitat area	The permanent habitat area is stable or increasing, subject to natural processes.	Habitat area was estimated as **21,421ha** from the 2010 intertidal and subtidal reef survey (Aquafact 2011a, 2011b)

3.4.5.2.1. Loss Due to Installation of Jetty Piles

As a result of the 203 piles, approximately 163m^2 of benthic habitat within Annex I habitats will be lost pending decommissioning of the development and the removal of jetty and piles. Of the 203 piles, approximately 10 piles will be installed in the Annex I habitat Reefs [1170] while approximately 193 will be located within the Annex I habitat Estuaries [1130].

The spatial extent of Annex I habitat 1130 Estuaries and 1170 Reefs within the cSAC is estimated to be 24,273 ha and 21,421 ha respectively (NPWS, 2012) (see **Table 3.12** and **Table 3.13** respectively).

The approximate spatial extent of Annex I habitat lost pending decommissioning of the development and the removal of jetty and piles is presented in **Table 3.14**. Installation of the jetty piles will result in the loss of 0.000064% and 0.000004% of the Annex I habitats 1130 Estuaries and 1170 Reefs respectively.

Table 3.14. Loss of Annex I habitat 1130 and 1170 due to installation of piles.

Annex I habitat	Habitat area within cSAC[28]	Area of Annex I habitat lost pending decommissioning	% of Annex I habitat lost pending decommissioning
1130 Estuaries	24,273ha	155 m^2	6.4×10^{-5} %
1170 Reefs	21,421ha	8 m^2	3.7×10^{-6} %

[28] Estimates of habitat area taken extent from NPWS (2012) Conservation Objectives Series - Lower River Shannon SAC 002165 Version 1.0. https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO002165.pdf

3.4.5.2.2. Loss Due to Installation of Jetty Piles

The installation of the outfall pipe will result in the loss of approximately 90m^2 of Annex I habitat above the low water mark and 10m^2 below the low water. Loss of Annex I habitat Estuaries [1130] habitat is estimated to be approximately 100m^2, while the loss of Reef [1170] habitat is approximately 65m^2.

The approximate spatial extent of Annex I 1130 and 1170 habitat lost pending decommissioning is presented in **Table 3.15**. Installation of the outfall pipe will result in the loss of 0.000041% and 0.000030% of the Annex I habitats 1130 Estuaries and 1170 Reefs respectively.

Table 3.15. Loss of Annex I habitat 1130 and 1170 due to installation of outfall pipe.

Annex I habitat	Habitat area within cSAC	Area of Annex I habitat lost	% of Annex I habitat lost
1130 Estuaries	24,273ha	100 m^2	4.1 x 10^{-5} %
1170 Reefs	21,421ha	65 m^2	3.0 x 10^{-5} %

3.4.5.2.3. Assessment

The loss of Annex I habitats 1130 Estuaries and 1170 Reefs habitat due to the installation of the piles and the outflow pipe, relative to the total area of the habitats in the cSAC is negligible and will not give rise to negative impacts to the functioning of the habitats. Following decommissioning, measures will however be taken to reinstate the small areas of habitat lost.

Jetty Piles

Jetty piles will be installed in two constituent community type of the Annex I habitats (see **Figure 3-54**), namely;

- Subtidal sand to mixed sediment with *Nucula nucleus* community complex;
- Fucoid-dominated intertidal reef community complex;

At decommissioning of the Proposed Development, jetty piles installed in soft sediment areas (Subtidal sand to mixed sediment with *Nucula nucleus* community complex) will be removed. Upon removal of the pile, the void will be is left to refill naturally through sedimentation and sediment movement processes. The sediments will be naturally recolonised by the migration of flora and fauna from local sediments and the settlement of larvae.

At decommissioning jetty piles in areas of hard substrate (Fucoid-dominated intertidal reef community complex) will be cut below the level of the seabed. The voids created will be infilled with concrete and embedded with reef stone native to the area. The embedded reef stone will rapidly recolonise naturally.

Outflow Pipe

As illustrated in **Figure 3-54** the outflow pipe will be entrenched through two community types;

- Subtidal sand to mixed sediment with *Nucula nucleus* community complex;
- Fucoid-dominated intertidal reef community complex;

Parts of the trench installed in reef areas, which will have been recolonised by reef flora and fauna assemblages, will be left in-situ.

Parts of the trench installed in soft sediments (Subtidal sand to mixed sediment with *Nucula nucleus* community complex) will be removed. The voids created will be left to infill naturally by sedimentation and sediment movement processes. The sediments will be naturally recolonised by the migration of flora and fauna from local sediments and the settlement of larvae.

3.4.5.3. Conclusion

The loss of Annex I habitats 1130 Estuaries and 1170 Reefs pending decommissioning relative to the total area of the habitats in the cSAC is negligible, and will not result in significant effects.

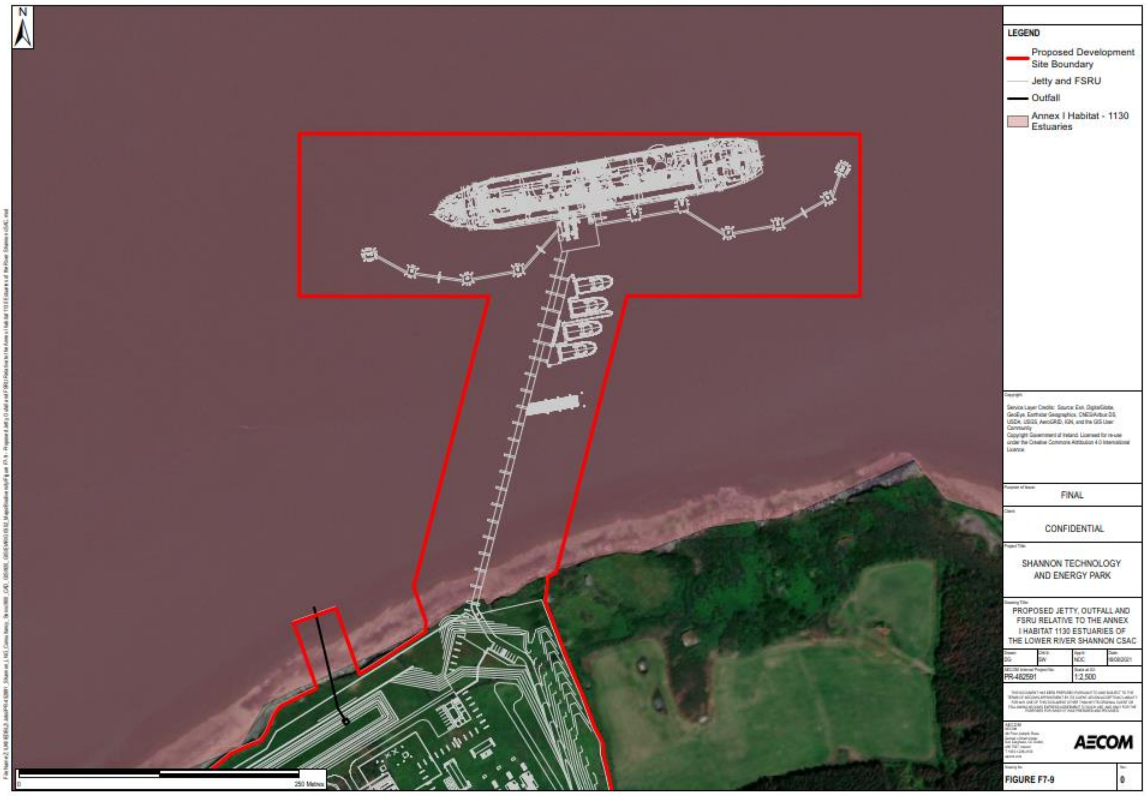


Figure 3-52: Proposed jetty, outfall and FRSU relative to the Annex I Habitat 1130 Estuaries of the Lower River Shannon cSAC.

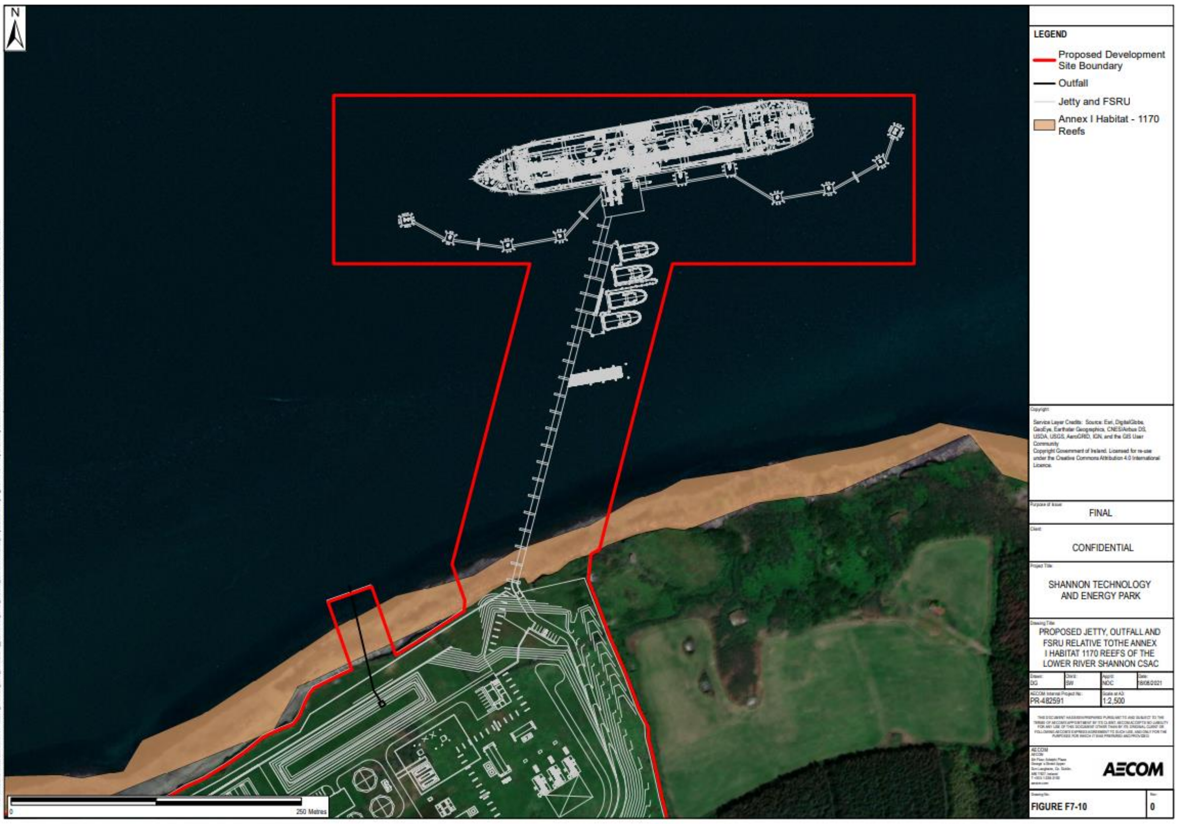


Figure 3-53: Proposed jetty, outfall and FRSU relative to the Annex I Habitat 1170 Reefs of the Lower River Shannon cSAC

Figure 3-54: Marine community types identified relative to marine community types within Annex I Habitats of the Lower River Shannon cSAC.

3.4.6. Impact Mechanism 6. Vessel physical disturbance and collision injury

3.4.6.1. Relevant Conservation Features

- *Tursiops truncatus* (Common Bottlenose Dolphin) [1349]
- *Lutra lutra* (Otter) [1355]*
- *Phalacrocorax carbo* Cormorant [A017]

3.4.6.2. Assessment

Impact mechanism 6 is associated with the construction and operation phase.

According to the Shannon Foynes Port Company (SFPC) approximately 1,800 vessel movements are made within the estuary, equating to 900 different AIS (automatic identification system) tracked vessels travelling into the estuary annually. EMODnet[29] vessel density mapping indicates that high levels of shipping activity occur throughout the year along the Shannon estuary and, in particular, in the vicinity of the Proposed Development area. In general, average monthly vessel density in 2017, 2018, 2019 and 2020 in the Shannon estuary ranged between 2 and 10 hours per km^2 and exceeded 100+ hours per km^2 in the vicinity of the Proposed Development area. The presence of the project vessels (*i.e.* construction scows and storage vessels, and, the FSRU, LNGC, tugs) will not significantly increase the level of overall vessel activity in the area; consequently there is no significant increase in the risk of disturbance to common bottlenose dolphin, otter and cormorant. In addition during operations the vessels will be travelling at low speeds below which most lethal and serious injuries occur (Laist *et al*., 2001). It is therefore very unlikely that common bottlenose dolphin, otter or cormorant will collide with the slow moving vessel.

3.4.6.3. Conclusion

It is concluded that will be no significant adverse effects to the conservation features from impact mechanism 6.

[29] https://www.emodnet-humanactivities.eu/view-data.php

3.4.7. Impact Mechanism 7. Discharge of treated cooled seawater

3.4.7.1. Relevant Conservation Features

- Estuaries [1130]
- Reefs [1170]
- *Tursiops truncatus* (Common Bottlenose Dolphin) [1349]
- *Lampetra planeri* (Brook Lamprey) [1096]
- *Salmo salar* (Atlantic Salmon) [1106]
- *Lampetra fluviatilis* (River Lamprey) [1099]
- *Petromyzon marinus* (Sea Lamprey) [1095]

3.4.7.2. Assessment

Impact mechanism 7 is associated with the operation phase.

3.4.7.3. Discharge of Treated Cooling Water

Overview

As outlined in Chapter 02, the LNG vaporisation process equipment to regasify the LNG to natural gas will be on-board the FSRU. The heat for LNG regasification will be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate. The seawater intake for the LNG regasification system will be on the side of the FSRU underwater. Screens will be installed to prevent debris in the sea water from entering the FSRU. The approach velocity at the screens will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm. However, some small debris, leaves, plankton, and larvae may be drawn in through the screens. It is expected that any silt entering the seawater circulating water system will remain in suspension and carry right through the system.

The regasification water outlet is also on the side of the FSRU underwater. The maximum projected change in water temperature is 8 °C below ambient seawater temperature. The FSRU regasification seawater discharge point is the largest discharge point from the FSRU.

Following the intake of seawater into the vessel, an electric current is passed through the seawater (a process known as electrolysis). Electrolysis breaks up the naturally occurring salt molecules (sodium chloride) in seawater and produces chlorine and hypochlorite, which prevents the growth of marine organisms in the internal piping system and the seawater heat exchangers of the FSRU. When the seawater is discharged from the vessel back into the marine environment, some short-lived residual chlorine would be present before mixing and decay. The concentration of residual chlorine at the discharge shall be monitored and shall not exceed the permissible limit of 0.5 mg/l.

Modelling Assessment

Discharge Characteristics

The characteristics of the cooled water to be discharged from the FRSU are shown in **Table 3.16**. It was decided to model the peak flow so that a ‘worst case scenario’ could be observed in the receiving water (*i.e.* 22,000m^3/hr is the peak loading from the FSRU and is equivalent to 6,111l/s (6.111 cumec[30]). The modelling considered the background concentration of chlorine to be zero and that the

[30] Cumec = Cubic metres per second

differential change in temperature is 8°C below ambient with ambient modelled at 12d °C so that the output represents solely the effect of discharging effluent in the receiving waters.

Table 3.16. Characteristics of the cold water discharge from outfall pipe.

Maximum Discharge rate (m^3/hr)	Maximum Residual Total Chlorine Concentration (mg/l)	Maximum Differential Temperature (°C)
22,000	0.50	-8.0

Intake and Outfall Location of the Cooling Water

Using the maximum flow rate of 22,000m^3/hr, the modelling was undertaken to estimate the concentrations of the total residual Chloride and water temperature within the receiving waters of the Shannon Estuary from the regasification process.

The discharge was specified with a residual total chlorine concentration of 0.5mg/l and a maximum temperature decrease over the ambient temperature of 8° C. The ambient Temperature in the Shannon Estuary was set at 12° C, and the discharging water temperature was set to 4° C. The duration of the modelling simulation was sufficiently long enough to allow steady state conditions to be attained in the vicinity of the outfall and in the nearby waters. This ensured that the minimum temperature and maximum concentration values, which would be reached throughout the water body, would be observed.

Water Temperature Simulation

Modelling showed that the discharge plume sinking towards the seabed due to its higher density with minimum temperatures of the discharge water towards the bottom layers at 130m from the site. At the site itself due to the elevation of the discharge from the vessel minimum temperature is encountered at mid-depth. At the medium and far fields from the discharge outfall point, the temperature change is small and is well mixed vertically and horizontally due to the high ebb and flood velocities. At the outfall the predicted minimum temperature is 10.38°C representing a maximum temperature change over the ambient of 1.62°C. The maximum temperature change (decrease) in bottom layer along the seabed is 0.76° C. At 140m from the discharge outfall point the minimum temperature which occurs on spring tides is 11.54° C occurring in the bottom layer and representing a maximum decrease in ambient temperature of 0.46° C.

The EPA proposal for estuarine waters states that the temperature measured downstream of a point of thermal discharge (at the edge of the mixing zone) must not exceed the unaffected temperature by more than 1.5°C. The EPA have in previous discharge licenses allowed a regulatory mixing zone length of no greater than 10% of the channel width. In the case of the Shannon Estuary at Ardmore Point the minimum estuary width is 2.3km indicating an allowable mixing zone of 230m. **Table 3.16** presents the maximum reduction in ambient temperature within the receiving water body. This plot shows that within 200m of the discharge the maximum reduction in ambient temperature is less than 0.5° C and that within 3km it is less than 0.1°C. The maximum reduction in beyond this area temperature outside is > 0.05° C and < 0.1°C which is insignificant.

Given the minor insignificant relative change in water temperature, there will be no significant effects to habitats, marine mammals or fish species.

Residual Chlorine Simulation

The residual chlorine plume acts in a similar fashion as the temperature plume, sinks vertically at the discharge point and generally has maximum concentrations within a relatively short distance of the discharge point at the seabed due to the higher density of the colder discharge water over the ambient receiving waters. Within a reasonably short distance the plume due to the high ebb and flood velocities and associated turbulence becomes well mixed vertically and horizontally.

Within 1.5km both east and west of the discharge point the predicted maximum residual chlorine concentration is less than 0.01mg/l. Maximum Concentration above 0.1mg/l are shown to occur only within 20m of the discharge point and for a short period of time.

Given the minor insignificant relative change in chlorine level, there will be no significant effects to habitats, marine mammals or fish species.

3.4.7.4. Conclusion

It is concluded that will be no significant adverse effects to the conservation features from impact mechanism 7.

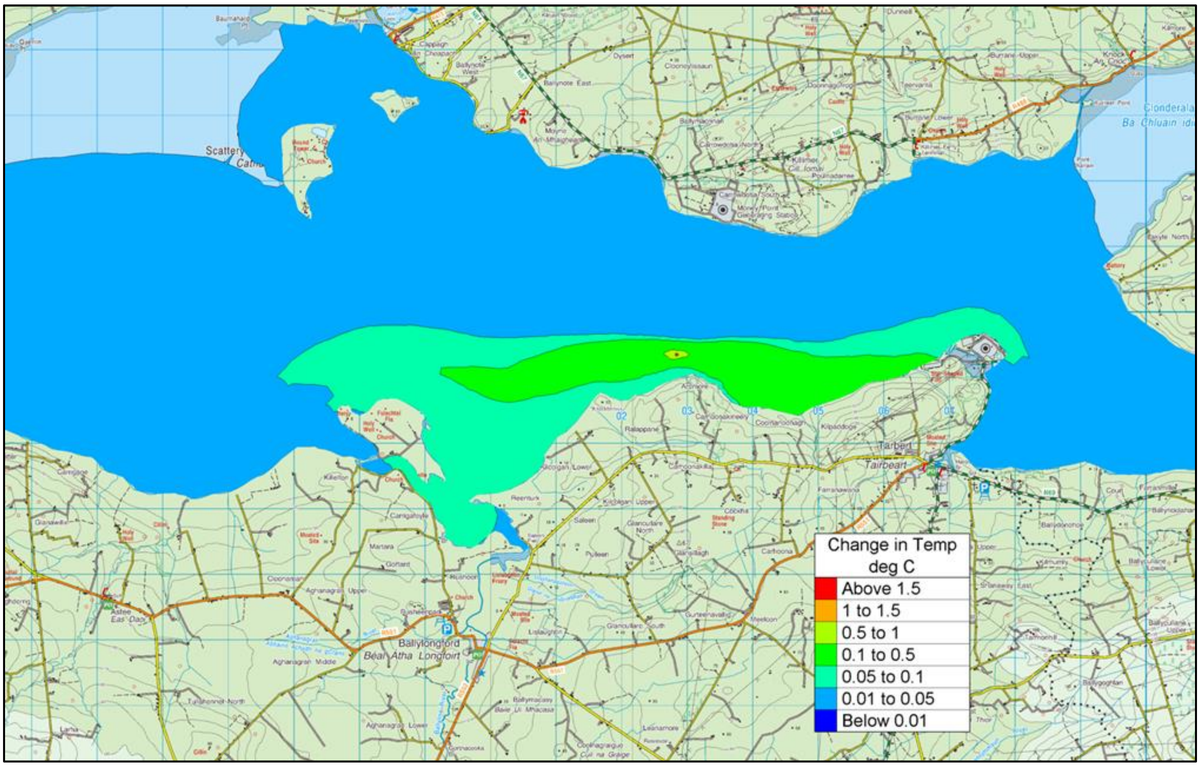


Figure 3-55: Maximum Temperature reduction envelope within receiving Shannon Estuary Water body over full 15 day simulation.

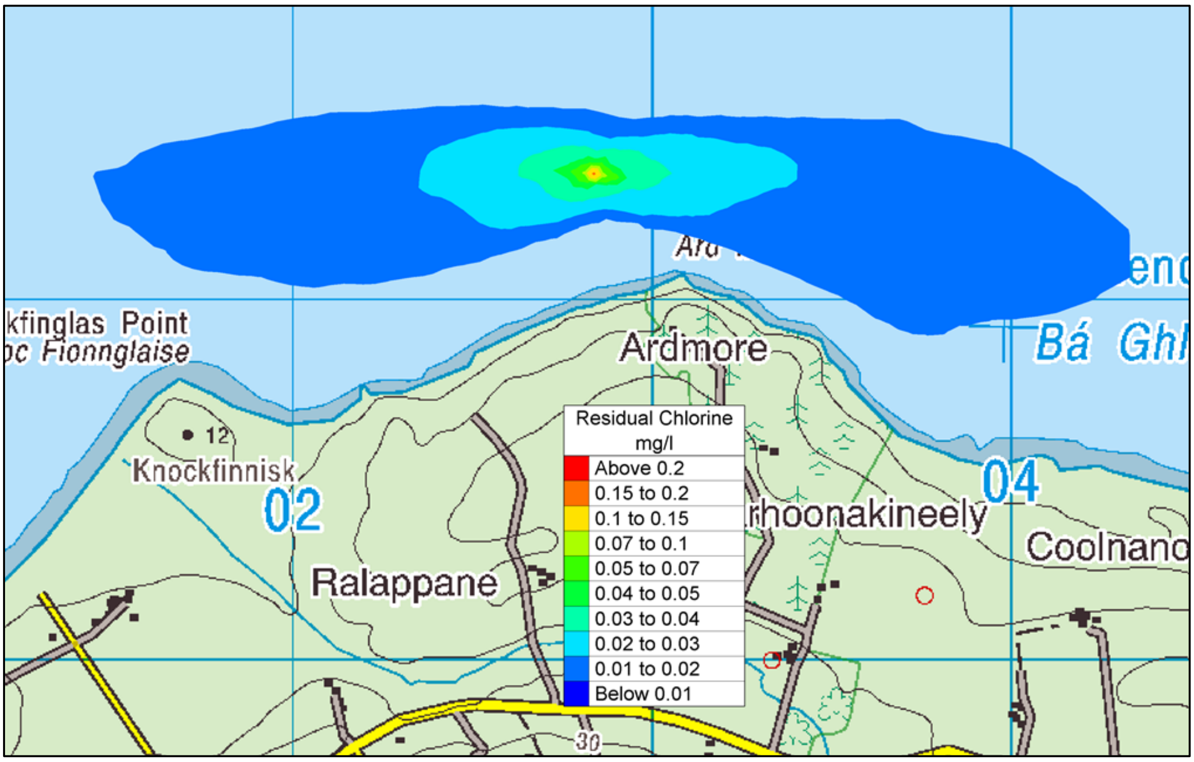


Figure 3-56: Maximum Residual Chlorine envelope within receiving Shannon Estuary Water body over full 15 day simulation (all vertical layers).

3.4.8. Impact Mechanism 8. Entrainment and impingement of fauna by the FRSU seawater system

3.4.8.1. Relevant Conservation Features

- *Lampetra planeri* (Brook Lamprey) [1096]
- *Salmo salar* (Atlantic Salmon) [1106]
- *Lampetra fluviatilis* (River Lamprey) [1099]
- *Petromyzon marinus* (Sea Lamprey) [1095]

3.4.8.2. Assessment

Impact mechanism 8 is associated with the operation phase.

Overview

An assessment of the impact of the FRSU seawater system on conservation feature fish species of the in the Shannon Estuary was carried out by reviewing relevant scientific literature on the life cycle of the species[31].

The approach velocity at the seawater intakes will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm.

Atlantic Salmon *Salmo salar*

Salmon spend their juvenile phase in rivers before migrating to sea to grow and mature. The life cycle of salmon begins where salmon lay eggs at spawning grounds located upstream. After 2 to 6 months the eggs hatch into tiny larvae called sac fry or alevin. The alevin has a sac containing the remainder of the yolk, and they stay hidden in the gravel for a few days while they feed on the yolk. When the sac or yolk has almost gone the larvae leave the protection of the gravel and start feeding on plankton. At this point the salmon are called fry. At the end of the summer the fry develop into juvenile fish called parr that feed on small invertebrates and are camouflaged with a pattern of spots and vertical bars. Once the parr have grown to between 10 and 25cm in body length, they undergo a physiological pre-adaptation to life in seawater. At this point the salmon are called smolt. As salmon larvae will not be present in the project area there is no potential for impact from entrainment and impingement by the FRSU seawater system.

Sea Lamprey *Petromyzon marinus* and River Lamprey *Lampetra fluviatilis*

Lamprey spawning habitat requires a gravel bottom with swift-running water and nearby sheltered areas with muddy bottoms for the larvae (Wheeler, 1969). Sea lamprey congregate at spawning gravels to spawn in May and June, and river lamprey spawning in March and April (Kelly and King, 2001). Hatching occurs two weeks after egg deposition and within a further one to three weeks the ammocoete larvae emerge from the spawning substrate and burrow into muddy beds in sheltered areas. Ammocoetes (larvae) are relatively immobile and remain in the muddy beds in freshwater stretches of rivers for between 3 – 8 years (Kelly and King, 2001; Dawson *et al.,* 2015). As larvae will not be present in the project area there is no potential for impact from entrainment and impingement by the FRSU seawater system.

[31] Chapter 07A of EIAR Vol. 1 considers effect to the larvae of fish species and crustaceans species that are not conservation features.

Brook Lamprey *Lampetra planeri*

The Brook Lamprey (*Lampetra planeri*) is a freshwater species occurring in streams and occasionally in lakes in northwest Europe, particularly in basins associated with the North and Baltic seas. Spawning occurs in the rivers in March and April.

Once hatched Brook Lamprey larvae leave the nest at 3-5mm in length and drift downstream, settling in depositing substrates in in freshwater stretches of river margins and back-waters. The larval period lasts for approximately 6 years. Following metamorphosis Brook Lamprey turn more silvery along the sides and the belly and the back remains a dark grey-brown colour. At this stage of the life cycle the brook lamprey has reached a length of 12-15cm. The adult brook lamprey moves out from the silt beds as spawning time approaches and start to migrate upstream in search of a suitable habitat for spawning. They continue to burrow as adults or hide under stones during the day. As larvae will not be present in the project area there is no potential for impact from entrainment and impingement by the FRSU seawater system.

3.4.8.3. Conclusion

Based on the above, it can be concluded there will be no significant adverse effects to the conservation features of the Lower River Shannon cSAC from impact mechanism 8.

3.4.9. Impact Mechanism 9. Discharge of Wastewater and Power Plant Process Heated Water Effluent

3.4.9.1. Relevant Conservation Features

- Mudflats and sandflats not covered by seawater at low tide [1140]
- Large shallow inlets and bays [1160]
- Estuaries [1130]
- Reefs [1170]
- Sandbanks which are slightly covered by sea water all the time [1110]
- Coastal lagoons [1150]
- Perennial vegetation of stony banks [1220]
- Salicornia and other annuals colonising mud and sand [1310]
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]
- Mediterranean salt meadows (*Juncetalia maritimi*) [1410]
- *Tursiops truncatus* (Common Bottlenose Dolphin) [1349]
- *Lampetra planeri* (Brook Lamprey) [1096]
- *Salmo salar* (Atlantic Salmon) [1106]
- *Lampetra fluviatilis* (River Lamprey) [1099]
- *Petromyzon marinus* (Sea Lamprey) [1095]
- *Lutra lutra* (Otter) [1355]*
- *Phalacrocorax carbo* (Cormorant) [A017]
- *Anas crecca* (Teal) [A052]
- *Anas acuta* (Pintail) [A054]
- *Aythya marila* (Scaup) [A062]
- *Anas penelope* (Wigeon) [A050]
- *Anas clypeata* (Shoveler) [A056]
- *Tadorna tadorna* (Shelduck) [A048]
- *Charadrius hiaticula* (Ringed Plover) [A137]
- *Pluvialis apricaria* (Golden Plover) [A140]
- *Pluvialis squatarola* (Grey Plover) [A141]
- *Calidris canutus* (Knot) [A143]
- *Calidris alpina* (Dunlin) [A149]
- *Limosa limosa* (Black-tailed Godwit) [A156]
- *Limosa lapponica* (Bar-tailed Godwit) [A157]
- *Numenius arquata* (Curlew) [A160]
- *Tringa totanus* (Redshank) [A162]
- *Tringa nebularia* (Greenshank) [A164]
- *Vanellus vanellus* (Lapwing) [A142]
- *Branta bernicla hrota* (Light-bellied Brent Goose) [A046]
- *Cygnus cygnus* (Whooper Swan) [A038]
- *Chroicocephalus ridibundus* (Black-headed Gull) [A179]
- Wetland and waterbirds [A999]

3.4.9.2. Assessment

Impact mechanism 9 is associated with the operation phase.

Overview

The proposed treated sanitary effluent discharge from development was modelled discharging from the proposed nearshore outfall pipe located on the sea bed.

The outfall pipe is also the discharge point for effluent from the Power Plant.

The parameters of interest modelled are temperature, BOD, Ammonia, Total Phosphorous and *E.coli*.

Modelling Assessment

Power Plant Process Heated Water Effluent

The Power Plant will generate several process water effluent streams. Some of the effluent streams will be collected and removed offsite and the remaining effluent streams will be pumped or fall by gravity to the effluent sump. Process water effluent leaving the effluent sump, will be continuously monitored for pH before discharging to the estuary via the storm water outfall pipe.

The automatic control system associated with the effluent sump will sound an alarm if the pH goes outside a pre-set range – typically 6 to 9. This will alert the operator to take corrective action to remedy the problem. If the pH continues to go outside the pre-set range, this will automatically close the discharge valve and open the associated re-circulation valve and will then start the re-circulation process during which period the sump will be dosed with either acid or caustic soda to return the pH to between 7 and 8. At this stage the automatic discharge valve will re-open and the re-circulation valve will close. A regular visual check on oils and greases will also be made in this sump to ensure that the discharge will be free of these contaminants before discharge. The process effluent in the sump will be monitored for compliance with the IE licence limits and then discharged, via the storm water outfall pipe, to the Shannon Estuary. **Table 3.17** below summarises the Power Plant Process Effluent Sump Discharge.

Table 3.17. Power Plant Process Effluent Sump Discharge.

Parameter	Typical Range of Emissions (min to max)
Volume range	0 to 1,128m^3/day
pH	6 – 9
Temperature range	25^{0}C to 40°C
BOD	20 mg/l
Suspended Solids	30 mg/l
Total Dissolved Solids	5000 mg/l
Mineral Oil	20 mg/l
Total Ammonia (as N)	5 mg/l
Total Phosphorous (as P)	5 mg/l

Treated Sanitary Effluent Discharge

Sanitary effluent will be generated by the LNG Terminal and by the Power Plant. All sanitary effluent will be pumped or fall by gravity to a common wastewater treatment plant (WWTP) on site. The effluent waste stream will be monitored for compliance with the licence limits and then discharged, via the storm water outfall pipe, to the Estuary.

A biological Wastewater Treatment System is proposed. It will be sized for a headcount of 67. **Table 3.18** summarises the effluent stream generated from the WWTP and provides estimated quantities.

Effluent leaving the WWTP will be continuously monitored for pH before discharging to the estuary. The automatic control system associated with the WWTP will sound an alarm if pH falls outside of expected range. This will alert the operator to take corrective action to remedy the problem. If the problem continues to go outside the pre-set range, this will automatically close the discharge valve and effluent will be diverted to a holding tank.

Table 3.18. Characteristics of WWTP Discharges.

Parameter	Emission Limit Value
Volume	$35m^3$/day
pH	6 – 10
BOD	25 mg/l
Suspended Solids	35 mg/l
Ammonia (as N)	5 mg/l
Total Phosphorous (as P)	2 mg/l

Modelled Discharges

The modelled effluent was a combination of the treated sanitary effluent of $35m^3$/day and the process effluent at a mean daily discharge of $778m^3$/day and an instantaneous maximum hydraulic load of 1,128 m^3/day. This was modelled as a thermal discharge at 40°C with the receiving waterbody ambient temperature of 12°C (effluent at 20°C above ambient). The various treated effluent concentrations are outlined in **Table 3.17** and **Table 3.18**.

The Heated discharge from the processed waters was modelled at 28°C above ambient with the ambient at 12°C. The maximum and mean temperature envelope are presented in **Figure 3-57** and **Figure 3-58** over a full 15 day spring-neap-spring tidal period. These plots show very local rise in temperature at the outfall site having a maximum increase of 0.9135°C and mean increase at outfall site of 0.069°C. The maximum temperature increase reduces within 100m of the discharge point to 0.171°C which is an insignificant impact. The heated plume rises and mixes in the water column due to a lower density than the receiving waters. At the outfall site the maximum temperature occurs at the sea bed but within a short distance the plume is well mixed vertically.

E.coli was modelled from the sanitary discharge only using a conservative die-off rate of T_{90} = 36hours (winter conditions) at a secondary treated effluent concentration of 10^6 No./100ml and a discharge rate of 0.41l/s. The maximum and mean concentration envelopes for *E.coli* are presented in **Figure 3-**

59 and **Figure 3-60** over a complete spring-neap-spring tidal period. The highest concentration occurs in the receiving waters at the outfall site which is predicted to reach 1,458 No/100ml *E.coli* and within 100m (mixing zone) this has reduced to 279 No. / 100ml. The tidal mean concentration over 15days of tides is 102 No./100ml at the outfall site and significantly lower elsewhere. The predicted concentration plume shows no impact on Ballylongford and Glencloosagh Bays where shellfish activities are located.

BOD concentration was modelled at 9l/s at concentration of 20mg/l from the process effluent and at 0.41l/s at 25mg/l from the sanitary effluent discharge. The maximum and mean concentration envelopes for BOD are presented in **Figure 3-61** and **Figure 3-62** over a complete spring-neap-spring tidal period. The highest concentration occurs in the receiving waters at the outfall site at a concentration of 0.692mg/l BOD. The maximum BOD concentration within 100m of the outfall site is 0.132mg/l. The average BOD concentration in the receiving water at the outfall site is 0.048mg/l.

The total ammonia discharge from the treated process water and treated sanitary water produces a maximum ammoniacal nitrogen concentration within the receiving waterbody of 0.1513mg/l N and a mean concentration at the outfall site of 0.012mg/l N, refer to **Figure 3-63** and **Figure 3-64**. The maximum Ammoniacal nitrogen concentration within 100m of the outfall site is predicted to be 0.033mg/l N.

The dispersion simulations show that the total Phosphorous Concentration from the treated process water and treated sanitary water produce a maximum concentration within the receiving waterbody of 0.167mg/l P occurring at the outfall site and a mean concentration at the outfall site of 0.0117mg/l P, refer to Figures 20 and 21. The maximum Total phosphorous concentration at 100m from the outfall site is predicted to be 0.032mg/l P.

3.4.9.3. Conclusion

All of the above modelled water quality parameters are shown to easily satisfy the permissible limits set out in the surface water regulations and will not impact the water quality status of the receiving Shannon Estuary waters. Consequently, it can be concluded there will be no significant environmental impact from impact mechanism 9.

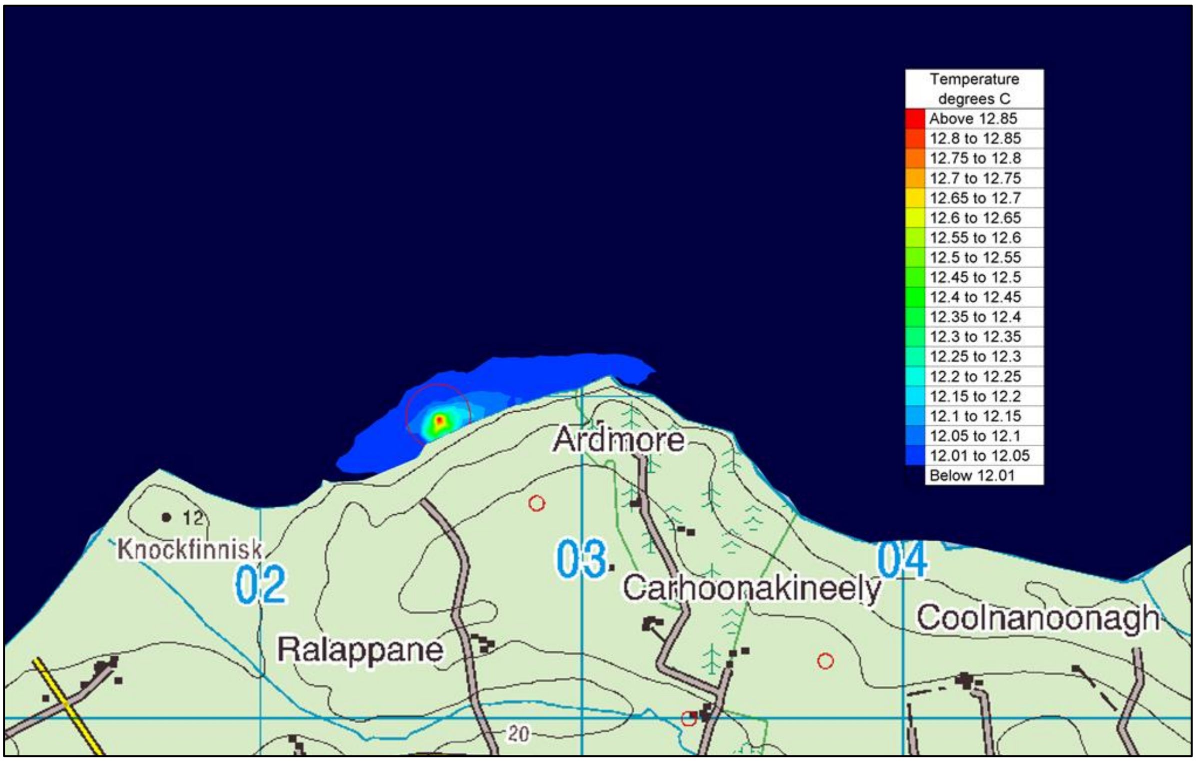


Figure 3-57: Predicted Maximum Temperature Envelope over 15 day for spring-neap-spring tide simulation modelling effluent at 40°C and ambient temperature at 12°C.

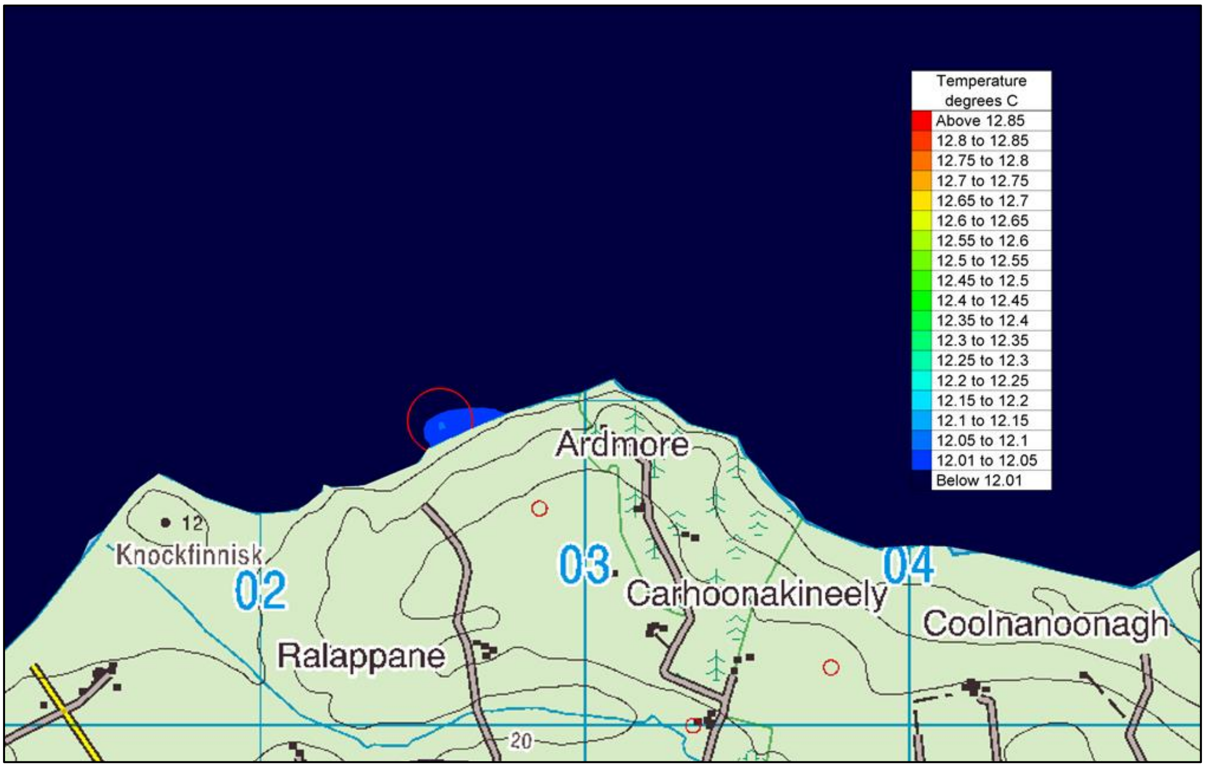


Figure 3-58: Predicted Mean Temperature Envelope over 15 day for spring-neap-spring tide simulation modelling effluent at 40 °C and ambient temperature at 12 °C.

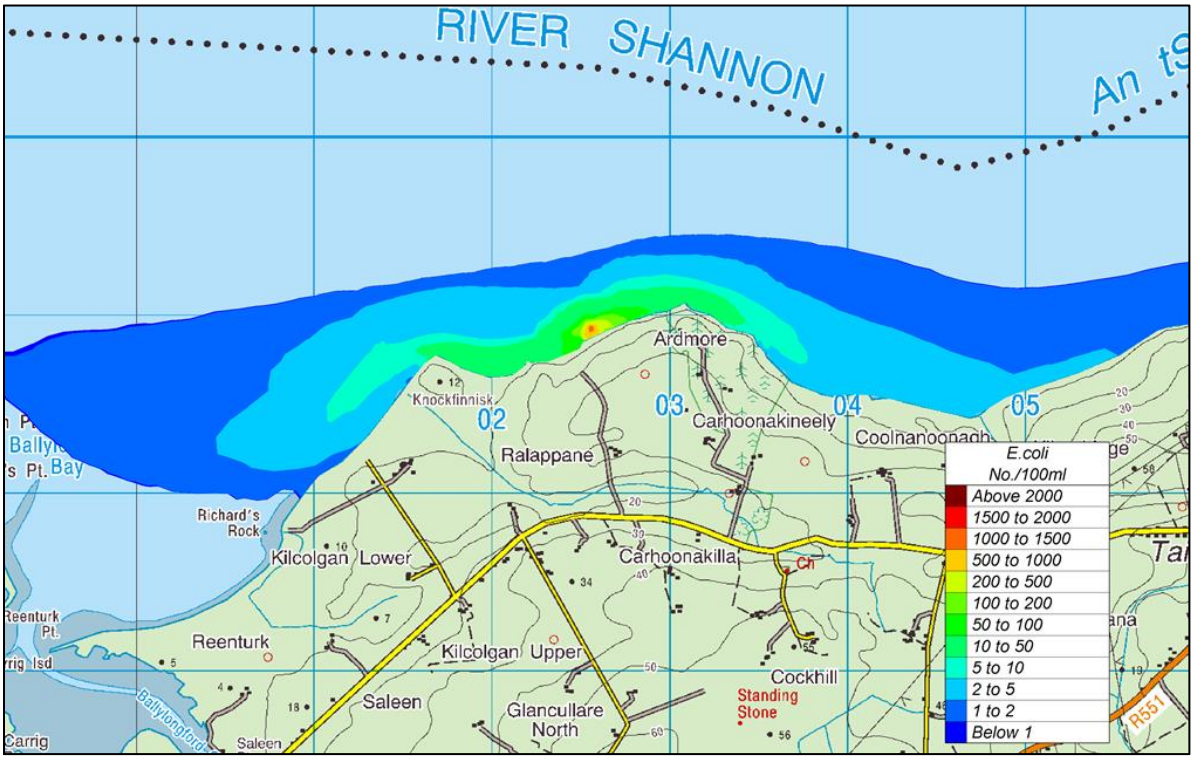


Figure 3-59: Predicted Maximum *E.coli* concentration (No./100ml) Envelope over 15 day for spring-neap-spring tide simulation.

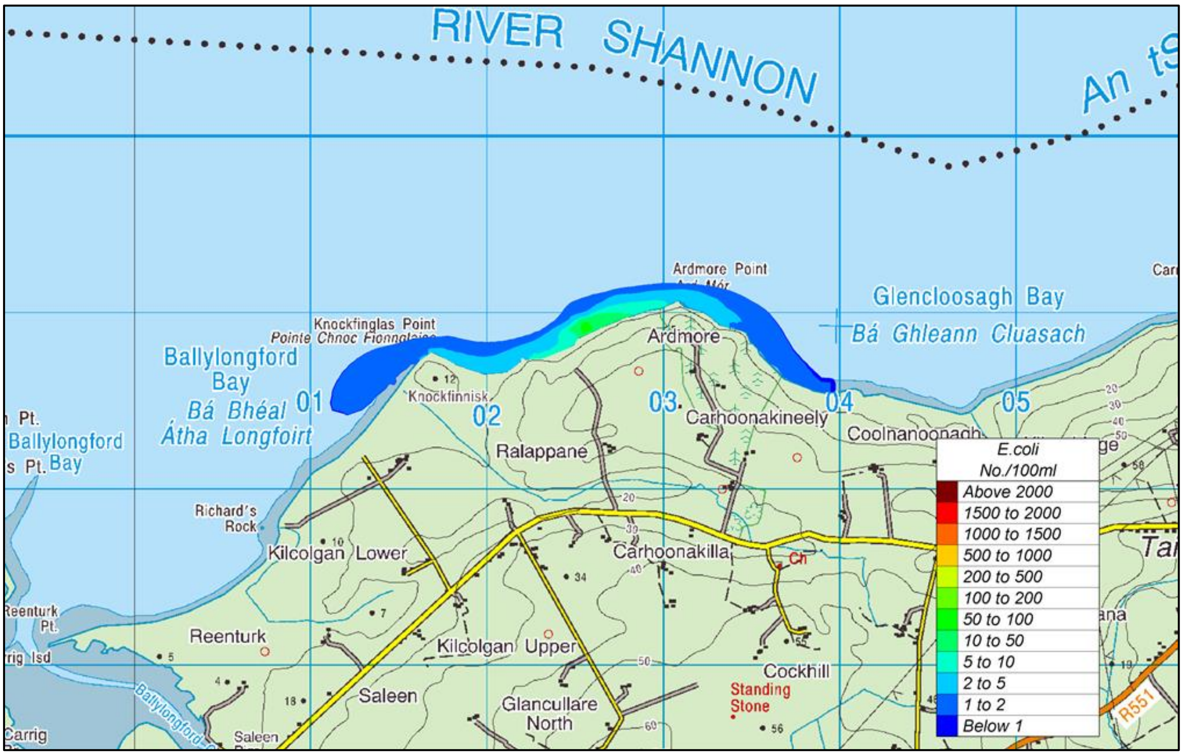


Figure 3-60: Predicted average *E.coli* concentration (No./100ml) Envelope over 15 day for spring-neap-spring tide simulation.

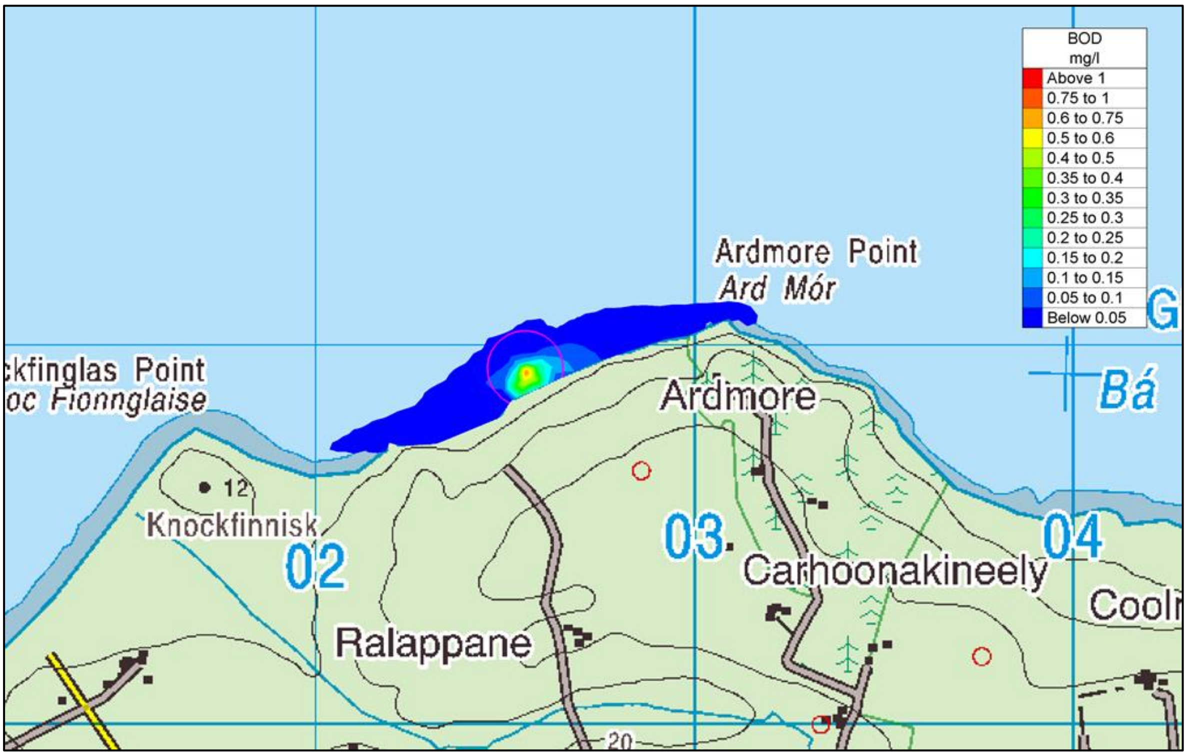


Figure 3-61: Predicted Maximum BOD Concentration (mg/l) Envelope over 15 day for spring-neap-spring tide simulation.

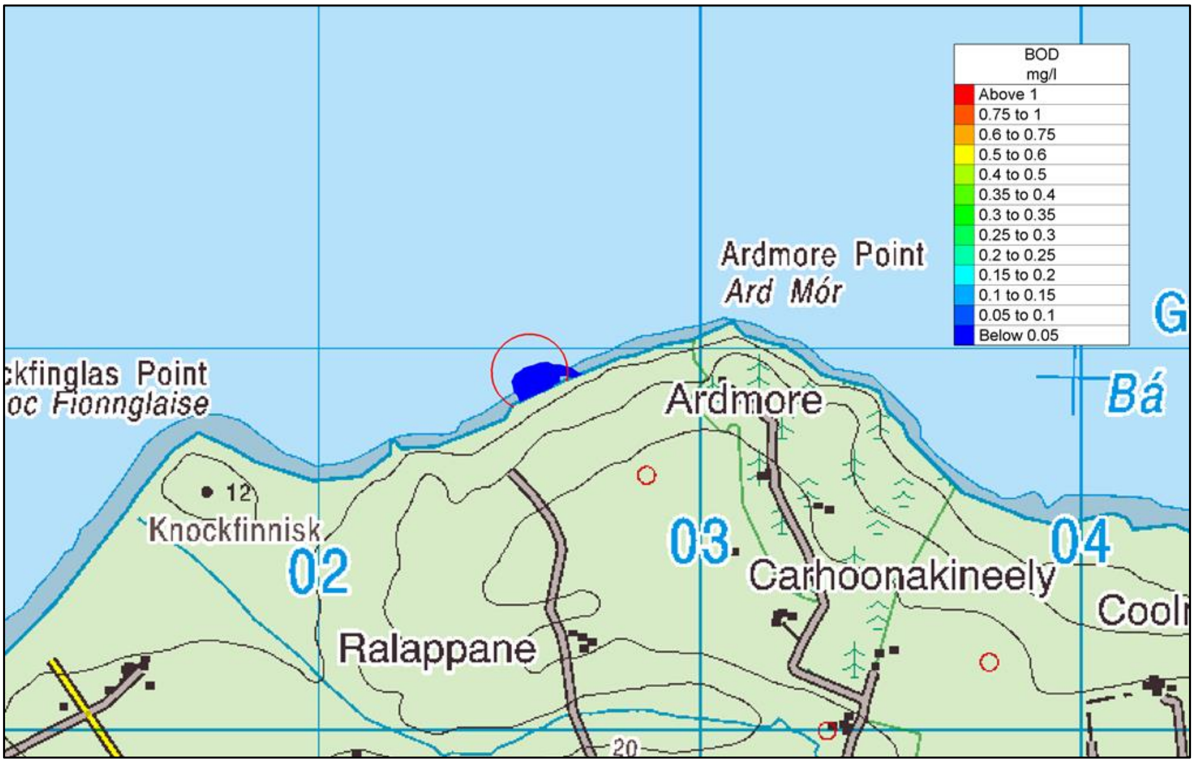


Figure 3-62: Predicted Mean BOD concentration (mg/l) Envelope over 15 day for spring-neap-spring tide simulation.

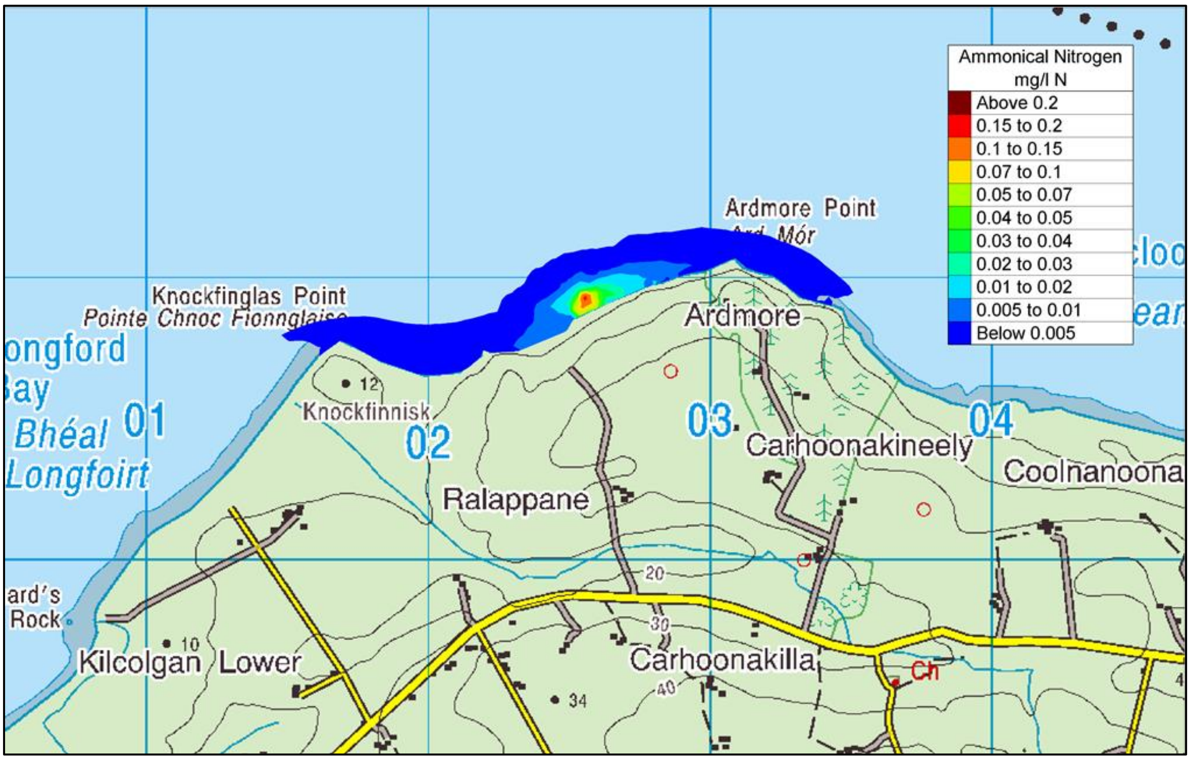


Figure 3-63: Predicted Maximum Ammoniacal Nitrogen concentration (mg/l N) Envelope over 15 day for spring-neap-spring tide simulation.

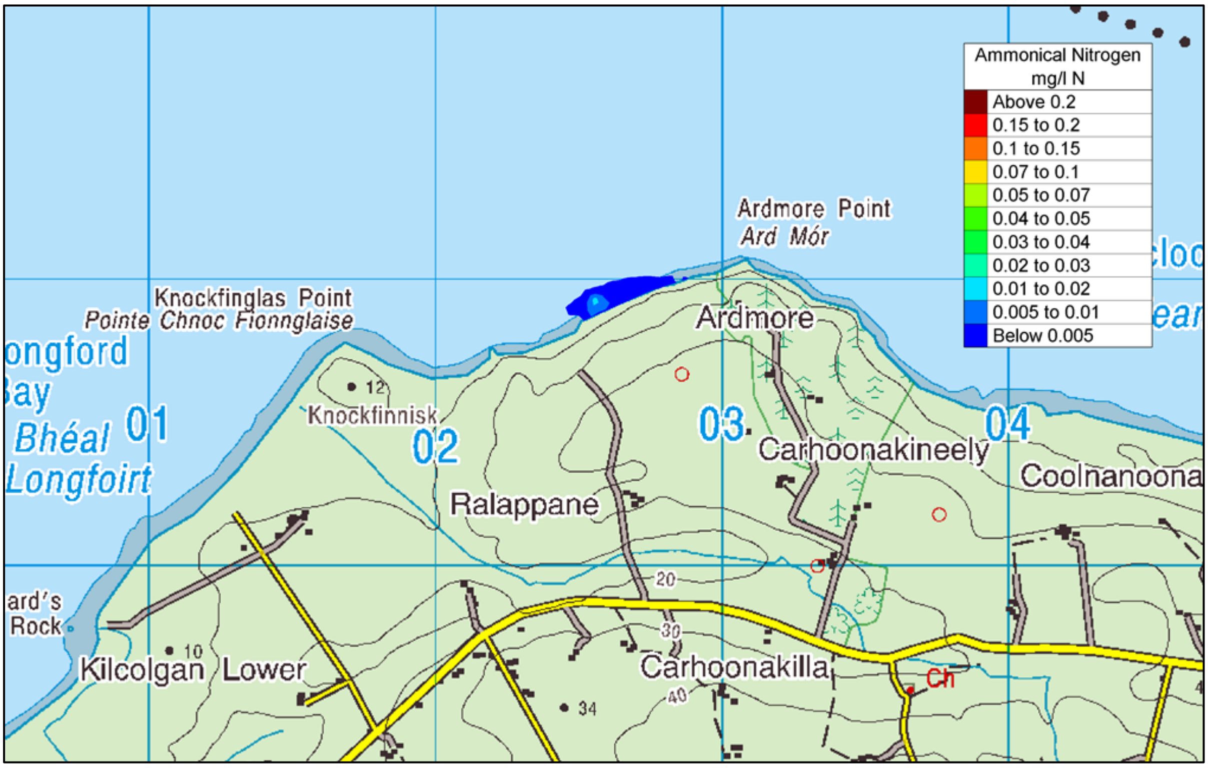


Figure 3-64: Predicted Mean Ammoniacal Nitrogen concentration (mg/l N) Envelope over 15 day for spring-neap-spring tide simulation.

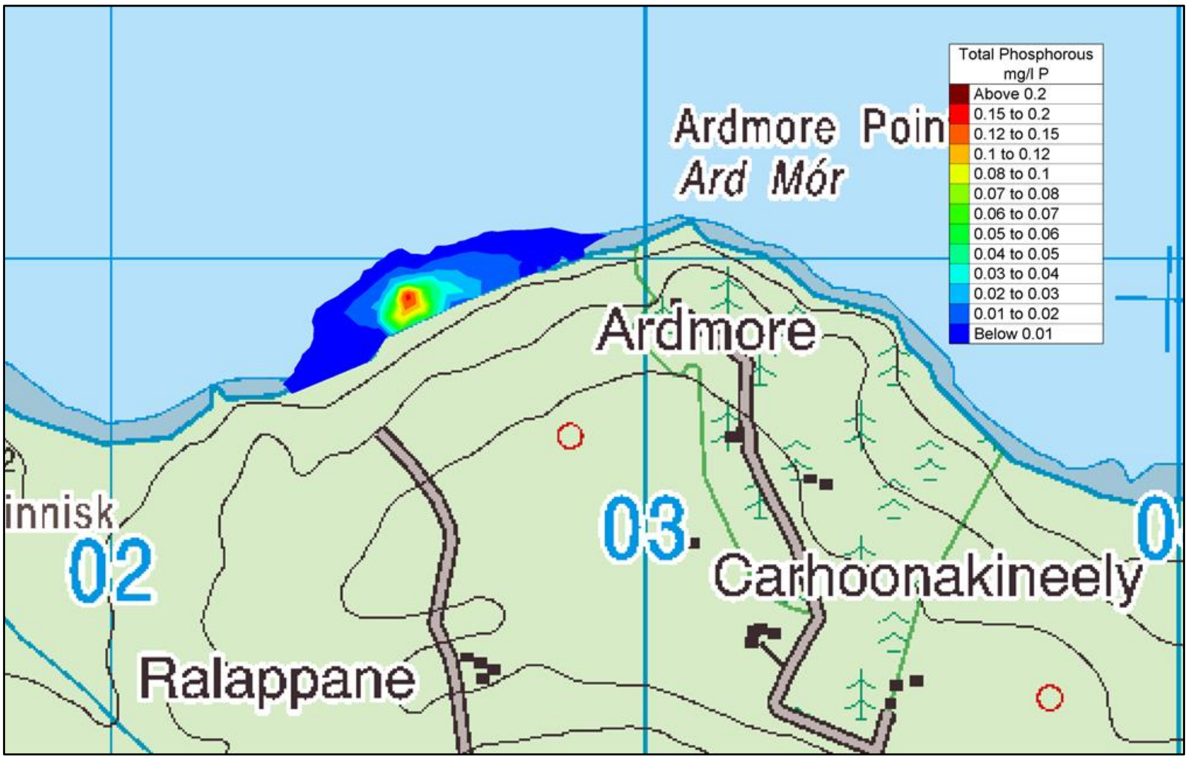


Figure 3-65: Predicted Maximum Total Phosphorous concentration (mg/l P) Envelope over 15 day for spring-neap-spring tide simulation.

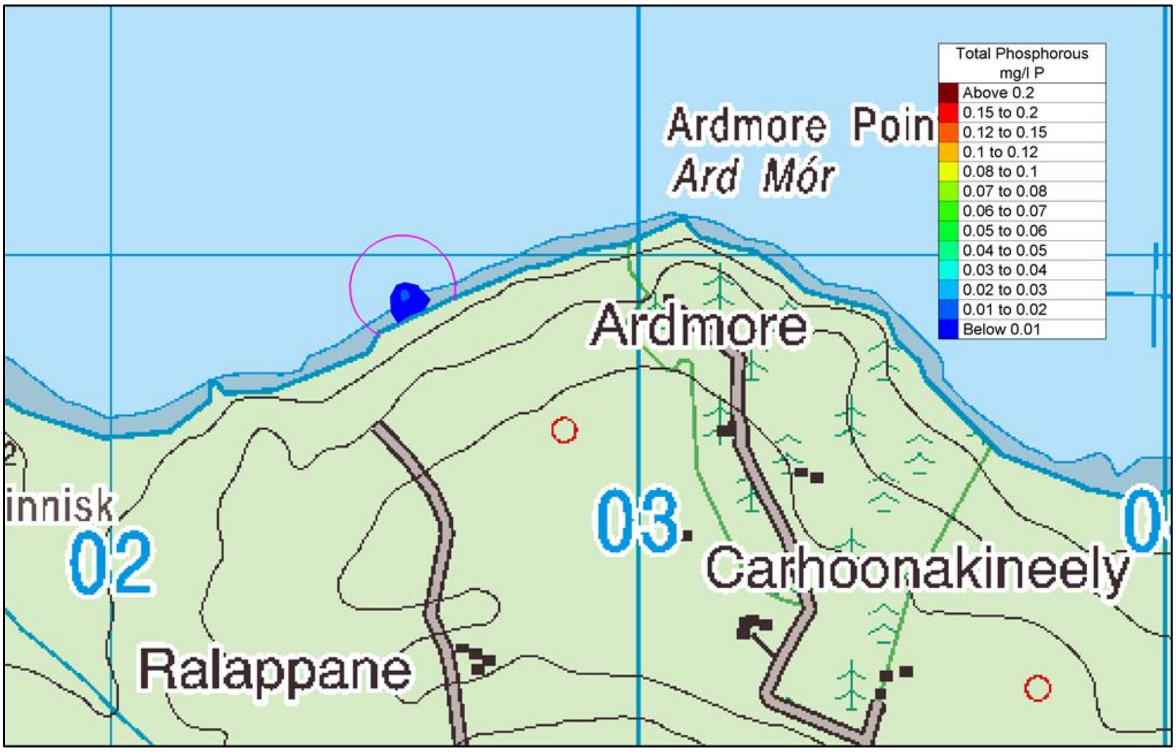


Figure 3-66: Predicted Mean Total Phosphorous concentration (mg/l P) Envelope over a 15 day period for spring-neap-spring tide simulation.

3.4.10. Impact Mechanism 10. Introduction of invasive species

3.4.10.1. Assessment

3.4.10.1.1. Overview

Impact mechanism 10 is associated with the operation phase.

Invasive non-native plant and animal species are a significant threat to biodiversity worldwide. 'Non-native species' are the equivalent of 'alien species' as used by the Convention of Biological Diversity[32]. It refers to a species, subspecies or lower taxon, introduced by human action outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce. An invasive non-native species is any non-native animal or plant that has the ability to spread causing damage to the environment. Alien species that become invasive are considered to be main direct drivers of biodiversity loss across the globe. Invasive species are non-native species that can cause harm to the natural ecology of an area, often by out-competing native species.

3.4.10.1.2. Terrestrial Invasive Non-Native Species

A survey for terrestrial invasive species was carried out in conjunction with habitat surveys and any observations of invasive species made during other surveys were recorded. No Schedule 7 invasive species (Wildlife Act 1976, as amended) or any High impact or Medium impact invasive species as classified by the NBDC were recorded within the site of the Proposed Development.

A potential threat to terrestrial habitats and species is the risk of introduction or spread of invasive species, either through the movement of topsoil, fill, gravel, construction equipment, or during restoration activities.

Recommendations of suitable control measures to manage the risk of introduction and spread of invasive species is provided in **Section 3.6** below.

3.4.10.1.3. Marine Invasive Non-Native Species

Ballast water which is used by commercial vessels to control trim, draft and stability is widely recognised as one of the key dispersal mechanisms for marine invasive species. These species can affect the ecological balance of their new regions by outcompeting native species or otherwise impacting native ecosystems. Established protocols to manage the use of ballast water and the risk of introduction and spread of marine invasive species is provided in **Section 3.6.6** below.

3.4.10.2. Conclusion

Strict adherence to protocols will ensure there is no risk of significant risk of environmental impact from the introduction and spread of marine invasive species is managed.

[32] Convention on Biological Diversity. Invasive Alien Species. https://www.cbd.int/invasive/. Accessed 10/01/2017.

3.4.11. Impact Mechanism 11. Accidental large-scale oil or LNG spill

3.4.11.1. Assessment

Impact mechanism 10 is associated with the operation phase.

The likelihood of large-scale oil and LNG spills due to accidents and vessel collision during operations at the Proposed Development is regarded as remote, while the risk of accidental small spillages of pollutants (including fuels, hydrocarbons, oils etc.) is considered to be low.

Specifically, the assessment of likelihood of release events from the Proposed Development are set out in the following

- Marine Navigation Risk Assessment, which was prepared by the Shannon Foynes Port Company (see Appendix A2-2 of EIAR Vol. 4).
- Quantitative Risk Assessment (QRA) and associated Major Accidents to the Environment (MATTE) submitted to the HSA as part of the planning application (see Appendix A2-5, Vol. 4).
- EIAR for the Proposed Development submitted ABP as part of the planning application
- OCEMP (see Appendix 7 of NIS Vol. 2).

Additionally, the operation of the Proposed Development will be controlled and regulated by the following bodies:

- Environmental Protection Agency;
- Commission for Regulation of Utilities;
- Health and Safety Authority;
- KCC; and
- The Shannon Foynes Port Company.

However, in consultation with Shannon Foynes Port Company and the Shannon Estuary Anti-Pollution Team (SEAPT), Shannon LNG has prepared an Oil and Hazardous and Noxious Substances (HNS) Spill Plan Development Framework (see Appendix A2-6 of EIAR Vol. 4). This document describes the graduated and tiered response process to fulfil these obligations and to provide a robust and coordinated response to release incidents in the unlikely event they should occur. The developed plans will follow international best practice guidelines of the International Maritime Organization (IMO), The Society of International Gas Tanker and Terminal Operators (SIGTTO), and International Petroleum Industry Environmental Conservation Association (IPIECA) while taking into account relevant Irish legislative and regulatory approval requirements. In particular the plans will follow the requirements made within the National Maritime Contingency Plan Oil and HNS Spills 2019 (NCP) and the National Framework for the Management of Major Emergencies. The plans will be developed to cover both In-Land (onshore) and Marine based releases and shall cover the Construction and Operational Phases of the Proposed Project. Key objectives and the format of the Oil and HNS Spill Plan Oil and how the plan relates to the National Contingency Plan (NCP) are described in **Section 3.6.7**.

The development has (provisional to project go-ahead) been accepted as member of the Shannon Estuary Anti-Pollution Team (SEAPT). Membership of SEAPT will enable the development to interface directly with the approved Shannon Estuary Oil/HNS Plan and access additional response equipment to augment that held within the terminal (see in **Section 3.6.7** for further details)

LNG is stored on the FSRU and LNGC site as a liquefied gas and when released to its surroundings it vaporises rapidly to form natural gas, leaving no residue. LNG (methane and other light hydrocarbons) is classed under the COMAH Regulations as 'Liquefied Flammable Gasses'. As LNG and natural gas are not toxic to the environment, hazards are associated with exposure to low temperatures from an LNG release (cryogenic burns), or fires if a release of LNG or natural gas is ignited. Environmental receptors at risk are flora and fauna.

The MATTE assessment determined that thermal radiation from jet fires and flash fires will not affect the NHA and onshore cSAC to the west of the Site. LNG Pool fires on the sea surface could lead to thermal radiation effects at the NHA and onshore SAC to the west of the Site. The frequency of these events have been calculated within the Safeti QRA Model and are at most 3.7 x 10^{-6} per year (once in 270,270 years) at the closest point of the onshore SAC. This frequency is considered to be very low. It should be noted that the 5 kw/m^2 thermal radiation intensity is below that which would lead to a fire and therefore recovery from this type of event would be less than three years. Modelling indicates that the jet and pool fire contours of 5kW/m^2 reach areas of the estuary that forms part of the SAC and SPA close to the jetty/terminal. While harm to birds present on the estuary surface close to the Proposed Development may be possible in the event of a fire, bird surveys have identified that there are no significant populations of bird species in the vicinity of the Proposed Development site. Based on the definition of a MATTE jet fires and LNG pool fires are not considered credible MATTE events. All of the MATTE events identified are considered to be low frequency and consequently low risk.

Based on the assessments described above, the likelihood of major accident is predicted to be remote and therefore does not pose a significant risk to habitats or species within or in the vicinity of the Proposed Development site.

3.4.11.2. Conclusion

Based on the assessments described above, the risk of major accident is predicted to be very low and therefore does not pose a significant risk to habitats or species within or in the vicinity of the Proposed Development site.

Small-scale accidental spillages will be contained and cleaned up immediately. Remediation measures will be carried out in the unlikely event of pollution of the marine environment.

3.4.12. Impact Mechanism 12. Collision with site infrastructure

3.4.12.1. Relevant Conservation Features

- *Phalacrocorax carbo* (Cormorant) [A017]
- *Anas crecca* (Teal) [A052]
- *Anas acuta* (Pintail) [A054]
- *Aythya marila* (Scaup) [A062]
- *Anas penelope* (Wigeon) [A050]
- *Anas clypeata* (Shoveler) [A056]
- *Tadorna tadorna* (Shelduck) [A048]
- *Charadrius hiaticula* (Ringed Plover) [A137]
- *Pluvialis apricaria* (Golden Plover) [A140]
- *Pluvialis squatarola* (Grey Plover) [A141]
- *Calidris canutus* (Knot) [A143]
- *Calidris alpina* (Dunlin) [A149]
- *Limosa limosa* (Black-tailed Godwit) [A156]
- *Limosa lapponica* (Bar-tailed Godwit) [A157]
- *Numenius arquata* (Curlew) [A160]
- *Tringa totanus* (Redshank) [A162]
- *Tringa nebularia* (Greenshank) [A164]
- *Vanellus vanellus* (Lapwing) [A142]
- *Branta bernicla hrota* (Light-bellied Brent Goose) [A046]
- *Cygnus cygnus* (Whooper Swan) [A038]
- *Chroicocephalus ridibundus* (Black-headed Gull) [A179]

3.4.12.2. Assessment

Impact mechanism 12 is associated with the construction and operation phase.

Collision risk associated with construction machinery and built structures is highest amongst "heavy wing loading" species such as geese and swans. It is also increased where birds undertake daily migrations during the hours of dusk and dawn to foraging and roosting locations. Potential collision risk impacts to SCI species, in particular whooper swan and light-bellied brent goose, and to a lesser extent cormorant, arise from the temporary presence of construction plant on the Shannon estuary shoreline and the presence of the jetty during operation.

Construction plant

Construction plant present during construction could potentially create a collision risk for birds. The greatest risk of this is likely to be night. Lighting of structures at night has been shown to increase the risk of bird collision and collision rates have been found to increase with increased lighting (Evans Ogden 2002, Zink and Eckles 2010). Mitigation measures during the construction phase outlined in **Section 3.6**, will reduce onsite lighting and light spillage. Lighting on cranes onsite will be down angled to minimise collision risk during the construction phase. Furthermore, given that jetty works will be 24 hours a day, the noise associated with construction works, means that during both day and night, birds are unlikely to fly towards this area. No significant impacts on birds due to collisions with plant machinery during construction of the jetty will occur.

Jetty

Potential collision risk impacts to SCI species such as whooper swan and light-bellied brent goose, and to a lesser extent cormorant arise from the presence of the jetty along the Shannon Estuary shoreline during operation.

The risk of diurnal collision for other SCI species is not considered to be significant due to the small size and/or agile flight ability of these species. It is also noted that the lattice structure of the jetty means that smaller birds can also fly beneath the structure.

The proposed jetty will be 345-m in length and +9m high. It is noted that similar structures along the southern shores of the Shannon Estuary at Tarbert and Foynes do not appear to pose any current collision risk to whooper swan, light-bellied brent goose or any other SCI species. Observations on overflying birds at the proposed jetty location as well as to the east and west of this area confirmed that there were no commuting routes for whooper swan or light-bellied brent goose along this stretch of coastline or within 1km east or west of the site. On one occasion, two whooper swans were observed flying close to the jetty area (Point B), 100-250m offshore at a height of between 25-50m. However, this flight height is significantly above the height of the jetty platform (9m OD). Cormorants are likely to fly in the vicinity of the proposed jetty during foraging and commuting flights. Blew *et al.* (2008) in a study of a Swedish windfarm found that resident cormorants will effectively avoid collision with wind turbines. Furthermore, cormorants are known to effectively forage and breed in the vicinity of busy ports throughout Ireland (RPS, 2012, 2014, 2017) and their risk of collision with the jetty structure is not significant.

Lighting of structures at night has been shown to increase the risk of bird collision and collision rates have been found to increase with increased lighting (Evans Ogden 2002, Zink and Eckles 2010). Storms and inclement weather can also increase the susceptibility of migratory birds to the effects of light pollution and collisions with structures (Rich and Longcore 2006, Newton 2007). Heavy precipitation, strong winds, fog and low clouds, often interacting with disorienting effects of artificial light at night can cause migrating birds to fly at lower altitudes or to be grounded, leading many to collide with structures such as offshore oil platforms, lighthouses, communication towers and wind turbines (Kemper 1996, Johnson *et al.* 2002, Jones and Francis 2003). However, except for descriptive accounts of storms causing large numbers of birds to collide with a variety of structures (Roberts 1907, Johnston and Haines 1954), few published studies analyse the link between weather and bird collision rates. In a recent study on the link between weather and rates of collision, Loss *et al.* (2020) analysed American Woodcock *Scolopax minor* collisions during a range of weather conditions. This study found that collisions were greatly influenced by inclement weather, specifically the coincidence of strong north wind and low clouds.

Migratory birds, including SCI species, appear to be most at risk of night-time and/or poor weather collision, particularly in areas with strong levels of artificial light. Low-flying birds may experience elevated collision risk during night-time or poor weather conditions, due to the disorienting effects of artificial night lighting emitted from and near buildings/structures (Evans Ogden 1996, Arnold and Zink 2011, Winger *et al.* 2019), especially because light pollution 'skyglow' is exacerbated by low clouds and precipitation (Rich and Longcore 2006). While the linear nature of the Shannon Estuary is likely to provide a flight path for nocturnal migrants, bird migration altitudes are likely to be between 2,000-6,000m (Lindstrom *et al*. 2021). Lighting of the jetty will be at the minimal levels to meet national and international engineering standards. Although bird collision is a well-documented phenomenon, it should be noted that following an extensive review of the available literature no studies were found which recorded bird collision with jetties (piers, wharfs, marinas *etc*), during day or night. A small number of studies have examined the bird collision with bridges, which may be comparable to jetties in their location over water and 24 hour lighting (Zielinska-Dabkowska 2013, Godinho *et al*. 2017, Hu *et al.* 2020). However, within these studies, the majority of the collision associated with bridges were with the traffic (car/rail) on the bridge rather than with the bridge structure itself.

Reducing lighting has proven effective in reducing mortality of night migrants at buildings (Brown and Caputo 2007, Sheppard 2011) and mitigation measures to reduce bird collision centre around turning off lighting when not required, downlighting and generally avoiding "over lighting" (National Audubon Society 2019, USFWS 2016). Lighting of the jetty and powerplant will be down angled, the height of the proposed light columns will been kept to a minimum throughout the Proposed Development site and light columns will be fitted with focused luminaires to avoid glare, sky glow and light spill. As can be seen from Appendix 8 in NIS Vol. 2 Photomontages, the lighting of the jetty along the southern shore of the Shannon Estuary is not excessive. The levels of light of the proposed development within the Shannon Estuary means the risk of the jetty lighting at night diverting nocturnal migrants is not significant and no significant impact on nocturnal migrating birds will occur. It is also noted at comparable structures along the southern shores of the Shannon Estuary i.e. Foynes Port, Tarbert Port, no records of night-time or poor weather bird collision have been found.

Given the low risk of collision with jetty structures, the lattice design of the jetty, the location of the jetty outside commuting routes for large SCI birds and the lighting design measures at the site, no significant risk of collision has been identified and no impact on SCI birds due to collision is predicted to occur

3.4.12.3. Conclusion

Based on the above and subject to implementation of mitigation, it can be concluded there will be no significant adverse effects to the conservation features within the River Shannon and River Fergus Estuaries SPA from impact mechanism 12.

3.4.13. Impact Mechanism 13 Barrier to Connectivity

3.4.13.1. Relevant Conservation Features

- *Phalacrocorax carbo* Cormorant [A017]
- *Lutra lutra* (Otter) [1355]*

3.4.13.2. Assessment

Impact mechanism 13 is associated with the construction and operation phase.

NPWS (2012b) (Map 17) shows a 250m wide Otter commuting buffer to be present all along the Shannon Estuary, including the area proposed for the STEP jetty. As outlined in **Section 3.4.4**, PTS effects are not predicted to occur as a result of construction activities generating the most significant levels of underwater noise.

The jetty structure, at a length of 354m within the Shannon Estuary could in theory create a barrier to otter movement within the 250m commuting buffer during the operational phase. It is noted that the jetty trestle will be elevated above the foreshore to allow access for walkers and wildlife and there will be no physical barrier to otter movement along the shoreline. Given otter's ability to adapt to disturbance and their regular use of habitats in the vicinity of human habitation and lit area including bridges (See **Section 3.4.2.2**) they will continue to use the habitats in the vicinity of the jetty during operation. Therefore, no significant physical or disturbance barriers to connectivity for otter have been identified during the construction or operational phase.

This attribute applies to breeding cormorant within the SPA. As noted in **Section 3.4.1**, there are no breeding cormorants in the vicinity of the proposed development. Cormorants using waters within 258m (± 215m) of the works area could be displaced during construction or operation (Fliessbach *et al.* 2019). However, as with other SCI species very small numbers of cormorant were recorded in the vicinity of the proposed jetty location (peak number = 4). Furthermore, it is noted that cormorant are considerably more tolerant to disturbance than other diving bird species (Garthe and Hüppop 2004; Furness and Wade 2012; Fliessbach *et al.* 2019). Evidence from Burbo Bank (CMACS 2008) and Robin Rigg (E.ON/Natural Power 2012) offshore wind farms has shown that densities of cormorant increased during the construction phases. Cormorant are also relatively flexible with respect to habitat use (Garthe and Hüppop 2004; Furness and Wade 2012) and likely to readily forage in other areas within the SPA during peak construction works. While they may temporarily avoid construction works, they are likely to continue to use the site during the operational phase. Potential collision risk is discussed in **Section 3.4.12** and found no significant risk to cormorant from collision with the jetty. No significant barriers to connectivity for cormorant will occur during the construction or operational phase. Based on the tolerance of cormorant and otter to anthropogenic disturbance, no significant in-combination effects from disturbance, noise or collision have been identified.

Mitigation measures to reduce noise, vibration and lighting levels during construction and operation are detailed in **Section 3.6**.

3.4.13.3. Conclusion

Based on the above and subject to implementation of mitigation, it can be concluded there will be no significant adverse effects to the conservation features within the Lower River Shannon cSAC or River Shannon and River Fergus Estuaries from impact mechanism 13.

3.4.14. Impact Mechanism 14. Loss of prey biomass

3.4.14.1. Relevant Conservation Features

- *Phalacrocorax carbo* Cormorant [A017]
- *Lutra lutra* (Otter) [1355]*

3.4.14.2. Assessment

Impact mechanism 14 is associated with the construction and operation phase.

During construction, the potential release of pollutants, as well as the underwater noise and sediment plumes during piling works could lead to fish mortality. The removal of wet grassland habitat within the Proposed Development site, where small numbers of common frog are known to occur, could also lead to a reduction in prey species for otter. During operation there is potential that discharges of treated cooled seawater, discharges as well as entrainment and impingement of fish during operation could lead to fish mortality. Overall this could lead to loss of prey biomass for SCI birds and otter during construction and operation. Given the small numbers of fish in the Ralappane Stream, the absence of instream works and mitigation measures proposed to prevent impacts on water quality during construction, there is no potential for a reduction in prey biomass from bridge works.

The potential impacts of release of pollutants during construction are discussed in **Section 3.4.1.** Mitigation measures to prevent the release of chemical and pollutants from construction plant equipment are detailed in **Section 3.6.1** and the OCEMP provided in Appendix 7 of NIS Vol. 2. **Section 3.4.1** concluded that following the implementation of mitigation measures there would be no impact on conservation features. Similarly following these mitigation measures, there will be no impact on other fish species in the vicinity from pollution during construction.

The potential impacts of release of spoil during piling are discussed in **Section 3.4.3.** As noted, Shannon LNG commissioned AQUAFACT to carry out a hydrodynamic and dispersion modelling study to determine the fate of sediment generated during piling operations. Based on the predicted sedimentation rates at the site, there will no significant impact on marine life. Therefore, there will be no fish mortality as a result of sedimentation from piling.

Potential impact to fish from underwater noise during are discussed in **Section 3.4.4.** This concluded that there would be no significant impact on fish populations as a result of underwater noise.

Potential impacts of treated seawater on marine species is discussed in **Section 3.4.7.** This concluded that based on the results of the modelling dispersion study the impact on receiving waters would be negligible/undetectable. Therefore, there will no impact on fish species from treated seawater discharges during operation.

Potential impacts of wastewater discharges and heated water effluent are discussed in **Section 3.4.9**. As noted, Shannon LNG commissioned AQUAFACT to carry out a hydrodynamic and dispersion modelling study to determine the fate of discharges and effluent from the Proposed Development. Based on this report there will be no significant impact on marine life, including fish species from wastewater discharges.

Potential impacts of entrainment and impingement of SCI fish numbers by the FRSU seawater system is discussed in **Section 3.4.8**. Based on the behaviour of SCI fish species, approach velocity of the seawater and the screen mesh size, no significant potential for impact from entrainment and impingement was identified. Similarly, it was concluded in Chapter 07A of EIAR Vol. 2 there are no predicted significant effects on larvae of fish species and crustaceans species that are not conservation features.

The loss of wet grassland within the site, where a small number of frogs are known to occur, may lead to a small loss of prey availability for otter. However, given the limited area of suitable habitat and therefore the small numbers of common frog at the Proposed Development site there will be no significant impact from loss of prey biomass.

3.4.14.3. Conclusion

Based on the above, it can be concluded there will be no significant adverse effects to the conservation features within the Lower River Shannon cSAC or River Shannon and River Fergus Estuaries from impact mechanism 12.

3.5. Potential for Adverse Effects on Site Integrity

3.5.1. Lower River Shannon cSAC

Potential for effect on Estuaries [1130] and Reefs [1170] was identified in **Section 3.4.1**. The Conservation Objective for the Estuaries [1130] and Reefs [1170] are to maintain the favourable conservation condition (NPWS, 2012). In addition, potential noise effects have been identified in **Section 3.4.4** for common bottlenose dolphin (NPWS, 2012).

For the QI habitats and species, favourable conservation condition is defined by a list of attributes and targets. An assessment of the potential impacts on the integrity of the cSAC was undertaken in relation to the attributes and targets set for the habitats and species (see **Table 3.19**).

3.5.2. River Shannon and River Fergus Estuaries SPA

The assessment of the potential impact of a project or plan on the integrity of SPAs is undertaken in relation to the site specific Conservation Objective attributes and targets. Article 6 defines 'integrity' as the 'coherence of the site's ecological structure and function, across its whole area, or the habitats, complex of habitats and / or population of species for which the site is or will be classified'. Conservation Objective attributes and targets broadly relate to

1. characteristics of the SPA site
2. characteristics of the SCI populations.

Attributes and targets related to **1**, namely characteristics of SPA sites include wetland habitat area, barriers to connectivity, disturbance at breeding sites (cormorant only) and number of breeding colonies (cormorant only). As detailed mapping and the characteristics of designated wetlands within the SPA are not available on the NPWS website, the assessment of potential adverse effects to wetlands relies on the detailed assessments of the effects of sediment and water discharge plumes on Annex I habitats designated for the Lower River Shannon cSAC. No significant impacts on Annex I habitats from changes in water quality have been identified and therefore there will be no adverse impacts on wetland habitat within the SPA. Given the distribution of breeding colonies within the SPA, the design elements of the project which ensure no barriers to connectivity will ensure no adverse effects on the characteristics of the SPA site will occur.

Attributes and targets related to **2,** namely characteristics of SCI populations, include population trends and distribution, breeding population abundance (cormorant only), productivity rates (cormorant only), distribution of breeding colonies (cormorant only) and breeding population abundance (cormorant only). While the SPA and surrounding areas provide suitable habitat and foraging opportunities for the SCI species, it should be noted that these species do not occur in high numbers in the vicinity of the Proposed Development site. In the absence of mitigation. there may be potential effect to individual birds, however there is no risk of significant adverse population level effects.

Table 3.19: Assessment of potential for adverse effects on the integrity of the Lower River Shannon cSAC – Annex I habitat reef. Attributes, measure and targets identified in NPWS (2012).

QI	Attribute	Measure	Target	Potential Impact	Potential for Adverse Effects on Site Integrity in the Absence of Mitigation
Estuaries [1130]	Habitat area	Hectares	The permanent habitat area is stable or increasing, subject to natural processes	Loss of Qualifying Interest Annex I habitat due to the installation of piles and outfall pipe.	As outlined in **Section 3.4.5** the installation of the piles will result in the loss of **155 m²** of Annex I habitat 1130 within the cSAC. The total extent of habitat 1130 within the cSAC is 24,273 ha (or 242,730,000 m²). The loss of 1130 habitat due to piles is 0.000064% of the total 1130 habitat within the cSAC. The installation of the outflow will result in the loss **100 m²** of the habitat 1130 within the cSAC. The loss due to the outflow represents 0.000041% of the habitat 1130 within the cSAC. The combined loss of 1130 habitat due to the piles and the outflow is **255 m²**. The total are of 1130 habitat lost is negligible when compared to the full spatial of the habitat within the cSAC. While the loss of **255 m²** Annex I 1130 habitat pending decommissioning contravenes the Conservation Objective target for habitat area (*i.e.* habitat area is stable of increasing), the loss of habitat is negligible at **0.000105%** of the habitat area within the cSAC and will not have a significant adverse effect on the integrity of the site.

QI	Attribute	Measure	Target	Potential Impact	Potential for Adverse Effects on Site Integrity in the Absence of Mitigation
Estuaries [1130]	**Community distribution**	**Hectares**	**Conserve the following community types in a natural condition: Intertidal sand with *Scolelepis squamata* and Pontocrates spp. community; Intertidal sand to mixed sediment with polychaetes, molluscs and crustaceans community complex; Subtidal sand to mixed sediment with *Nucula nucleus* community complex; Subtidal sand to mixed sediment with Nephtys spp. community complex; Fucoid-dominated intertidal reef community complex; Mixed subtidal reef community complex; Faunal turf-dominated subtidal reef community; Anemone-dominated subtidal reef community; and Laminaria-dominated community complex**	**Release of sediment, chemicals or other waste material pollution during construction could result in impact to constituent community types and ecological function.**	**Yes – pollution effects and associated impacts would constitute a negative effect on site integrity.**

QI	Attribute	Measure	Target	Potential Impact	Potential for Adverse Effects on Site Integrity in the Absence of Mitigation
Reef [1170]	Habitat distribution	Occurrence	The distribution of Reefs is stable, subject to natural processes	None	No
Reef [1170]	Habitat area	Hectares	The permanent habitat area is stable, subject to natural processes	Loss of Qualifying Interest Annex I habitat due to the installation of piles.	As outlined in **Section 3.4.5** the installation of the piles will result in the loss of **8 m^2** of Annex I habitat 1170 within the cSAC. The total extent of habitat 1170 within the cSAC is 21,421 ha (or 214,210,000 m^2). The loss of 1170 habitat due to piles is 0.000004% of the total 1130 habitat within the cSAC. The installation of the outflow will result in the loss **65 m^2** of the habitat 1170 within the cSAC. The loss due to the outflow represents 0.000030% of the habitat 1170 within the cSAC. The combined loss of 1170 habitat due to the piles and the outflow is **73 m^2**. The total are of 1170 habitat lost is negligible when compared to the full spatial of the habitat within the cSAC. While the loss of Annex I 1170 habitat pending decommissioning contravenes the Conservation Objective target for habitat area (*i.e.* habitat area is stable of increasing), the loss of habitat is negligible at **0.000034%** of the habitat area within the cSAC and will not have a significant adverse effect on the integrity of the site.

QI	Attribute	Measure	Target	Potential Impact	Potential for Adverse Effects on Site Integrity in the Absence of Mitigation
Reef [1170]	Community distribution	Hectares	Conserve the following reef community types in a natural condition: Fucoid-dominated intertidal reef community complex; Mixed subtidal reef community complex; Faunal turf-dominated subtidal reef community; Anemone- dominated subtidal reef community; and Laminaria- dominated community complex	**Pollution effects.** **Release of sediment, chemicals or other waste material pollution during construction (*i.e.* impact mechanism 1) could result in impact to constituent community types and ecological function.**	**Yes – pollution effects and associated impacts would constitute a negative effect on site integrity. Mitigation measure to avoid impact are detailed in Section 3.6 below.**

QI	Attribute	Measure	Target	Potential Impact	Potential for Adverse Effects on Site Integrity in the Absence of Mitigation
Bottlenose dolphin [1349]	Access to suitable habitat	Number of artificial barriers	Species range within the site should not be restricted by artificial barriers to site use	None	No
	Habitat use: critical areas	Location and hectares	Critical areas, representing habitat used preferentially by bottlenose dolphin, should be maintained in a natural condition	**Noise disturbance.**	**Yes - noise disturbance and associated impacts would constitute a negative effect on site integrity. Mitigation measure to avoid impact are detailed in Section 3.6 below.**
	Disturbance	Level of impact	Human activities should occur at levels that do not adversely affect the bottlenose dolphin population at the site		

3.6. Mitigation Measures

3.6.1. Construction Mitigation Measures and Best Practice

This will take into account measures presented in the CEMP regarding construction activities including any that are required to ensure no significant release of pollutants, sediment laden water, runoff chemicals or other waste material pollution into the nearby habitats, watercourses and waterbodies.

Measures will also include standard construction best practice used to manage the risk of potential for loss hydrocarbons such as diesel and hydraulic fluids. Careful supervision of construction operations and general construction practice will reduce the risk from impacts so that the likelihood of impacts is best described as low.

Storage of storage of oil spill accident response equipment. At a minimum the oil spill response equipment will include the following: absorbent mats, waste- bags, oil splash goggles, gloves and vinyl or rubber shoe covers to protect the user from the harmful effects of the spilled material.

Imported backfill material will be washed (cleaned) to remove fines and checked for invasive species before use.

Imported material to be used backfill will be stored on the site; measures to avoid the release of sediment will be implemented (including silt fences).

Clean (washed) rock material will be used as rock protection to minimise the risk of introducing fine materials.

The implementation of general construction practice will ensure that the likelihood of pollution in a well-equipped, maintained and managed construction site is low.

3.6.2. Underwater Noise mitigation

To mitigate potential impact to marine mammal species Shannon LNG will implement relevant impact mitigation and monitoring measures in relation to marine mammals as outlined in DAHG Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (DAHG, 2014).

3.6.2.1. NPWS 2014 Required mitigation

- Pre-start Observation: Marine mammal observation period of 30 minutes minimum prior to start (or re-start after a break of 30 minutes) of any impact piling and any drilling;
- Start delay due to observation: a gap of at least 30 minutes required between the last observation of a marine mammal and start of operations;
- Observation zone: The observation zone is 1000 m for impact piling and 500 m for drilling (thus impact piling likely to require > 1 marine mammal observer);
- Commence in daylight only: Impact piling and drilling can only start in daylight conditions when visual monitoring can take place (*i.e.* when wind/wave conditions mean observation is possible: NPWS guidance recommends “sea conditions for effective visual monitoring by MMOs are WMO Sea State 4 (≈Beaufort Force 4 conditions) or less;
- Soft-start: For any source, including equipment testing, exceeding 170 dB re: 1µPa @1m an appropriate ramp-up procedure (i.e., “soft-start”) must be used. This should be a minimum of 20 minutes and no longer than 40 minutes;
- Continuity: once piling or drilling has started it can continue into darkness and does not need to stop even if marine mammals are seen in the observation zone (in fact, an MMO is not required once the sound generating activity starts though continued observation can be

beneficial for unexpected breaks or down-time as the 30 minute observation period can start immediately;

- Marine mammal observer: MMOs must be dedicated to and engaged solely in monitoring an operator's implementation of the NPWS technical guidance. A sufficient number of MMO personnel must be assigned to ensure that the role is performed effectively. Avoidance of observer fatigue is essential;
- MMO training: use trained and experienced marine mammal observers – the guidance states this should be a visual observer who has undergone formal marine mammal observation and distance estimation training (JNCC MMO training course or equivalent) and also has a minimum of 6 weeks full-time marine mammal survey experience at sea over a 3-year period in European waters.

3.6.2.2. Additional mitigation

- Piling activities: No simultaneous impact piling;
- Continuity between activities: Pile installation will require a combination of techniques including impact piling, vibratory piling and drilling requiring breaks in activity as equipment is changed. Where an activity progresses to a lower sound level activity – i.e. from impact piling to vibratory piling or drilling, and the break between activities is less than 30 minutes a new period of observation is not required and activities can be considered to be continuous;
- Additional seasonal observation for bottlenose dolphin: For any impact piling taking place during August, an additional MMO will be present at Moneypoint to undertake additional observations for mother-young dolphin pairings. There is known presence of neonatal bottlenose dolphin in the estuary between July and September, peaking in August, and though numbers are low there is potential for presence in the region of the Proposed Development. There will be full communication between the Moneypoint MMO and the construction team to ensure no impact piling commences until animals have moved away from a 1000 m radius observation zone (ensuring the full width of the estuary is observed in August);
- Mitigation measures during blasting: Whilst all blasting is land based there will be propagation of sound into the underwater environment. Thus, the standard mitigation measures for blasting will be adopted as a precautionary measure – qualified MMO, a 1000 m observation zone and an observation period of 30 minutes. As only single blasts will take place in each event (not a series) a soft-start is not included.
- Monitoring: The marine mammal monitoring programme, currently being undertaken by the Irish Whale and Dolphin Group (in the vicinity of the project using CPODs) will be continued into the construction phase for the validation of predictions (based on observations from other studies – see impact assessment) that any animals displaced from an area return after the construction activity stops.

3.6.3. Lighting Mitigation

Site lighting will typically be provided by tower mounted temporary portable construction floodlights. The floodlights will be cowled and angled downwards to minimise spillage to surrounding properties. The following measures will be applied in relation to construction works lighting:

- Lighting will be provided with the minimum luminosity necessary for safety and security purposes. Where practicable, precautions will be taken to avoid shadows cast by the site hoarding on surrounding footpaths, roads and amenity areas and
- During construction, lighting will be positioned and directed so that it does not unnecessarily intrude on adjacent ecological receptors and structures used by protected species. The

primary area of concern is the potential impact at the SAC/SPA boundary, the Ralappane Stream as well as hedgerows and treelines. With the exception of the jetty dock, there will be no directional lighting focused towards these areas and cowling and focusing lights downwards will minimise light spillage.

3.6.4. Land Based Noise Mitigation

To ensure sound and vibration levels are kept to a minimum and to reduce the risk of cumulative impacts, it is recommended the following measures are adopted during the construction phase:

- Fixed and semi-fixed ancillary plant such as generators, compressors and pumps shall be located away from sensitive receptors wherever possible.
- All plant used on site shall be regularly maintained, paying attention to the integrity of silencers and acoustic enclosures.
- All noise generating construction plant shall be shut down when not in use.
- The loading and unloading of materials shall take place away from residential properties, ideally in locations which are acoustically screened.
- Materials shall be handled with care and placed rather than dropped where possible. Drop heights of materials from lorries and other plant shall be kept to a minimum.
- Modern plant shall be selected which complies with the latest European Commission noise emission requirements. Electrical plant items (as opposed to diesel powered plant items) shall be used wherever practicable. All major compressors shall be low noise models fitted with properly lined and sealed acoustic covers. All ancillary pneumatic percussive tools would be fitted with mufflers or silencers of the type recommended by the manufacturers.
- Site operations and vehicle routes shall be organised to minimise the need for reversing movements, and to take advantage of any natural acoustic screening present in the surrounding topography.
- No employees, subcontractors and persons employed on the site shall cause unnecessary noise from their activities *e.g.* excessive 'revving' of vehicle engines, music from radios, shouting and general behaviour etc. All staff inductions at the site shall include information on minimising noise and reminding them to be considerate of the nearby residents.
- As far as practicable, noisier activities shall be planned to take place during periods of the day which are generally considered to be less noise sensitive *i.e.* not particularly early or late in the day.
- Measures shall be put in place to ensure that employees know that minimisation of noise will be important at the site; and
- Blasting vibration limits will be achieved by limiting the Maximum Instantaneous Charge (MIC) based on the results of trial blasts carried out in accordance with the procedure detailed in BS6472.
- A commitment is made to ensure construction traffic from this and other concurrent development (i.e. Pipeline and Grid Connections, see below for details) will be coordinated to minimise traffic and site noise impacts where possible.

In addition to the above measures, a regime of noise and vibration monitoring will be undertaken during the construction phase to determine compliance with the nominated criteria and to provide a feedback mechanism so that corrective action can be taken in the event of exceedances.

Approximately three to four long term noise monitoring stations and one to two long term vibration monitors will be set up on the construction site boundary. The exact location of these stations will be determined in due course and will be chosen to best represent noise and/ or vibration emissions in the direction of nearby receptor positions. Monitoring will continue throughout the entire construction phase.

Long term noise monitoring stations will be equipped with an SMS and/ or email alert system so that site staff can be informed of potential exceedances. The results of the monitoring will be recorded and reported to relevant stakeholders in an appropriate manner and frequency, to be agreed in due course.

A commitment has been made to adopt the operational noise limits detailed in this assessment as requirements in final design, including the need to address distinctive acoustic characteristics and/or adjust the noise limits accordingly. Mitigation measures are likely to include the following:

- Silencers
- Attenuators
- Specification of low noise plant wherever possible
- Inclusion of acoustic barriers

Furthermore, compliance with the nominated criteria will be confirmed via pre-completion testing. The exact details of the testing will be confirmed with the regulating authority in due course.

Long term monitoring will be undertaken for a period of at least 12 months from the commencement of site operations and again following any subsequent substantive change in site operations. After 12 months the need for long term monitoring will be reviewed with the relevant authority.

In addition to the above, short-term attended noise measurements will be carried out. Short term measurements will take place at the commencement of site operations and again following any subsequent substantive change in site operations. They will then be repeated no less than once a year. As a minimum, measurements will comprise a 30-minute measurement at each location during the daytime, evening and night time.

If exceedances of the predicted levels are identified by either the long term or short-term monitoring, the causes will be thoroughly investigated, and corrective action will be taken.

The Proposed Development would be licensed by the Environmental Protection Agency (EPA) under an Industrial Emissions (IE) licence, the terms and conditions of which are anticipated to be requiring a noise monitoring protocol to be adopted.

3.6.5. Invasive Species Surveys

A post consent verification invasive species survey will be undertaken within the Proposed Development boundary and by a competent ecologist to determine if invasive species listed under Part 1 of the Third Schedule of S.I No. 477 of 2011 have established in the area in the period between pre-planning and post consent. In the event that invasive species are identified within the works area a site-specific Invasive Species Management Plan will be developed and implemented by a competent specialist on behalf of the Contractor. In addition, in order to comply with Regulations 49 and 50 of the European Communities (Birds and Natural Habitat) Regulations (2011) the appointed Contractor will ensure biosecurity measures are implemented throughout the construction phase to ensure the introduction and translocation of invasive species is prevented. The appointed Environmental (Ecological) Clerk of Works (ECoW) will carry out a toolbox talk which will identify invasive species and will also implement biosecurity measures such as the visual inspection of vehicles for evidence of attached plant or animal material prior to entering and leaving the works area.

To ensure the spread of invasive species is avoided a 'Check, Clean, Dry' protocol will be undertaken by the appointed ECoW with all equipment, machinery and vehicles entering and leaving the Proposed Development boundary.

3.6.6. Ballast Management

Ballast water for the FSRU and LNGC would be managed in accordance with the vessels Ballast Water Management Plan in accordance with Flag State requirements, Shannon Foynes Port Company operating procedures and the provisions of Section 34 of the Sea Pollution (Miscellaneous Provisions) Act 2006 referencing the International Convention for the Control and Management of Ships' Ballast Water and Sediments, which entered into force in September 2017.

The FSRU would initially arrive at the terminal full of LNG and therefore would not be carrying ballast. Ballasting of vessels within the River Shannon is a routine practice and the FSRU would take on ballast water from the river once in operation. There is therefore, no risk of extra marine invasive species being introduced to the River Shannon from FSRU ballast water. LNGCs also would arrive full of LNG and with no ballast water. The LNGC's would take in ballast water in accordance with routine practice.

3.6.7. Pollution Mitigation and Response Protocols

HNS Spill Plan

The primary objectives of Oil and HNS Contingency Plans under the framework are:

To assess the pollution risk from operations and ensure sufficient preventative and response measures are in place to ensure the risk of a pollution incident "as low as reasonably practicable" (ALARP);

To ensure the safety of employees, contractors, response personnel and the

community/members of the public throughout the response to a pollution incident;

- To detail the internal and external notification processes and set-in motion practices for an integrated efficient pollution response;
- To ensure the timely mobilisation of resources, both personnel and equipment, to combat a pollution incident within the geographical scope of this plan;
- To have in place actions and procedures to ensure the response to a pollution incident is both timely and effective in mitigating any adverse impact on vulnerable socio-economic and environmental receptors and
- To be compliant with regulatory and best practice guidance on pollution preparedness and response.

In accordance with the requirements of the NCP Standard Operation Procedure 05, the Plan is developed around the five operational phases of the core document:

Phase 1 – Discovery and Notification, Evaluation, Identification and Activation
Phase 2 – Development of an Action Plan
Phase 3 – Action Plan Implementation
Phase 4 – Response Termination and Demobilisation
Phase 5 – Post Operations, Documentation of Costs/Litigation

The Oil and HNS Spill Plan is presented in Appendix A2-6 in EIAR Vol. 4).

The Shannon Estuary Anti-Pollution Team

The Shannon Estuary Anti-Pollution Team (SEAPT) is a Mutual Aid Group and the primary response organisations for oil and HNS spills within the Shannon Estuary. The SEAPT consists of the Shannon Foynes Port company, Kerry, Limerick and Clare Local Authorities and commercial and industrial entities operating within the Shannon Estuary. SEAPT was initiated to form a unified coordinated response to pollution incidents on the Shannon Estuary. SEAPT is a member's organisation. Members contribute annually to maintain equipment, carry out exercises and training and purchase new and replacement equipment. SEAPT holds a significant stockpile of equipment. This equipment is available to respond to any pollution incident or threat thereof the development would also be able to avail of spill dispersion modelling capability held by SEAPT. SEAPT are also the custodians of the Shannon Estuary Oil/HNS Contingency Plan developed in accordance with the NCP and approved by the Irish Coast Guard. Shannon LNG Limited has consulted extensively with SEAPT and the intention is to join the SEAPT organisation on successfully receiving development consents and prior to commencement of the construction phase. The development has (provisional to project go-ahead) been accepted as members of the SEAPT. Membership of SEAPT will enable the development to interface directly with the approved Shannon Estuary Oil/HNS Plan and access additional response equipment to augment that held within the Terminal. Through the membership process, the development will additionally be contributing to the on-going development and strengthening of the SEAPT organisation.

Incident Response

In accordance with the requirements of the National Contingency Plan (NCP) Standard Operation Procedure 05, and the final Oil and HNS Spill Plan, there will be the five operational phases of an incident response:

- **Phase 1** - Discovery and Notification, Evaluation, Identification and Activation
- **Phase 2** - Development of an Action Plan
- **Phase 3** - Action Plan Implementation
- **Phase 4** - Response Termination and Demobilisation
- **Phase 5** - Post Operations, Documentation of Costs/Litigation

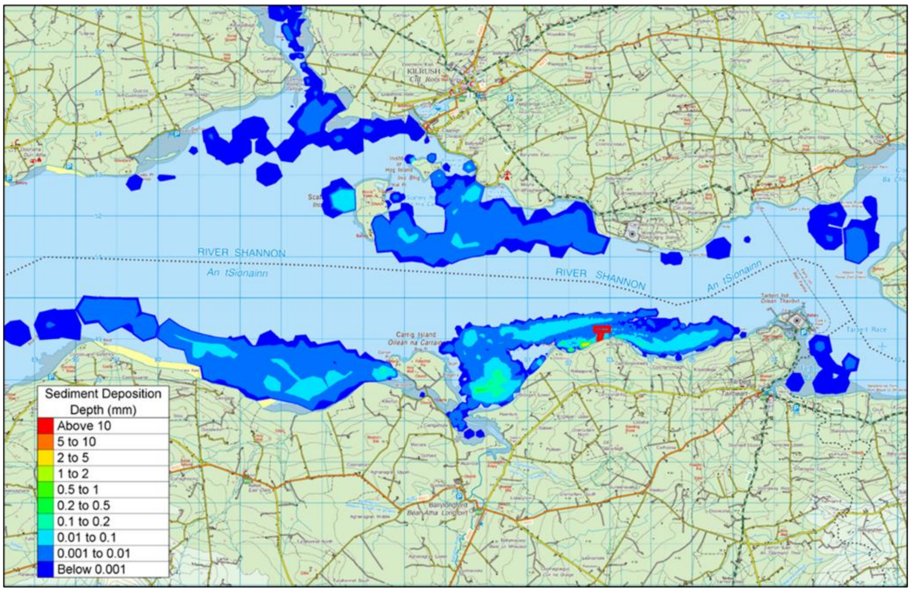
The development will manage the response to any Tier 1 (Local - within the capability of the operator on site) and Tier 2 (Regional - beyond the in-house capability of the operator) incident for any pollution on the water within their area of jurisdiction with the full cooperation and integration of the response with the Shannon Foynes Port, the SEAPT mutual aid group which includes the three local authorities of Kerry, Clare and Limerick and other agencies as appropriate. However, the developed plans will identify realistic Tier 1 and Tier 2 scenarios and the resources required to effectively response to and mitigate these. The plans will further describe any escalation to Tier 3 (requiring national resources) and as discussed above, interface with the National Marine Oil/HNS Spill Contingency Plan. A training and exercising program forms part of the plans. The completed plans will be submitted to the Irish Coast Guard and EPA for appropriate approvals.

3.7. Plans or Projects That Might Act In-Combination

The screening exercise presented in **Section 2.3** identified potential for effect in combination with the following other plans or projects:

- Cross Shannon 400 kV Cable Project

Assessment of the potential in-combination effects are presented below.

Project/ Plan/ Activity	Summary of Project/ Plan/ Activity and Assessment of Potential In-Combination Effects
Cross Shannon 400 kV Cable Project	If the sediment plumes associated with the Cross Shannon 400 kV Cable Project overlap plumes generated due to the installation of piles there is potential that combined sediment deposition depths could exceed the threshold for impact to habitats and associated faunal communities. As discussed in Section 3.4.3, OSPAR Commission (OSPAR 2008, 2009) outline that benthic fauna can survive rapid sediment deposition up to depths of 100mm, while negative impacts to marine life are only expected when sediment deposition depths exceed 150mm. While the sediment plumes generated due to the installation of piles (see **Figure 3-67**) overlap the sediment plumes generated by the Cross Shannon 400 kV Cable Project (see **Figure 3-68**), the combined sediment deposition depths do not exceed the threshold identified in OSPAR (2008, 2009) for impact to habitats and associated faunal communities; consequently in-combination effect will not occur.  **Figure 3-67: Marine community types identified within Annex I Habitats in relation to the modelled sediment plume associated with sediment generated by piling.**

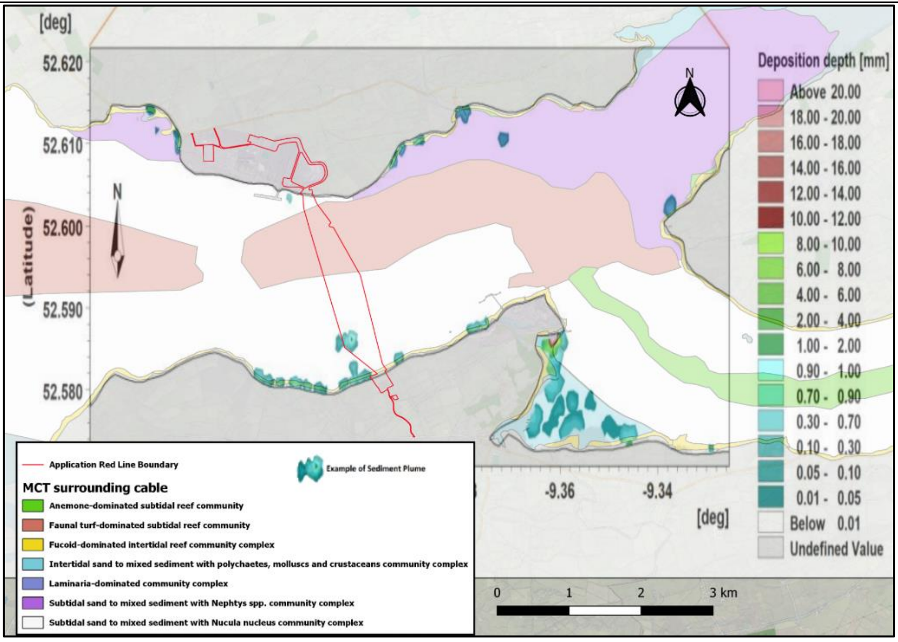


Figure 3-68: Marine community types identified within Annex I Habitats in relation to the modelled sediment plume for trenching activities proposed for the Cross Shannon 400 KV cable project (Mott McDonald, 2019).

3.8. Outcomes and Conclusions

Where possible, mitigation measures have been developed and proposed, with the purpose of avoiding impacts on the conservation features (*i.e.* QIs and SCIs) and the Conservation Objective of SACs and SPAs. The likely success of the measures identified was also considered and no difficulties in their effective implementation were identified.

The provisions of Article 6 of the 'Habitats' Directive 92/43/EC (2000) defines 'integrity' as the 'coherence of the site's ecological structure and function, across its whole area, or the habitats, complex of habitats and / or population of species for which the site is or will be classified'. The European Commission publication Managing Natura 2000 Sites: the provisions of Article 6 of the 'Habitats' Directive 92/43/EEC (EC, 2018), states that the integrity of the site can be usefully defined as the coherent sum of the site's ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated.

Following a comprehensive evaluation of the potential direct, indirect and cumulative impacts on the conservation features in light of their Conservation Objectives, it has been concluded that with the construction and operation of the STEP development will have no adverse effect on the River Shannon and River Fergus Estuaries SPA.

Following a comprehensive evaluation of the potential direct, indirect and cumulative impacts on the conservation features in light of their Conservation Objectives, it has been concluded that with the construction and operation of the STEP development will have no adverse effect on the Lower River Shannon cSAC.

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Shannon Technology and Energy Park

Natura Impact Statement (NIS)

Shannon Technology and Energy Park

Screening Statement for Appropriate Assessment and Natura Impact Statement

Volume 2 – Appendices

Prepared by

AQUAFACT International Services Ltd

On behalf of

Shannon LNG Ltd

August 2021

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Report Approval Sheet

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Appendix 1

Site Synopsis Reports

Site Name: Lower River Shannon SAC

Site Code: 002165

This very large site stretches along the Shannon valley from Killaloe in Co. Clare to Loop Head/ Kerry Head, a distance of some 120 km. The site thus encompasses the Shannon, Feale, Mulkear and Fergus estuaries, the freshwater lower reaches of the River Shannon (between Killaloe and Limerick), the freshwater stretches of much of the Feale and Mulkear catchments and the marine area between Loop Head and Kerry Head. Rivers within the sub-catchment of the Feale include the Galey, Smearlagh, Oolagh, Allaughaun, Owveg, Clydagh, Caher, Breanagh and Glenacarney. Rivers within the sub-catchment of the Mulkear include the Killeenagarriff, Annagh, Newport, the Dead River, the Bilboa, Glashacloonaraveela, Gortnageragh and Cahernahallia.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[1110] Sandbanks
[1130] Estuaries
[1140] Tidal Mudflats and Sandflats
[1150] Coastal Lagoons*
[1160] Large Shallow Inlets and Bays
[1170] Reefs
[1220] Perennial Vegetation of Stony Banks
[1230] Vegetated Sea Cliffs
[1310] *Salicornia* Mud
[1330] Atlantic Salt Meadows
[1410] Mediterranean Salt Meadows
[3260] Floating River Vegetation
[6410] *Molinia* Meadows
[91E0] Alluvial Forests*
[1029] Freshwater Pearl Mussel (*Margaritifera margaritifera*)
[1095] Sea Lamprey (*Petromyzon marinus*)
[1096] Brook Lamprey (*Lampetra planeri*)
[1099] River Lamprey (*Lampetra fluviatilis*)
[1106] Atlantic Salmon (*Salmo salar*)
[1349] Bottle-nosed Dolphin (*Tursiops truncatus*)
[1355] Otter (*Lutra lutra*)

The Shannon and Fergus Rivers flow through Carboniferous limestone as far as Foynes, but west of Foynes Namurian shales and flagstones predominate (except at Kerry Head, which is formed from Old Red Sandstone). The eastern sections of the Feale catchment flow through Namurian rocks and the western stretches through Carboniferous limestone. The Mulkear flows through Lower Palaeozoic rocks in the upper reaches before passing through Namurian rocks, followed by Lower Carboniferous shales and Carboniferous limestone. The Mulkear River itself, immediately north of Pallas Green, passes through an area of Rhyolites, Tuffs and Agglomerates.

The Shannon and Fergus Estuaries form the largest estuarine complex in Ireland. They form a unit stretching from the upper tidal limits of the Shannon and Fergus Rivers to the mouth of the Shannon Estuary (considered to be a line across the narrow strait between Kilcredaun Point and Kilconly Point). Within this main unit there are several tributaries with their own 'sub-estuaries' e.g. the Deel River, Mulkear River, and Maigue River. To the west of Foynes, a number of small estuaries form indentations in the predominantly hard coastline, namely Poulnasherry Bay, Ballylongford Bay, Clonderalaw Bay and the Feale or Cashen River estuary.

Both the Fergus and inner Shannon Estuaries feature vast expanses of intertidal mudflats, often fringed with saltmarsh vegetation. The smaller estuaries also feature mudflats, but have their own unique characteristics, e.g. Poulnasherry Bay is stony and unusually rich in species and biotopes. Plant species are typically scarce on the mudflats, although there are some eelgrass (*Zostera* spp.) beds and patches of green algae (e.g. *Ulva* sp. and *Enteromorpha* sp.). The main macro-invertebrate community which has been noted from the inner Shannon and Fergus estuaries is a *Macoma-Scrobicularia-Nereis* community.

In the transition zone between mudflats and saltmarsh, specialised colonisers of mud predominate. For example, swards of Common Cord-grass (*Spartina anglica*) frequently occur in the upper parts of the estuaries. Less common are swards of Glasswort (*Salicornia europaea* agg.). In the innermost parts of the estuaries, the tidal channels or creeks are fringed with species such as Common Reed (*Phragmites australis*) and club-rushes (*Scirpus maritimus, S. tabernaemontani* and *S. triquetrus*). In addition to the nationally rare Triangular Club-rush (*Scirpus triqueter*), two scarce species are found in some of these creeks (e.g. Ballinacurra Creek): Lesser Bulrush (*Typha angustifolia*) and Summer Snowflake (*Leucojum aestivum*).

Saltmarsh vegetation frequently fringes the mudflats. Over twenty areas of estuarine saltmarsh have been identified within the site, the most important of which are around the Fergus estuary and at Ringmoylan Quay. The dominant type of saltmarsh present is Atlantic salt meadow occurring over mud. Characteristic species occurring include Common Saltmarsh-grass (*Puccinellia maritima*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Sea-milkwort (*Glaux maritima*), Sea Plantain (*Plantago maritima*), Red Fescue (*Festuca rubra*), Creeping Bent (*Agrostis stolonifera*), Saltmarsh Rush (*Juncus gerardi*), Long-bracted Sedge (*Carex extensa*), Lesser Sea-spurrey

(*Spergularia marina*) and Sea Arrowgrass (*Triglochin maritima*). Areas of Mediterranean salt meadows, characterised by clumps of Sea Rush (*Juncus maritimus*) occur occasionally. Two scarce species are found on saltmarshes in the vicinity of the Fergus estuary: a type of robust saltmarsh-grass (*Puccinellia foucaudii*), sometimes placed within the species Common Saltmarsh-grass (*P. maritima*) and Hard-grass (*Parapholis strigosa*).

Saltmarsh vegetation also occurs around a number of lagoons within the site, two of which have been surveyed as part of a National Inventory of Lagoons. Clonconeen Pool (4-5 ha) is a natural sedimentary lagoon impounded by a low cobble barrier. Seawater enters by percolation through the barrier and by overwash. This lagoon represents a type which may be unique to Ireland since the substrate is composed almost entirely of peat. The adjacent shore features one of the best examples of a drowned forest in Ireland. Aquatic vegetation in the lagoon includes typical species such as Beaked Tasselweed (*Ruppia maritima*) and green algae (*Cladophora* sp.). The fauna is not diverse, but is typical of a high salinity lagoon and includes six lagoon specialists (*Hydrobia ventrosa, Cerastoderma glaucum, Lekanesphaera hookeri, Palaemonetes varians, Sigara stagnalis* and *Enochrus bicolor*). In contrast, Shannon Airport Lagoon (2 ha) is an artificial saline lake with an artificial barrier and sluiced outlet. However, it supports two Red Data Book species of stonewort (*Chara canescens* and *Chara cf. connivens*).

Most of the site west of Kilcredaun Point/Kilconly Point is bounded by high rocky sea cliffs. The cliffs in the outer part of the site are sparsely vegetated with lichens, Red Fescue, Sea Beet (*Beta vulgaris* subsp. *maritima*), Sea Campion (*Silene vulgaris* subsp. *maritima*), Thrift and plantains (*Plantago* spp.). A rare endemic type of sea-lavender, *Limonium recurvum* subsp. *pseudotranswallianum,* occurs on cliffs near Loop Head. Cliff-top vegetation usually consists of either grassland or maritime heath. The boulder clay cliffs further up the estuary tend to be more densely vegetated, with swards of Red Fescue and species such as Kidney Vetch (*Anthyllis vulneraria*) and Common Bird's-foot-trefoil (*Lotus corniculatus*).

The site supports an excellent example of a large shallow inlet and bay. Littoral sediment communities in the mouth of the Shannon Estuary occur in areas that are exposed to wave action and also in areas extremely sheltered from wave action. Characteristically, exposed sediment communities are composed of coarse sand and have a sparse fauna. Species richness increases as conditions become more sheltered. All shores in the site have a zone of sand hoppers at the top, and below this each of the shores has different characteristic species giving a range of different shore types.

The intertidal reefs in the Shannon Estuary are exposed or moderately exposed to wave action and subject to moderate tidal streams. Known sites are steeply sloping and show a good zonation down the shore. Well developed lichen zones and littoral reef communities offering a high species richness in the sublittoral fringe and strong populations of the Purple Sea Urchin *Paracentrotus lividus* are found. The communities found are tolerant to sand scour and tidal streams. The infralittoral reefs range from sloping platforms with some vertical steps, to ridged bedrock with gullies of sand between the ridges, to ridged bedrock with boulders or a mixture of cobbles, gravel and sand. Kelp is very common to about 18 m. Below this it becomes rare and the community is characterised by coralline crusts and red foliose algae.

Other coastal habitats that occur within the site include stony beaches and bedrock shores (these support a typical zonation of seaweeds such as *Fucus* spp., *Ascophyllum nodosum* and kelps), shingle beaches (with species such as Sea Beet, Sea Mayweed - *Matricaria maritima*, Sea Campion and Curled Dock - *Rumex crispus*), sandbanks which are slightly covered by sea water at all times (e.g. in the area from Kerry Head to Beal Head) and sand dunes (a small area occurs at Beal Point, where Marram – *Ammophila arenaria* is the dominant species).

Freshwater rivers have been included in the site, most notably the Feale and Mulkear catchments, the Shannon from Killaloe to Limerick (along with some of its tributaries, including a short stretch of the Kilmastulla River), the Fergus up as far as Ennis, and the Cloon River. These systems are very different in character: the Shannon is broad, generally slow flowing and naturally eutrophic; the Fergus is smaller and alkaline; while the narrow, fast flowing Cloon is acid in nature. The Feale and Mulkear catchments exhibit all the aspects of a river from source to mouth. Semi-natural habitats, such as wet grassland, wet woodland and marsh occur by the rivers, but improved grassland is the most common habitat type. One grassland type of particular conservation significance, *Molinia* meadows, occurs in several parts of the site and the examples at Worldsend on the River Shannon are especially noteworthy. Here are found areas of wet meadow dominated by rushes (*Juncus* spp.) and sedges (*Carex* spp.), and supporting a diverse and species-rich vegetation, including such uncommon species as Blue-eyed Grass (*Sisyrinchium bermudiana*) and Pale Sedge (*C. pallescens*).

Floating river vegetation characterised by species of water-crowfoot (*Ranunculus* spp.), pondweeds (*Potamogeton* spp.) and the moss *Fontinalius antipyretica* are present throughout the major river systems within the site. The rivers contain an interesting bryoflora with *Schistidium alpicola* var. *alpicola* recorded from in-stream boulders on the Bilboa, new to Co. Limerick.

Alluvial woodland occurs on the banks of the Shannon and on islands in the vicinity of the University of Limerick. The woodland is up to 50 m wide on the banks and somewhat wider on the largest island. The most prominent woodland type is gallery woodland where White Willow (*Salix alba*) dominates the tree layer with occasional Alder (*Alnus glutinosa*). The shrub layer consists of various willow species with Rusty Willow (*Salix cinerea* ssp. *oleifolia*) and what appear to be hybrids of *S. alba* x *S. viminalis.* The herbaceous layer consists of tall perennial herbs. A fringe of bulrush (*Typha* sp.) occurs on the river side of the woodland. On slightly higher ground above the wet woodland and on the raised embankment remnants of mixed oak-ash-alder woodland occur. These are poorly developed and contain numerous exotic species but locally there are signs that it is invading open grassland. Alder is the principal tree species, with occasional Pedunculate Oak (*Quercus robur*), elm (*Ulmus glabra* and *U. procera*), Hazel (*Corylus avellana*), Hawthorn (*Crataegus monogyna*) and the shrubs Guelder-rose (*Viburnum opulus*) and willows. The ground flora is species-rich.

While woodland is infrequent within the site, however Cahiracon Wood contains a strip of old oak woodland. Sessile Oak (*Q. petraea*) forms the canopy, with an understorey of Hazel and Holly (*Ilex aquifolium*). Great Wood-rush (*Luzula sylvatica*) dominates the ground flora. Less common species present include Great Horsetail (*Equisetum telmeteia*) and Pendulous Sedge (*Carex pendula*).

In the low hills to the south of the Slievefelim Mountains, the Cahernahallia River cuts a valley through the Upper Silurian rocks. For approximately 2 km south of Cappagh Bridge at Knockanavar, the valley sides are wooded. The woodland consists of birch (*Betula* spp.), Hazel, oak, Rowan (*Sorbus aucuparia*), some Ash (*Fraxinus excelsior*) and willow (*Salix* spp.). Most of the valley is not grazed by stock, and as a result the trees are regenerating well. The ground flora features prominent Great wood-rush and Bilberry (*Vaccinium myrtillus*), along with a typical range of woodland herbs. Bracken (*Pteridium aquilinum*) is a feature in areas where there is more light available.

The valley sides of the Bilboa and Gortnageragh Rivers, on higher ground north-east of Cappamore, support patches of semi-natural broadleaf woodland dominated by Ash, Hazel, oak and birch. There is a good scrub layer with Hawthorn, willow, Holly and Blackthorn (*Prunus spinosa*) common. The herb layer in these woodlands is often open, with a typically rich mixture of woodland herbs and ferns. Moss species diversity is high. The woodlands are ungrazed. The Hazel is actively coppiced in places.

There is a small area of actively regenerating cut-away raised bog at Ballyrorheen. It is situated approximately 5 km north-west of Cappamore in Co. Limerick. The bog contains some wet areas with good cover of bog mosses (*Sphagnum* spp.). Species of particular interest include Cranberry (*Vaccinium oxycoccos*) and White Sedge (*Carex curta*), along with two regionally rare mosses, including the bog moss *S. fimbriatum*. The site is being invaded by Downy Birch (*Betula pubescens*) scrub woodland. Both commercial forestry and the spread of Rhododendron (*Rhododendron ponticum*) has greatly reduced the overall value of the site.

A number of plant species that are listed in the Irish Red Data Book occur within the site, and several of these are protected under the Flora (Protection) Order, 1999. These include Triangular Club-rush (*Scirpus triquetrus*), a species which is only found in Ireland only in the Shannon Estuary, where it borders creeks in the inner estuary. Opposite-leaved Pondweed (*Groenlandia densa*) is found in the Shannon where it passes through Limerick City, while Meadow Barley (*Hordeum secalinum*) is abundant in saltmarshes at Ringmoylan and Mantlehill. Hairy Violet (*Viola hirta*) occurs in the Askeaton/Foynes area. Golden Dock (*Rumex maritimus*) is noted as occurring in the River Fergus estuary. Finally, Bearded Stonewort (*Chara canescens*), a brackish water specialist, and Convergent Stonewort (*Chara connivens*) are both found in Shannon Airport Lagoon.

Overall, the Shannon and Fergus Estuaries support the largest numbers of wintering waterfowl in Ireland. The highest count in 1995-96 was 51,423 while in 1994-95 it was 62,701. Species listed on Annex I of the E.U. Birds Directive which contributed to these totals include: Great Northern Diver (3; 1994/95), Whooper Swan (201; 1995/96), Pale-bellied Brent Goose (246; 1995/96), Golden Plover (11,067; 1994/95) and Bar-tailed Godwit (476; 1995/96). In the past, three separate flocks of Greenland White-fronted Goose were regularly found, but none were seen in 1993/94.

Other wintering waders and wildfowl present include Greylag Goose (216; 1995/96), Shelduck (1,060; 1995/96), Wigeon (5,976; 1995/96), Teal (2,319; 1995-96), Mallard (528; 1995/96), Pintail (45; 1995/96), Shoveler (84; 1995/96), Tufted Duck (272; 1995/96), Scaup (121; 1995/96), Ringed Plover (240; 1995/96), Grey Plover (750; 1995/96), Lapwing (24,581; 1995/96), Knot (800; 1995/96), Dunlin (20,100; 1995/96), Snipe (719, 1995/96), Black-tailed Godwit (1,062; 1995/96), Curlew (1,504; 1995/96), Redshank (3,228; 1995/96), Greenshank (36; 1995/96) and Turnstone (107; 1995/96). A number of wintering gulls are also present, including Black-headed Gull (2,216; 1995/96), Common Gull (366; 1995/96) and Lesser Black-backed Gull (100; 1994/95). This is the most important coastal site in Ireland for a number of the waders including Lapwing, Dunlin, Snipe and Redshank. It also provides an important staging ground for species such as Black-tailed Godwit and Greenshank.

A number of species listed on Annex I of the E.U. Birds Directive breed within the site. These include Peregine Falcon (2-3 pairs), Sandwich Tern (34 pairs on Rat Island, 1995), Common Tern (15 pairs: 2 on Sturamus Island and 13 on Rat Island, 1995), Chough (14-41 pairs, 1992) and Kingfisher. Other breeding birds of note include Kittiwake (690 pairs at Loop Head, 1987) and Guillemot (4,010 individuals at Loop Head, 1987).

There is a resident population of Bottle-nosed Dolphin in the Shannon Estuary. This is the only known resident population of this E.U. Habitats Directive Annex II species in Ireland. The population is estimated (in 2006) to be 140 ± 12 individuals. Otter, a species also listed on Annex II of this Directive, is commonly found on the site.

Five species of fish listed on Annex II of the E.U. Habitats Directive are found within the site. These are Sea Lamprey (*Petromyzon marinus*), Brook Lamprey (*Lampetra planeri*), River Lamprey (*Lampetra fluviatilis*), Twaite Shad (*Allosa fallax fallax*) and Salmon (*Salmo salar*). The three lampreys and Salmon have all been observed spawning in the lower Shannon or its tributaries. The Fergus is important in its lower reaches for spring salmon, while the Mulkear catchment excels as a grilse fishery, though spring fish are caught on the actual Mulkear River. The Feale is important for both types. Twaite Shad is not thought to spawn within the site. There are few other river systems in Ireland which contain all three species of lamprey.

Two additional fish species of note, listed in the Irish Red Data Book, also occur, namely Smelt (*Osmerus eperlanus*) and Pollan (*Coregonus autumnalis pollan*). Only the former has been observed spawning in the Shannon.

Freshwater Pearl Mussel (*Margaritifera margaritifera*), a species listed on Annex II of the E.U. Habitats Directive, occurs abundantly in parts of the Cloon River.

There is a wide range of land uses within the site. The most common use of the terrestrial parts is grazing by cattle, and some areas have been damaged through over-grazing and poaching. Much of the land adjacent to the rivers and estuaries has been improved or reclaimed and is protected by embankments (especially along the Fergus estuary). Further, reclamation continues to pose a threat, as do flood relief works (e.g. dredging of rivers). Gravel extraction poses a major threat on the Feale.

In the past, cord-grass (*Spartina* sp.) was planted to assist in land reclamation. This has spread widely, and may oust less vigorous colonisers of mud and may also reduce the area of mudflat available to feeding birds.

Domestic and industrial wastes are discharged into the Shannon, but water quality is generally satisfactory, except in the upper estuary where it reflects the sewage load from Limerick City. Analyses for trace metals suggest a relatively clean estuary with no influences of industrial discharges apparent. Further industrial development along the Shannon and water polluting operations are potential threats.

Fishing is a main tourist attraction on the Shannon and there are a large number of angler associations, some with a number of beats. Fishing stands and styles have been erected in places. The River Feale is a designated Salmonid Water under the E.U. Freshwater Fish Directive. Other uses of the site include commercial angling, oyster farming, boating (including dolphin-watching trips) and shooting. Some of these may pose threats to the birds and dolphins through disturbance. Specific threats to the dolphins include underwater acoustic disturbance, entanglement in fishing gear and collisions with fast moving craft.

This site is of great ecological interest as it contains a high number of habitats and species listed on Annexes I and II of the E.U. Habitats Directive, including the priority habitats lagoon and alluvial woodland, the only known resident population of Bottle-nosed Dolphin in Ireland and all three Irish lamprey species. A good number of Red Data Book species are also present, perhaps most notably the thriving populations of Triangular Club-rush. A number of species listed on Annex I of the E.U. Birds Directive are also present, either wintering or breeding. Indeed, the Shannon and Fergus Estuaries form the largest estuarine complex in Ireland and support more wintering wildfowl and waders than any other site in the country. Most of the estuarine part of the site has been designated a Special Protection Area (SPA), under the E.U. Birds Directive, primarily to protect the large numbers of migratory birds present in winter.

Site Name: Moanveanlagh Bog SAC

Site Code: 002351

Moanveanlagh Bog is situated in Co. Kerry approximately 6 km east of Listowel, mainly within the townlands of Carhooeara and Bunagarha. The site comprises a raised bog that includes both areas of high bog and cutover bog.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[7110] Raised Bog (Active)*
[7120] Degraded Raised Bog
[7150] Rhynchosporion Vegetation

Active raised bog comprises areas of high bog that are wet and actively peat-forming, where the percentage cover of bog mosses (*Sphagnum* spp.) is high, and where some or all of the following features occur: hummocks, pools, wet flats, *Sphagnum* lawns, flushes and soaks. Degraded raised bog corresponds to those areas of high bog whose hydrology has been adversely affected by peat cutting, drainage and other land use activities, but which are capable of regeneration. The Rhynchosporion habitat occurs in wet depressions, pool edges and erosion channels where the vegetation includes White Beak-sedge (*Rhynchospora alba*) and/or Brown Beak-sedge (*R. fusca*), and at least some of the following associated species, Bog Asphodel (*Narthecium ossifragum*), sundews (*Drosera* spp.), Deergrass (*Scirpus cespitosus*) and Carnation Sedge (*Carex panicea*).

This is a relatively flat site with some marginal areas that slope relatively steeply towards the cutover. There are a few large hummocks but over much of the site the micro-topography is very uniform. A flush area extends along the north and north-east of the site. In the south-west a bog burst has occurred and concentrically arranged tear pools can be seen, some of which are up to 12 m long. A swallow hole occurs near the middle of the site. Cutover bog occurs around the south-west, south and south-eastern margins of the high bog.

Much of the high bog has vegetation typical of a Western Raised Bog. The vegetation of the high bog is dominated by Bog Asphodel, White Beak-sedge, Cross-leaved Heath (*Erica tetralix*) and Carnation Sedge. Small patches of the moss *Racomitrium lanuginosum* and Common Lousewort (*Pedicularis sylvatica*) occur at the site. Purple Moor-grass (*Molinia caerulea*) is very common in the flush areas. The tear pools are mostly bare of vegetation but some support bladderwort (*Utricularia* sp.) and the bog mosses *S. cuspidatum* and *S. auriculatum*, with *S. papillosum* and the moss *Campylopus* *atrovirens* occurring at the pool edges. Towards the margins of the bog Bog-myrtle (*Myrica gale*) is frequent.

Current land uses on the site consist of a small area of peat-cutting at the margins and a low level of grazing by cattle in the north-east section of the high bog. Peat-cutting has significantly declined since the 1970s. Other damaging operations include extensive fire damage, which is still occurring, and the dumping of household refuse and cars around the high bog. These are all activities that have resulted in the loss of habitat and damage to the hydrological status of the site, and pose a continuing threat to its viability. This site also suffers from invasive species, with the shrub Rhododendron (*Rhododendron ponticum*) recorded on the western edge of the site and the carnivorous Pitcher Plant (*Sarracenia purpurea*) forming a large colony.

Moanveanlagh Bog is significant in terms of its geographical location as it is at the extreme south-western range of raised bogs in Ireland. Moanveanlagh Bog is a site of considerable conservation significance as it comprises a raised bog, a rare habitat in the E.U. and one that is becoming increasingly scarce and under threat in Ireland. This site supports a good diversity of raised bog microhabitats, including flushes. Active raised bog is listed as a priority habitat on Annex I of the E.U. Habitats Directive. Priority status is given to habitats and species that are threatened throughout the E.U. Ireland has a high proportion of the total E.U. resource of this habitat type (over 60%) and so has a special responsibility for its conservation at an international level.

Site Name: Tullaher Lough and Bog SAC

Site Code: 002343

Tullagher Lough and Bog is located 4 km south-east of Doonbeg in the townlands of Carrowmore South, Carrowblough Beg and Tullaher in Co. Clare. This is a diverse site comprising of raised bog (including areas of high bog and cutover bog), wet grassland, improved grassland, scrub woodland, alkaline fen and lake. It is bounded to the east by the Doonbeg to Moyasta road, to the west by a local road, to the north by bog tracks and to the south by a conifer plantation.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[7110] Raised Bog (Active)*
[7120] Degraded Raised Bog
[7140] Transition Mires
[7150] Rhynchosporion Vegetation

Active raised bog comprises areas of high bog that are wet and actively peat-forming, where the percentage cover of bog mosses (*Sphagnum* spp.) is high, and where some or all of the following features occur: hummocks, pools, wet flats, *Sphagnum* lawns, flushes and soaks. Degraded raised bog corresponds to those areas of high bog whose hydrology has been adversely affected by peat cutting, drainage and other land use activities, but which are capable of regeneration. The Rhynchosporion habitat occurs in wet depressions, pool edges and erosion channels where the vegetation includes White Beak-sedge (*Rhynchospora alba*) and/or Brown Beak-sedge (*R. fusca*), and at least some of the following associated species, Bog Asphodel (*Narthecium ossifragum*), sundews (*Drosera* spp.), Deergrass (*Scirpus cespitosus*) and Carnation Sedge (*Carex panicea*).

The raised bog habitat at this site consists of a small dome of high bog with extensive cutover areas to the west and south. The high bog is flat, with slopes to the south-west associated with marginal drainage. There are wet hollows and a large pool with quaking margins at the centre of the high bog. There are also a number of small flushes. The extensive cutover consists of numerous old peat cuttings with turf banks and hollows. A mineral ridge with improved grassland adjoins the high bog to the north-west and there is semi-improved wet grassland to the north-east.

The high bog has vegetation typical of a raised bog, consisting of Heather (*Calluna vulgaris*), Common Cottongrass (*Eriophorum angustifolum*) and Bog Asphodel, with occasional Lousewort (*Pedicularis sylvatica*) a species typical of western raised bogs.

Bog mosses (*Sphagnum* spp.) are abundant, with 95% moss cover. Extensive lawns of *Sphagnum capillifolium* and *S. papillosum* occur, with occasional *S. magellanicum. Sphagnum cuspidatum* and *S. auriculatum* occur in wet hollows. The large pool in the centre of the high bog probably has mineral input as indicated by the presence White Water-lily (*Nymphaea alba*), Bottle Sedge (*Carex rostrata*) and Water Avens (*Geum rivale*). A dense quaking carpet of bog moss (*S. cuspidatum*) occurs at the pool margin. Heather, Purple Moor-grass (*Molinia caerulea*), Cranberry (*Vaccinium oxyoccos*) and Common Cottongrass are also present. The flushes are dominated by Purple Moor-grass, Heather and Bog -myrtle (*Myrica gale*). The old peat cuttings are dominated by Purple Moor-grass, with Heather on dry turf banks.

The vegetation of the low-lying areas beside the open water bodies of Tullaher Lough is dominated by Common Reed (*Phragmites australis*). Extensive quaking *Sphagnum* lawns with low hummocks, corresponding to the E.U. Habitats Directive Annex I habitat transition mire, also occur. These are separated from the reedbeds by small-sedge vegetation. To the north of Tullaher Lough there is a small area of birch (*Betula* sp.) wood and scrub. Species-rich hay meadows occur to the south-west of Tullaher Lough and there is improved grassland along the western boundary. The grasslands are not fertilised and are cut in late summer.

Several noteworthy species occur at the site including Pipewort (*Eriocaulon aquaticum*), Six-stamened Waterwort (*Elatine hexandra*), Quillwort (*Isoetes echinospora*) and Brown Beak-sedge.

The site is important for over-wintering Greenland White-fronted Goose, a species listed on Annex I of the E.U. Birds Directive, which regularly use the grasslands to the west of Tullaher Lough – average of 47 birds over the four winters 1994/95 to 1998/99. Small numbers (less than 20) of Whooper Swan also occur.

The great bulk of the site has been heavily exploited in the past by drainage and turf cutting and some areas have been reclaimed. Current land use of the site consists of domestic peat cutting and grazing. Peat cutting is restricted to the cutover areas to the west. There is no active peat cutting at the high bog margins. The area of high bog is small, but is quite intact with no active peat cutting or drainage. The cutover to the east of the high bog has been reclaimed for agriculture and cattle graze on these grasslands and the improved grassland on the mineral ridge to the north. Damaging activities associated with these land uses include drainage and occasional burning. These activities have resulted in habitat loss and damage to the hydrological status of the high bog and pose a continuing threat to its viability.

Tullaher Lough and Bog is a site of considerable conservation significance as it comprises a diverse site with lake, transition mire and raised bog habitats. The site contains one of the few remaining examples of raised bog in Co. Clare and represents the western extreme of the range of raised bogs in Ireland. Raised bog is a rare habitat in the E.U. and one that is becoming increasingly scarce and under threat in Ireland. Ireland has a high proportion of the total E.U. resource of raised bog (over 60%) and so has a special responsibility for its conservation at an international level.

The presence of a good example of transition mire is also of particular significance. Its value as a wintering ground for Greenland White-fronted Goose is also noteworthy.

SITE SYNOPSIS

SITE NAME: RIVER SHANNON AND RIVER FERGUS ESTUARIES SPA

SITE CODE: 004077

The estuaries of the River Shannon and River Fergus form the largest estuarine complex in Ireland. The site comprises the entire estuarine habitat from Limerick City westwards as far as Doonaha in Co. Clare and Dooneen Point in Co. Kerry.

The site has vast expanses of intertidal flats which contain a diverse macro-invertebrate community, e.g. *Macoma-Scrobicularia-Nereis*, which provides a rich food resource for the wintering birds. Salt marsh vegetation frequently fringes the mudflats and this provides important high tide roost areas for the wintering birds. Elsewhere in the site the shoreline comprises stony or shingle beaches.

The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Cormorant, Whooper Swan, Light-bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Scaup, Ringed Plover, Golden Plover, Grey Plover, Lapwing, Knot, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Curlew, Redshank, Greenshank and Black-headed Gull. It is also of special conservation interest for holding an assemblage of over 20,000 wintering waterbirds. The E.U. Birds Directive pays particular attention to wetlands and, as these form part of this SPA, the site and its associated waterbirds are of special conservation interest for Wetland & Waterbirds.

The site is the most important coastal wetland site in the country and regularly supports in excess of 50,000 wintering waterfowl (57,133 - five year mean for the period 1995/96 to 1999/2000), a concentration easily of international importance. The site has internationally important populations of Light-bellied Brent Goose (494), Dunlin (15,131), Black-tailed Godwit (2,035) and Redshank (2,645). A further 17 species have populations of national importance, i.e. Cormorant (245), Whooper Swan (118), Shelduck (1,025), Wigeon (3,761), Teal (2,260), Pintail (62), Shoveler (107), Scaup (102), Ringed Plover (223), Golden Plover (5,664), Grey Plover (558), Lapwing (15,126), Knot (2,015), Bar-tailed Godwit (460), Curlew (2,396), Greenshank (61) and Black-headed Gull (2,681) - figures are five year mean peak counts for the period 1995/96 to 1999/2000. The site is among the most important in the country for several of these species, notably Dunlin (13 % of national total), Lapwing (6% of national total) and Redshank (9% of national total).

The site also supports a nationally important breeding population of Cormorant (93 pairs in 2010).

Other species that occur include Mute Swan (103), Mallard (441), Red-breasted Merganser (20), Great Crested Grebe (50), Grey Heron (38), Oystercatcher (551), Turnstone (124) and Common Gull (445) - figures are five year mean peak counts for the period 1995/96 to 1999/2000.

Apart from the wintering birds, large numbers of some species also pass through the site whilst on migration in spring and/or autumn.

The River Shannon and River Fergus Estuaries SPA is an internationally important site that supports an assemblage of over 20,000 wintering waterbirds. It holds internationally important populations of four species, i.e. Light-bellied Brent Goose, Dunlin, Black-tailed Godwit and Redshank. In addition, there are 17 species that have wintering populations of national importance. The site also supports a nationally important breeding population of Cormorant. Of particular note is that three of the species which occur regularly are listed on Annex I of the E.U. Birds Directive, i.e. Whooper Swan, Golden Plover and Bar-tailed Godwit. Parts of the River Shannon and River Fergus Estuaries SPA are Wildfowl Sanctuaries.

30.5.2015

SITE SYNOPSIS

SITE NAME: STACK'S TO MULLAGHAREIRK MOUNTAINS, WEST LIMERICK HILLS AND MOUNT EAGLE SPA

SITE CODE: 004161

The Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA is a very large site centred on the borders between the counties of Cork, Kerry and Limerick. The site is skirted by the towns of Newcastle West, Ballydesmond, Castleisland, Tralee and Abbeyfeale. The mountain peaks included in the site are not notably high or indeed pronounced, the highest being at Knockfeha (451 m). Other mountains included are Mount Eagle, Knockanefune, Garraunbaun, Taur, Rock Hill, Knockacummer, Mullaghamuish, Knight's Mt, Ballincollig Hill, Beennageeha Mt, Sugar Hill, Knockanimpuba and Knockathea, amongst others. Many rivers rise within the site, notably the Blackwater, Owentaraglin, Owenkeal, Glenlara, Feale, Clydagh, Allaghaun, Allow, Oolagh, Galey and Smerlagh.

The site consists of a variety of upland habitats, though almost half is afforested. The coniferous forests include first and second rotation plantations, with both pre-thicket and post-thicket stands present. Substantial areas of clear-fell are also present at any one time. The principal tree species present are Sitka Spruce (*Picea sitchensis*) and Lodgepole Pine (*Pinus contorta*). A substantial part (28%) of the site is unplanted blanket bog and heath, with both wet and dry heath present. The vegetation of these habitats is characterised by such species as Ling Heather (*Calluna vulgaris*), Bilberry (*Vaccinium myrtillus*), Common Cottongrass (*Eriophorum angustifolium*), Hare's-tail Cottongrass (*Eriophorum vaginatum*), Deergrass (*Scirpus cespitosus*) and Purple Moor-grass (*Molinia caerulea*). The remainder of the site is mostly rough grassland that is used for hill farming. This varies in composition and includes some wet areas with rushes (*Juncus* spp.) and some areas subject to scrub encroachment.

The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for Hen Harrier.

This SPA is a stronghold for Hen Harrier and supports the largest concentration of the species in the country. A survey in 2005 recorded 45 pairs, which represents over 20% of the all-Ireland total. A similar number of pairs had been recorded in the 1998-2000 period. The mix of forestry and open areas provides optimum habitat conditions for this rare bird, which is listed on Annex I of the E.U. Birds Directive. The early stages of new and second-rotation conifer plantations are the most frequently used nesting sites, though some pairs may still nest in tall heather of unplanted bogs and heath. Hen Harriers will forage up to *c*. 5 km from the nest site, utilising open bog and moorland, young conifer plantations and hill farmland that is not too rank. Birds will often forage in openings and gaps within forests. In Ireland, small birds and small mammals appear to be the most frequently taken prey.

Short-eared Owl, a very rare species in Ireland, has been known to breed within the site. Nesting certainly occurred in the late 1970s and birds have been recorded intermittently since. The owls are considered to favour this site due to the presence of Bank Voles, a favoured prey item. Merlin also breed within the site but the size of the population is not known. Red Grouse is found on some of the unplanted areas of bog and heath – this is a species that has declined in Ireland and is now Red-listed.

The Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA is of ornithological importance because it provides excellent nesting and foraging habitat for breeding Hen Harrier and is one the top sites in the country for the species. The presence of three species, Hen Harrier, Merlin and Short-eared Owl, which are listed on Annex I of the E.U. Birds Directive is of note.

20.1.2015

Appendix 2

STEP EIAR - Marine Ecology and Terrestrial Ecology Chapters

AECOM Delivering a better world

CHAPTER 07A
Marine Ecology

Shannon LNG Limited
August 2021

Shannon Technology and Energy Park
Environmental Impact Assessment Report

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7A. Marine Ecology

7A.1 Introduction

7A.1.1 Overview

AQUAFACT International Services Ltd (AQUAFACT) was commissioned to assess the potential impact of the proposed Shannon Technology and Energy Park (STEP) development on marine ecology The impact assessments presented here have been prepared by Dr. Brendan O'Connor (B.Sc., Ph.D., MCIEEM) and Dr James Forde (B.Sc., M.Sc., Ph.D., MCIEEM). Brief descriptions of Dr. O'Connor's and Dr. Forde's expertise in marine ecology are provided in Section 7A.1.2 below. Other experts who contributed include Tony Cawley (B.Sc., MSc., BE, M.Eng.Sc, C.Eng, M.I.E.I) (Hydro Environmental), Dr. Simon Berrow (BSc Ph.D.) (Irish Whale and Dolphin Group), Darren Ireland (B.A, M.Sc.) (LGL Ecological Research Associates), and Per Trøjgård Andersen (B. Eng) (Vysus (formerly Lloyds Register)).

This chapter describes the likely significant direct and indirect effects of the STEP development on marine ecology, including species and habitats, of the marine environment (below the mean high water spring mark).

This chapter describes and evaluates aspects of the marine environment at the site of the Proposed Development in order to describe and assess the impacts that would result from the Proposed Development. The chapter follows the protocols detailed in the Environmental Protection Agency's Draft Guidelines on the information to be contained in Environmental Impact Assessment Reports (EPA, 2017).

A detailed description of the STEP development is provided in Chapter 02; a summary of aspects of the Proposed Development relevant to marine species and habitats of the Shannon Estuary is presented in Section 7A.2 below. Section 7A.2 outlines the specific potential impact mechanisms associated with the development relevant to marine biodiversity and ecology.

Chapter 05 – Land and Soils and Chapter 06 – Water address the changes in hydrology and hydrogeology that can have an impact on biodiversity and ecology.

Chapter 07B assesses potential impacts to terrestrial environment (above mean high water spring mark) (including avifauna).

7A.1.2 Competent Experts

Brendan O'Connor is the marine ecology lead for the STEP development and has responsibility for all associated ecological surveys and reporting. He is expert in ecological matters and the full spectrum of environmental assessment techniques, methodologies, and statutes. Professionally, he is a member of relevant Institutes requiring the highest standards of professional competence and integrity. He is a member of the Chartered Institute of Ecology and Environmental Management (CIEEM).

Brendan has 40 years of experience in the field of marine science and has published approximately 75 scientific papers and numerous reports specialising in the biology and ecology of sea-floor communities. Brendan is an internationally recognised polychaete taxonomist and has led numerous international workshops in polychaete taxonomy including workshops as part of the UK BEQUALM/ NMBAQC. He has 33 publications on marine invertebrate taxa including descriptions of new species, revisions of families and additions to the European and Irish fauna.

As Managing Director of AQUAFACT Brendan has been responsible for all aspects of management including the design, execution and reporting of numerous desk studies, surveys, assessments, and environmental outputs including NIS, AA screening and EIARs.

James Forde has a Ph.D. in Marine Ecology and is a full member of the CIEEM. James has over fifteen years' experience in marine research and environmental consultancy. James specialises in marine ecology and has a full appreciation of the objectives and mechanisms of national and international environmental legislation and policy.

James' academic research has focused on benthic habitats and communities, and techniques used to assess ecological impacts under European environmental legislation including the Habitats Directive and the Water Framework Directive.

As part of James' consultancy work, he has delivered assessment reports to meet the provisions of the Habitats Directive and EIA Directive to accompany planning applications for a wide range of developments including pier enhancement projects, coastal defence projects, and aquaculture.

James was a member of the International Union for Conservation of Nature (IUCN) expert working group for marine red-list habitats for the North Atlantic and has collaborated with international experts on the designation of sensitive marine habitats including *Ostrea edulis* beds, *Mytilus edulis* beds, seagrass meadows and offshore biogenic and geogenic reef habitats. James has collaborated with national experts on the assessment of deep-water reef habitats in Irish waters to support Ireland's national assessment of reef as required under Article 17 of the Habitats Directive. Recently James has also worked with national experts on the classification of lagoon habitats, a Habitats Directive Annex I priority habitat.

Of particular relevance to this assessment of the marine ecological environment for the STEP development is Brendan's and James' specialist input on biodiversity for the recent EirGrid Cross Shannon 400 kV Cable Project (Capital Project 0970).

Anthony Cawley holds a honours degree in Civil Engineering and a post graduate master's degree in Engineering Hydrology. He is a Chartered Civil Engineer with Specialist education and 30years professional consulting experience in the water engineering field in a wide variety of activities relating to hydrology, hydrogeology and flooding, and hydrodynamic and hydraulic assessment of fluvial and tidal processes.

Anthony was expert witness on hydrology and flooding related issues at numerous Oral Hearings for major Infrastructure projects (such as many of the Motorways, M6, M20/ M21 N23, Landsdown Stadium redevelopment).

Anthony was a lecturer in hydrology and hydraulics at the Hydrology and Civil Engineering Department at NUI Galway and is currently Lectures in Hydrology at the University of Limerick (2011 to date). Mr Cawley has provided training courses in Hydrology to the Western and Northwestern Fisheries Board and to Engineers Ireland, and Irish Rail and NRA Design Offices.

Anthony is an expert hydraulic and coastal processes modeller and analyst with considerable experience in application of 1D, 2D and 3D models to rivers, estuaries and coastal waters. Anthony has estuarine and coastal modelling experience using Telemac Software system with recent projects that include the Shannon Estuary hydrodynamic model and tidal harmonic analysis of tide elevations and velocities for oil spill tracking, the sediment transport, wave climate and hydrodynamic assessment of the proposed New Port for Galway and the flood impact and scour assessment of Arklow Bridge and Kish Bank Wind Farm and numerous Sewage outfall and numerous aquaculture studies in Irish coastal waters

Dr Simon Berrow is a marine mammal biologist with over 30 years experience. He is CEO of the Irish Whale and Dolphin Group and lecturer at the Galway-Mayo Institute of Technology. He started the Shannon Dolphin Project in the estuary in 1993, which has been ongoing each year for the last 28 years. The IWDG have extensive knowledge of the bottlenose dolphins in the estuary, having built the most comprehensive database and published widely.

For the current Proposed Development Simon prepared a series of survey reports on the use of the site by bottlenose dolphins including two years fieldwork, to assess potential impacts and provide advice on mitigation.

Darren Ireland holds a master's degree in ecology (fish and wildlife management) from Montana State University where he conducted research on Weddell seals in Antarctica. He is currently a Senior Wildlife Biologist and Vice President at LGL Ecological Research Associates, Inc. where he began working in 2005. While at LGL, Darren has worked primarily on projects related to anthropogenic sound impacts on marine mammals from a variety of activities including pile driving for wind farm and port development projects, deep penetration seismic surveys, high-resolution geophysical surveys, geotechnical investigations, exploration drilling programs, underwater explosions, and ice breaking.

Darren has authored or co-authored more than 45 environmental impact assessments and permit applications related to impacts of these activities on marine mammals, there habitat, and other marine life. Many of these projects also included developing and managing the implementation of multi-disciplinary monitoring plans to record and estimate potential impacts using methods such as vessel-based observers, manned and digital aerial surveys, unmanned aerial systems, static and towed passive acoustic recorders, and infrared camera systems.

Darren has also conducted baseline research on marine mammal distribution and abundance, conducted studies of novel research tools like unmanned aerial systems, infrared cameras, and satellite imagery, and performed evaluations of the potential impacts from new technologies and low-impact seismic sources. Through this work Mr. Ireland has gained a high level of expertise with the scientific and policy issues related to impacts of sound in the marine environment.

Per Trøjgård Andersen graduated from the Technical University in Denmark with a degree in acoustics in 1995. He has worked as consultant within noise, vibration, acoustics (including underwater noise) for more than 10 years in the company Odegaard & Danneskiold-Samsøe, and since 2005 at Lloyds Registers Engineering dynamics Team in Copenhagen, Denmark.

As part of the carve out of the Energy division from Lloyds Register, the Engineering Dynamics team became part of the Vysus Group in 2020, where he currently holds the position as Operations Manager for Engineering dynamics. Per's experience with underwater noise include consultancy on numerous projects with prediction and measurement of underwater noise from ships, wind turbines, oil & gas installations, as well as EU and privately funded research and development. He is the main author of the Lloyds Register underwater noise notation. He has further participated in ISO Technical Committee TC43 workgroup, developing the international standards for underwater noise measurements, including the ISO 17208 series

7A.2 Summary of Proposed Development

The development can be split into three phases: operation, construction, and decommissioning. Key activities proposed for the phases of the development relevant to marine species and habitats of the Shannon Estuary are summarised in Section 7A.2.1 through Section 7A.2.3 below, while Section 7A.2.4 outlines the potential impact mechanisms associated with the phases relevant to the marine biodiversity and ecology.

7A.2.1 Summary of Construction Phase Activities

This phase of the development includes the construction of the LNG Terminal and jetty and a Power Plant.

Works required for the construction of the LNG Terminal include the construction of the jetty, the administration and security building, stores, workshops, various other buildings, and process equipment associated with the receiving facilities and the Above Ground Installation (AGI). Other construction works include the installation of structural steel piping and supports between the Floating Storage and Regasification Unit (FSRU) and the onshore receiving facility and AGI. The FSRU will arrive at the LNG Terminal fully fitted out. Only minor installation works are anticipated to facilitate the connection between the FSRU and the jetty based systems.

Construction of the LNG Terminal, the Power Plant, and the AGI will require extensive pre-construction site preparation works including earth moving and rock breaking, installation of temporary surface water drainage and silt ponds, and temporary site access roads. Site preparation works may also require controlled rock blasting. Works at the Power Plant include the installation of gas turbine generators, heat recovery steam generator, a steam turbine generator, and an air cooled condenser.

For the jetty, up to 203 construction piles for the structures' foundations will be required. The construction piles will support a jetty trestle on steel piles. The trestle will support a concrete deck constructed of reinforced concrete. The jetty trestle and platform will include docking locations alongside for tugs, and berthing facilities and unloading arms at the jetty head for the FRSU. During the construction phase a trenched water outfall will be constructed across the shoreline into the Shannon estuary extending approximately 5m beyond the low water mark.

7A.2.2 Summary of Operation Phase Activities

As part of operational activities the FRSU will be typically, but not permanently, moored at the jetty. LNG will be transferred to the FSRU via a ship to ship transfer from an LNG Carrier (LNGC) berthed alongside. The LNG will be returned to a gaseous state using the FRSU onboard regasification unit. Gas Loading Arms on the jetty connect to the FSRU via a 30 inch gas pipe, also installed on the jetty, to transfer the gas from the FSRU to the onshore receiving facility. Tugs will typically be used to moor the LNGC safely next to the FSRU. The heat required for the LNG vaporisation will be primarily via seawater, supplemented by gas fired heaters when the seawater temperature is inadequate. Up to 60 visits of LNGC are expected every year.

Seawater intakes will be located in the hull of the FSRU, approximately 2 metres below water level. Screens will be covering the intakes to prevent fish, crustaceans and debris from entering the seawater system within the FSRU. The design of the water intakes will be such that the approach velocity of the seawater entering the screens will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm. It is anticipated that any silt entering the seawater circulation system will remain in suspension and carry right through the system.

A small amount of sodium hypochloride is injected into the FSRU seawater systems to control microbial growth. The sodium hypochlorite is generated onboard in an electro-chlorination unit. The electro-chlorination unit will consist of cells housing platinised titanium electrodes between which a direct electric current flows. The sodium chloride salts in the sea water passing between the electrodes dissociate to form residual sodium hypochlorite (chlorine) without the addition of any chemicals. As the seawater passes through the system and is discharged back into the estuary, the chlorine will dissipate back into the sea water from which it will have been produced. Other routine activities associated with the operational phase of the development include inspection and maintenance of the facilities at the LNG Terminal and Power Plant buildings including carpark surface, access roadways *etc.* Other operation phase activities include the periodic maintenance of the jetty structure and pipeline infrastructure, and electrical substation and pump station.

7A.2.3 Summary of Decommissioning Phase Activities

The Proposed Development is expected to have a design life of 50 years, but this could be extended by maintenance, equipment replacement and upgrades or by the transition of the site to use hydrogen capability (which would be subject to a future planning application).

The Proposed Development will be maintained in the long term by Shannon LNG. It is expected that it would be a condition for the Proposed Development that a closure and residuals management plan, including a detailed decommissioning plan, be submitted to the EPA for their approval. Strict adherence to the proposed plan will ensure no significant impacts associated with decommissioning will occur.

7A.2.4 Potential Impact Mechanisms

Table 7A-1 below lists the potential impact mechanisms associated with the phases of the Proposed Development relevant to receptors of the marine environment (see Section 7A.4). Brief descriptions of the impact mechanisms are presented in Section 7A.5.1, while assessment of impacts and effects of the impact mechanisms to the marine environment is presented in Section 7A.5.3 through Section 7A.5.14.

Table 7A-1 Potential Impact Mechanisms

Potential Impact Mechanisms	Development Phase
1. Release of pollutants during construction	Construction Phase
2. Release of spoil during piling	Construction Phase
3. Underwater noise	Construction Phase **and** Operation Phase
4. Seabed habitat loss	Construction Phase **and** Operation Phase
5. Vessel physical disturbance and collision injury	Operation Phase **and** Operation Phase
6. Discharge of treated cooled seawater	Operation Phase

Potential Impact Mechanisms		Development Phase
7.	Entrainment and impingement of fauna by the FSRU seawater system	Operation Phase
8.	Wastewater discharge and Power Plant Process Heated Water Effluent	Operation Phase
9.	Introduction of invasive species	Operation Phase
10.	Accidental large scale oil or LNG spill	Operation Phase

7A.3 Methodology

7A.3.1 Overview

The assessment addresses the likely significant direct and indirect effects of the Proposed Development on marine ecology and biodiversity, including flora, fauna and habitats.

The assessment has been carried out in three stages:

- A desk study was undertaken to review published data describing ecological conditions within the greater area of the Proposed Development. Data bases included the National Parks and Wildlife Service (NPWS), the National Biodiversity Data Centre (NBDC), Inland Fisheries Ireland (IFI), Birdwatch Ireland (BWI) and the Irish Whale and Dolphin Group (IWDG);
- Site visits and field surveys by specialist ecologists to establish the existing ecological conditions at the location of the Proposed Development. The field surveys included intertidal and subtidal habitat surveys, walk over surveys, and land-based Vantage Point (VP) watches and static acoustic monitoring (SAM) to describe the use of the locality by marine mammals; and
- Evaluation of the Proposed Development and determination of the scale and extent of likely direct and indirect significant effects on marine biodiversity (i.e. flora, fauna and habitats) and the provision of appropriate mitigation and monitoring.

The impact assessments and surveys undertaken for the marine ecology element of the EIAR was prepared by AQUAFACT ecologists. In addition to Brendan O'Connor and James Forde, specialist ecologists who contributed include:

- Tony Cawley (Hydro Environmental);
- Dr Simon Berrow – IWDG;
- Darren Ireland– LGL; and
- Dr. Per Trøjgård Andersen.

7A.3.2 Legislation and Policy

The biodiversity assessment has been prepared with reference to the following legislation and guidance:

- Wildlife Act 1976, as amended;
- European Communities (EC) (Birds and Natural Habitats) Regulations 2011, as amended;
- Directive 2011/ 92/ EU of the European Parliament and the Council on the assessment of the effects of certain public and private projects on the environment, as amended by Directive 2014/ 52/ EU (the 'EIA Directive');
- Council Directive 2009/ 147/ EEC, i.e. Birds Directive;
- Council Directive 92/ 43/ EEC (as amended), i.e. Habitats Directive;
- Heritage Council (2011) Best Practice Guidance for Habitat Survey and Mapping;

- Department of Arts, Heritage and the Gaeltacht – National Parks and Wildlife Service (DAHG NPWS) (2012) Marine Natura Impact Statements in Ireland Special Areas of Conservation, A Working Document;
- DEHLG (2009) Appropriate Assessment of Plans and Projects in Ireland Guidance for Planning Authorities (Revised 2010);
- EC (2018) Managing Natura 2000 sites. The provisions of Article 6 of the Habitats Directive92/ 43/ EEC Commission Notice (2018);
- Office of the Planning Regulator (OPR) (2021) Appropriate Assessment Screening for Development Management. Practice Note PN01. March 2021;
- EC (2018) Managing Natura 2000 sites. The provisions of Article 6 of the Habitats Directive 92/ 43/ EEC Commission Notice (2018);
- EC (2001) Managing Natura 2000 Sites: The provisions of Article 6 of the Habitats Directive 92/ 43/ EEC;
- EC (2002) Assessment of plans and projects significantly affecting Natura 2000 sites;
- EU (2013) Guidelines on Climate Change and Natura 2000: Dealing with the impact of climate change on the management of the Natura 2000 Network of areas of high biodiversity value;
- CIEEM (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal;
- IFI (2016) Guidelines on Protection of Fisheries during Construction Works in and adjacent to Waters. Inland Fisheries Ireland;
- EPA (2017) Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports; and
- EU (2017) Guidance on the preparation of the EIA Report (Directive 2011/ 92/ EU as amended by 2014/ 52/ EU).

7A.3.3 Sources of Information

A review was carried out to collate the available information on the local ecological environment. The purpose of the review was to identify features of ecological value occurring within the Proposed Development site and those occurring in proximity to it. The review also allowed the key ecological issues to be identified early in the assessment process and facilitates the planning of surveys.

- Specialist surveys and studies carried out in 2020 and 2021 as part of the EIA process to assess the potential impact of the Proposed Development on the ecology of the receiving marine environment included:
    - Surveys of intertidal and subtidal marine habitats;
    - Marine mammal monitoring, comprising a combination of land-based Vantage Point (VP) watches and static acoustic monitoring (SAM).
    - Hydrodynamic and dispersion modelling study to inform assessments of the environmental impact of:
        - Sediment generated during piling operations;
        - Treated cooled seawater discharges;
        - Process water discharges; and
        - Wastewater discharges.
    - Detailed modelling of noise emissions to inform assessment of the impact of noise:
        - Fish species; and
        - Marine mammals.

Further details on the surveys undertaken in 2020 and 2021 are presented in Section 7A.3.5.

In 2008 Shannon LNG was granted permission[1] to develop a LNG Terminal at Ralappane and Kilcolgan Lower, Co Kerry. The planning application which was submitted on 24.09.2007 was accompanied by an Environment Impact Statement (EIS). As part of EIS the entire site of the LNG Terminal, including the area now intended for the Proposed Development, was surveyed in 2006/ 2007 and 2011/ 2012. Thus a large amount of existing background information of the Proposed Development site was obtained during the assessment process for the 2008 LNG terminal. This information has been used to inform the current planning application for the Proposed Development. Details of surveys undertaken in 2006/ 2007 and 2011/ 2012 are summarised in Section 7A.3.5.

In 2013 Shannon LNG was granted permission[2] to develop a combined Heat and Power (CHP) Plant at Ralappane and Kilcolgan Lower, Co Kerry. The planning application which was submitted on 21.12.2012. As part of the impact assessment undertaken for the proposed CHP Plant a range of surveys were carried out in 2011/ 2012 and impact assessment reports prepared; further details of these is presented in Section 7A.3.5.

Other sources of information utilised for this report include the following:

- Conservation Status Assessment Reports, Backing Documents and Maps prepared to inform national reporting required under Article 17[3] of the Habitats Directive and Article 12[4] of the Bird Directive;
- Site Synopsis, Conservation Objective Reports and Natura 2000 Forms available from NPWS;
- Published and unpublished NPWS reports on protected habitats and species including Irish Wildlife Manual reports, Species Action Plans, and Conservation Management Plans;
- Existing relevant mapping and databases *e.g.* waterbody status, species and habitat distribution *etc.* (sourced from the Environmental Protection Agency, 2021, the National Biodiversity Data, 2021 and the NPWS, 2021);
- National Parks and Wildlife Service (NPWS);
- Environmental Protection Agency (EPA);
- National Biodiversity Data Centre;
- Published academic papers and reports;
- National Biodiversity Action Plan 2017-2021 (NPWS 2017);
- Kerry Co. Council (KCC) (2019) *Council Climate Change Adaptation Strategy 2019-2024;*
- KCC (2008) *Biodiversity Action Plans 2008-2012*; and
- KCC (2015) *County Development Plan 2015 – 2021*.

7A.3.4 Limitations and Assumptions

Some general assumptions that have been made during preparation of this EIAR are set out below:

- In undertaking cumulative assessments, consented, but as yet un-built, developments have been assumed to have been built in accordance with and within the duration permitted by the associated grant of permission;
- Information provided by third parties, including publicly available information and databases, is correct at the time of publication;
- Local Authority and An Bord Pleanála public planning registers reviewed as part of the assessment process are up-to-date; and

[1] PL08B. PA0002 – Permission granted for a LNG terminal at Ralappane and Kilcolgan Lower, Co. Kerry. Application submitted on 24.09.2007. Permission granted on 31.03.2008.
[2] PL08. PA0028 – Permission granted for a CHP Plant at Ralappane and Kilcolgan Lower, Co. Kerry. Application submitted on 21.12.2013. Permission granted on 09.07.2013.
[3] Most recent Article 17 report is available at https://www.npws.ie/publications/article-17-reports/article-17-reports-2019
[4] Most recent Article 12 report is available at https://www.npws.ie/news/birds-directive-article-12-reporting

- Baseline conditions and assessments are accurate at the time of the surveys.

Some general limitations associated with the preparation of this chapter are set out below:

- The assessment of cumulative effects from built or consented developments is partially reliant on the availability of information provided by relevant third parties.

7A.3.5 Specialist Surveys and Studies

As outlined in Section 7A.3.3 the assessment of potential impact to intertidal and subtidal benthic marine habitats, marine mammals and fish is supported by specialist studies and extensive marine survey work carried out over several years at the site. The surveys which have been undertaken using standard methodologies are briefly described in Section 7A.3.5.1 while Section 7A.3.5.2 outlines the specialist studies undertaken to inform impact assessments.

7A.3.5.1 Surveys

Intertidal and Subtidal Marine Habitats

In 2005/ 2006 and in 2012, AQUAFACT undertook intertidal transect surveys to the west and east of the Proposed Development north of Ballylongford Bay to Carrowdotia east of Ardmore Point. In 2020, three of the transects previously surveyed (T3, T7, T8) were revisited and resurveyed (see Figure 7A-5). In 2020 an additional transect (T1) was identified and surveyed. In 2006/ 2007, a total of 31 subtidal sites were surveyed; of these sites, 10 sites were resurveyed in 2012 and 2020 (see Figure 7A-8). AQUAFACT survey reports are included in Appendix A7A-1. The intertidal and subtidal data collected are further augmented by data available on NPWS documents and data collated for the Lower River Shannon SAC. There are no limitations in relation to the suitability of the data to support the impact assessments presented within this chapter.

Lagoons

There is also a small undocumented lagoon located approximately 4.5 south west of Proposed Development. The Conservation Objectives report for the cSAC (NPWS, 2013) indicates that the site is designated for four lagoons. The lagoons are: Scattery Lagoon (5.9 km northwest of the development), Clooconeen Pool (18.1 km west), Quayfield and Poulaweala Loughs (26.5 km east), Shannon Airport Lagoon (35.5 km northeast of the development). To augment information included in the Conservation Objectives report, a specialist survey of the lagoon located at Knockfinglas Point was carried out in October 2007.

Marine Mammals

The assessment of potential impact to marine mammals is supported by extensive marine survey work. For the Proposed Development, the Irish Whale and Dolphin Group (IWDG) were contracted to monitor the use of the site of the proposed LNG Terminal by bottlenose dolphins and any other marine mammals present. Monitoring, comprising a combination of land-based Vantage Point (VP) watches and static acoustic monitoring (SAM), was used to describe the use of the site by bottlenose dolphins and any other marine mammals (seals) present, and their distribution and relative abundance at the site. Dedicated weekly VP watches were carried out over 6 months (April and September 2020) while CPOD passive acoustic devices were deployed at two sites for a period of 12 months to collect SAM data. These data augment marine mammal data collected in the Shannon Estuary over 20 years, which has spawned a wealth of scientific publications and datasets, including NPWS documents and data collated for the Lower River Shannon cSAC, for which the bottlenose dolphins are a conservation feature. There are no limitations in relation to the suitability of the data to support assessment of the occurrence of marine mammals in the development area. IWDG monitoring reports are presented in Appendix A7A-2.

Fish

Fish diversity in the Shannon Estuary was identified using a wide range of published reports, the most important of which are the stock surveys conducted by Inland Fisheries Ireland (IFI) in 2008 and in 2014 in the Upper and Lower Shannon Estuary using a beach seine, fyke net, or beam trawl and reported in Kelly et al., 2015. There are no limitations in relation to assessment of fish diversity in the Shannon Estuary. The assessment also relied on document prepared by NPWS for the Lower River Shannon cSAC. (NPWS, 2013).

7A.3.5.2 Specialist Studies

Shannon LNG Limited commissioned Lloyd's Register (now Vysus Group) (VG) to carry out a modelling study on various sources of noise that would arise during the construction and operation phases of the Proposed Development in the Shannon Estuary. The VG noise modelling report is presented in Appendix A7A-3.

The output of the VG noise modelling study was used by LGL Ecological Research Associates Ltd (LGL) to assess the impact of noise generated during the construction and operation phases of the development on fish and marine mammal species. The impact assessments undertaken by LGL were informed by published scientific literature on the effects of noise of fish and marine mammal species. LGL impact assessments were used as the basis for noise impact assessments in this chapter. There are no limitations in relation to the suitability of the VG noise modelling and the impact assessments undertaken by LGL. The LGL noise impact assessment report is presented in Appendix A7A-4.

AQUAFACT was commissioned by Shannon LNG to carry out a dispersion modelling study to determine the fate of sediment and water discharges generated during the construction and operation phases of the Proposed Development. The AQUAFACT Hydrodynamic and Dispersion Modelling report is presented in Appendix A7A-5. The dispersion modelling study was used as the basis of assessment of impact to aspects of the marine environment. There are no limitations in relation in relation to the suitability of the dispersion modelling and the impact assessments undertaken.

7A.3.6 Consultation

Consultations were carried out with statutory and non-statutory bodies. The bodies are listed in alphabetical order below.

- An Bord Pleanála (ABP);
- Commission for Regulation of Utilities (CRU);
- EirGrid;
- Environmental Protection Agency (EPA);
- Gas Networks Ireland (GNI);
- Health and Safety Authority (HSA);
- Inland Fisheries Ireland (IFI);
- Irish Whale and Dolphin Group (IWDG);
- KCC;
    - County Archaeologist,
    - Chief Fire Officer, and
    - Planning Department;
- National Monuments Service's Underwater Archaeology Unit;
- National Parks and Wildlife Service (NPWS) Development Applications Unit (DAU); and
- Shannon Foynes Port Company.

Of particular relevance to the assessment exercises undertaken for this chapter of the EIAR were consultations held with IFI and NPWS; the issues raised by these consultations are presented in Table 7A-2 and Table 7A-3 below. The tables indicate where the consultation comments have been addressed in the EIAR. Where possible, summary responses to the comments are alongside the consultation comments.

Table 7A-2 IFI (Letter Dated 13th April 2021)

Consultation Comment	Response
With regard to tanker access to the new jetty, will additional dredging of the channel be required and if so, the impact of this must be adequately assessed.	For the Proposed Development there will be no marine dredging.
IFI request modelling of the impact and dispersion of the outlet water and its impact on the temperature and salinity regime in the vicinity of the proposed plant. This is particularly important given the proximity of the plant to the West Shannon Ballylongford Designated Shellfish Area. This is also relevant to the spawning of estuarine fish and other invertebrate species.	Detailed Hydrodynamic and Dispersion Modelling of treated cooled water discharges is presented in Appendix A7A-5, Vol. 4. An assessment of impacts is presented in Section 7A.10 and no impacts are predicted.
IFI request detail of the proposals to prevent fish impingement/entrainment on any water intake pipes and the adequacy of any proposed systems to prevent same.	A description of the seawater intake and discharge system is provided in Chapter 02. Assessment of the likely impact of impingement/ entrainment impacts on fish and crustaceans is included in Section 7A.5.9. The seawater system has been designed to avoid significant impingement/ entrainment of fauna occurring.
Fire water will likely be required for the plant and the BESS, the source of this should be addressed.	Details of firewater are provided below in Chapter 02.
Detail should be provided as to the treatment and disposal of wastewater from on-site hygiene facilities.	Detailed Hydrodynamic and Dispersion Modelling of treated cooled water discharges is presented in Appendix A7A-5, Vol. 4. Assessment of impacts is presented below in Section 7A.5.10. Given the scale of effluent and treatment proposed, and the diluting factor of the Shannon estuary, significant impacts can be excluded.
A pollution prevention and rapid response plan should be prepared in the event of an oil spill during refuelling or a spill of LNG during the unloading/ regasification process.	Pollution Mitigation and Response Protocols are detailed below in Section 7A.7.5**.**
The management of ballast water to prevent the further introduction of alien invasive species should be dealt with.	Details of the ballast management plans that will be implemented are provided below in Section 7A.6**.**
The impact of construction/piling noise on the auditory and migratory response of resident estuarine and migrant fish species is of concern to IFI. Twaite Shad (*Allosa fallax fallax*) are particularly hearing sensitive and have been recorded in the estuary. The European Red Data Book species Smelt (*Osmerus eperlanus*) also migrates to spawn in the Upper Estuary at Limerick City during early Spring.	Detailed modelling of noise emissions is presented in Appendix A7A-3, Vol. 4 while assessment of the impact of noise on fish and marine mammal species in presented in Appendix A7A-4, Vol. 4. Assessments of impacts to fish and marine species are presented below in Section 7A.5.5**.**
The in-combination effects of all of the above with the Data Centre and 220kV connection should be addressed.	Cumulative impacts are considered in Section 7A.6. In-combination effects are considered in Section 2.16.6 and Section 3.7 of NIS Vol1[5].

[5] For the application for consent for the Proposed Development a *Screening Statement for Appropriate Assessment (AA) and Natura Impact Statement (NIS)* report has been prepared. The *Screening Statement for AA and NIS* report has been prepared to inform the AA determination in respect of the Proposed Development by the competent authorities, as required under Article 6(3) of the Habitats Directive. The report comprises the following two parts; Vol. 1 – Main Report, and Vol. 2 – Appendices.

Table 7A-3 NPWS DAU (Letter Dated 26th April 2021)

Consultation Comment	Response
LNG FRSU terminal	
Net loss of Annex I habitat: See conservation target for area on Conservation Objectives for the Lower River Shannon cSAC[6]. The estimated extent of the loss of this habitat, permanently and/or during the lifetime of the development, due to the construction of the jetty and FSRU infrastructure, will need to be calculated. Net loss of habitats may constitute an adverse effect on the integrity of the cSAC.	An estimation of the habitat lost during the lifetime of the Proposed Development is presented in assessed in Section 7A.5.6. An estimation of the habitat lost during the lifetime of the Proposed Development and an assessment of impact on the integrity of the cSAC is presented in *Screening Statement for AA and NIS*.
Where post-development decommissioning of the jetty and marine infrastructure is proposed, the expected maximum lifetime of the project needs to be clearly stated, as does the method of decommissioning envisaged, with comparable thoroughly researched examples of successful restoration carried out in similar circumstances elsewhere.	The Proposed Development is expected to have a design life of 50 years. Details of the decommissioning phase are presented in Chapter 02. Habitat recovery following decommissioning is discuss in Section 7A.5.6.
A thorough and comprehensive baseline survey of the benthic biodiversity of the total effective footprint of the jetty and marine infrastructure needs to be carried out.	The baseline surveys of the intertidal and subtidal environment are summarised in in Section 7A.4.3. Full survey reports are included in Appendix A7A-1, Vol. 4.
The area proposed for the jetty and FSRU infrastructure is within the area mapped as critical habitat for the bottle-nosed dolphin Map 16, Conservation Objectives). The conservation target for these areas is that they "should be maintained in a natural condition". The NIS will need to address the compatibility of the Proposed Development with the conservation objective for this species within the cSAC, and provide sufficient data and expert opinion to satisfy reasonable scientific doubt that the proposal will not adversely affect the integrity of the Lower River Shannon cSAC.	An assessment of the noise disturbance to bottlenose dolphin Section 7A.5.5.
Sublethal effects of pile-driving (jetty and FSRU infrastructure), and any near-shore blasting, on dolphins using adjacent part of the estuary. Unless adequate data is already available, a *two-year* survey of dolphin use of the estuary within 2 km of the proposed jetty and FSRU infrastructure is recommended, with a year being the minimum requirement, but open to query regarding its representivity.	Monitoring survey reports of marine mammals are presented in full in Appendix A7A-2, Vol. 4 with the key findings summarised in Section 7A.4.4. Assessment of noise disturbance impacts to species is presented below in Section 7A.5.5.
Any increase in the risk of oil spills from increased ship traffic need to be fully assessed.	A Marine Navigation Risk Assessment, which was prepared by the Shannon Foynes Port Company in presented in Appendix A2-2, Vol. 4. The risk assessment was used to assess potential risk of oil spills.
The risk of invasive organisms being imported in ballast water and as ship hull fouling need to be assessed.	Details of the ballast management plans that will be implemented are provided below in Section 7A.7.4.
Effect of the lighted jetty on bird mortality during poor weather condition, based on evidence from monitoring of jetties elsewhere.	An assessment of the likely impact of bird collisions with lighting of the jetty associated with the Proposed Development is presented in Chapter 07B – Terrestrial Biodiversity.

[6] https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO002165.pdf

Consultation Comment	Response
	Bird surveys undertaken to inform the impact assessments for the Proposed Development are also detailed in Chapter 07B – Terrestrial Biodiversity
Effect of pile-driving on estuarine birds: The seasonal timing and type of pile driving needs to be clearly described, and its impact of estuarine birds assessed. Unless adequate data is already available, a *two-year* survey of bird use of the estuary within 2 km of the proposed jetty and FSRU infrastructure is recommended, with a year being the minimum requirement.	An assessment of the effects of the noise emissions on estuarine birds, including piling noise associated with the Proposed Development, and details of bird surveys undertaken to inform the impact assessments are presented in Chapter 07B EIAR Vol. 2.
Modelling of pool fires and accidents: The impact of shipping accidents and pool fires on estuarine and sea-birds needs to be assessed. Although there is a good safety record for LNG ship transport, nevertheless it is recommended that such risks are formally modelled (*e.g.* Woodward & Pitbaldo (2010)[7]. The feasibility of bird surveys at and on each side of the slip lane within the SPA need to be established and if feasible such data is recommended to be collected.	A discussion on the potential risk of accidents associated with the Proposed Development is included in Section 7A.5.12.
It needs to be established if dredging is required to facilitate ship access.	For the Proposed Development there will be no marine dredging.
Entrainment and/or impingement for fish and macrocrustaceans at water intake. An estimate of the number of fish and macrocrustaceans which are predicted to be killed by being entrained in the cooling water intake, or by being impinged on the filter screens of the intake, as a proportion of the fish and macrocrustaceans population available to predatory fauna in the estuary (see, for comparison, Henderson (1999)[8] and Hadderingh and Jager (2002)[9]	A description of the seawater intake and discharge system is provided in Chapter 02. Assessment of likely impingement/ entrainment impacts to fish and crustaceans is included in Section 7A.5.9. The seawater system has been designed to avoid significant impingement/ entrainment of fauna occurring.
If any chemicals are proposed to be used to remove intake and outlet pipe fouling by marine organisms, then this needs to be assessed for impact on the estuarine ecosystem.	To avoid fouling hypochlorite will be used to treat water. Modelling of treated cooled water discharge is discussed in Section 7A.5.8 while full the Hydrodynamic and Dispersion Modelling report is presented in Appendix A7A-5, Vol. 4. Dispersion of residual chlorine at 0.5 mg/l was modelled. Results show that within 1.5 km both east and west of the discharge point the predicted maximum residual chlorine concentration is less than 0.01 mg/l. Concentration above 0.1 mg/l are shown to occur only within 20 m of the discharge point and for a short period of time. Significant effects can be excluded.
Power plant at Ralappane	
The requirement for blasting for the construction of the proposed power plant need to be established, and it impact fully assessed.	Detailed modelling of noise emissions is presented in Appendix A7A-3, Vol. 4 while assessment of the impact of noise species in presented in Appendix A7A-4, Vol. 4. Assessments of impacts to species are presented below in Section 7A.5.5**.**
The full accounting of all excavated waste needs to be thoroughly controlled as part of a C & D waste management plan. The NPWS has been involved in several cases where construction	Details provided in Chapter 02.

[7] Woodward, J. L. & Pitbaldo, R. (2010). LNG Risk Based Safety: modelling and consequence analysis. John Wiley & Sons. https://www.wiley.com/en-us/LNG+Risk+Based+Safety%3A+Modeling+and+Consequence+Analysis-p-9780470317648

[8] Henderson, P.A. (1999). Stepping back from the brink: estuarine communities and their prospect British Wildlife 11: 85-91.

[9] Hadderingh, R.H. and Jager, Z. (2002). Comparison of fish impingement by a thermal power station with fish population in the Ems Estuary. Journal of Fish Biology 61: 105-124.

Consultation Comment	Response
waste has been illegally used for purposes of private coastal protection works in European sites.	
If any indirect effects are likely, a re-assessment of the small lagoon near the land bank site, for typical lagoonal species, is recommended; in particular the protected species *Lamprothamnium papillosum.*	The main source of potential indirect effects impacts to lagoons are pollutants and water discharges. Potential for impacts are considered in Section 7A.5.3, Section 7A.5.4, and Section 7A.5.8**.** Indirect effects of pollutants and water discharges to lagoons can excluded. There is potential that lagoon may be indirectly affected by invasive species, however, the risk of invasive organisms will be managed through the implementation of mitigation (see in Section 7A.7).
A re-assessment of the use of the terrestrial and shore development area by otter needs to be carried out.	A re-assessment of otter use of terrestrial and shore habitats at the Proposed Development is presented in Chapter 07B.
Gas pipeline to Foynes	
As more than 12 years have elapsed since the Environmental Impact Statement (EIS) for the gas pipeline, and this being an integral part of the whole project, a revised assessment (Screening for appropriate assessment (at least) and Environmental Impact Assessment Report (EIAR) supplement (at least) would appear to be necessary.	The 26 km gas pipeline that will connect the Proposed Development to the existing natural gas network is already permitted. By decision dated 17th February 2009, An Bord Pleanála granted approval for this gas pipeline under section 182D of the Planning and Development Act, 2000 (as amended) (Board ref. PL08.GA0003). It follows that the permitted pipeline is an 'approved project', to which Annex IV(5)(e) of the EIA Directive applies. This means the EIA of the Proposed Development must include effects resulting from the cumulation of effects with the permitted pipeline. Similarly, the permitted pipeline is a project for the purposes of the 'in combination' assessment under the Habitats Directive. The pre-application observations made by the Development Applications Unit of the Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media suggest that a revised assessment of the permitted pipeline would appear to them to be necessary. That revised assessment will be included within the required future application for consent under section 39A of the Gas Act 1976 (as amended). We are advised that no such revised assessment is necessary to complete necessary cumulative and in combination assessments. The necessary cumulative and in combination assessments have been completed, on the basis that the permitted pipeline is built in accordance with its existing approval. The potential for cumulative impacts with the gas pipeline are considered in Section 7A.6 below**.**
Powerlines exporting electricity	
It is understood that an underground cable is the preferred means of exporting electricity. However, if powerlines remain an option then the impact on birds dispersing between different parts of the SPA need to be assessed, with particular reference to mortality and/or electrocution.	The export of power from the site will form part of a separate application.
It is recommended that the following conservation issues are addressed in the Environmental Impact Assessment Report (EIAR) for the proposed development.	
White-tailed sea eagles There is a current release site for white-tailed sea eagles, under Phase II of the White-tailed Sea Eagles Reintroduction Project, within 7 km of the proposed development, and the potential impact on recently-released young eagles needs to be assessed. This species is particularly	Addressed in Chapter 07B – Terrestrial Biodiversity. An application to connect to the national electrical transmission network was submitted to EirGrid in September 2020 under the Enduring Connection Policy 2 (ECP2) process. As part of this grid connection application, Shannon LNG Limited made a specific connection method request for underground cabling, in lieu of overhead lines. Given the expressed preference for underground cabling by the Applicant, and the resistance of the Applicant to

Consultation Comment	Response
susceptible to powerline collision and electrocution.	overhead powerlines, no assessment of the impact of collision to birds from overhead powerlines is required.
Protected mammals A re-assessment of the use of the terrestrial and shore development area by the strictly protected species, otter needs to be carried out. Use of the terrestrial development site by dispersing and migrating bats also needs re-assessment.	Addressed in Chapter 07B – Terrestrial Biodiversity.
Fracked gas source – USA It is noted from the pre-planning meeting mentioned above that the project is not dependent on the use of shale (fracked) gas. However, in the event that this remains a possible option which is not strictly excluded from the proposed project, the following may need to be taken into account in the EIAR. There is concern of potential threats from gas fracking in Pennsylvania (in the Marcellus shale formation) to the listed species, rayed bean (*Villosa fabalis*), and snuffbox mussel (*Epioblasma triquetra*)[10]. While the obligation to assess impacts on jurisdictions outside of the European Union is not clear, nonetheless, it would be best practice to examine the impact of source gas extraction on protected wildlife, where such data is available.	The application does not propose or request permission for any extraction, refining or liquefaction of natural gas. The potential sources of liquefied natural gas (LNG) are varied and, although not possible to identify, will all be located outside of the State and almost all will be located outside of the European Union. The pre-application observations made by the Development Applications Unit of the Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media suggest that the impacts of source gas extraction should be examined, where such data is available. In accordance with the decision of the High Court in An Taisce v. An Bord Pleanála [2021] IEHC 254 and 422, any impacts on the environment from extraction, refining or liquefaction of source gas are too remote from the Proposed Development to require examination, analysis and evaluation within the environmental impact assessment and appropriate assessment of the Proposed Development. We are advised that, for this reason, it is neither necessary nor appropriate to include particulars of any one place where source gas might be extracted.

[10] Federal Register (2012) 77:8650 https://www.govinfo.gov/content/pkg/FR-2012-04-14/pdf/2012-2940.pdf

7A.4 Baseline Environment

7A.4.1 Site Area Description

The Proposed Development will be located on the Shannon Estuary, 4.5 km from Tarbert and 3.5 km Ballylongford in Co. Kerry. The site for the Proposed Development is 52 hectares. The Shannon Landbank on which the site is located has a total area of 243 ha (603 acres).

The site boundary is shown in Figure 7A-1. The site consists primarily of agriculturally improved grassland, which runs along the southern shore of the Shannon estuary. The proposed jetty extends from the shoreline into the estuary. The shoreline in the general area is relatively sheltered and composed of shingle or low earthen cliffs. The land within the site is primarily used for grazing or hay/ silage. The type of grassland varies considerably with topography with some waterlogged sections. The lower section of a small watercourse forms the western boundary of the Proposed Development site. To the west of the Proposed Development site boundary, this stream forms a tidal creek and dense reed beds adjoin parts of its lower reaches near its discharge into the Shannon Estuary. Some drier land occurs close to the coast and there are larger, drier fields to the east of the site where the land is more intensively farmed. The site boundary is partly within and adjacent to the Lower River Shannon candidate Special Area of Conservation[11] (cSAC) and the River Shannon and River Fergus Estuaries Special Protection Area (SPA) (see Section 7A.4.2 below). SACs and SPAs are designated respectively due to their significant ecological importance for habitats and species protected under Annex I and Annex II respectively of the Habitats Directive, and for the protection of populations and habitats of bird species protected under the EU Birds Directive (Council Directive 2009/ 147/ EC).

Figure 7A-1 Proposed Development Site Boundary

[11] Candidate SAC sites (cSAC) or candidate SPA sites (cSPA) have the same level of protection as fully designated sites under Irish Law. Candidate sites are those that have been submitted to the European Commission, but not yet formally adopted under Ministerial Statutory Instrument (S.I.) (OPR, 2021). Legal protection, and therefore, the requirement for AA, arises from the date that the Minister gives notice of his/her intention to designate the site.

7A.4.2 Designated Sites

Designated sites in Ireland include Special Area of Conservation (SAC) and Special Protection Area (SPA) sites designated respectively under the Habitats Directive and Birds Directive. SACs and SPAs are considered further in the following section.

In Ireland, areas considered important for the habitats present or which hold species of plants and animals whose habitat needs protection are designated as Natural Heritage Areas (NHAs). NHAs and proposed NHAs (pNHAs) are considered in Chapter 07B – Terrestrial Biodiversity.

7A.4.2.1 Overview

Sites of conservation importance hosting habitats and species needing to be either maintained at or, where appropriate, restored to favourable conservation status have been identified by each Member State. Sites, species, and habitats protected under Directive 92/ 43/ EEC (Habitats Directive) and Directive 2009/ 147/ EC (Birds Directive). These are referred to as Natura 2000 sites. Natura 2000 sites are referred to as European sites in the Planning and Development Act 2000 (as amended) and in other Irish legislation. These terms are synonymous. European sites in Ireland, which form part of the EU-wide Natura 2000 network of protected sites, comprise SAC sites designated due to their significant ecological importance for habitats and species protected under Annex I and Annex II respectively of the Habitats Directive, and SPA sites designated for the protection of populations and habitats of bird species protected under the EU Birds Directive (Council Directive 2009/ 147/ EC). A specific named habitat and/ or (non-bird) species for which a SAC or SPA is selected is called a 'Qualifying Interest' (QI) of the site, while a specific named bird species for which a SPA is selected is called a 'Special Conservation Interest' (SCI) of the site (OPR, 2021). QIs and SCIs can be collectively referred to as ‘conservation features’. European sites are formally designated under a statutory instrument.

Under Article 6(3) and 6(4) of the Habitats Directive, competent authorities are required to conduct a screening for Appropriate Assessment (AA) and, if necessary, an AA, on any plan or project for which it receives an application for consent, or which the authority itself wishes to undertake or adopt.

The Habitats Directive was originally transposed into Irish law by the *European Communities (Natural Habitats) Regulations, 1997* (S.I. No. 94 of 1997). The 1997 Regulations were subsequently revoked and replaced by the *European Communities (Birds and Natural Habitats) Regulations 2011*, as amended (herein referred to as the 2011 Birds and Natural Habitats Regulations).

Under Regulation 42 of the 2011 Birds and Natural Habitats Regulations, all competent authorities are required to conduct a *Stage 1 screening for Appropriate Assessment* (AA) and, if necessary, a *Stage 2 AA* on any plan or project on the foreshore for which it receives an application for consent, or which the authority itself wishes to undertake or adopt. This obligation derives from Article 6(3) and 6(4) of the Habitats Directive.

The AA provision of the Habitats Directive is also transposed in Ireland by the Planning and Development Act 2000 (as amended) in respect of land use plans and proposed developments requiring development consent.

For the Proposed Development a *Screening Statement for Appropriate Assessment (AA) and Natura Impact Statement (NIS)* has been prepared to provide information to enable the competent authority to carry out a *Stage 1: Screening for AA* and a *Stage 2: AA* of the Proposed Development as required under Article 6(3) obligations under the Habitats Directive. The *Screening Statement for Appropriate Assessment* is discussed in Section 7A.4.2.2 below.

7A.4.2.2 European Sites

The lower River Shannon cSAC site and the River Shannon and River Fergus Estuaries SPA site extend along the northern/ north-western boundary and also along part of the eastern boundary of the Proposed Development site (Figure 7A-2). The proposed jetty and outfall will extend into the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA (see Figure 7A-3 and Figure 7A-4 respectively). The

Short descriptions of the SACs and SPA are provided below, while detailed site descriptions are included in the site synopsis reports presented in Appendix A7A-6.

Lower River Shannon cSAC (Site code: 002165) (overlaps development area) – This very large site stretches along the Shannon valley from Killaloe in Co. Clare to Loop Head/ Kerry Head, some 120 km. The site thus encompasses the Shannon, Feale, Mulkear and Fergus estuaries, the freshwater lower reaches of the River Shannon (between Killaloe and Limerick), the freshwater stretches of much of the Feale and Mulkear catchments and the marine area between Loop Head and Kerry Head. The site is designated for a wide range of Annex I marine, coastal, freshwater aquatic and terrestrial habitats, while Annex II species for which the site is designated include marine mammals, diadromous fish species and freshwater aquatic species.

River Shannon and River Fergus Estuaries SPA (Site code: 004077) (overlaps development area) – The estuaries of the River Shannon and River Fergus form the largest estuarine complex in Ireland. The site comprises the entire estuarine habitat from Limerick City westwards as far as Doonaha in Co. Clare and Dooneen Point in Co. Kerry. The site has vast expanses of intertidal flats which contain a diverse macroinvertebrate community which provides a rich food resource for wintering birds. Salt marsh vegetation frequently fringes the mudflats and provides important high tide roost areas for the wintering birds. Elsewhere in the site the shoreline comprises stony or shingle beaches. The site is designated for the following species: Cormorant, Whooper Swan, Light bellied Brent Goose, Shelduck, Wigeon, Teal, Pintail, Shoveler, Scaup, Ringed Plover, Golden Plover, Grey Plover, Lapwing, Knot, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Curlew, Redshank, Greenshank and Black-headed Gull. The site is also designated for wetlands.

Potential impacts on designated European sites are addressed in the *Screening Statement for AA and NIS* which has been prepared to provide information to enable the competent authority to carry out a *Stage 1: Screening for AA* and a *Stage 2: AA* of the Proposed Development as required under Article 6(3) of the Habitats Directive. The *Screening Statement for AA and NIS* report concluded that the there are no likelihood of significant adverse effects on European sites.

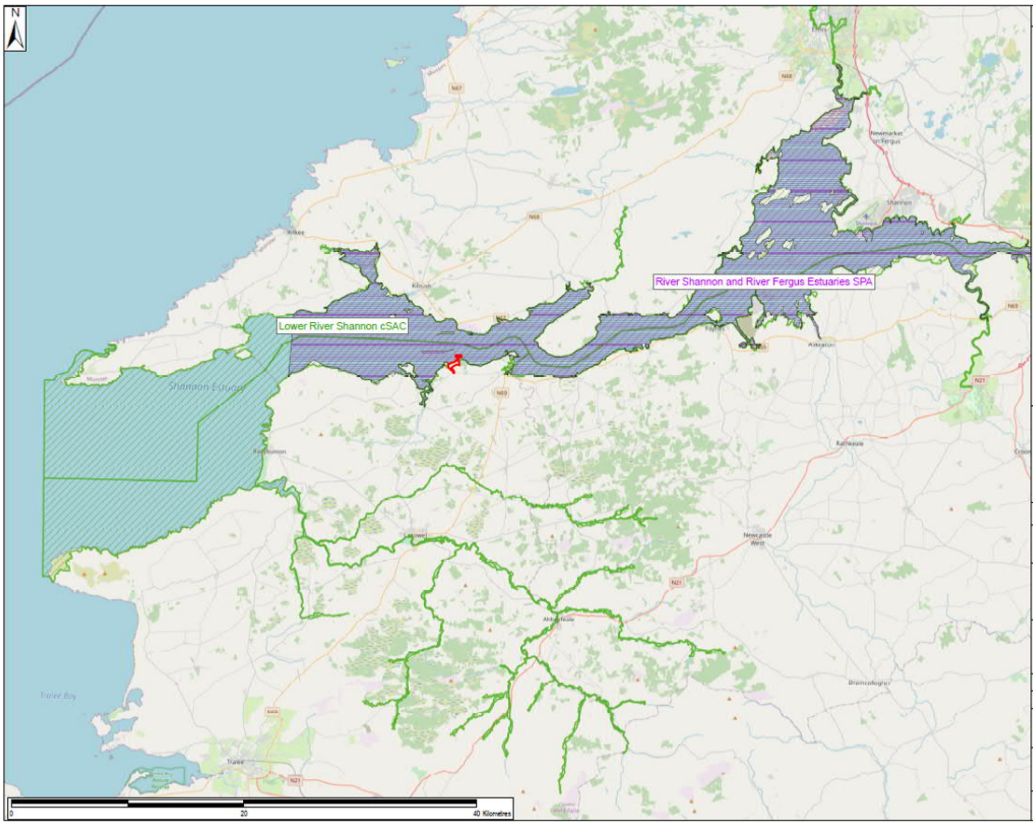

Figure 7A-2 Proposed Development Site Boundary Relative to the Lower River Shannon cSAC and the River Shannon and River Fergus SPA

Figure 7A-3 Proposed Jetty, Outfall and FRSU Relative to the Lower River Shannon cSAC

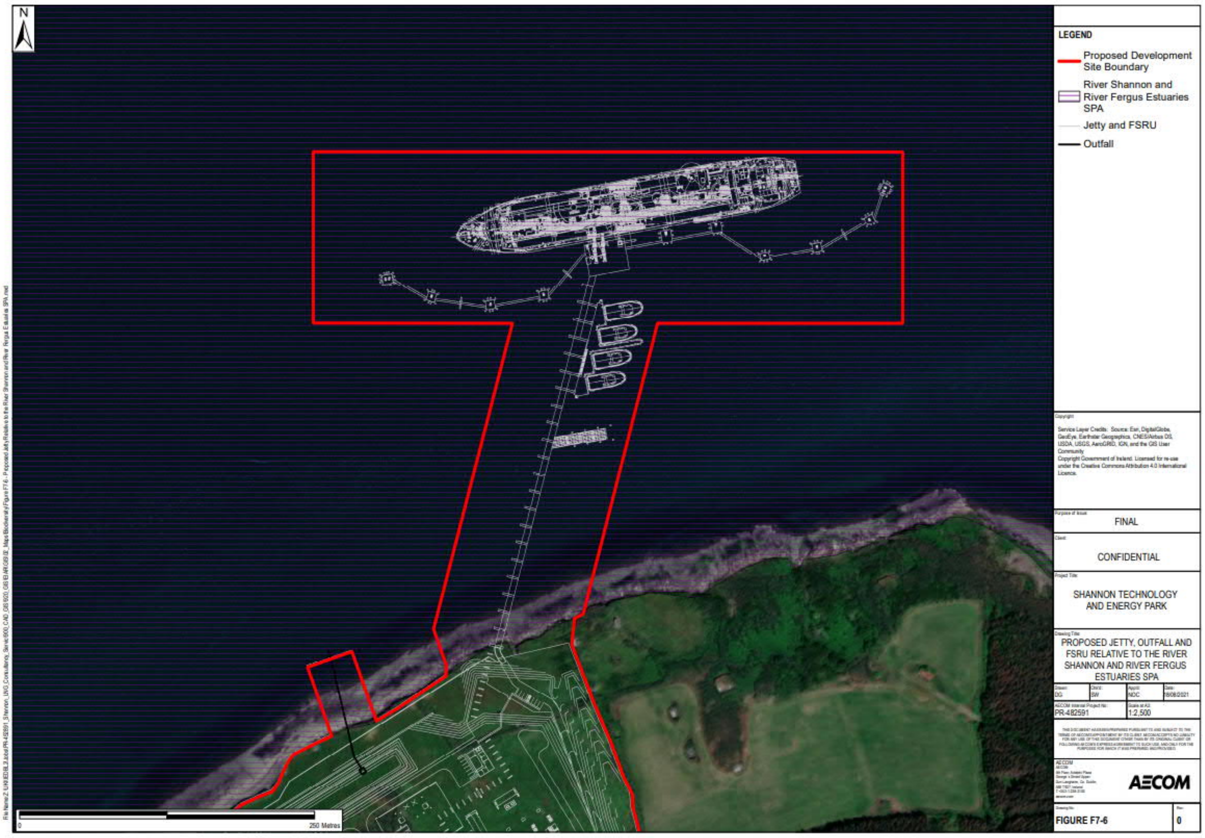

Figure 7A-4 Proposed Jetty, Outfall and FRSU Relative to the River Shannon and River Fergus SPA

7A.4.3 Habitats

7A.4.3.1 Marine/ Coastal Habitats

The Shannon and Fergus Estuaries form the largest estuarine complex in Ireland. They form a unit stretching from the upper tidal limits of the Shannon and Fergus Rivers to the mouth of the Shannon Estuary (considered to be a line across the narrow strait between Kilcredaun Point and Kilconly Point). Within this main unit there are several tributaries with their own 'sub-estuaries' *e.g.* the Deel River, Mulkear River, and Maigue River. To the west of Foynes, a number of small estuaries form indentations in the predominantly hard coastline, namely Poulnasherry Bay, Ballylongford Bay, Clonderalaw Bay and the Feale or Cashen River estuary. Both the Fergus and inner Shannon Estuaries feature vast expanses of intertidal mudflats, often fringed with saltmarsh vegetation (NPWS, 2013). The smaller estuaries also feature mudflats, but have their own unique characteristics, *e.g.* Poulnasherry Bay is stony and unusually rich in species and biotopes. Plant species are typically scarce on the mudflats, although there are some eelgrass (*Zostera* spp.) beds and patches of green algae (*e.g. Ulva* sp. and *Enteromorpha* sp.). The main macro-invertebrate community which has been noted from the inner Shannon and Fergus estuaries is a *Macoma-Scrobicularia-Nereis* community.

In the transition zone between mudflats and saltmarsh, specialised colonisers of mud predominate. For example, swards of Common Cord-grass (*Spartina anglica*) frequently occur in the upper parts of the estuaries. Less common are swards of Glasswort (*Salicornia europaea* agg.). In the innermost parts of the estuaries, the tidal channels or creeks are fringed with species such as Common Reed (*Phragmites australis*) and club-rushes (*Scirpus maritimus*, *S. tabernaemontani* and *S. triquetrus*). In addition to the nationally rare Triangular Club-rush (*Scirpus triqueter*), two scarce species are found in some of these creeks (*e.g*. Ballinacurra Creek), Lesser Bulrush (*Typha angustifolia*) and Summer Snowflake (*Leucojum aestivum).*

The site is an example of a large shallow inlet and bay. Littoral sediment communities in the mouth of the Shannon Estuary occur in areas that are exposed to wave action and also in areas extremely sheltered from wave action. Characteristically, exposed sediment communities are composed of coarse sand and have a sparse fauna. Species richness increases as conditions become more sheltered. All shores in the site have a zone of sand hoppers (small crustaceans) at the top, and below this each of the shores has different characteristic species giving a range of different shore types (NPWS, 2013)

The intertidal reefs in the Shannon Estuary are exposed or moderately exposed to wave action and subject to moderate tidal streams (NPWS, 2013). Known sites are steeply sloping and show a good zonation down the shore. Well-developed lichen zones and littoral reef communities offering a high species richness in the sublittoral fringe and strong populations of the Purple Sea Urchin (*Paracentrotus lividus*) are found. The communities found are tolerant to sand scour and tidal streams. The infralittoral reefs range from sloping platforms with some vertical steps, to ridged bedrock with gullies of sand between the ridges, to ridged bedrock with boulders or a mixture of cobbles, gravel and sand. Kelp is very common to about 18 m. Below this depth, it becomes rare, and the community is characterised by coralline crusts and red foliose algae.

Other coastal habitats that occur within the site include stony beaches and bedrock shores (these support a typical zonation of seaweeds such as *Fucus spp., Ascophyllum nodosum* and kelps), shingle beaches (with species such as Sea Beet, Sea Mayweed – *Matricaria maritima*, Sea Campion and Curled Dock – *Rumex crispus*), sandbanks which are slightly covered by sea water at all times (*e.g.* in the area from Kerry Head to Beal Head) and sand dunes (a small area occurs at Beal Point, where Marram – *Ammophila arenaria* is the dominant species) (NPWS, 2013).

The Conservation Objectives report for the cSAC (NPWS 2013) indicates that the site is designated for four lagoons. The lagoons are: Scattery Lagoon (5.9 km northwest of the development), Clooconeen Pool (18.1 km west), Quayfield and Poulaweala Loughs (26.5 km east), Shannon Airport Lagoon (35.5 km northeast of the development). There is also a small undocumented lagoon located approximately 4.5 km south west of Proposed Development. Saltmarsh vegetation also occurs around a number of lagoons within the site, two of which have been surveyed as part of a National Inventory of Lagoons. Cloonconeen Pool (4-5 ha) is a natural sedimentary lagoon impounded by a low cobble barrier. Seawater enters by percolation through the barrier and by overwash. This lagoon represents a type which may be unique to Ireland since the substrate is composed almost entirely of peat. The adjacent shore features one of the best examples of a drowned forest in Ireland. Aquatic vegetation in the lagoon includes typical species such as Beaked Tassle Weed (*Ruppia maritima*) and green algae (*Cladophora* sp.). The fauna is not diverse, but is typical of a high salinity lagoon and includes six lagoon specialists (*Hydrobia ventrosa*, *Cerastoderma glaucum*, *Lekanesphaera hookeri*, *Palaemonetes varians*, *Sigara stagnalis* and *Enochrus bicolor*). In contrast, Shannon Airport Lagoon (2 ha) is an artificial saline lake with an artificial barrier and sluiced outlet. However, it supports two Red Data Book species of stonewort (*Chara canescens* and *Chara cf. connivens*).

A brackish lagoon (CW1) occurs within to the south west of the Knockfinglas Point. A specialist survey of the lagoon was carried out in October 2007. A report on these surveys which was prepared concluded: 'Despite the recorded salinity (0.8 – 1.1 parts per thousand) and presence of one plant, the brackish water Tassle Weed *Ruppia maritima*, none of the faunal taxa can be regarded as indicator species of coastal lagoons. One species, *Sigara concinna* has been listed by some authors as a lagoonal specialist in Britain but is found at inland sites in Ireland. The lake may have been a brackish water coastal lagoon in the past and still has a barrier typical of lagoons but is at present dominated by characteristically freshwater insects and molluscs with only a few species, *e.g.* Three-spined Stickleback, *Sigara concinna*, *Haliplus rufficollis*) that can tolerate any measure of salinity. In particular, the presence of Common newts indicate that the lake has been dominated by fresh water for some time. This water body is a marginal example of a lagoon as salinity barely exceeds 1 psu. Plants frequently found in lagoons include *Ruppia maritima*, *Ranunculus baudotii* and *Potamogeton pectinatus* (although this species also occurs in freshwater and is not indicative of lagoons). No lagoonal specialist animals were noted. However the pond's morphology-isolated from the sea by a shingle barrier is a typical lagoonal feature. On balance the pond may be regarded as a lagoon based on plants and morphology but with no fauna of note. Its conservation interest lies in its transitional nature between fresh and brackish conditions.'

7A.4.3.2 Intertidal and Subtidal Survey

Shannon LNG commissioned AQUAFACT to undertake a series intertidal and subtidal surveys in the vicinity of the Proposed Development. The details of the surveys undertaken in 2020 are provided in full in Appendix A7A-1. In April 2020, four intertidal transects (T1, T3, T7, T8) were surveyed. Transects T3, T7 and T8 were previously surveyed in 2012 while T1, T3, T7 and T8 were surveyed in 2006/ 2007. The locations of the transects are shown in Figure 7A-7. For the subtidal survey a total of 10 stations were sampled in April 2020. All stations sampled can be seen in Figure 7A-8 and their locations were selected in order to be representative of the previous survey sites. Station coordinates are presented in Table 7A-3. The intertidal habitats encountered are typical of cobbly rocky shores in Ireland being dominated by *Pelvetia canaliculata*, Fucus sp. and *Ascophyllum nodosum*. No rare, protected or unusual species were observed, and no changes were observed compared to previous surveys undertaken.

The subtidal fauna was dominated by species typical of fine sandy habitats *e.g.* the polychaetes *Nephtys cirrosa*, *Paradoneis lyra*, *Travisia forbesii*, *Pholoe inornata* and *Scoloplos armiger*, the bivalve *Nucula* spp. and the amphipods *Metaphoxus simplex* and *Harpinia antennaria*. In areas with boulders or cobbles there were abundant populations of the tunicate *Dendrodoa grossularia*. No rare, protected or unusual species were observed. One-way ANOVA shows a significant difference between the Shannon-Weiner Diversity and the Effective Number of Species between the 2020 and 2012 results. Whether this is a seasonal variation due to the difference in time of surveys (October in 2012 and April in 2020) is unknown. Despite the significant decreases in these indices from 2012 to 2020, the dominant taxa present are similar in both surveys and indicate similar community types between surveys. All species observed are typical of this area of the Lower River Shannon Estuary cSAC. AMBI analysis indicated that all sites were either undisturbed or slightly disturbed due to the high proportion of sensitive species at each station. Slight variations in the substrate type were observed between this survey and the previous one. Given the strong current speeds and mobile sediments in the area, this is not unusual.

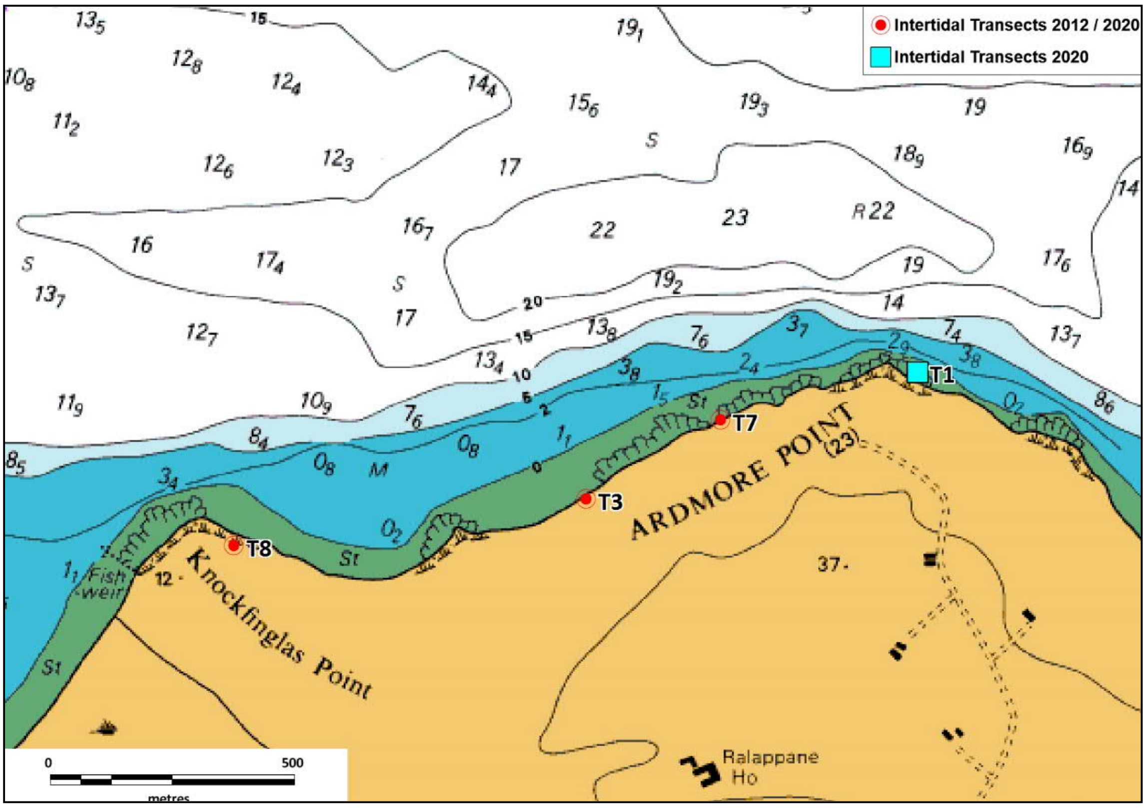

Figure 7A-5 Location of the Intertidal Transects Surveyed

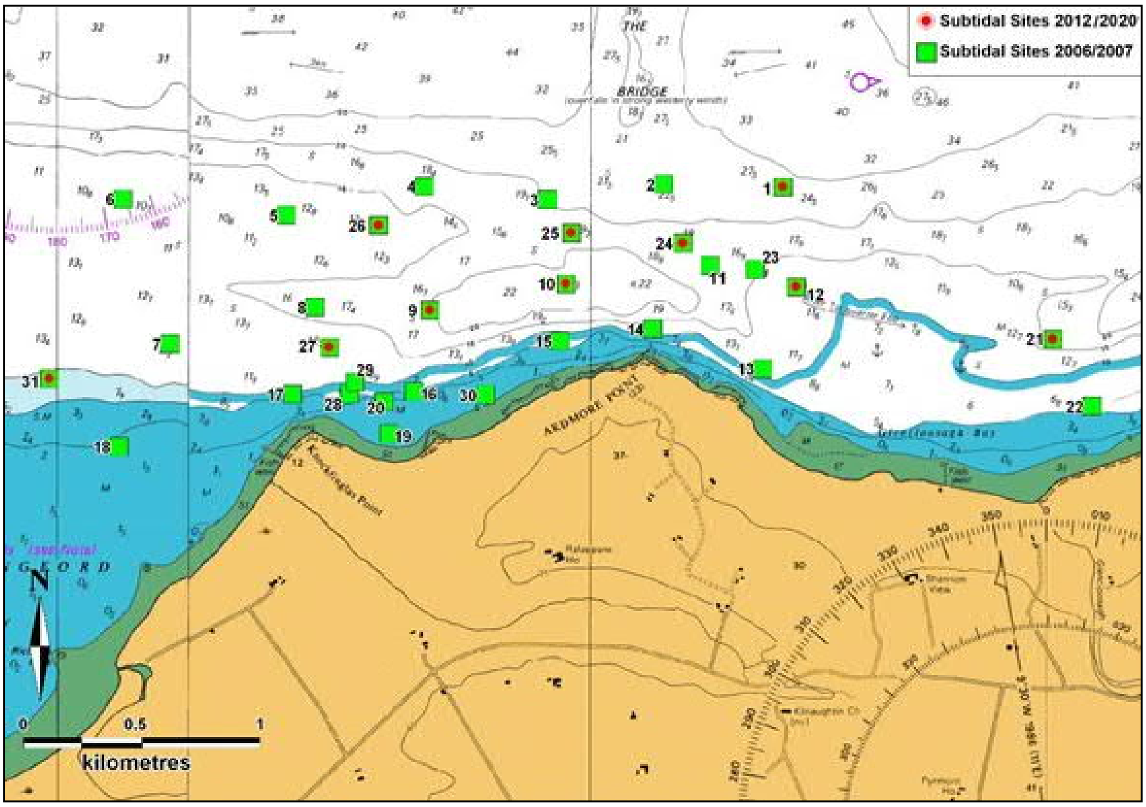

Figure 7A-6 Location of all 10 Stations Sampled in April 2020 and October 2012, and the 31 Stations Sampled in 2006/ 2007

Table 7A-4 Coordinates

Station	Longitude	Latitude	Longitude	Easting	Northing
S1	-9.42206	52.59132	-9.42206	103676.3	149798.2
S9	-9.44401	52.58662	-9.44401	102178.6	149304.8
S10	-9.43554	52.58762	-9.43554	102754.8	149404.6
S12	-9.42125	52.58752	-9.42125	103722.9	149374.3
S21	-9.40523	52.58555	-9.40523	104804.4	149134.3
S24	-9.42828	52.58917	-9.42828	103250.1	149567.5
S25	-9.43522	52.58955	-9.43522	102781.1	149619.4
S26	-9.44723	52.58982	-9.44723	101967.3	149665.4
S27	-9.45025	52.5852	-9.45025	101752.5	149155.8
S31	-9.4677	52.58398	-9.4677	100567.1	149044.3

7A.4.4 Marine Mammals

Bottlenose Dolphin (*Tursiops truncatus*)

The Lower River Shannon cSAC is one of five sites designated for bottlenose dolphins in Irish waters. Studies on the resident bottlenose dolphin population in Shannon Estuary have been occurring since 1993 by the Irish Whale and Dolphin Group (IWDG) and by the National Parks and Wildlife Service (NPWS) of Ireland as part of the EU's obligation to ensure conservation of this species (Blázquez *et al.,* 2020).

Data collected over 20 years show that the Shannon Estuary dolphin population is genetically and demographically isolated from other coastal dolphins (Mirimin *et al.,* 2011; O'Brien *et al.,* 2016; Rogan *et al.,* 2018). Mark-recapture photo-identification studies indicate that bottlenose dolphins in the Shannon Estuary exhibit long-term site fidelity and seasonal residency (*e.g.*, Ingram 2000; Ingram and Rogan 2002; Ingram and Rogan 2003; Englund *et al.,* 2007, 2008; Berrow 2009; Rogan *et al.,* 2018). The most recent photo-identification study occurred during June–October 2018, resulting in a mark-recapture abundance estimate of 139 individuals (CV=0.11, 95% CI=121–160) (Rogan *et al.,* 2018). Baker *et al.,* (2018a) provided an estimate of 145 individuals for 2015, based on direct counts. The median group size based on boat surveys throughout the estuary is 6 (*e.g.*, Englund *et al.,* 2007, 2008; Rogan *et al.,* 2018), and the average group size has been reported as 9.71 (Barker and Berrow, 2016). The mean group size (±SD) at the proposed LNG site at Ardmore Point was estimated at 6.2 ± 3.1 dolphins, based on watches from shore (Berrow *et al.,* 2020).

Although the dolphins inhabit the Shannon Estuary year-round, the greatest number appear to occur there between June and August (Garagouni *et al.,* 2019), with decreasing numbers during the winter (Ingram 2000; Englund *et al.,* 2007; Rogan *et al.,* 2018). The lower numbers during winter may be due to animals dispersing over a wider region in pursuit of prey affected by the seasonal changes (Garagouni *et al.,* 2019); however, data on the distribution of the population during winter is generally lacking. However, dolphin sightings were made off Ardmore Point each month during monitoring from October 2020 to March 2021 (Berrow, 2020 a,b,c, 2021 a,b,c). One photo-identification study found that at least 62% of individuals from the Shannon bottlenose dolphin population also use waters outside of the Shannon Estuary during the summer (May–August), including Brandon Bay and Tralee Bay located adjacent to estuary (Levesque *et al.,* 2016).

Bottlenose dolphins in the Shannon Estuary prefer areas with the greatest slope and depth (Ingram and Rogan 2002). Two critical habitat areas occur within Shannon Estuary that at least part of the population migrates between throughout the year; the larger of the two areas is located near the mouth of the estuary closest to Kilcredaun, and the smaller is located off Moneypoint, close to the proposed STEP development (see Figure 7A-9; NPWS 2012, Ingram and Rogan, 2002; Rogan *et al.,* 2018). In general, a smaller proportion of the population is found in the eastern part of the estuary compared to the western part (Baker *et al.,* 2018b). The distribution of sightings in 2018 showed that dolphin presence throughout the estuary was similar to past studies but noted greater activity within the inner estuary where it constricts near Tarbert/ Killimer and farther upriver (see Figure 7A-10 and Figure 7A-11) (Ingram and Rogan, 2002; Rogan *et al.,* 2018). Baker *et al.,* (2018b) found that only 25% of the population regularly uses the inner estuary; those dolphins were also seen in the outer estuary. Within the critical habitat areas, the dolphins appear to most commonly be found near northern-facing slopes (Garagouni *et al.,* 2019). Dolphin distribution in the estuary is also correlated with tide level, with higher presence in bottleneck areas during ebb and slack low tides (Garagouni *et al.,* 2019).

The area around the proposed LNG site at Ardmore Point has not been identified as a hot spot for bottlenose dolphin occurrence based on commercial dolphin-watching activities (see Berrow *et al.,* 2020 (see Appendix A7A-2). However, sightings have been made in the area during several vessel-based surveys (*e.g.*, Ingram and Rogan, 2003; Englund *et al.,* 2007, 2008; Berrow *et al.,* 2012). Visual observations from shore at Ardmore Point show that the site is regularly used by the dolphins, which pass by the area but rarely stop and socialize or forage there; it is more likely used as a transition corridor to move between the outer and inner estuary (Berrow *et al.,* 2020). During 23 days of observations from April through September 2020, 21 sightings of dolphins were made on 13 separate watch days. Most sightings were made off Moneypoint, near the ferry, near Scattery Island, and mid-channel; six sightings were made within 500 m of Ardmore Point, and a total of 22 individual dolphins were identified. During 23 observation days from October 2020 to March 2021, 20 dolphin sightings were made on 15 different watch days (Berrow, 2020 a,b,c, 2021 a,b,c). Thus, the encounter rates of bottlenose dolphin groups were similar during spring/ summer and fall/ winter, at 0.2 groups/hour of observation.

Passive acoustic monitoring with C-POD porpoise detectors was also conducted at two sites off Ardmore Point from August 2019 through May 2020; dolphin clicks were detected on 62% of monitoring days at each of the two sites (Berrow *et al.,* 2020). The C-POD located closest to the LNG site (LNG1) had a mean detection positive minutes (DPM) per day of 4.4, whereas LNG2 had a DPM of 3.6; DPM was lower at LNG1 during the winter than during other seasons. The low DPM per day at these two sites supports evidence from visual monitoring that the area around Ardmore Point is primarily a transit corridor (Berrow *et al.,* 2020). There were significantly more detections during the evening than during the day at LNG1, and significantly more detections in the evening and at night than during the day at LNG2 (Berrow *et al.,* 2020).

The Shannon Estuary also acts as a calving area for the species, with neonates most frequently observed from July to September (Ingram, 2000; Baker *et al.,* 2018a). An average of seven calves are born each year, with weaning taking place at a mean age of 2.9 years (Baker *et al.,* 2018a). During watches from Ardmore Point, 10 calves were recorded, including four that were born in 2018 and 2019 (Berrow *et al.,* 2020).

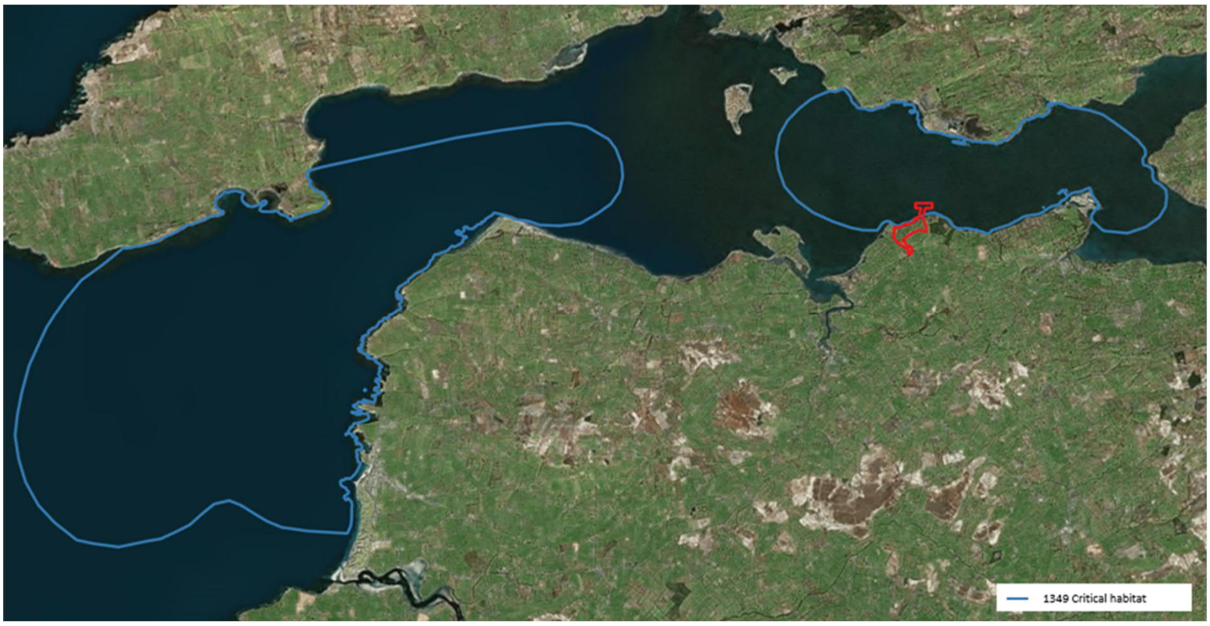

Figure 7A-7 Bottlenose Dolphin Critical Areas, Representing Habitat Used Preferentially by the Species (adapted from NPWS 2012, Ingram and Rogan 2002; Rogan *et al*. 2018).

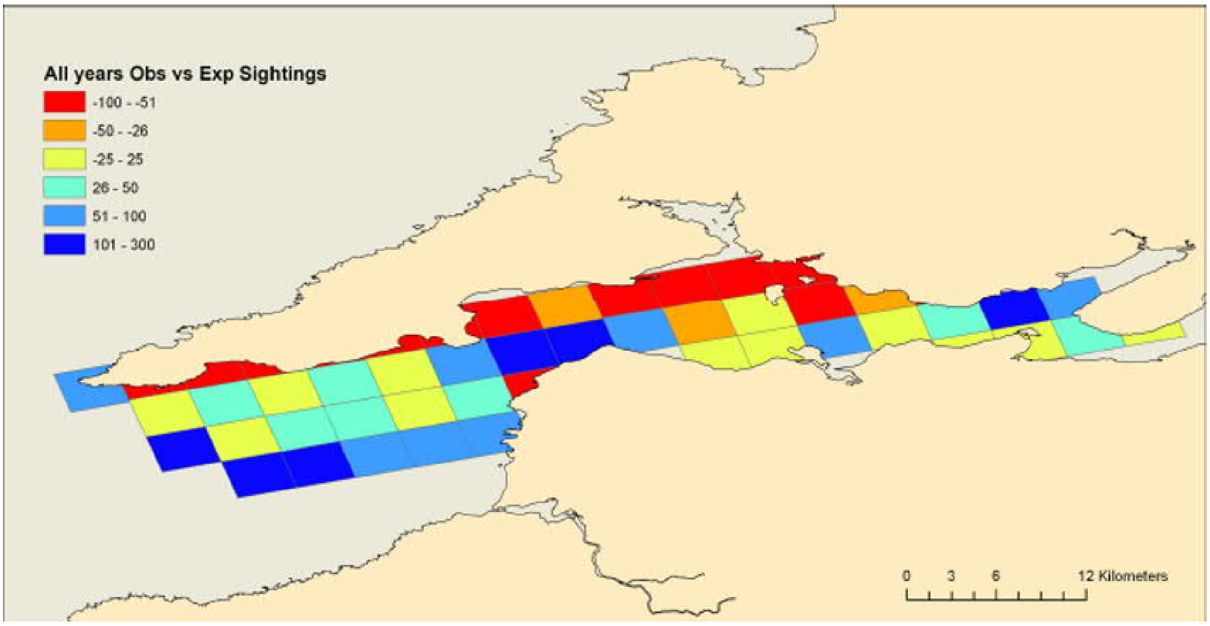

Figure 7A-8 Scoring Assessment for Habitat Suitability for Bottlenose Dolphins in the Shannon Estuary (adapted from Berrow *et al*., 2012)

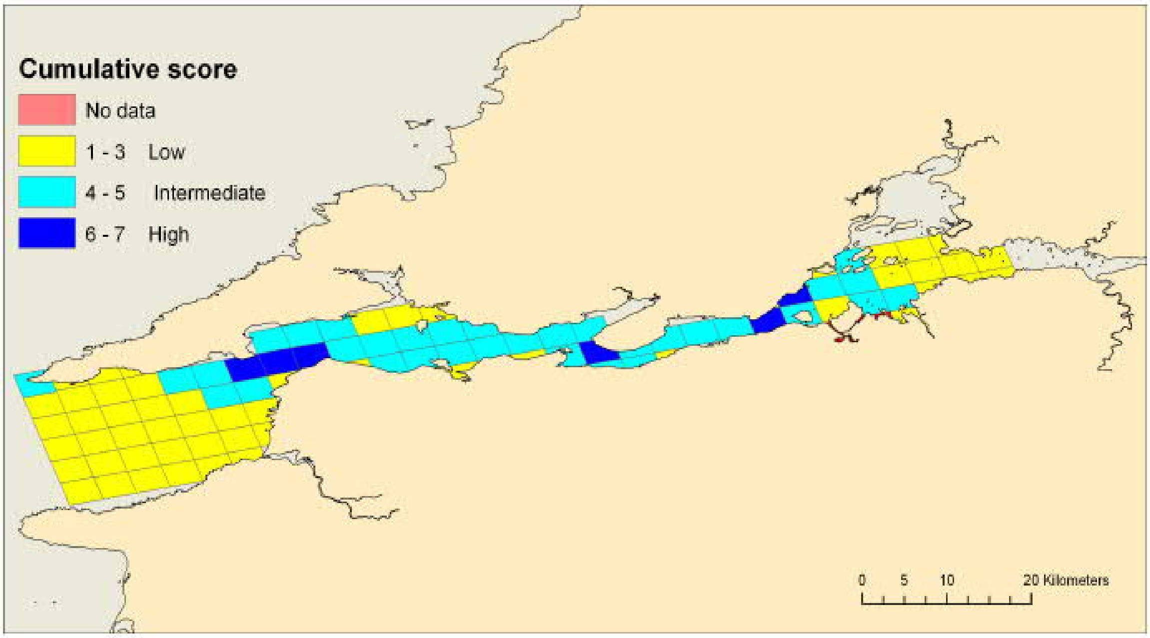

Figure 7A-9 Scoring assessment for Habitat Suitability for Bottlenose Dolphins in the Shannon Estuary (adapted from Berrow *et al.,* 2012)

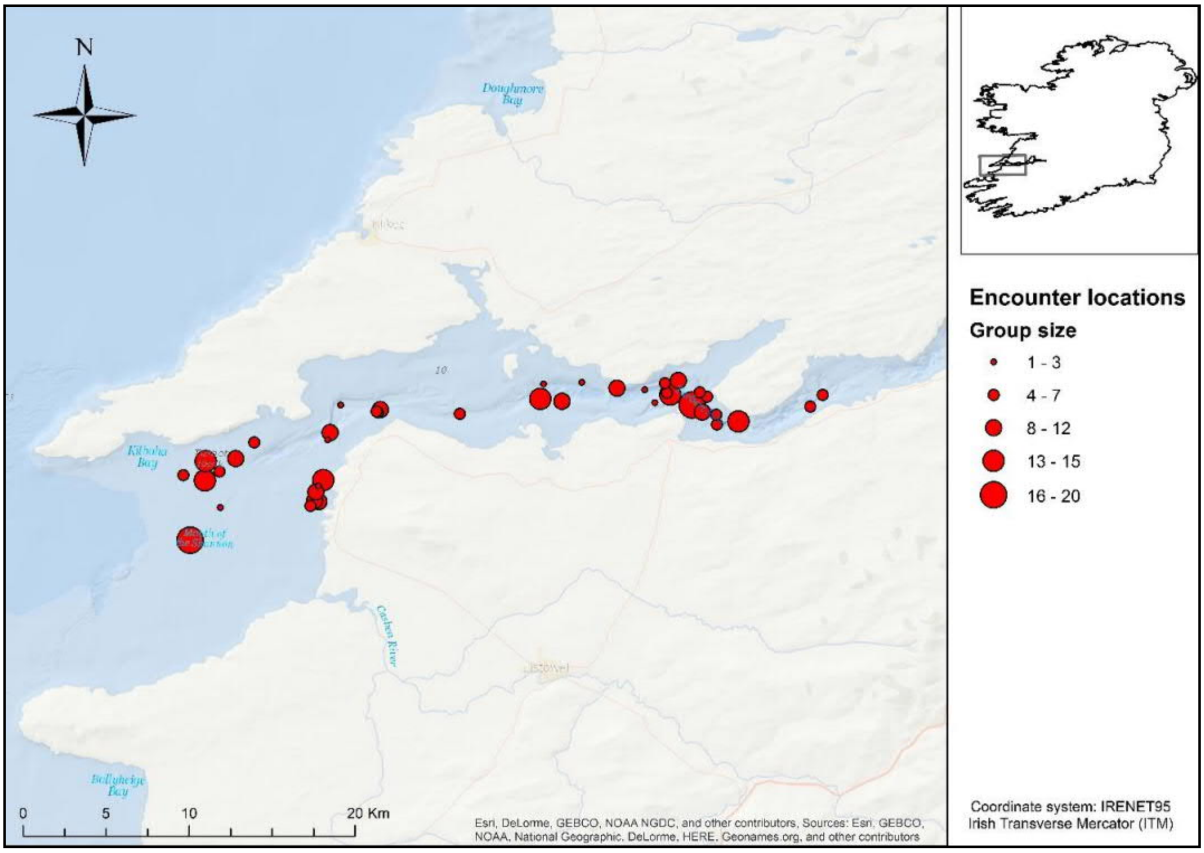

Figure 7A-10 Locations of Bottlenose Dolphin Schools Encountered during Surveys of the Lower Shannon Estuary, 2018. Estimated Group Sizes are Denoted by Symbol Diameters (adapted from Rogan *et al*., 2018)

Harbour Porpoise (*Phocoena phocoena*)

The Harbour Porpoise (*Phocoena phocoena*) (Linnaeus, 1758) is the most widespread and abundant cetacean species present in Irish waters (Berrow, 2001). Harbour Porpoise have been recorded all along the Irish coast but are most abundant off the south west and south east coasts (Wall *et al.* 2013). Harbour porpoise are listed on Annex II of the EU Habitats Directive and thus Special Areas of Conservation are required in order to protect a representative range of the habitats for this species in the member state. The sites are designated as Special Areas of Conservation (SACs) and must be surveyed regularly to ensure favourable conservation status of the qualifying interest is achieved.

Although harbour porpoise occurs regularly along the coast of Ireland (O'Brien, 2016), they are rarely seen in the Shannon Estuary (O'Callaghan *et al*. 2021). Sightings have occurred in the inner estuary (Berrow, 2020a, Berrow *et al.,* 2020; O'Callaghan *et al*,. 2021). One sighting was made on 22 October 2020 of a single harbour porpoise that was foraging for ~1 hr near Moneypoint (Berrow, 2020a; O'Callaghan *et al*., 2021). Another sighting of an adult and juvenile was made near Scattery Island in 2018 (O'Callaghan *et al.,* 2021). One sighting of two porpoise was made in the outer estuary during July 2005 (O'Callaghan *et al.,* 2021). In addition, six strandings have been reported in the Shannon Estuary (O'Callaghan *et al*., 2021). Possible porpoise clicks have also been detected during monitoring in summer/ fall 2018 at two sites off Ardmore Point (Berrow *et al.,* 2020) and off Moneypoint (O'Brien *et al.,* 2013). However, O'Callaghan *et al*., (2021) note that these high-frequency clicks could have been generated by dolphins.

Grey seal (*Halichoerus grypus*)

The grey seal (*Halichoerus grypus*) is the larger of two species of true seal (Phocidae) that commonly breed around the coast of Ireland and that travel, find food and engage in other ecological functions in its inshore and offshore waters. Grey seals in Ireland are generally considered part of a larger interacting population or metapopulation that also inhabits adjacent jurisdictions (*i.e.,* the UK and France at least). They occur widely in estuarine, coastal and offshore marine areas while individual seals may also occasionally travel upstream within river systems to a distance several kilometres from the coast (Ó Cadhla *et al*., 2013).

Grey seals are common in the Shannon Estuary. The National Biodiversity Data Centre (NBDC) database contains 231 records of the species in the Shannon Estuary, 46 of which are within close proximity to the proposed project. Rogan *et al*. (2018) reported four sightings of grey seals in Shannon Estuary during dolphin surveys in the summer/ fall of 2018, including two pups hauled out on a beach. During shore-based observations from Ardmore Point from April to August 2020, individual grey seals were seen on six occasions, five of which occurred within 500 m of the site (Berrow *et al*., 2020). Sightings of individual grey seals were also made during monitoring in October 2020, January 2021, February 2021 (Berrow, 2020a, 2021a,b). Cronin *et al.,* (2011) also reported movement of grey seals from the outer coast into the estuary and Cadhla and Strong (2007) documented a breeding site in the outer estuary. Duck and Morris (2013) reported two sightings in the Inner Shannon Estuary during summer surveys in 2003, but no sightings during surveys in 2012.

Harbour seal (*Phoca vitulina vitulina*)

The harbour seal *Phoca vitulina vitulina* is one of two seal species native to Irish waters. Like their larger grey seal (*Halichoerus grypus*) relatives, harbour seals have established themselves at terrestrial colonies (or haul-outs) along all coastlines of Ireland, which they leave when foraging or moving between areas, for example, and to which they return to rest ashore, rear young, engage in social activity, etc. (Cronin *et al.,* 2004). These seals come to shore during June to give birth and mate again around this time but usually in the water. Pups are capable of swimming within a few hours of being born but stay with their mother until weaned. Common Seals also come to shore to moult (shed their fur) during July and August often forming large groups on sheltered shores that have ready access to the sea. During this period when the majority of seals are ashore is when counts of animals are undertaken to estimate population size (Cronin *et al*., 2004).

Sightings reported through the NBDC identify three records of sightings of harbour seal in the inner Shannon Estuary, in the Fergus Estuary. The NBDC also identifies seven sightings of harbour seal close to the vicinity of the project, three at Kilrush, three at Scattery Island, and one at Tarbert.

Cronin *et al*., (2010) reported a gap in harbour seal distribution in the Shannon Estuary. Sightings reported through the NBDC include three records for the Fergus Estuary, and seven records near the proposed project location — three at Kilrush, three at Scattery Island, and one at Tarbert. Duck and Morris (2013) reported one harbour seal sighting in the Inner Shannon Estuary during surveys in 2012, and eight sightings during surveys in 2003; no sightings were made in the Outer Shannon Estuary during either survey.

Other Species of Marine Mammal

The NBDC online database records sightings and strandings of marine mammal species around the Irish coast. A total of 4 other whale and dolphin species have been recorded in the Shannon Estuary see Table 7A-5.

Table 7A-5 Marine Mammals Recorded in the Shannon Estuary (source NBDC)

Odontocetes (Toothed Whales and Dolphins)
Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)
Common Dolphin (*Delphinus delphis*)
Long-finned Pilot Whale (*Globicephala melas*)
Striped Dolphin (*Stenella coeruleoalba*)

Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

This dolphin often occurs in groups from tens to hundreds, and can occur in groups of up to 1,000, most often offshore. Their distribution in northwest Europe is predominantly clustered in an area from west of Ireland, to the north and north-west of Britain. Smaller numbers occur around the west of Ireland. It is possible that they follow mackerel as they spawn off the south-west of Ireland's coast in February/ March. The only record of an Atlantic White-sided dolphin in the Shannon Estuary was a stranded animal observed in 2005.

Common dolphin (*Delphinus delphis*)

Common dolphin is the most widespread and abundant dolphin species in Ireland, occurring throughout all Irish waters to varying densities with the bulk of the records from offshore waters on the Irish Shelf off the south and southwest coasts (Wall *et al*., 2013). Recorded all year round, the highest densities were recorded off the south and south-west coasts in the summer and autumn. Extremely large pods (100 – 1000s) can occur in the southern approaches of the Irish Sea in spring and summer. There are three records of Common Dolphin strandings from 2005-2015.

Long-finned Pilot Whale (*Globicephala melas*)

The long-finned pilot whale is one of the largest dolphins, with lengths averaging 6.7m for males and 5.7m for females, they have a square bulbous head with a lightly protruding beak. The body is dark grey to black with a grey-white anchor shaped patch on the chin. The species is typically found in water depth of 200 – 3,000 m beyond the Irish shelf edge where bottom relief is greatest but can also swim into coastal bays and fjords. They are often seen with other cetaceans, notably bottlenose dolphins. Most often, pilot whales occur in large pods (approximately 20 individuals), and large numbers of up to 1,000 have been observed off the British Isles during April, coinciding with the start of peak conception. There have been 4 events involving long-finned pilot whales in the Shannon Estuary according to the NBDC. These events occurred at Ballybunnion, Kerry; Carrigaholt, Clare; Beal Strand, Kerry and Poulnasherry, Clare.

Striped Dolphin (*Stenella coeruleoalba*)

These dolphins are sleek in appearance, with a body coloration consisting of dark grey cape extending from the beak to the dorsal fin, lighter grey flanks, leading to a pink-white underside. Sightings of striped dolphin in Ireland are very rare. By-catch data indicate their presence in the deep waters to the southwest of the Irish Shelf. This data is insufficient to infer seasonal or temporal trends. The NBDC database includes a number of 4 recorded strandings of the species in the Shannon Estuary, 1 at Carrigaholt, Clare, in 1993 and 3 at Ballybunnion between 2007 and 2012.

7A.4.5 Fish

A number of Ireland's native diadromous species pass through the Lower Shannon Estuary on their way to or from freshwater spawning grounds or reside there for feeding as they mature. These include four species of nature conservation interest in the area, namely twaite shad (*Allosa fallax fallax*), sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), and Atlantic salmon (*Salmo salar*). These are all listed on Annex II of Council Directive 92/ 43/ EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (EU Habitats Directive). The Habitats Directive ensures the conservation of a wide range of rare, threatened, or endemic species in Europe. Annex II species are classified as such when core areas of their habitat are designated as sites of community importance (SCIs), which must be managed corresponding to the species' ecological requirements. Additionally, the twaite shad and the sea lamprey are listed under Annex V, which mandates that EU Member States are required to manage exploitation of the species so that conservation status remains favourable (EU Commission 2021).

Fish stock surveys were conducted by Inland Fisheries Ireland in September to November 2008 and in October 2014 in the Upper and Lower Shannon Estuary using a beach seine, fyke net, or beam trawl (Kelly *et al*. 2015). Within the Upper Shannon Estuary, 15 and 22 species of fish were recorded during 2008 and 2014, respectively, and flounder, sprat and sandy goby were the most abundant species during the 2014 survey. Within the Lower Shannon Estuary, 31 fish species were recorded in a 2008 survey and 29 were recorded in 2014. Out of these species, sprat was the most abundant, followed by sand goby, thick-lipped mullet, and sand smelt (Kelly *et al*., 2015). European eels were caught in the Upper Shannon Estuary in 2008 and 2014, and the Lower Shannon Estuary in 2014 only (Kelly *et al.,* 2015).

Twaite Shad (*Alosa alosa fallax*)
Twaite shad is an anadromous fish and member of the herring (Clupeidae) family that is distributed across the north-eastern Atlantic, with Iceland as the northernmost extent of its range, Morocco as the southernmost and the Baltic Sea as the easternmost (Aprahamian *et al*., 2003). They are listed as *least concern* globally on the IUCN Red List (IUCN 2021) but as *vulnerable* in the Ireland Red List (King *et al*., 2011), a version of the IUCN Red List (using the same population status evaluations) in which regional species population statuses in Ireland are assessed, established by the National Parks and Wildlife Service. Adult twaite shad generally migrate from the marine environment into freshwater environments to spawn from February in the south of its range to May and June in the north (Davies *et al.,* 2020). The river migration period can last for three months, and seaward migration occurs for surviving adults after spawning and for young-of-the-year in the summer and fall (Maitland and Hatton-Ellis, 2003; Davies *et al*., 2020).

Four rivers in Ireland have been shown to support spawning grounds and spawning populations of twaite shad including the Munster Blackwater and the three rivers within the Barrow-Nore-Suir river system (King and Roche, 2008; Davies *et al*., 2020; Gallagher *et al*,. 2020), entries to which are located on the southwestern coast of Ireland.

Sea Lamprey (*Petromyzon marinus*) and River Lamprey (*Lampetra fluviatilis*)
Sea lamprey and river lamprey are anadromous species found in the Northern Hemisphere. The sea lamprey is listed as near threatened in the Ireland Red List (King *et al*., 2011), but as least concern globally on the IUCN Red List (IUCN, 2021), and the river lamprey is listed as least concern on both Red Lists. Their populations are declining in Ireland and Europe due to overharvesting, habitat destruction, and the loss of spawning and nursery grounds from the construction of anthropogenic barriers blocking upstream access (Igoe *et al*., 2004; Bracken *et al*., 2018). For example, Silva *et al*. (2019) found that sea lampreys in the River Ulla experience a mean delay of 6.3 days per river obstacle during upstream migration. Lampreys typically spend their first years (two to eight for sea lampreys, three to five for river lampreys) in freshwater before migrating out to sea following a period of metamorphosis (Igoe *et al*. 2004). During this period of metamorphosis, lampreys will spend up to ten months without feeding and will begin early feeding in estuarine or coastal waters (Silva *et al.* 2012). Sea and river lampreys return to freshwater as adults and will spawn in areas with fast-flowing water and gravel bottoms where they can create shallow depressions or nests. All lampreys are semelparous and will die after a single spawning event (Bracken *et al*., 2018).

Sea lampreys are found in all suitable rivers in Ireland and have been particularly noted in the River Shannon, River Suir, River Nore, River Moy, and the River Corrib (Igoe *et al.*, 2004). On the Mulkear

River, a main tributary of the River Shannon, adult sea lamprey have been found spawning over nests until mid-May, and most adults leave by early August (Igoe *et al.,* 2004). A study by Bracken *et al.* (2018) used environmental DNA (eDNA) to identify critical habitat for sea lamprey in Ireland. The eDNA sampling technique allows for the detection of low-density species and enables more effective and accurate deployment of resources and time allocation when collecting biological samples. Over a three-year period (2015-2017), they surveyed two different catchments in Ireland that included the Munster Blackwater and the Mulkear, the latter of which forms part of the Lower River Shannon cSAC. Sea lamprey spawning aggregations and habitat use within both catchment areas were confirmed following eDNA collection and eDNA concentrations were higher within the Mulkear catchment (Bracken *et al.,* 2018). River lampreys are less apparent than sea lampreys due to smaller body size, and documentation of distribution information in Ireland is less thorough, although its riverine range seems to largely overlap with that of the sea lamprey (Igoe *et al.*, 2004). Key populations of river lamprey have been documented in the Mulkear River, and large numbers have been recorded in the Lower River Shannon and its tributaries. Additionally, they inhabit rivers including the Slaney, Barrow, Nore, Munster Blackwater, Laune and Boney (Igoe *et al*., 2004), and lamprey larvae have been found in the Mulkear and Munster Blackwater rivers

European Eel (*Anguilla anguilla*)

The common or European eel, *Anguilla anguilla* (Linnaeus, 1758), occur throughout Ireland. The European eel is not listed as part of the EU Habitats Directive; however, it is considered critically endangered on the IUCN Red List (IUCN, 2021) and the Ireland Red List (King *et al.,* 2011) and is listed as a CITES Appendix II species, meaning the species is not currently threatened with extinction but trade is controlled to prevent this from occurring (CITES, 2021). Recruitment of juveniles into Irish catchments has declined dramatically.

European eels are a catadromous species that undergo five principal stages throughout their life history including the *leptocephalus*, glass eel, elver, yellow eel, and silver eel (adult) stages. Adult eels spawn in the Sargasso Sea, and larvae and *leptocephali* drift on the Gulf Stream until they are transported across the Atlantic Ocean (Arai *et al.*, 2006). *Leptocephali* metamorphose into glass eels and then elvers, with both stages typically arriving on the Irish coast during December and increasing in numbers during spring (Moriarty, 1999). At this point they typically migrate upstream, approximately six to eight months after hatching, with elvers using freshwater habitats to grow into yellow eels and mature as silver eels. However, not all eels undergo full upstream migration and are instead estuary-dependent, relying entirely on the estuarine environment for food resources, shelter, and nursing grounds. The estuarine environments in Ireland, however, are limited by high altitude land patterns; therefore, most eels are constrained during their growth period to either freshwater or marine environments (Arai *et al*., 2006). Mature adults will then migrate downstream to the sea in autumn with possible continuation through late spring.

The River Shannon is Ireland’s largest river system, and it has a network of lakes which are important habitats for the European eel. Within the river system, otolith analysis has determined that male silver eels are 11 years old on average, and females are 15 years old (McCarthy *et al*., 2008). Stocking programs of juvenile eel have been in place to address adverse effects of the Shannon hydropower structures on eel recruitment and were most successful during the 1970s and 1980s; however there are still steady declines in both yellow and silver eel populations in the Shannon system (McCarthy *et al.,* 2008). The fishery for European eel in the River Shannon is long established, with detailed records dating from 1960 onwards (McCarthy *et al.,* 1999).

Atlantic Salmon (*Salmo salar*)

Atlantic salmon is an anadromous species that is found in Europe and North America. Adult salmon migrate from the sea into rivers to spawn, usually in the same river that they spent time as a juvenile (CEFAS, 2021). Salmon require clean, well oxygenated rivers with gravel beds for the female to bury her eggs in redds. Spawning in Europe typically takes place from November to December. Juveniles hatch as alevins, emerge from the redds as fry and grow into parr. After approximately four years, parr become smolt through a process called smoltification and migrate to sea where they can mature (CEFAS, 2021). Atlantic Salmon are listed as vulnerable in Europe under the IUCN Red list (IUCN, 2021) and in Ireland under the Ireland Red List (King *et al*., 2011). Atkinson *et al.* (2020) studied the effects of river obstacles to anadromous species including Atlantic salmon and concluded that the removal of river obstacles such as bridges, culverts, would improve connectivity between river catchments and habitats.

Atlantic salmon has been observed spawning in the Lower Shannon Estuary and its tributaries. Catch and release studies of Atlantic salmon have estimated that the annual rod catch between 2009-2013 in the Mulkear, a large tributary of the Shannon catchment, was 970 salmon, while the Feale had an annual catch average of 1,350 (Gargan *et al*., 2015). Salmon monitoring programs conducted in the Shannon River Basin district since 2007 have concluded that three rivers (the Feale, Kilmastula, and Old Shannon) meet the conservation threshold of 17 salmon fry/ 5 min during electrofishing surveys showing healthy juvenile salmon abundance (Gargan *et al*., 2020).

Hearing

All fish have hearing and skin-based mechanosensory systems, such as the inner ear and the lateral line, that provide information about their surroundings (Popper *et al*., 2019a; Putland *et al*., 2019). While all fish are likely sensitive to particle motion, not all fish (*e.g.*, cartilaginous fish, such as sharks and jawless fish) are sensitive to the sound pressure component. Potential effects of exposure to anthropogenic sound on fish can be behavioural, physiological, or pathological.

Several authors have reviewed the hearing ability of fish (*e.g.* Popper and Fay, 1993, 2011; Popper *et al*., 2014, 2019a; Putland *et al*., 2019). At least two major pathways for sound transmittance between sound source and the inner ear have been identified for fish. The most primitive pathway involves direct transmission to the inner ear's otolith, a calcium carbonate mass enveloped by sensory hairs. The inertial difference between the dense otolith and the less-dense inner ear causes the otolith to stimulate the surrounding sensory hair cells. This motion differential is interpreted by the central nervous system as sound. The second transmission pathway between externally received sounds and the inner ear of fish is via the swim bladder, a gas-filled structure that is much less dense than the rest of the fish's body. The swim bladder, being more compressible and expandable than either water or fish tissue, will differentially contract and expand relative to the rest of the fish in a sound field. The pulsating swim bladder transmits this mechanical disturbance directly to the inner ear.

Some fish have been described as being hearing 'generalists' or 'specialists' where generalists conventionally detect sound to no more than 1-1.5 kHz and only detect the particle motion component of the sound field. Whereas specialists detect sounds above 1.5 kHz and detect both particle motion and pressure. However, Popper and Fay (2011) have suggested that the terms be dropped due to vagueness in the literature, and that the most common mode of hearing in fishes involves sensitivity to acoustic particle motion via direct inertial stimulation of the otolith organs. Additionally, they found that any possible sensitivities to pressure were the result of the presence of a swim bladder in the fish and that hearing sensitivity may be enhanced if the fish has a specific connection between the inner ear and the swim bladder (Popper and Fay, 2011).

Popper and Fay (2011) have also noted that there is a range of hearing abilities across fish species that is like a continuum, presumably based on the relative contributions of pressure to the overall hearing abilities of a species. One end of this continuum is represented by fish that only detect particle displacement because they lack pressure-sensitive gas-filled body parts (*e.g.* swim bladder). These species include elasmobranchs (*e.g.* sharks) and jawless fish and some teleosts including flatfish. Fish at this end of the continuum are typically capable of detecting sound frequencies <1.5 kHz *(e.g*., Casper *et al*., 2003; Casper and Mann, 2006; 2007; 2009). The other end of the fish hearing continuum is represented by fishes with highly specialized otophysical connections between pressure receptive organs, such as the swim bladder and the inner ear. These fishes include some squirrelfish, mormyrids, herrings and otophysan fishes (freshwater fishes with Weberian apparatus, an articulated series of small bones that extend from the swim bladder to the inner ear). Rather than being limited to 1.5 kHz or less in hearing, these fishes can typically hear up to several kHz. One group of fish in the anadromous herring sub-family Alosinae (shads and menhaden) can detect sounds to well over 180 kHz (Mann *et al*., 1997, 1998, 2001). This is one of the widest hearing ranges of any vertebrate that has been studied to date. While the specific reason for this very high frequency hearing is not totally clear, there is strong evidence that this capability evolved for the detection of the ultrasonic sounds produced by echolocating dolphins to enable the fish to detect, and avoid, predation (Mann *et al*., 1997; Plachta and Popper, 2003). All other fishes have hearing capabilities that fall somewhere between these two extremes of the continuum. Some have unconnected swim bladders located relatively far from the inner ear (*e.g*. salmonids, tuna) while others have unconnected swim bladders located relatively close to the inner ear (*e.g*. Atlantic cod, *Gadus morhua*).

Trout *(Salmo trutta)*

Trout share many of the biological features of its close relative, the salmon, but forms two basic types, the migratory sea trout and the non-migratory brown trout, *Salmo trutta* (Linnaeus, 1758). Trout spawn in winter from October to January. The eggs are shed in redds cut by the female in the river gravel, usually in upstream reaches, although many spawn in the gravel below weirs.

The Rivers Shannon, Fergus and Ballycorick are important habitats for trout (Michael Fitzsimons, Shannon Regional Fisheries Board, pers. comm.)

Smelt *(Osmerus eperlanus)*

The smelt, *Osmerus eperlanus* (Linnaeus, 1758), is considered an indigenous species in Ireland despite being recorded from only six locations. It is primarily a marine pelagic fish which congregates in river mouths before moving upstream to spawn in February to April (Whitehead *et al.*, 1984). The adults spawn in rivers and estuaries before returning to the sea. Juvenile fish remain in the estuary for the rest of the summer.

Smelt are one of the rarest fish in Ireland and are listed as vulnerable in the Irish Red Data Book. Smelt have been recorded from the River Shannon (Kennedy, 1948) and river Fergus where breeding populations have been confirmed (Quigley & Flannery, 1996). Their main breeding grounds are in the Shannon, upstream of Limerick to the Ardnacrusha Power Station Tailrace canal (M. Fitzsimmons, pers. comm.).

Resident fish species

The lower Shannon estuary, the River Fergus and Ballycorick Creek are typical estuarine environments and support diverse communities of small fish species, juvenile flatfish, gobies and sticklebacks. They are rich feeding grounds for adults and juvenile fish of many species including bass (*Dicentrarchus labrax*) plaice (*Pleuronectes platessa*) and flounder (*Platichthys flesus*).

In addition to diadromous species, the Shannon Estuary hosts a number of resident species, comprising rich species diversity. A survey was carried out by Inland Fisheries Ireland in 2014 and looked at the composition of fish species in the Lower Shannon estuary. A total of 29 fish species were recorded in the Lower Shannon Estuary in October 2014. Sprat was the most abundant fish species, followed by sand goby, thick-lipped mullet and sand smelt. Flounder was well distributed throughout this water body.

A number of species were newly recorded in 2014, including bib, coalfish/ saithe, grey gurnard, mackerel and sand sole. A number of species were previously caught in 2008 but not captured in the 2014 survey, including black goby, cod, European sea bass and European eel. This was the only water body surveyed during 2014 in which thornback ray was recorded.

Other species which account for a large proportion of the biomass in the Shannon Estuary include flounder (*Platichthys flesus*) and common goby (*Pomatoschistus microps*). The Shannon estuary provides rich feeding grounds for many other species such as sand smelt (*Atherina presbyter*), dab (*Limanda limanda*), three-spined stickleback (*Gasterosteus aculeatus*) and cod (*Gadus morhua*).

7A.5 Assessment of Impact and Effect

7A.5.1 Likely Significant Effects

Annex III of the amended Directive 2014/ 52/ EU requires that the EIAR should assess:

- The magnitude and spatial extent of the impact (for example geographical area and size of the population likely to be affected);
- The nature of the impact;
- The transboundary nature of the impact;
- The intensity and complexity of the impact;
- The probability of the impact;
- The expected onset, duration, frequency and reversibility of the impact;
- The cumulation of the impact with the impacts of other existing and/ or approved projects; and
- The possibility of effectively reducing the impact.

The potential impact mechanisms of the construction and operational phases of the Proposed Development on marine ecology are presented in Table 7A-6. Impact mechanism 1 and 2 are associated with the construction phase, impact mechanism 3, 4 and 5, are common to both the construction and operation phase, while impact mechanism 6, 7, 8, 9 and 10 are associated with the operation phase. Table 7A-6 also indicates where in this chapter impacts are assessed (Section 7A.5.3 through Section 7A.5.11).

Table 7A-6 Potential Impact Mechanisms

Potential Impact Mechanisms	Development Phase	Description	Assessed in
1. Release of pollutants during construction	Construction Phase	As with any construction project there is a risk that activities proposed for the construction of the LNG Terminal, Power Plant and jetty, and the installation of the gas pipeline may result in the accidental release of chemical pollutants or other waste material pollution to nearby habitats, watercourses and waterbodies. Potential chemical pollutants associated with construction plant equipment include fuels, oils, greases, hydraulic fluids (hydrocarbons). There is also risk of the accidental release of construction materials including concrete. Runoff from construction excavated material may result in the release of sediment, potentially impacting habitat and water quality. Given the nature and scale of the proposed works, there is potential that conservation features located adjacent to the works and immediately downstream and upstream of the works may be affected.	Section 7A.5.3
2. Release of spoil during piling	Construction Phase	The construction of the jetty structure will require piles to be installed. Underwater pile drilling operations will result in the generation and release of spoil (rock particles and sediment) to the water column potentially affecting local water quality (*e.g.* turbidity) and result in the generation of sediment plumes in the water column extending beyond the immediate works area. There is potential that the plume of spoil released may extend a significant distance from the works area. The increase in	Section 7A.5.4

Potential Impact Mechanisms	Development Phase	Description	Assessed in
		turbidity could result in a significant reduction of light in the water column. Spoil generated and released by piling operation may be deposited on benthic habitats resulting in smothering effects.	
3. Underwater noise	Construction Phase **and** Operation Phase	Piling operations will result in the generation of underwater noise. Noise emissions could potentially cause disturbance, physical injury and behavioural changes in fauna. The vessel activity (including the FRSU, tugs and LNGC) will result in the generation of noise, potentially affecting local ambient noise levels resulting in disturbance to fauna. There is potential that controlled rock blasting on land will generate underwater noise disturbance.	Section 7A.5.5
4. Seabed habitat loss	Construction Phase **and** Operation Phase	The installation of the jetty requires drilled piles to be installed in the seabed which will result in the direct loss of habitats and associated fauna. During the construction phase a trenched water outfall will be constructed across the shoreline into the Shannon estuary, which will result in the direct loss of habitats and associated fauna.	Section 7A.5.6
5. Vessel physical disturbance and collision injury	Operation Phase **and** Operation Phase	Additional vessel activity (including the construction scows and storage vessels, and FRSU, tugs and LNGC) will increase the potential for physical disturbance and collision injury to fauna. There is potential that mobile conservation feature species (*e.g.* marine mammals, bird species) may occur in the area where the vessels are operating and thereby be affected.	Section 7A.5.7
6. Discharge of Wastewater and Power Plant Process Heated Water Effluent	Operation Phase	Cooled sea water discharged to the estuary close to the head of the jetty and will contain sodium hypochlorite, potentially affecting local water conditions in the vicinity of the proposed discharge points.	Section 7A.5.8
7. Entrainment and impingement of fauna by the FSRU seawater system	Operation Phase	Potential that abstracting and pumping of seawater will result in fish and macrocrustaceans being entrained in the FRSU water intake and/ or impinged on the filter screens of the intake.	Section 7A.5.9
8. Discharge of Wastewater and Power Plant Process Heated	Operation Phase	Potential environmental impact associated with the treatment and disposal of secondary treated wastewater from onsite hygiene facilities. Heated water will be discharged to the estuary via the storm water outfall point, potentially affecting local water conditions in the vicinity of the proposed discharge points.	Section 7A.5.10

Potential Impact Mechanisms		Development Phase	Description	Assessed in
	Water Effluent		Given local water currents, the plume of discharge waters may extend over a large area.	
9.	Introduction of invasive species	Operation Phase	Potential increase in the risk of invasive organisms being imported by LNGC and FRSU in ballast water and as ship hull fouling.	Section 7A.5.11
10.	Accidental large scale oil or LNG spill	Operation Phase	Potential habitat loss, changes in water quality and fauna mortality from oil spill and/ or fire associated oil/ LNG spill during operation.	Section 7A.5.12

7A.5.2 Impact Assessment

7A.5.2.1 Potential Impacts

When describing changes/ activities and impacts on ecosystem structure and function, important elements to consider include positive/ negative, extent, magnitude, duration, frequency and timing, and reversibility.

Section 3.7 of the *Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports'*, (EPA, 2017) provides standard definitions which have been used to classify the effects in respect of ecology. This classification scheme is outlined below in Table 7A-7.

Table 7A-7 EPA Impact Classification

Impact Characteristic	Term	Description
Quality	Positive	A change which improves the quality of the environment.
	Neutral	No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error.
	Negative	A change which reduces the quality of the environment.
Significance	Imperceptible	An effect capable of measurement but without significant consequences.
	Not Significant	An effect which causes noticeable changes in the character of the environment but without significant consequences
	Slight	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.
	Moderate	An effect that alters the character of the environment in a manner consistent with existing and emerging trends.
	Significant	An effect, which by its character, magnitude, duration or intensity alters a sensitive aspect of the environment.
	Very Significant	An effect which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment.
	Profound	An effect which obliterates sensitive characteristics.
Duration and Frequency	Momentary Effects	Effects lasting from seconds to minutes.
	Brief Effects	Effects lasting less than a day.

Impact Characteristic	Term	Description
	Temporary Effects	Effects lasting less than a year.
	Short-term	Effects lasting one to seven years.
	Medium-term	Effects lasting seven to fifteen years.
	Long-term	Effects lasting fifteen to sixty years.
	Permanent	Effects lasting over sixty years.
	Reversible Effects	Effects that can be undone.
	Frequency	Describe how often the effect will occur. (once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, monthly, annually)
	Irreversible	When the character, distinctiveness, diversity, or reproductive capacity of an environment is permanently lost.
	Residual	Degree of environmental change that will occur after the proposed mitigation measures have taken effect.
	Synergistic	Where the resultant effect is of greater significance than the sum of its constituents.
	'Worst Case'	The effects arising from a development in the case where mitigation measures substantially fail.

7A.5.2.2 Determining Impact Significance

According to the EPA (2017), significance of effects is usually understood to mean the importance of the outcome of the effects and is determined by a combination of objective (scientific) and subjective (social) concerns.

The EPA further notes that:

'*While guidelines and standards help ensure consistency, the professional judgement of competent experts plays a role in the determination of significance. These experts may place different emphases on the factors involved. As this can lead to differences of opinion, the EIAR sets out the basis of these judgements so that the varying degrees of significance attributed to different factors can be understood*'.

With this in mind, the geographic frame of reference applied to determining impact significance by the NRA (2009) in Ireland and CIEEM (2019) in Ireland and the UK, has been adopted in this report in tandem with the EPA's qualitative significance criteria**.** Table 7A-8 compares the qualitative versus geographic approaches to determining the significance of effects.

Table 7A-8 Equating the Definitions of Significance of Effects Using a Geographic vs. Qualitative Scale of Reference

Geographic Scale of Significance (NRA, 2009; CIEEM, 2019)	Qualitative Scale of Significance of Effects (EPA, 2017)
Negligible or Local Importance (Lower Value). No significant effects predicted to significant ecological features.	**Imperceptible**. An effect capable of measurement but without significant consequences. **Not significant**. An effect which causes noticeable changes in the character of the environment but without significant consequences.

Geographic Scale of Significance (NRA, 2009; CIEEM, 2019)	Qualitative Scale of Significance of Effects (EPA, 2017)
Local Importance (Higher Value), County, National, Regional, or International.	**Slight/ Moderate/ Significant/ Very Significant/ Profound** *i.e.* effects can be slight, moderate, significant, very significant, or profound at Local scale, subject to the proportion of the local population/ habitat area affected.

The geographic frame of reference can be a good fit to assessments of biodiversity impacts because it allows clear judgements to be made about the scale of significance, with reference to published estimates for the population size of a given species at county, national and/ or international scales or areas of habitats at such scales.

The proportion of a known feature impacted at county scale (*i.e.* 1% of the known or estimated population in a given county) is measurably different from that impacted at national scale (*i.e.* 1% of the known or estimated national population).

A non-geographic qualitative approach can be a poor fit to assessments of biodiversity since the definitions provided for the different qualitative terms do not relate to measurable units of space such as a county or national boundary. For instance, a significant effect is defined by the EPA as '*an effect which, by its character, magnitude, duration or intensity alters a sensitive aspect of the environment without affecting its sensitivities*', whilst a very significant effect is that which '*by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment*'.

7A.5.2.3 Summary Valuation of Significant Marine Ecology Features

As per the impact assessment methodology outlined in above, significant ecological features are considered to be those valued at Local Importance (Higher Value) or higher as per NRA (2009) and CIEEM (2019) definitions. Table 7A-9 summarises all significant ecological features identified within the ZoI of potentially significant impacts.

Table 7A-9 Summary Valuation of Significant Marine Ecological Features and Identification of Features

Feature		Highest Value within Zone of Influence	At risk of significant impact	Scoped into marine ecology assessment
Designated sites	Lower River Shannon SAC	International	Yes	Yes
	River Shannon and River Fergus Estuaries SPA	International	Yes	Yes
Habitats	Mudflats and sandflats not covered by seawater at low tide [1140]	International importance	Yes	Yes
	Large shallow inlets and bays [1160]	International importance	Yes	Yes
	Estuaries [1130]	International importance	Yes	Yes
	Reefs [1170]	International importance	Yes	Yes
	Sandbanks which are slightly covered by sea water all the time [1110]	International importance	Yes	Yes
	Coastal lagoons [1150]	International importance	Yes	Yes

Feature		Highest Value within Zone of Influence	At risk of significant impact	Scoped into marine ecology assessment
	Salicornia and other annuals colonising mud and sand [1310]	International importance	Yes	Yes
	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]	International importance	Yes	Yes
	Mediterranean salt meadows (*Juncetalia maritimi*) [1410]	International importance	Yes	Yes
Marine Mammals	*Tursiops truncatus* (Common Bottlenose Dolphin) [1349]	International importance	Yes	Yes
	Phocoena phocoena (Harbour Porpoise) [1351]	International importance	Yes	Yes
	Halichoerus grypus (Grey Seal) [1364]	International importance	Yes	Yes
	Phoca vitulina (Harbour Seal) [1365]	International importance	Yes	Yes
Fish species	*Salmo salar* (Atlantic Salmon) [1103]	International importance	Yes	Yes
	Lampetra fluviatilis (River Lamprey) [1099]	International importance	Yes	Yes
	Petromyzon marinus (Sea Lamprey) [1095]	International importance	Yes	Yes
	Alosa alosa fallax (Twaite Shad) [1103]	International importance	Yes	Yes
	Osmerus eperlanus (Smelt)	International importance	Yes	Yes
	Anguilla anguilla (European Eel)	International importance	Yes	Yes

7A.5.3 Impact Mechanism 1. Release of Pollutants During Construction

7A.5.3.1 Relevant Receptors

- Habitats;
- Marine Mammals; and
- Fish.

7A.5.3.2 Assessment

Impact mechanism 1 is associated with the construction phase.

Potential effects associated with construction activity include the accidental release of sediment and chemical pollutants to the Shannon Estuary immediately adjacent to, and upstream and downstream, of the Proposed Development.

Sediment

The Shannon Estuary is naturally turbid with background level suspended solids ranging from 1 mg/l up to 86 mg/l (McMahon and Quirke, 1992). Excessive suspended sediments can cause stress and affecting the gills of fish, resulting in injury or mortality and the loss of suitable fish spawning habitat and declines in egg and early life stage success rates. Increased turbidity can reduce feeding rates and affect prey abundance and predation efficacy in visual feeders such as salmon. Resident fish species in the Shannon Estuary including Lamprey, Salmon, Seatrout have evolved over geological time to migrate through estuaries on their way to spawning grounds and as many estuaries are naturally high in turbidity, these species evolved mechanisms to deal with high suspended sediment loads.

Bottlenose dolphin use echolocation as their principal means of navigation, communication, foraging and predator avoidance. In murky waters, the use of echolocation means that objects are often 'heard' before they are seen (Ansmann, 2005). As dolphin are accustomed to the naturally turbid nature of the Shannon Estuary impacts due to short-lived changes in turbidity are unlikely to impact the species.

Should sediments be released to the Shannon Estuary, the effect of increased turbidity, if realised, will be short lived with the local currents in the immediate area resulting in sediment being rapidly removed from the system and significant sediment deposition in the area will not occur. In the event of significant release of sediment from the construction works, local currents are such that any localised deposition of sediment will be short lived with sediments rapidly dispersed seaward.

In addition, any effects are not likely to be significant for local habitats and fauna, as the area is naturally turbid (see above) and hydrodynamically active and experiences a high degree of natural suspended solids. Consequently, there is no risk of significant effects to benthic habitats.

Through the implementation of construction best practice and mitigation and monitoring measures, the risk of activities during the construction resulting in the uncontrolled release of sediment material to the nearby river and habitat types is extremely unlikely to occur. Mitigation and monitoring measures and the general construction practices to be implemented are outlined in Section 7A.6 and the Outline Construction Environmental Management Plan (OCEMP) provided in Appendix A2-4, Vol. 4).

Chemical Pollutants

Accidental release of hydrocarbons from plant machinery and fuel stocks, and organic polymers or heavy metals associated with cementing/ concreting materials used for construction activities. These materials are toxic to organisms in sufficient quantities and will potentially contaminate the seabed sediments adjacent to the project, inhibiting recolonisation of the area.

Chemical contamination of the river and river sediments could also occur from accidental spillages, such as oil and other chemicals through poor operational management, the non-removal of spillages, poor storage, handling and transfer of oil and chemicals. Hydrocarbon spills from poorly secured or non-bunded fuel storage areas, leaks from vehicles or plant or spills during re-fuelling can all give rise to the escape of hydrocarbons from construction sites.

Wash off from poorly cured cement can also be highly alkaline and potentially dangerous to fish. Spills of hydrocarbons and chemicals can give rise to tainting of fish or, if large enough, fish kills and invertebrate kills. Accidental release of chemicals and pollutants must be controlled to ensure risk of impacts are minimised.

If suitable precautions are taken and best practice for the storage, handling and disposal of such material are followed, impacts should be minimal.

Mitigation measures specifically designed to avoid the introduction of runoff and contaminants to the Shannon Estuary are detailed in Section 7A.7.1 and the OCEMP provided in Appendix A2-4, Vol. 4).

Accidental spillages will be contained and cleaned up immediately. Remediation measures will be carried out in the unlikely event of pollution of the marine environment.

7A.5.3.3 Conclusion

Likely impacts during the construction phase in the absence of mitigation are assessed as **negative**, **significant** and **short-term**.

Mitigation measures to prevent release of sediments, chemical and pollutants during construction are detailed in Section 7A.7.1.

With the implementation of mitigation likely impacts associated with impact mechanism 1 are predicted to be **not significant**.

7A.5.4 Impact Mechanism 2. Release of Spoil During Piling

7A.5.4.1 Relevant Receptors

- Habitats;
- Marine Mammals; and
- Fish.

7A.5.4.2 Overview

Impact mechanism 2 is associated with the construction phase.

The construction of the 345-m jetty and access trestle will require the installation of approximately 203 piles.

Piling for the construction of the jetty will also commence during this period, initially from onshore (approximately four and half months) followed by approximately eleven months from the water. The jetty construction works will operate on a 24 hour basis, 6 days a week with maintenance works on Sundays and over approximately 15 ½ months. Security arrangements will also be in place full time. Note that impact piling activities will not commence during night-time hours.

The majority of the piles supporting the jetty would be driven, with some piles drilled and socketed into the underlying rock to ensure stability of the jetty. This operation would require a jack-up platform supporting a large crane-mounted drill and a large barge-mounted support crane.

There is potential that spoil (drilling rock particles and sediment) generated and released to the water column may increase turbidity resulting in a significant reduction of light for phytoplankton. There is also the potential that the deposition of solids on benthic habitats will result in the smothering of organisms. High levels of suspended solids settling on the seabed can alter habitats resulting in a potential loss of feeding and spawning grounds. Mobile species may move away from unfavourable conditions, however sessile, benthic fauna may be smothered and lost. Solid generated and released by piling may be deposited on benthic habitats.

Shannon LNG commissioned AQUAFACT to carry out a hydrodynamic and dispersion modelling study to determine the fate of sediment generated during piling operations required for the installation of the jetty for the Proposed Development. The full modelling report is included in Appendix A7A-5.

7A.5.4.3 Assessment

The average pile length will be approximately 20 m resulting in total pile volume of 1,980m^3. At a porosity of 20% the total mass of sediment spoil removed by the piling operation is estimated conservatively to be 5,500 tonnes. Spoil from the drilling operation will be conveyed to the surface using a reverse-circulation drilling rig (*e.g.* LD408 drilling rig) and collected in designated scows or other storage vessels.

Approximately 1000 m^3 pile arisings are anticipated from the socketed piles (approximately 80 no.), none of which will be from onshore piling operations. The spoils would be placed on a barge, dried, and then transferred to shore for drying and reused in general earthworks or in landscaped bunds. To allow for disturbance of sediments by the piling process and potential spillage of solids via reverse circulation drilling, a conservative factor of 25% of the sediment removed is used as a spillage rate of sediment. Sediment transport simulations are carried out based on a fine to very fine sand as identified in the geotechnical investigations. An 18-day simulation was performed with 0.9kg/s of sediment releases continuously from the site of the pilling operations. The full details of the model are included in the modelling report included in Appendix A7A-5.

Habitats

Modelling shows that while the predicted plumes of spoil extend significant distances from the operations deposition is largely spatially limited to areas along the south and north coasts of the estuary, and the islands to the north west of the jetty (see Figure 7A-13). This to be expected because, as noted above in Section 7A.5.3, the Shannon Estuary is naturally turbid (background suspended solids ranging from 1 mg/l up to 86 mg/l; McMahon and Quirke 1992) and hydrodynamically active and any release of sediment to the river will, at most, result in short lived and localised elevated turbidity levels with local water currents rapidly dispersing sediments seaward. On the south coast, sediment deposition rate in the majority of areas ranges is predicted to be between 0.01 and 0.001 mm/m^2 (see Figure 7A-13). In small discrete areas approximately 400 to 800 m downstream of the piling operations, predicted sediment disposition rate ranged between 2 to 5 mm/m^2 while further west at Ballylongford Bay and southwest of Carrig Island the deposition rate is predicted to be 2 mm/m^2 (see Figure 7A-14). Moving northward from the south coast and the piling operations, sedimentation rate drops below 0.001 mm/m^2 on account of fast moving currents resulting in all generated sediment being rapidly removed from the system. On the north coast, and around the islands to the north west of the jetty, the predicted rate of sediment deposition is low ranging from 0.01 to 0.001 mm/m^2.

The OSPAR Commission (OSPAR, 2008, 2009) note that benthic fauna can survive rapid sediment deposition up to depths of 100mm, 20 times the maximum depth predicted by the model (see Appendix A7A-5). Further, OSPAR (2008, 2009) also state that negative impacts to marine life are only expected when sediment deposition depths exceed 150 mm.

Likely impacts to habitats associated with the release of spoil during the construction phase is assessed as **negative**, **not significant** and **temporary**.

Species

As discussed in Section 7A.5.3, increased turbidity can reduce feeding rates and affect prey abundance and predation efficacy in visual feeders. Otter and cormorant are visual hunters with good eyesight both above and below the water. The release of sediments in the water column during piling and the resuspension of sediments during construction has the potential to significantly affect turbidity levels. Otter and cormorant are highly mobile species and while their eyes are adapted for seeing food item in murky or dark water, they will avoid areas of excessive turbidity. While significant increases in turbidity may result in the temporary displacement of the species, there are extensive alterative areas of otter and cormorant habitat available to the species away from the project area. Consequently, there is no risk of significant effects.

Prolonged suspension of sediments may also lead to reduced primary productivity in waters, in turn depressing oxygen levels. However, given the temporary nature of the work and the action of local water current removing suspended solids from the works area, there is no risk of significant effects.

Given the scale and temporary nature of piling works any significant elevated turbidity would be limited spatially and temporally to the immediate project area; consequently there is no risk of significant effects.

Diadromous fish species have evolved over geological time to migrate through estuaries on their way to spawning grounds and as many estuaries are naturally high in turbidity, these species evolved mechanisms to deal with high suspended sediment loads.

Likely impacts to species associated with the release of spoil during the construction phase is predicted to be **negative**, **not significant** and **short-term**.

7A.5.4.4 Conclusion

Based on the above, the likely impact of spoil released during piling operations the construction phase to habitats or species is predicted to be **negative**, **not significant** and **short-term**.

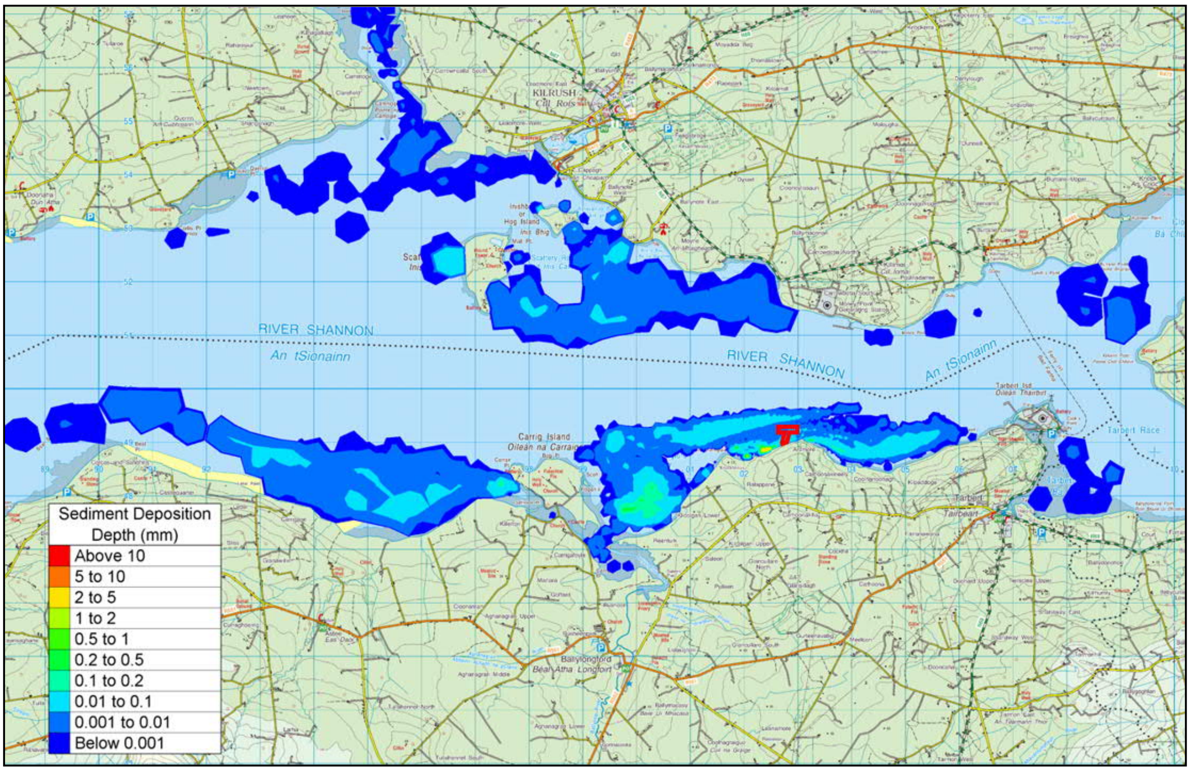

Figure 7A-11 Maximum Sediment Deposition Rate. Approximate Location of Jetty Shown in Red

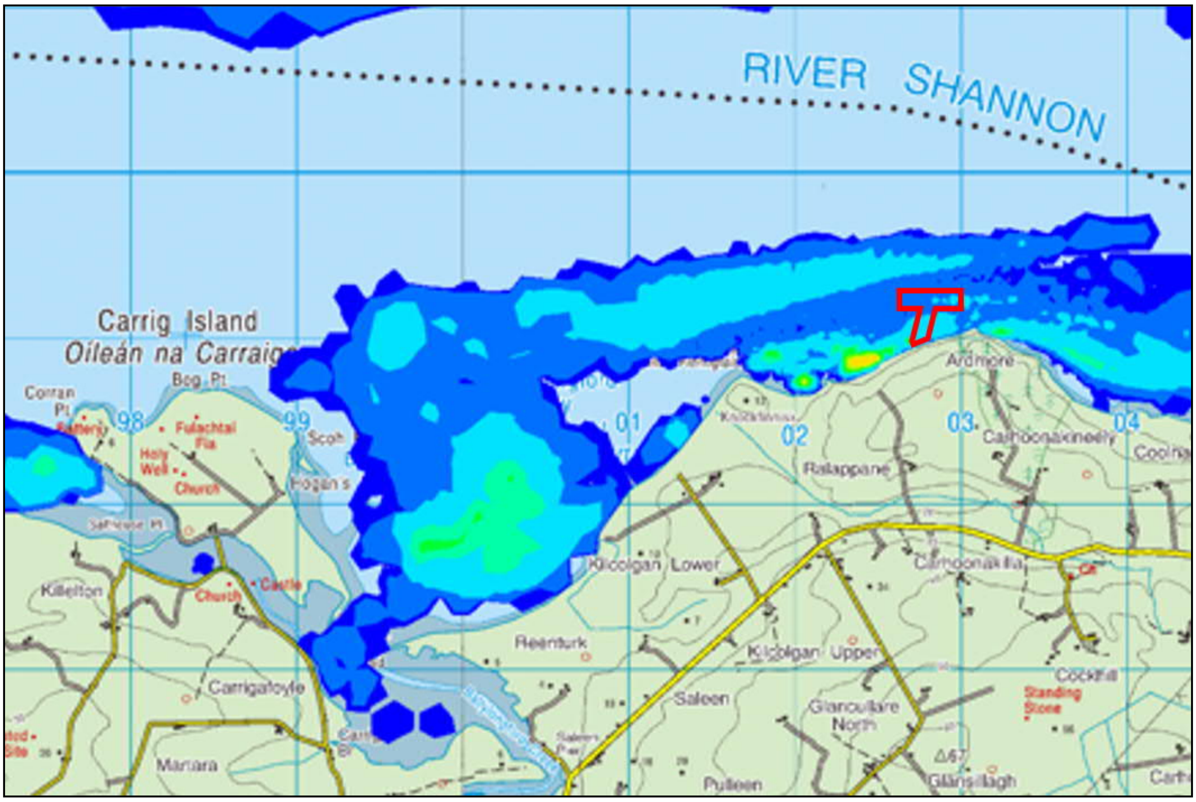

Figure 7A-12 Maximum Sediment Deposition Rate. Approximate Location of Jetty shown in Red

7A.5.5 Impact Mechanism 3. Underwater Noise

7A.5.5.1 Relevant Receptors

- Marine Mammals; and
- Fish.

7A.5.5.2 Assessment

Impact mechanism 3 is associated with the construction and operation phase.

Activities associated with the construction and operation of the LNG Terminal (*e.g.* pile driving, vessel noise) have the potential to impact marine mammals and fish by introducing sound into the marine environment.

To assess potential effects of project activities on bottlenose dolphins, the number of acoustic exposures that may occur during the planned activities was calculated based on the occurrence of dolphins in the area and the extent of the potentially affected area which was determined by underwater acoustic modelling and available sound threshold criteria.

In addition, the potential impact on other marine mammals and fish were also assessed, based on modelled distances to available sound threshold criteria. The results are discussed within the context of the Proposed Development and in light of the mitigation and monitoring measures that are anticipated to be implemented.

A 345-m jetty with a central loading platform, six mooring dolphins, and four breasting dolphins would be constructed to access the deeper waters of the estuary (Brown and Worbey 2020). Approximately 203 piles would be installed using a combination of techniques including a hydraulic impact hammer, vibratory hammer, and/ or continuous flight auger (CFA) techniques. The exact number of piles is subject to the final design. Piling for the construction of the jetty will commence, initially from onshore (approximately four and half months) followed by approximately eleven months from the water. The jetty construction works will operate on a 24 hour basis, 6 days a week with maintenance works on Sundays and over approximately 15 ½ months. Note that impact piling activities will not commence during night-time hours. The pile diameter would be ~1.067 m, and a 150 kJ impact hammer would be used. Noise from onshore blasting could also enter the water.

The FSRU would not be permanently moored at the jetty and would depart the jetty when necessary. Loading of LNG onto the FSRU would be via a ship-to-ship transfer from an LNG carrier berthed alongside. The FSRU would have an LNG storage capacity of up to 180,000 m^3. Up to one LNG carrier ship (LNGC) per week is expected to deliver its cargo to the FSRU (Brown and Worbey, 2020).

7A.5.5.3 Receptors

Common Bottlenose Dolphin

Bottlenose dolphin use echolocation as their principal means of navigation, communication, foraging and predator avoidance. The individual monitors its surroundings by emitting sound waves and waiting for them to reflect off different objects (Weilgart, 2007; Ansmann, 2005; Potter and Delroy, 1998). The time taken for these pulses to return to the animal, as well as the characteristics of the reflected pulse, gives an indication of the distance and nature of the object. Light propagates poorly in the viscous and opaque marine environment and is absorbed within a few tens of metres (Potter and Delroy, 1998; Nowacek *et al*., 2007). Low frequency underwater sound may travel for hundreds of kilometres without losing intensity (Nowacek *et al*., 2007). In murky waters, the use of echolocation means that objects are often 'heard' before they are seen (Ansmann, 2005). This ability is extremely effective; bottlenose dolphin, can differentiate between two aluminium plates varying by just 0.23 mm and can detect objects up to 113 m away (Au, 2002). This level of precision is indicative of the importance of echolocation for foraging and navigation by some species of cetaceans.

The potential impacts of noise on marine mammals have been the subject of considerable research; reviews are provided by Richardson *et al*. (1995), Nowacek *et al*. (2007), Southall *et al*. (2007), Weilgart (2007) and Wright *et al*. (2007). If the frequency of anthropogenic noise overlaps with the frequencies used by marine mammals, this may reduce the animal's ability to detect important sounds for navigation, communication and prey detection (Weilgart, 2007). This is termed acoustic masking, which may occur anywhere within an organism's auditory range (Wright *et al*., 2007; Richardson *et al*., 1995). Masking of important vocalisations will result in increasing information ambiguity and, in extreme circumstances, may result in cetaceans being unable to orientate themselves or hunt/ evade predation in the marine environment (Wright *et al*., 2007).

Exposure to high energy noise emissions (piling, drilling, seismic noise) can result in non-recoverable auditory injury (termed Permanent Threshold Shift (PTS). Behavioural reactions to acoustic exposure are generally more variable, context-dependent, and less predictable than the effects of noise exposure on hearing or physiology. This is because behavioural responses to anthropogenic sound are dependent upon operational and environmental variables, and on the physiological, sensory, and psychological characteristics of exposed animals. It is important to note that the variables may differ (greatly in some cases) among individuals, of a species and even within individuals depending on various factors (*e.g.* sex, age, previous history of exposure, season, and animal activity). NOAA (2013) outline that noise can affect cetacean behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Fish Species

Sound is perceived by fish through the ears and the lateral line (the acoustico-lateralis system) which is sensitive to vibration. Some species of fish such as salmon have a structure linking the gas filled swim bladder to the ear. The swim bladder is sensitive to the pressure component of a sound wave, which resonates as a signal that stimulates the ears. These species, therefore, usually have increased hearing sensitivity. Such species are considered to be more sensitive to anthropogenic underwater noise sources than species, such as lamprey, that do not possess a structure linking the swim bladder and inner ear.

It should be noted that the potential impact of noise on juvenile and adult fish in open water is considered to be minimal as they can readily move away from the noise source. Experiments on fry demonstrated balance problems resulting from exposure to an energy source, however, the effects were temporary with full recovery observed after a few minutes upon cessation of the noise (Kostyuchenko, 1971). Some studies of high energy seismic noise sources have also demonstrated fish's ability to acclimatise to noise associated with an energy source over time (*e.g.* Chapman and Hawkins, 1969).

Hearing in salmon is poor, the species responding only to low frequency tones (below 0.38 kHz). While there are no data available for hearing in lamprey, it is highly unlikely that they detect sound close to 10 kHz (Popper, 2005). The lamprey ear is relatively simple and there is nothing within the structure of the ear or associated structures to suggest any specialisations that would make them into anything but a hearing generalist, with maximum hearing to no more than several hundred Hz.

7A.5.5.4 Assessment of Potential Noise Impacts

The Irish Whale and Dolphin Group (IWDG) was contracted by Shannon LNG to monitor the use of the site by bottlenose dolphins (Berrow *et al.,* 2020). A combination of land-based Vantage Point (VP) watches and static acoustic monitoring (SAM) was used to describe the use of the site by bottlenose dolphins and any other marine mammals (seals) present, and their distribution and relative abundance at the site. The survey work built upon data obtained from 2006 and 2007 and other recent publicly available information. The report concluded that:

In conclusion, we have shown that bottlenose dolphins regularly use the waters off Ardmore Point, which is the site of the proposed Shannon LNG terminal. The results *from monitoring during 2019-2020 are broadly* consistent *with results obtained during monitoring at the same site during 2006-2007. Although dolphins were regularly recorded at the site there use seems largely transitory, passing through the site. There was no evidence dolphins are present for long periods or that it is used for foraging. However, the site is an important part of the range of the bottlenose dolphins in the Shannon estuary.*

LGL was commissioned by Shannon LNG to carry out an ecological assessment of noise generated by the construction and operational phases of the project on fish and marine mammal species (LGL, 2021) (see Appendix A7A-4). The findings of the LGL assessment are presented below.

The ecological assessment of the potential impacts of noise on marine mammals is based on estimates of how many marine mammals are likely to be present within a particular distance of activities and/or exposed to a particular level of sound. This approach is an accepted common practice, that in most cases, likely overestimates the numbers of marine mammals that would be affected in some biologically important manner, as animals tend to move away from loud sound sources before the sound level is at or above the threshold.

The assessment considered potential impacts associated with different scenarios/project activities at various positions: (1) a stationary FSRU which emits hull-radiated sound continuously, including noise from seawater cooling pumps, (2) an FSRU with an offloading LNGC tied to it and one idling tug, (3) impact pile driving, (4) vibratory pile driving with support vessels (5) socket drilling with support vessels, and (6) blasting were all modelled at the marine terminal, while (7) an approaching LNGC assisted by four transiting tugs was modelled at a location 1,150 m northwest of the terminal, along with the FSRU at the marine terminal; and (8) the FSRU together with a berthing LNGC and four sailing tugs were modeled at the marine terminal together with a general cargo ship sailing in the middle of the estuary and a ship moored at Moneypoint. Scenario 8 is referred to as the cumulative sound scenario. This multi-sequence scenario is based on the offloading scenario, with the addition of the cargo ship and moored ship. For this scenario, the following were assumed: FSRU operating continuously for 24 h, LNGC and idling tug performing offloading for 6 h, LNGC and 4 sailing/engaged tugs transiting for 15 min, cargo ship sailing for 15 min, and moored ship at Moneypoint continuously for 24 h.

Although two potential PTS exposures have been estimated for bottlenose dolphins from impact pile driving over the course of all pile driving activity, no PTS or other injuries would be expected because of the relatively short distance (94 m) to the threshold criteria and the monitoring and mitigation measures that would be implemented. Monitoring and mitigation measures would follow those in the NPWS 2014 guidance (Section 7A.7.2 for details) and would lower the likelihood of impacts from construction activities. Although PTS was modelled to be a possibility relatively far from impact pile driving (up to 3163 m) for harbour porpoise, these cetaceans rarely occur within the Shannon Estuary.

Monitoring and mitigation measures during project construction would include the use of qualified marine mammal observers to monitor during sub-tidal piling operations and the commencement of piling would be delayed if the observers sight any marine mammals within 1,000 m of the site for 30 minutes prior to the planned start of piling. Since impact piling cannot always be stopped immediately if a marine mammal approaches once piling has commenced, some potential for impacts would remain, including potential for TTS. Nonetheless, the 1,000-m mitigation zone is overly precautionary given that the MF-weighted PTS threshold was modelled to occur out to a maximum distance of 94 m.

During operations, the PTS and TTS thresholds that could be exceeded by the activities are all based on accumulated sound over a period of time (sound exposure levels). This means that individuals would have to remain within the predicted distances for the entire duration of the activity, or for at least 24 hrs if the activity lasts longer than a day, in order to experience TTS or PTS. Additionally, the operational scenarios often involved multiple sources operating in different locations. This means that the distances calculated are not continuous in all directions and any one of the sources, resulting in gaps where received sound levels would be below the threshold levels. These factors, along with the highly mobile nature of marine mammals means the it is very unlikely that any marine mammals will experience PTS or even TTS from the planned activities.

Using the available information on dolphin abundance and distribution within the Shannon Estuary, we have estimated that there are likely to be very few daily instances of bottlenose dolphins (or other marine mammals) being affected via disturbance during either construction or operational activities associated with the Shannon LNG project. For all construction activities, and most of the operational scenarios, distances to disturbance thresholds would be less than 140 m. Since the location where the in-water structures will be installed and the immediate vicinity around that are not known to be important feeding or calving areas, temporary avoidance at these distances is not likely to have significant impacts. In addition, strong impulsive sounds from impact pile driving would occur over relatively short periods of time (1 hr per day, or 4% of the time), leaving most of the time available for undisturbed movements through the area. Similarly, the two operational scenarios with disturbance threshold distances of almost 1 km, Scenarios D and E, would only occur for relatively short periods of time (less than 1 hr per day) and infrequently (up to 3 times per week). The temporal aspects (limited duration and infrequent occurrence) of these most potentially behaviourally disruptive activities mean they are unlikely to substantially disrupt important marine mammal behaviours that might occur in this region of the estuary. Since dolphins are highly mobile within the estuary and operations will occur over many years, it is likely that all individuals in the population could be exposed at some point in time to noise from the project. Nonetheless, the potential disturbance exposures likely would have no more than a minor effect, such as localized short-term avoidance of the area around the activities by individual animals and no effect on the population.

Our analysis method used MF-weighting for estimating potential disturbance exposures since it emphasizes the frequencies that are of most relevance to bottlenose dolphins. However, Kastelein et al. (2015, 2016) reported that harbour porpoise (high-frequency cetacean) hearing sensitivity was reduced when exposed to multiple impulsive pile-driving sounds with most energy at low frequencies. These findings suggest that there could be potentially greater impacts of low-frequency sounds on bottlenose dolphins than expected, but the exposure estimates for the development are almost certainly overestimates, and there is no indication that the project activities would be likely to cause significant harm to individuals or the population.

The population of bottlenose dolphins in the Shannon Estuary has remained stable for the past 20 years and has demonstrated evidence of long-term fidelity and seasonal residency despite inhabiting a busy and noisy region with various industrial activities, ferry traffic, and shipping (Ingram 2000; Ingram and Rogan 2002; Englund et al. 2007, 2008; Rogan et al. 2018). Thus, it is anticipated that the dolphins in the vicinity of the project would likely habituate to the sounds produced during project activities as they have to other similar noise and vessel traffic in the estuary. Habituation of bottlenose dolphins to noise has been shown to occur elsewhere. For example, in Aberdeen Harbour, Scotland, an area with high vessel activity, bottlenose dolphins showed a change in normal behaviour around boats, but rarely left the area; this type of response suggested habituation and tolerance, especially due to the estuary's importance for prey availability (Sini et al. 2005).

Although there is some indication that fish (especially those with swim bladders used in hearing) within hundreds of metres of impact pile driving could be at high risk of disturbance or even potentially experience injury or TTS, impact piling would occur for a relatively short duration (60 min) for each pile, once per day. Thus, impact pile driving is unlikely to hinder fish migration, and for most fish, the distances within which mortality and/or mortal injuries could occur are relatively small and should not impact the overall populations if these types of effects were to take place. Although continuous sounds during project construction and operation have little likelihood of causing injury or TTS in fish, fish that use their swim bladder for hearing could potentially be at high risk of disturbance near those sound sources. It is possible that the continuous noise emission from the FSRU during project operation could cause fish to avoid the immediate area around the FSRU, but avoidance behaviour would likely be restricted within tens of metres from the FSRU.

7A.5.5.5 Conclusion

In summary, the proposed construction and operational activities associated with Shannon LNG are similar to other activities that currently occur routinely within the estuary and are therefore unlikely to have adverse effects that could impact populations of marine mammals or fish in the long-term. The most potentially impactful activity on marine mammals and fish during construction would be impact pile driving because of the potential for PTS in marine mammals and injury or mortality in fish, but this would be of limited duration and impacts will be mitigated in multiple ways. Additionally, there is no evidence to suggest that the project site provides critical habitat for bottlenose dolphins (Berrow et al 2020) so avoidance of these activities would be unlikely to have significant impacts. During operations, underwater sounds would be created by vessel traffic and contribute to the pre-existing ambient noise within the estuary. The cumulative sound scenario and approaching/departing LNGC have the largest distances to behavioural disturbance thresholds during operations, but both scenarios would occur only briefly up to 3 times per week, and only if other vessels are located within the vicinity of the project site. Once the other power stations located in the Shannon Estuary shut down, there would be even less potential for cumulative effects from the proposed activities and existing shipping activities occurring in the estuary. In addition, harbour porpoise and grey seals rarely occur in the Shannon Estuary, and harbour seals are uncommon. Thus, any effects from project activities are expected to be **minor**, **temporary**, and localized to the area immediately around the terminal, with **no long-term** effects on marine mammal or fish populations.

7A.5.6 Impact Mechanism 4. Seabed Habitat Loss

7A.5.6.1 Relevant Receptors

- Habitats.

7A.5.6.2 Overview

Impact mechanism 4 is associated with the construction and operation phase.

There are two distinct sources of habitat loss due to the Proposed Development; one being the installation of construction piles for the jetty structure foundations and, the other being the installation of a trenched water outfall across the shoreline into the Shannon estuary.

The assessment of the potential impact of seabed habitat loss is undertaken here with respect to the Annex I habitats for which the Lower River Shannon cSAC is designated. Specifically, the assessment considers the area of Annex I habitat lost relative to the full areal extent of the Annex I habitat within the cSAC.

The construction of the jetty requires the installation of approximately 203 piles. As shown in Figure 7A-13 and Figure 7A-14 the proposed jetty overlaps the Annex I habitats 1130 Estuaries and 1170 Reefs of the Lower River Shannon cSAC. The majority of the piles supporting the jetty would be driven, with some piles drilled and socketed into the underlying rock to ensure stability of the jetty.

The proposed outfall overlaps Annex I habitats 1130 Estuaries and 1170 Reefs (see Figure 7A-13 and Figure 7A-14 respectively and Figures F7-9 and F7-10 in Volume 3). The width of the trench will be approximately 2 m while its total length through Annex I habitats is approximately 50 m. Once the outflow pipe is set position the trench will be infilled using concrete to approximately 30 mm below the surface of the level of the adjoining substrate. In areas of reef substrate, the surface concrete of the trench will be embedded with reef cobbles and stone excavated from the trench, while in areas of soft sediment the void to will left to infill naturally by sedimentation and sediment movement processes.

The Conservation Objectives[12], attributes and targets relating to the area of Annex I habitat 1130 Estuaries and 1170 Reefs within the cSAC are presented respectively in Table 7A-10 and Table 7A-11 (NPWS, 2012).

[12] NPWS (2012) Conservation Objectives Series. Lower River Shannon SAC Site Code: 002165.

Table 7A-10 Annex I Habitat 1130 Estuaries

To maintain the favourable conservation condition of Estuaries in the Lower River Shannon SAC, which is defined by the following list of attributes and targets:

Annex I habitat	Measure	Target	Notes
1130 Estuaries	Habitat area	The permanent habitat area is stable or increasing, subject to natural processes.	Habitat area was estimated as **24,273ha** using OSi data and the Transitional Water Body area as defined under the Water Framework Directive

Table 7A-11 Annex I Habitat 1170 Reefs

To maintain the favourable conservation condition of Reefs in the Lower River Shannon SAC, which is defined by the following list of attributes and targets:

Annex I habitat	Measure	Target	Notes
1170 Reefs	Habitat area	The permanent habitat area is stable or increasing, subject to natural processes.	Habitat area was estimated as **21,421ha** from the 2010 intertidal and subtidal reef survey (Aquafact 2011a, 2011b)

7A.5.6.3 Loss due to Installation of Jetty Piles

As a result of the 203 piles, approximately 163m^2 of benthic habitat within Annex I habitats will be lost pending decommissioning of the development and the removal of jetty and piles. Of the 203 piles, approximately 10 piles will be installed in the Annex I habitat Reefs [1170] while approximately 193 will be located within the Annex I habitat Estuaries [1130].

The spatial extent of Annex I habitat 1130 Estuaries and 1170 Reefs within the cSAC is estimated to be 24,273 ha and 21,421 ha respectively (NPWS, 2012) (see Table 7A-10 and Table 7A-11 respectively).

The approximate spatial extent of Annex I habitat lost pending decommissioning of the development and the removal of jetty and piles is presented in Table 7A-12. Installation of the jetty piles will result in the loss of 0.000064% and 0.000004% of the Annex I habitats 1130 Estuaries and 1170 Reefs respectively.

Table 7A-12 Loss of Annex I Habitat 1130 and 1170 due to Installation of Piles

Annex I habitat	Habitat area within cSAC[13]	Area of Annex I habitat lost pending decommissioning	% of Annex I habitat lost pending decommissioning
1130 Estuaries	24,273ha	155 m^2	6.4×10^{-6} %
1170 Reefs	21,421ha	8 m^2	3.7×10^{-5} %

7A.5.6.4 Loss due to Installation of Outfall Pipe

The installation of the outfall pipe will result in the loss of approximately 90m^2 of Annex I habitat above the low water mark and 10m^2 below the low water. Loss of Annex I habitat Estuaries [1130] habitat is estimated to be approximately 100m^2, while the loss of Reef [1170] habitat is approximately 65m^2.

[13] Estimates of habitat area taken extent from NPWS (2012) Conservation Objectives Series - Lower River Shannon SAC 002165 Version 1.0.

The approximate spatial extent of Annex I habitat lost is presented in Table 7A-13. Installation of the pipe will result in the loss of 0.000041% and 0.000030% of the Annex I habitats 1130 Estuaries and 1170 Reefs respectively.

Table 7A-13 Loss of Annex I Habitat 1130 and 1170 due to Installation of Outfall Pipe

Annex I habitat	Habitat area within cSAC[14]	Area of Annex I habitat lost pending decommissioning	% of Annex I habitat lost pending decommissioning
1130 Estuaries	24,273ha	100 m^2	4.1×10^{-5} %
1170 Reefs	21,421ha	65 m^2	3.0×10^{-5} %

7A.5.6.5 Assessment and Conclusion

The loss of Annex I habitats 1130 Estuaries and 1170 Reefs habitat due to the installation of the piles and the outflow pipe, relative to the total area of the habitats in the cSAC is negligible and will not give rise to negative impacts to the functioning of the habitats. Following decommissioning, measures will however be taken to reinstate the small areas of habitat lost.

Jetty Piles

Jetty piles will be installed in two constituent community type of the Annex I habitats (see Figure 7A-15), namely;

- Subtidal sand to mixed sediment with *Nucula nucleus* community complex; and
- Fucoid-dominated intertidal reef community complex.

At decommissioning of the Proposed Development, jetty piles installed in soft sediment areas (Subtidal sand to mixed sediment with *Nucula nucleus* community complex) will be removed. Upon removal of the pile, the void left will be left to refill naturally through sedimentation and sediment movement processes. The sediments will be naturally recolonised by the migration of flora and fauna from local sediments and the settlement of larvae.

At decommissioning, jetty piles in areas of hard substrate (fucoid-dominated intertidal reef community complex) will be cut below the level of the seabed. The voids created will be infilled concrete and embedded with reef stone native to the area. The embedded reef stone will rapidly recolonise naturally.

Outflow Pipe

As illustrated in Figure 7A-15 the outflow pipe will be entrenched through two community types;

- Subtidal sand to mixed sediment with *Nucula nucleus* community complex; and
- Fucoid-dominated intertidal reef community complex.

Parts of the trench installed in reef areas, which will have been recolonised by reef flora and fauna assemblages, will be left *in-situ*.

Parts of the trench installed in soft sediments (Subtidal sand to mixed sediment with *Nucula nucleus* community complex) will be removed. The void created will left to infill naturally by sedimentation and sediment movement processes. The sediments will be naturally recolonised by the migration of flora and fauna from local sediments and the settlement of larvae.

7A.5.6.6 Conclusion

The loss of Annex I habitats 1130 Estuaries and 1170 Reefs pending decommissioning relative to the total area of the habitats in the cSAC is negligible. The likely impact of habitat is predicted to be **negative** and **not significant**.

[14] Estimates of habitat area taken extent from NPWS (2012) Conservation Objectives Series - Lower River Shannon SAC 002165 Version 1.0.

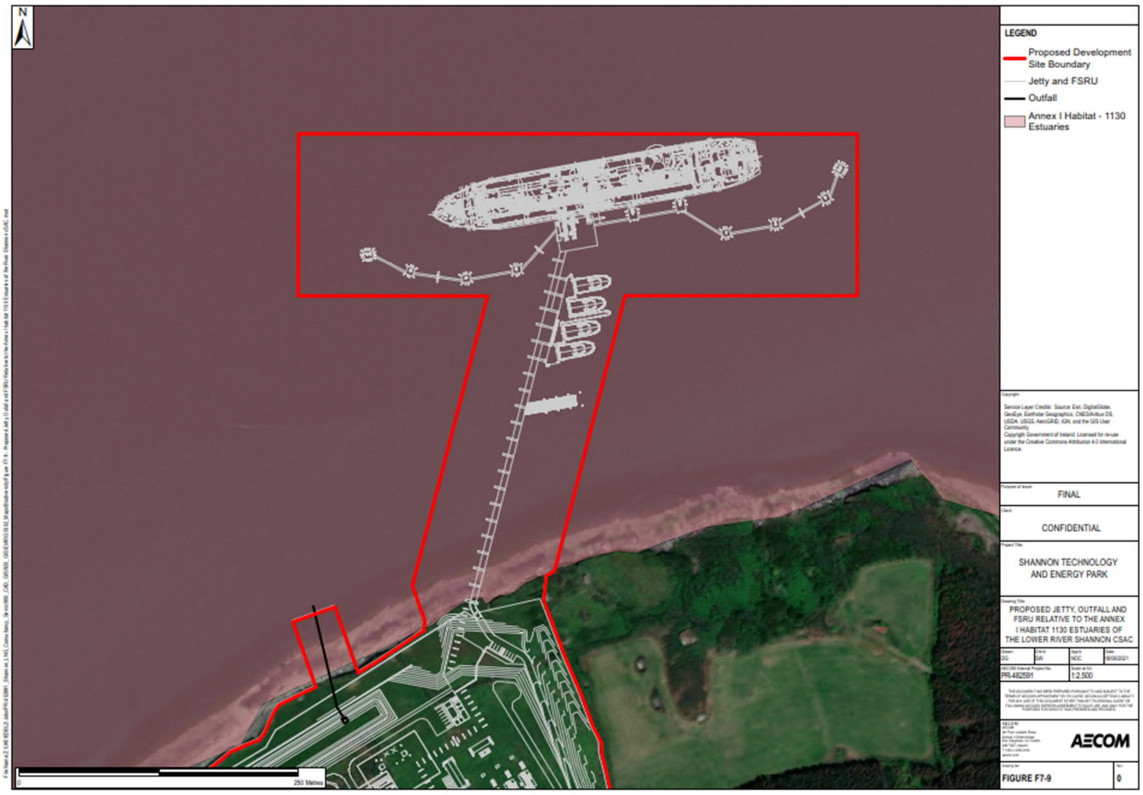

Figure 7A-13 Proposed jetty, outfall and FRSU relative to the Annex I Habitat 1130 Estuaries of the Lower River Shannon cSAC.

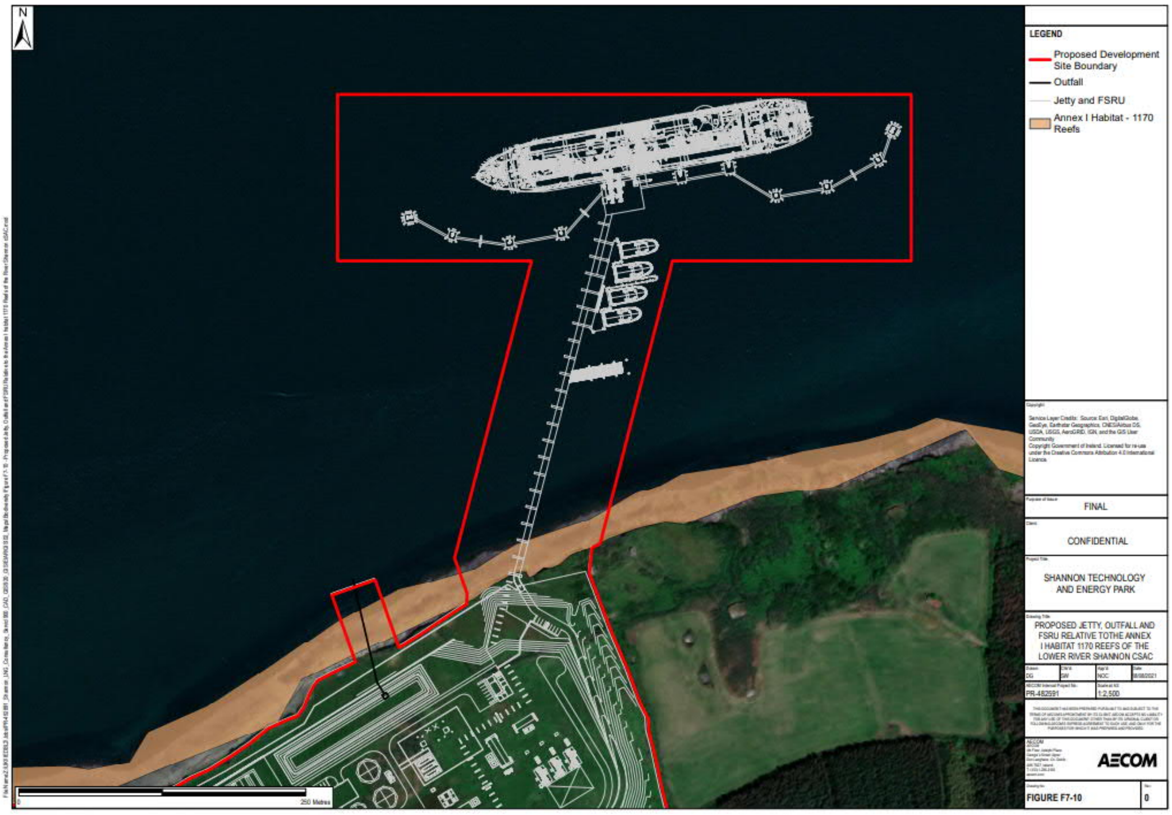

Figure 7A-14 Proposed jetty, outfall and FRSU relative to the Annex I Habitat 1170 Reefs of the Lower River Shannon cSAC

Figure 7A-15 Marine community types identified relative to marine community types within Annex I Habitats of the Lower River Shannon cSAC

7A.5.7 Impact Mechanism 5. Vessel Physical Disturbance and Collision Injury

7A.5.7.1 Relevant Receptors

- Marine Mammals.

7A.5.7.2 Assessment

Impact mechanism 5 is associated with the construction and operation phase.

According to the Shannon Foynes Port Company (SFPC), approximately 1,800 vessel movements are made within the estuary, equating to 900 different AIS (automatic identification system) tracked vessels travelling into the estuary annually. EMODnet (2021) vessel density mapping indicates that high levels of shipping activity occur throughout the year along the Shannon estuary and, in particular, in the vicinity of the Proposed Development area. In general, average monthly vessel density in 2017, 2018, 2019 and 2020 in the Shannon estuary ranged between 2 and 10 hours per km^2 and exceeded 100+ hours per km^2 in the vicinity of the Proposed Development area. The presence of the project vessels (*i.e.* construction scows and storage vessels, and the FSRU, LNGC, tugs) will not significantly increase the level of overall vessel activity in the area. In addition, during operations the vessels will be travelling at low speeds below which most lethal and serious injuries occur (Laist *et al.,* 2001). It is therefore very unlikely that marine mammals will collide with the slow moving vessel.

7A.5.7.3 Conclusion

It is predicted that there will be **no significant** impact to marine mammals from impact mechanism 5.

7A.5.8 Impact Mechanism 6. Discharge of Treated Cooled Seawater

7A.5.8.1 Relevant Receptors

- Habitats;
- Marine Mammals; and
- Fish.

7A.5.8.2 Assessment

Impact mechanism 6 is associated with the operation phase.

7A.5.8.3 Discharge of Treated Cooling Water

Overview

As outlined in Chapter 02, the LNG vaporisation process equipment to regasify the LNG to natural gas will be onboard the FSRU. The heat for LNG regasification will be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate. The seawater intake for the LNG regasification system will be on the side of the FSRU underwater. Screens will be installed to prevent debris in the sea water from entering the FSRU. The approach velocity at the screens will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm. However, some small debris, leaves, plankton and larvae may be drawn in through the screens. It is expected that any silt entering the seawater circulating water system will remain in suspension and carry right through the system.

The regasification water outlet is also on the side of the FSRU underwater. The maximum projected change in water temperature is 8°C below ambient seawater temperature. The FSRU regasification seawater discharge point is the largest discharge point from the FSRU.

Following the intake of seawater into the vessel, an electric current is passed through the seawater (a process known as electrolysis). Electrolysis breaks up the naturally occurring salt molecules (sodium chloride) in seawater and produces chlorine and hypochloride, which prevents the growth of marine organisms in the internal piping system and the seawater heat exchangers of the FSRU. When the seawater is discharged from the vessel back into the marine environment, some short-lived residual chlorine would be present before mixing and decay. The concentration of residual chlorine at the discharge shall be monitored and shall not exceed the permissible limit of 0.5 mg/l.

Modelling Assessment

Discharge Characteristics

The characteristics of the cooled water to be discharged from the FRSU are shown in Table 7A-14. It was decided to model the peak flow so that a 'worst case scenario' could be observed in the receiving water (*i.e.* 22,000m^3/hr is the peak loading from the FSRU and is equivalent to 6,111l/s (6.111 cumec[15]). The modelling considered the background concentration of chlorine to be zero and that the differential change in temperature is 8^{o}C below ambient with ambient modelled at 12^{o}C so that the output represents solely the effect of discharging effluent in the receiving waters.

[15] Cumec = Cubic metres per second

Table 7A-14 Characteristics of the Cold Water Discharge from Outfall Pipe

Maximum Discharge rate (m^3/hr)	Maximum Residual Total Chlorine Concentration (mg/l)	Maximum Differential Temperature (°C)
22,000	0.50	-8.0

Intake and Outfall Location of the Cooling Water

Using the maximum flow rate of 22,000m^3/hr, the modelling was undertaken to estimate the concentrations of the total residual Chloride and water temperature within the receiving waters of the Shannon Estuary from the regasification process.

The discharge was specified with a residual total chlorine concentration of 0.5mg/l and a maximum temperature decrease over the ambient temperature of 8°C. The ambient Temperature in the Shannon Estuary was set at 12° C, and the discharging water temperature was set to 4° C. The duration of the modelling simulation was sufficiently long enough to allow steady state conditions to be attained in the vicinity of the outfall and in the nearby waters. This ensured that the minimum temperature and maximum concentration values, which would be reached throughout the water body, would be observed.

Water Temperature Simulation

Modelling showed that the discharge plume sinking towards the seabed due to its higher density with minimum temperatures of the discharge water towards the bottom layers at 130 m from the site. At the site itself, due to the elevation of the discharge from the vessel, minimum temperature is encountered at mid-depth. At the medium and far fields from the discharge outfall point, the temperature change is small and is well mixed vertically and horizontally due to the high ebb and flood velocities. At the outfall the predicted minimum temperature is 10.38°C representing a maximum temperature change over the ambient of 1.62°C. The maximum temperature change (decrease) in bottom layer along the seabed is 0.76° C. At 140 m from the discharge outfall point, the minimum temperature which occurs on spring tides is 11.54° C occurring in the bottom layer and representing a maximum decrease in ambient temperature of 0.46° C.

The EPA proposal for estuarine waters states that the temperature measured downstream of a point of thermal discharge (at the edge of the mixing zone) must not exceed the unaffected temperature by more than 1.5°C. The EPA have in previous discharge licenses allowed a regulatory mixing zone length of no greater than 10% of the channel width. In the case of the Shannon Estuary at Ardmore Point the minimum estuary width is 2.3 km indicating an allowable mixing zone of 230 m. Table 7A-14 presents the maximum reduction in ambient temperature within the receiving water body. This plot shows that within 200m of the discharge the maximum reduction in ambient temperature is less than 0.5° C and that within 3 km it is less than 0.1°C. The maximum reduction in beyond this area temperature outside is > 0.05° C and < 0.1°C which is insignificant.

Given the minor insignificant relative change in water temperature, there will be no significant effects to habitats, marine mammals or fish species.

Residual Chlorine Simulation

The residual chlorine plume acts in a similar fashion as the temperature plume, sinks vertically at the discharge point and generally has maximum concentrations within a relatively short distance of the discharge point at the seabed due to the higher density of the colder discharge water over the ambient receiving waters. Within a reasonably short distance the plume due to the high ebb and flood velocities and associated turbulence becomes well mixed vertically and horizontally.

Within 1.5 km both east and west of the discharge point the predicted maximum residual chlorine concentration is less than 0.01 mg/l. Maximum Concentration above 0.1mg/l are shown to occur only within 20 m of the discharge point and for a short period of time.

Given the minor insignificant relative change in chlorine level, it is predicted that there will be **no significant** impacts to habitats, marine mammals or fish species.

7A.5.8.4 Conclusion

Given the above it is concluded that will be **no significant** impact from impact mechanism 6.

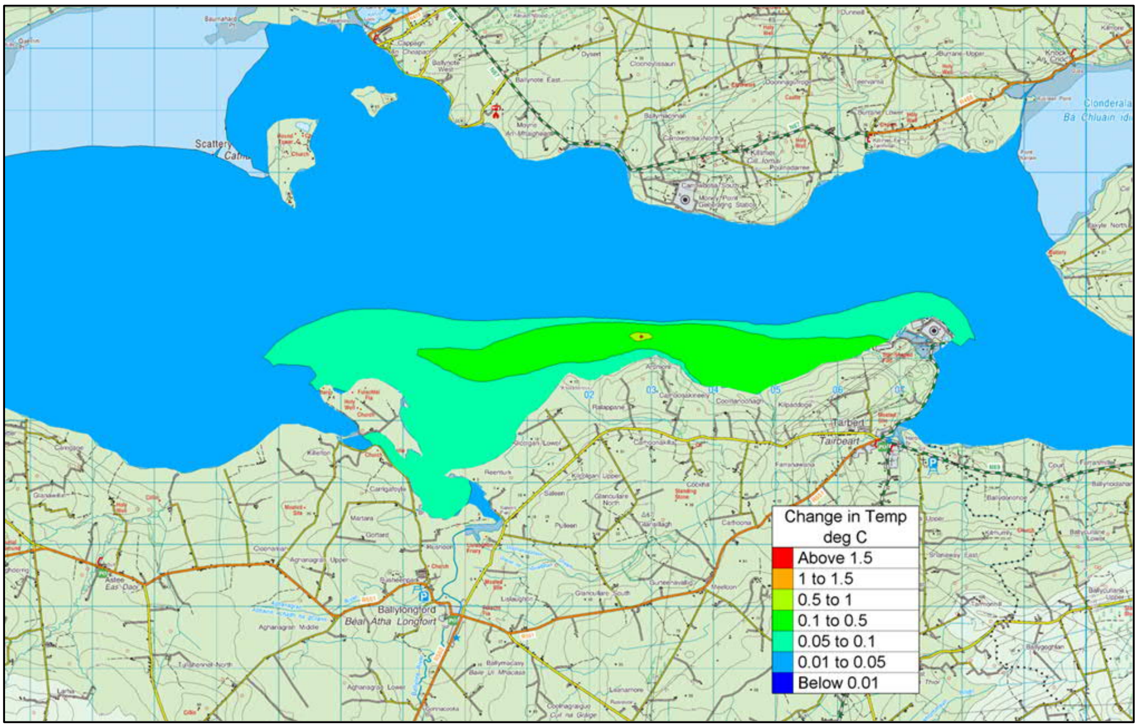

Figure 7A-16 Maximum Temperature Reduction Envelope Within Receiving Shannon Estuary Water body over a 15 day Simulation

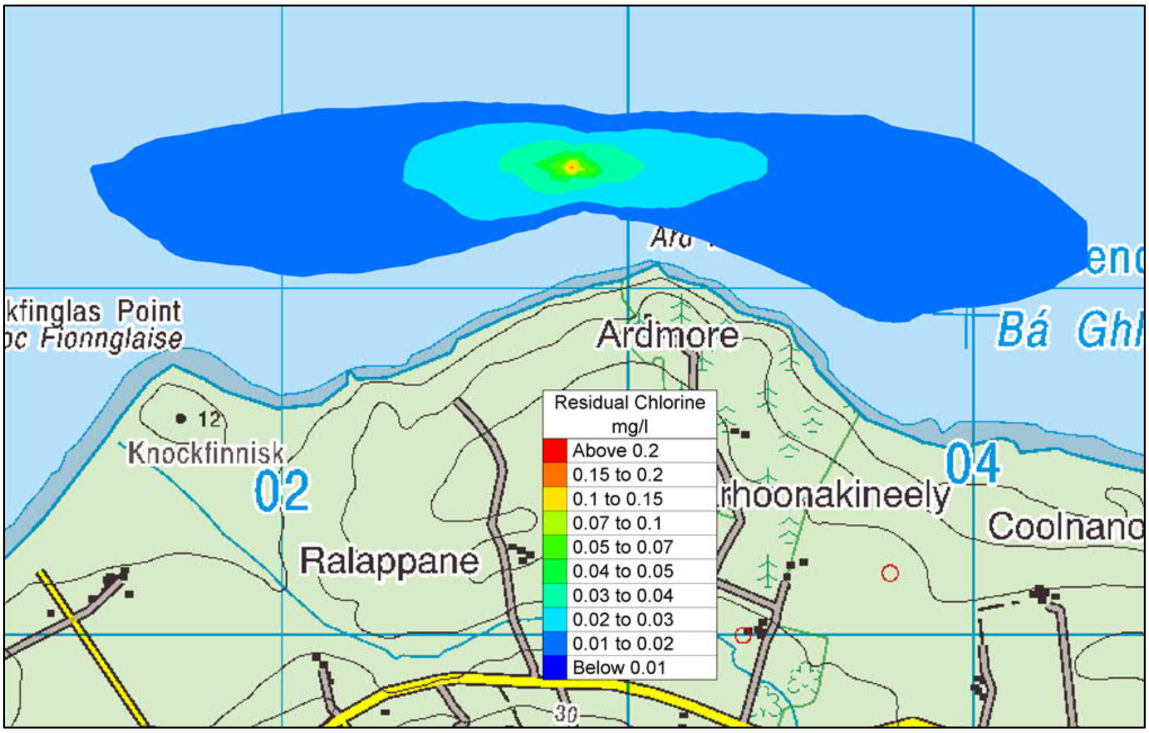

Figure 7A-17 Maximum Residual Chlorine Envelope within Receiving Shannon Estuary Water body over a 15 day Simulation (All Vertical Layers)

7A.5.9 Impact Mechanism 7. Entrainment and Impingement of Fauna by the FSRU Seawater System

7A.5.9.1 Relevant Receptors

- Fish and crustaceans; and
- Juvenile and adult fish.

7A.5.9.2 Assessment

Impact mechanism 7 is associated with the operation phase.

Fish and Crustaceans

An assessment of the impact of the LNG cooling water system, including the use of sodium hypochloride to control biofouling by epiflora and epifauna on macrocrustaceans and fish in the Shannon Estuary was carried out by reviewing relevant scientific literature on the topic. The review included*, inter alia,* Langford (1983), (1990), Rajagopal, Jenner and Venugopalan (2012), Barnthouse (2013) and Turnpenny and Horsfield (2014).

Entrainment and Impingement

Entrainment is the unwanted passage of organisms through a water intake, which is generally caused by an absence or inadequate screen surrounding the water intake while impingement is the physical contact of an organism with such a barrier structure (screen) due to intake velocities which are too high to allow the organism to escape.

With regard to flows in the Shannon Estuary, if all inflowing rivers are included along with the flows in the river, the total flow rate is 300 m^3 sec. The area of the estuarine section of the Shannon is *ca* 500 km^2 and a using a mean depth of *ca* 20, the volume of the estuary is 20 x 10^6 m^3.

The tidal prism at the mouth of the Shannon Estuary is the mean volume (500 km^3) x mean tidal height (4.5m) = 22.5 x $10^9 m^3$. The predicted volume of sea water abstracted at the LNG plant over a 12 h tidal cycle is 240,000m^3 or 0.24 x10^6 m^3.

Based on these estimates, the abstraction of 0.00024 x 10^6 m^3 of cooling water over a 12-hour period represents *ca* 0.01% of the average tidal prism volume of the Shannon Estuary which is a very small number. The potential impact of sea water abstraction therefore on crustacean and fish populations in the estuary is considered to be very low and any consequent impact on predators that feed on crustaceans and/ or fish will be imperceptible.

Seawater intakes will be located in the hull of the FSRU, approximately 2 metres below water level. A mesh size of 5 mm is proposed for the intake pipe and a velocity of 0.3 m sec (which is an order of magnitude lower than the maximum tidal velocity of the Shannon) is proposed for the intake. These physical characteristics have been designed to minimise possible intake of marine organisms including adult macrocrustaceans and fish larvae and juveniles. Some planktonic and larval forms of invertebrates and fish will however be entrained and impinged on the mesh.

Estuaries by their very nature are very variable ecosystems with considerable variations in such things as flow rates, scour, salinity and tidal fluctuations, rain fall and wind-induced variations in flows and directions, seasonal temperature variations, suspended solids loadings and oxygen levels. The Shannon Estuary has all these attributes in profusion.

With regard to macrocrustaceans that occur in the Shannon Estuary, benthic survey work carried out by AQUAFACT for the LNG project recorded the following species: *Eupagurus bernhardus* and *Leiocarcinus depurator*. Other taxa that are likely to be present include *Palaemon serratus, Homarus gammarus, Maja* sp (*sensu lato*), *Carcinus maenas* and *Cancer pagurus.* Given the physical oceanographic characteristics and the spatial extent of the Shannon compared to the size and physical characteristics of the intake pipe, the potential impact of sea water abstraction on crustacean and fish populations in the estuary is considered to be very low and any consequent impact on predators that feed on crustaceans and/ or fish will be imperceptible.

In terms of fish species, the Shannon Estuary, anadromous species include species Atlantic salmon (*Salmo salar*), Thwaite shad *(Alosa fallax*), Sea lamprey (*Petromyzon marinus*), River lamprey (*Lampetra fluviatilis*) while catadromous species include the European eel (*Anguilla anguilla*). However, as these species do not spawn in the Shannon Estuary, their larvae will not be affected by neither impingement nor entrainment.

The following is a list of fish species recorded in the Shannon Estuary by Inland Fisheries Ireland (2008): *Chelon labrosus* Thick Lipped Grey Mullet, *Platichthys flesus* Flounder, *Dicentrarchus labrax* Sea Bass, *Sprattus sprattus* Sprat, *Pomatoschistus microps* Common Goby, *Pomatoschistus minutus* Sand Goby, *Gobiusculus flavescens* 2 Spotted Goby, *Pleuronectes platessa* Plaice, *Entelurus aequoreus* Snake Pipefish, *Anguilla anguilla* Eel, *Pholis gunnellus* Butterfish, *Gobius niger* Black Goby, *Atherina presbyter* Sand Smelt, *Ciliata mustela* 5-Bearded Rockling, *Limanda limanda* Dab, *Taurulus bubalis* Long-Spined Sea-Scorpion, *Gasterosteus aculeatus* 3-Spined Stickleback, *Gadus morhua* Cod, *Pollachius pollachius* Pollock, *Myoxocephalus scorpius* Short-Spined Sea, *Labrus bergylta* Ballan Wrasse, *Syngnathus rostellatus* Nilsson's Pipefish, *Spinachia spinachia* 15-Spined Stickleback, *Syngnathus acus* Greater Pipefish, *Solea solea* Common Sole, *Symphodus melops* Corkwing Wrasse, *Callionymus lyra* Dragonet, *Scyliorhinus canicula* Lesser Spotted Dog fish, *Agonus cataphractus* Pogge, *Labrus mixtus* Cuckoo Wrasse, *Conger conger* Conger Eel, *Merlangus merlangus* Whiting, *Perca fluviatilis* Perch, *Trisopterus minutus* Poor Cod and *Osmerus eperlanus* Smelt.

Leuciscus leuciscus, Dace, is also known to be present in the Ratty River which is a tributary of the Shannon and other species that are likely to occur there are *Raja* sp., Ray, *Trigla* sp (*sensu lato*), Gurnard, *Ammodytes* sp. (*sensu lato*) Sand eel, *Blennius gattorugine* Tompot Blenny and *Pollachius viren*s Coalfish.

Given the physical oceanographic characteristics and the spatial extent of the Shannon compared to the size and physical characteristics of the intake pipe, the potential impact of sea water abstraction on the above list fish populations in the estuary is considered to be very low and any consequent impact on predators that feed on them will be imperceptible.

Barnthouse's (2013) important review of literature from many parts of the world on the impacts of cooling water systems at thermal electricity generating stations on the entrainment and impingement on fish at power plants included peer-reviewed publications, 'blue-ribbon' commission reports on aquatic resource degradation that evaluate causes of observed degradation of aquatic ecosystems and the USA's EPA's assessments of causes of degradation in coastal environments. His conclusion was that any impacts caused by impingement and entrainment were small compared to other impacts on fish populations caused by overfishing, habitat destruction, pollution and invasive species. The available scientific evidence did not support a conclusion that reducing entrainment and impingement mortality via regulation of cooling water intakes would result in significant improvements of fish populations.

He cited many studies which showed no environmental impact, in fisheries terms, of thermal electricity generating station cooling water system operation including Turnpenny (1988), Turnpenny and Taylor (2000) and Greenwood (2008) who used equivalent adult models to quantify impacts of impingement at plants in the U.K. and all of these studies found that impingement of mainly juvenile fish at power plants was equivalent to only a few percent of commercial harvest tonnages of adult fish.

Control of Biofouling

With regard to the control of biofouling, as stated in the *Integrated Pollution Prevention and Control (IPPC) Reference Document on the application of Best Available Techniques to Industrial Cooling Systems, December 2001*, open, once-through cooling systems are typically treated with oxidizing biocides to control fouling by epiflora and epifauna. The amount applied can be expressed in the yearly used oxidative additive expressed as chlorine-equivalent per Megawatt thermal (MWth) in connection with the level of fouling in or close to the heat exchanger. Operational measures for reducing harmful effects of cooling water discharge are the closing of the purge during shock treatment and the treatment of the blowdown before discharge into the receiving surface water.

According to the Reference Document, Free Oxidant (FO)/ Total Residual Oxidants (TRO) is defined as the applied measure of free oxidants in the discharge of cooling water systems, also referred to as TRO or Total Chlorine (TC) or Free Chlorine (FC). The document further defines TRO as the operational equivalent to total residual chlorine and total available chlorine. Free Residual Oxidant (FRO) is not defined.

The document cites a programme in The Netherlands for the optimised use of hypochlorite in cooling water. A concentration of 0.1 to 0.2 mg FO/l in the discharge was used as a target concentration for continuous dosed (once-through) cooling systems. For intermittent or shock chlorination regimes the FO or FRO concentration was always below 0.2 mg/l as a daily (24h) average value but during shock injection, the FO or FRO concentrations could be close or equal to 0.5 mg/l (hourly average).

The IPPC summarises the primary Best Available Technology (BAT) approach for the reduction of emissions to water by design and maintenance techniques in terms of emissions of free (residual) oxidant in once-through cooling system as follows:

- FO or FRO ≤ 0.5 mg/l at the outlet for intermittent and shock chlorination of sea water as an hourly average value within one day used for process control requirements; and
- FO or FRO ≤ 0.2 mg/l at the outlet for continuous chlorination of sea water as a daily (24h) average value.

Tarbert Power Plant Integrated Pollution Prevention Control Licence (P0607-02)

The ELV for chlorine in cooling water discharges to the Shannon Estuary, as specified in the SSE Generation Ltd.'s Integrated Pollution Prevention Control Licence (P0607-02) for Tarbert power plant, which was issued on 27th September 2012 to ensure that the emissions from the facility had due regard to the *European Communities Environmental Objectives (Surface Waters)* Regulations*, 2009,* is 0.5 mg/l. Hourly/ daily limit values are not specified.

SSE Generation Ltd is required to analyse weekly water samples for chlorine. According to its Annual Environmental Reports, chlorine is measured by colorimetric spectroscopy using the Hach 8167 method for Total Chlorine. Results are typically <1.2 x ELV (0.5 mg/l Chlorine). It is noted that dosing of the cooling system at Tarbert power plant with biocides is limited due to a lack of evidence of mussel growth within the system.

Great Island SSE Power Plant Integrated Pollution Prevention Control Licence (P0606-03)

The ELV for chlorine in cooling water discharges to Waterford Estuary, as specified in the SSE Generation Ltd.'s Integrated Pollution Prevention Control Licence (P0606-03) for the Great Island power plant, which was issued on 16th March 2011, by the EPA, is 0.3 mg/l.

Given the above, it is considered that an application for an ELV of 0.3 mg/l Total Chlorine is considered appropriate for cooling water discharges for the Shannon LNG project. It should be noted however, that the actual ELV applied will be determined by the Environmental Protection Agency under the IPPC regime.

As noted above, the Shannon Estuary is a highly variable ecosystem with considerable ranges in physical oceanographic characteristics as flow rates, scour, tidal fluctuations, wind-induced variations in flows and directions and turbulence that give rise to high levels of dilution and dispersion. Any sodium hypochlorite that is released to the estuary will be very quickly diluted and dispersed away from the end of the pipe.

Juvenile and Adult Fish

Seawater intakes will be located in the hull of the FSRU, approximately 2 m below water level. Screens will be covering the intakes to prevent fish, crustaceans and debris from entering the seawater system within the FSRU. The design of the water intakes will be such that the approach velocity of the seawater entering the screens will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm.

Conservation Feature Fish Species of the Lower Shannon cSAC

Atlantic Salmon *Salmo salar*

Salmon spend their juvenile phase in rivers before migrating to sea to grow and mature. The life cycle of salmon begins where salmon eggs are laid in spawning grounds located upstream. After 2 to 6 months the eggs hatch into tiny larvae called sac fry or alevin.

The alevin has a sac containing the remainder of the yolk, and they stay hidden in the gravel for a few days while they feed on the yolk. When the sac or yolk has almost gone the larvae leave the protection of the gravel and start feeding on plankton. At this point the salmon are called fry. At the end of the summer the fry develop into juvenile fish called parr that feed on small invertebrates and are camouflaged with a pattern of spots and vertical bars. Once the parr have grown to between 10 and 25 cm in body length, they undergo a physiological pre-adaptation to life in seawater. At this point the salmon are called smolt. As salmon larvae will not be present in the project area there is no potential for impact from entrainment and impingement by the cooling system.

Sea Lamprey *Petromyzon marinus* and River Lamprey *Lampetra fluviatilis*

Lamprey spawning habitat requires a gravel bottom with swift-running water and nearby sheltered areas with muddy bottoms for the larvae (Wheeler, 1969). Sea lamprey congregate at spawning gravels to spawn in May and June, and river lamprey spawning in March and April (Kelly and King, 2001).

Hatching occurs two weeks after egg deposition and within a further one to three weeks the ammocoete larvae emerge from the spawning substrate and burrow into muddy beds in sheltered areas. Ammocoetes (larvae) are relatively immobile and remain in the muddy beds in freshwater stretches of rivers for between 3 – 8 years (Kelly and King, 2001; Dawson et al., 2015). As larvae will not be present in the project area there is no potential for impact from entrainment and impingement by the cooling system.

Brook Lamprey *Lampetra planeri*

The Brook Lamprey (Lampetra planeri) are a freshwater species occurring in streams and occasionally in lakes in northwest Europe, particularly in basins associated with the North and Baltic seas. Spawning occurs in the rivers in March and April.

Once hatched, Brook Lamprey larvae leave the nest at 3-5 mm in length and drift downstream, settling in depositing substrates in in freshwater stretches of river margins and back-waters. The larval period lasts for approximately 6 years. Following metamorphosis, Brook Lamprey turn more silvery along the sides and the belly and the back remains a dark grey-brown colour. At this stage of the life cycle the brook lamprey has reached a length of 12-15 cm. The adult brook lamprey moves out from the silt beds as spawning time approaches and start to migrate upstream in search of a suitable habitat for spawning. They continue to burrow as adults or hide under stones during the day. As larvae will not be present in the project area there is no potential for impact from entrainment and impingement by the cooling system.

7A.5.9.3 Conclusion

Potential impacts are assessed as **negative** and **not significant**.

7A.5.10 Impact Mechanism 8. Discharge of Wastewater and Power Plant Process Heated Water Effluent

7A.5.10.1 Relevant Receptors

- Habitats;
- Marine Mammals; and
- Fish.

7A.5.10.2 Assessment

Impact mechanism 8 is associated with the operation phase.

Overview

The proposed treated sanitary effluent discharge from the development was modelled discharging from the proposed nearshore outfall pipe located on the sea bed.

The outfall pipe is also the discharge point for effluent from the Power Plant.

The parameters of interest modelled are temperature, BOD, Ammonia, Total Phosphorous and *E.coli.*

Modelling Assessment

Power Plant Process Heated Water Effluent

The Power Plant will generate several process water effluent streams. Some of the effluent streams will be collected and removed offsite and the remaining effluent streams will be pumped or fall by gravity to the effluent sump. Process water effluent leaving the effluent sump, will be continuously monitored for pH before discharging to the estuary via the storm water outfall pipe.

The automatic control system associated with the effluent sump will sound an alarm if the pH goes outside a pre-set range – typically 6 to 9. This will alert the operator to take corrective action to remedy the problem. If the pH continues to go outside the pre-set range, this will automatically close the discharge valve and open the associated re-circulation valve and will then start the re-circulation process during which period the sump will be dosed with either acid or caustic soda to return the pH to between 7 and 8. At this stage the automatic discharge valve will re-open and the re-circulation valve will close. A regular visual check on oils and greases will also be made in this sump to ensure that the discharge will be free of these contaminants before discharge. The process effluent in the sump will be monitored for compliance with the IE licence limits and then discharged, via the storm water outfall pipe, to the Shannon Estuary. Table 7A-15 below summarises the Power Plant Process Effluent Sump Discharge.

Table 7A-15 Power Plant Process Effluent Sump Discharge

Parameter	Typical Range of Emissions (min. to max.)
Volume range	0 to 1,128m^3/day
pH	6 – 9
Temperature range	25^{0}C to 40°C
BOD	20 mg/l
Suspended Solids	30 mg/l
Total Dissolved Solids	5000 mg/l
Mineral Oil	20 mg/l
Total Ammonia (as N)	5 mg/l
Total Phosphorous (as P)	5 mg/l

Treated Sanitary Effluent Discharge

Sanitary effluent will be generated by the LNG Terminal and by the Power Plant. All sanitary effluent will be pumped or fall by gravity to a common wastewater treatment plant (WWTP) onsite. The effluent waste stream will be monitored for compliance with the licence limits and then discharged, via the storm water outfall pipe, to the Estuary.

A biological Wastewater Treatment System is proposed. It will be sized for a headcount of 67. Table 7A-16 summarises the effluent stream generated from the WWTP and provides estimated quantities.

Effluent leaving the WWTP will be continuously monitored for pH before discharging to the estuary. The automatic control system associated with the WWTP will sound an alarm if pH falls outside of expected range. This will alert the operator to take corrective action to remedy the problem. If the problem continues to go outside the pre-set range, this will automatically close the discharge valve and effluent will be diverted to a holding tank.

Table 7A-16 Characteristics of WWTP Discharges

Parameter	Emission Limit Value
Volume	$35m^3$/day
pH	6 – 10
BOD	25 mg/l
Suspended Solids	35 mg/l
Ammonia (as N)	5 mg/l
Total Phosphorous (as P)	2 mg/l

Modelled Discharges

The modelled effluent was a combination of the treated sanitary effluent of $35m^3$/day and the process effluent at a mean daily discharge of $778m^3$/day and an instantaneous maximum hydraulic load of 1,128 m^3/day. This was modelled as a thermal discharge at 40°C with the receiving waterbody ambient temperature of 12°C (effluent at 20°C above ambient). The various treated effluent concentrations are outlined in Table 7A-15 and Table 7A-16.

The Heated discharge from the processed waters was modelled at 28°C above ambient with the ambient at 12°C. The maximum and mean temperature envelope are presented in Figure 7A-18 and Figure 7A-19 over a full 15 day spring-neap-spring tidal period. These plots show very local rise in temperature at the outfall site having a maximum increase of 0.9135°C and mean increase at outfall site of 0.069°C. The maximum temperature increase reduces within 100 m of the discharge point to 0.171°C which is an insignificant impact. The heated plume rises and mixes in the water column due to a lower density than the receiving waters. At the outfall site the maximum temperature occurs at the sea bed but within a short distance the plume is well mixed vertically.

E.coli was modelled from the sanitary discharge only using a conservative die-off rate of T_{90} = 36hours (winter conditions) at a secondary treated effluent concentration of 10^6 No./ 100ml and a discharge rate of 0.41l/s. The maximum and mean concentration envelopes for *E.coli* are presented in Figure 7A-20 and Figure 7A-21 over a complete spring-neap-spring tidal period. The highest concentration occurs in the receiving waters at the outfall site which is predicted to reach 1,458 No/100ml *E.coli* and within 100 m (mixing zone) this has reduced to 279 No./ 100ml. The tidal mean concentration over 15 days of tides is 102 No./100ml at the outfall site and significantly lower elsewhere. The predicted concentration plume shows no impact on Ballylongford and Glencloosagh Bays where shellfish activities are located.

BOD concentration was modelled at 9l/s at concentration of 20 mg/l from the process effluent and at 0.41 l/s at 25 mg/l from the sanitary effluent discharge. The maximum and mean concentration envelopes for BOD are presented in Figure 7A-22 and Figure 7A-23 over a complete spring-neap-spring tidal period.

The highest concentration occurs in the receiving waters at the outfall site at a concentration of 0.692 mg/l BOD. The maximum BOD concentration within 100 m of the outfall site is 0.132 mg/l. The average BOD concentration in the receiving water at the outfall site is 0.048 mg/l.

The total ammonia discharge from the treated process water and treated sanitary water produces a maximum ammoniacal nitrogen concentration within the receiving waterbody of 0.1513 mg/l N and a mean concentration at the outfall site of 0.012 mg/l N, refer to Figure 7A-24 and Figure 7A-25. The maximum Ammoniacal nitrogen concentration within 100 m of the outfall site is predicted to be 0.033 mg/l N.

The dispersion simulations show that the total Phosphorous Concentration from the treated process water and treated sanitary water produce a maximum concentration within the receiving waterbody of 0.167 mg/l P occurring at the outfall site and a mean concentration at the outfall site of 0.0117 mg/l P, refer to Figures Figure 7A-20 and Figure 7A-21. The maximum Total phosphorous concentration at 100 m from the outfall site is predicted to be 0.032 mg/l P.

7A.5.10.3 Conclusion

All of the above modelled water quality parameters are shown to easily satisfy the permissible limits set out in the surface water regulations and will not impact the water quality status of the receiving Shannon Estuary waters. Consequently, it can be concluded there will be **no significant** environmental impact from impact mechanism 8.

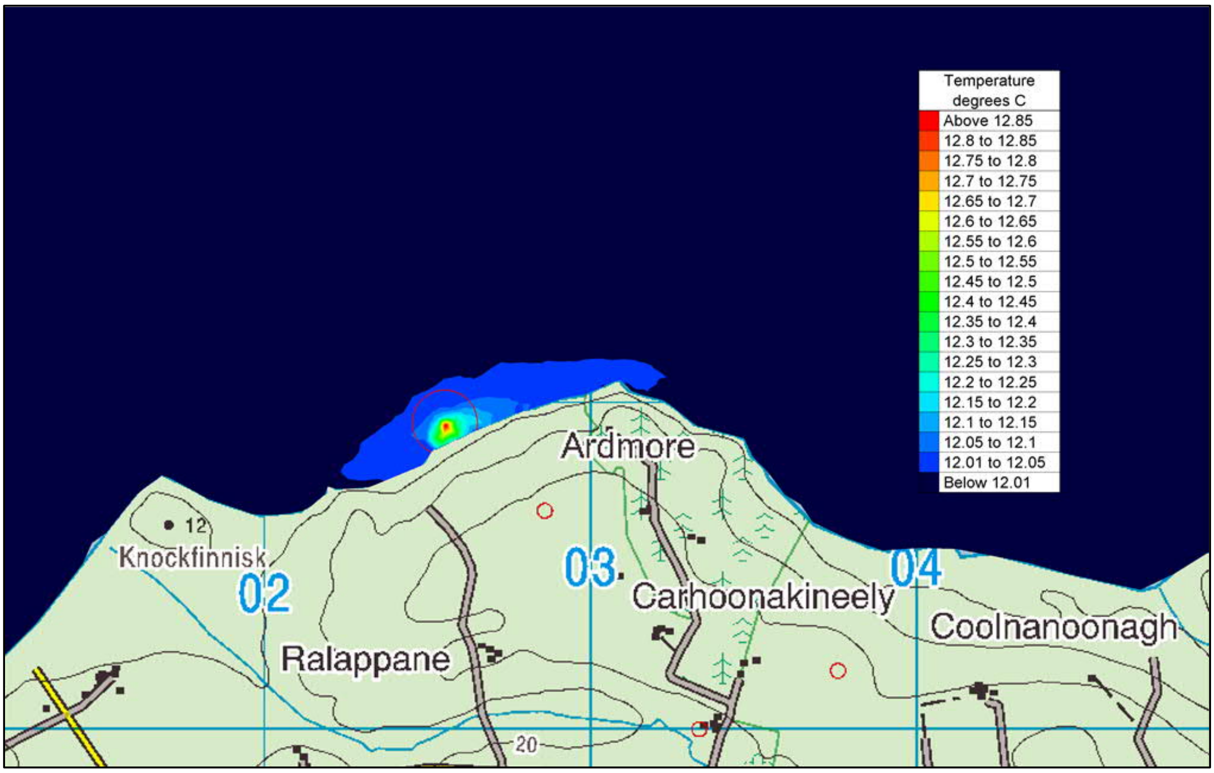

Figure 7A-18 Predicted Maximum Temperature Envelope over 15 Days for Spring-neap-spring Tide Simulation Modelling Effluent at 40ºC and Ambient Temperature at 12ºC

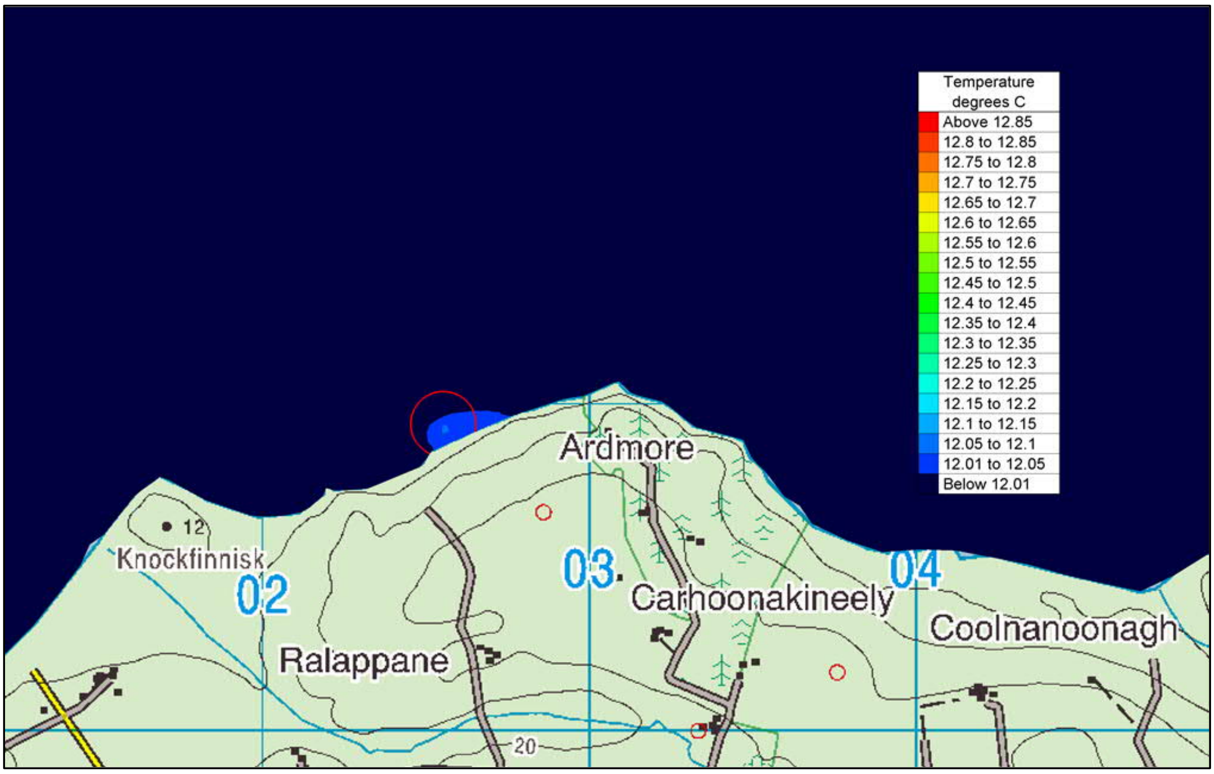

Figure 7A-19 Predicted Mean Temperature Envelope over 15 days for Spring-neap-spring Tide Simulation Modelling Effluent at 40 ºC and Ambient Temperature at 12 ºC

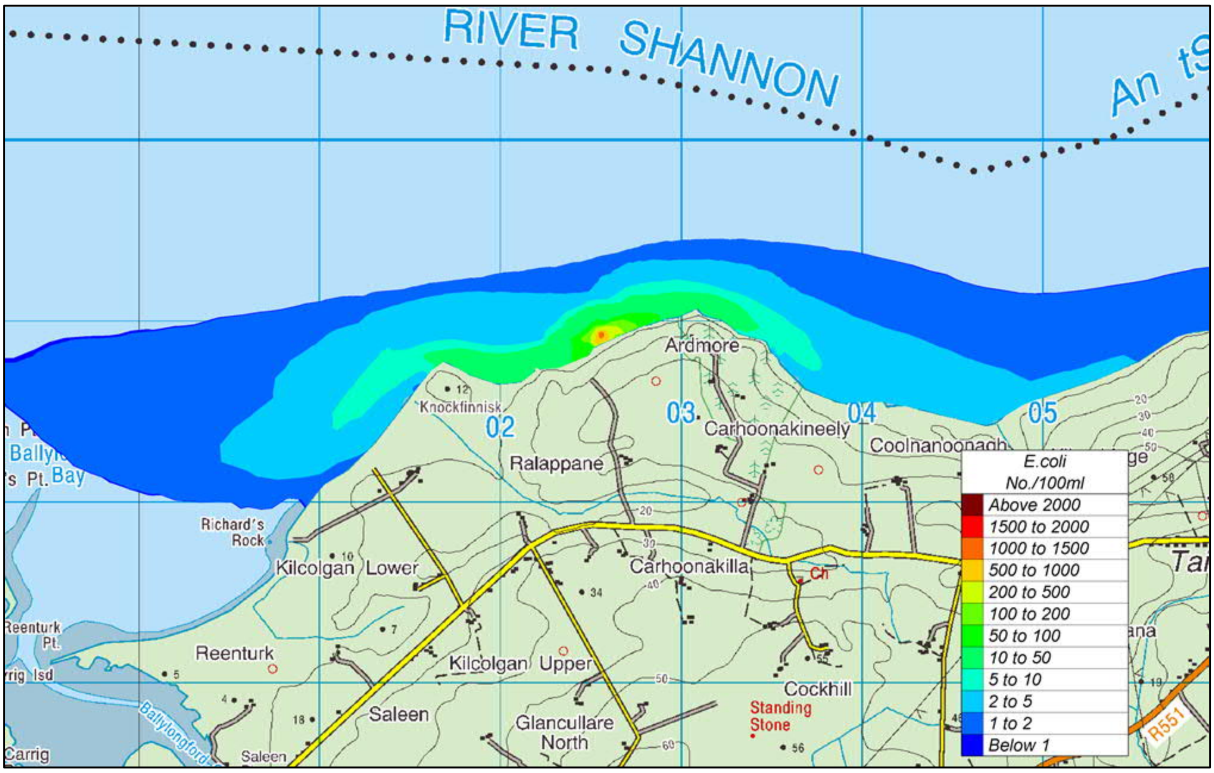

Figure 7A-20 Predicted Maximum *E.coli* concentration (No./ 100ml) Envelope over 15 Days for Spring-neap-spring Tide Simulation

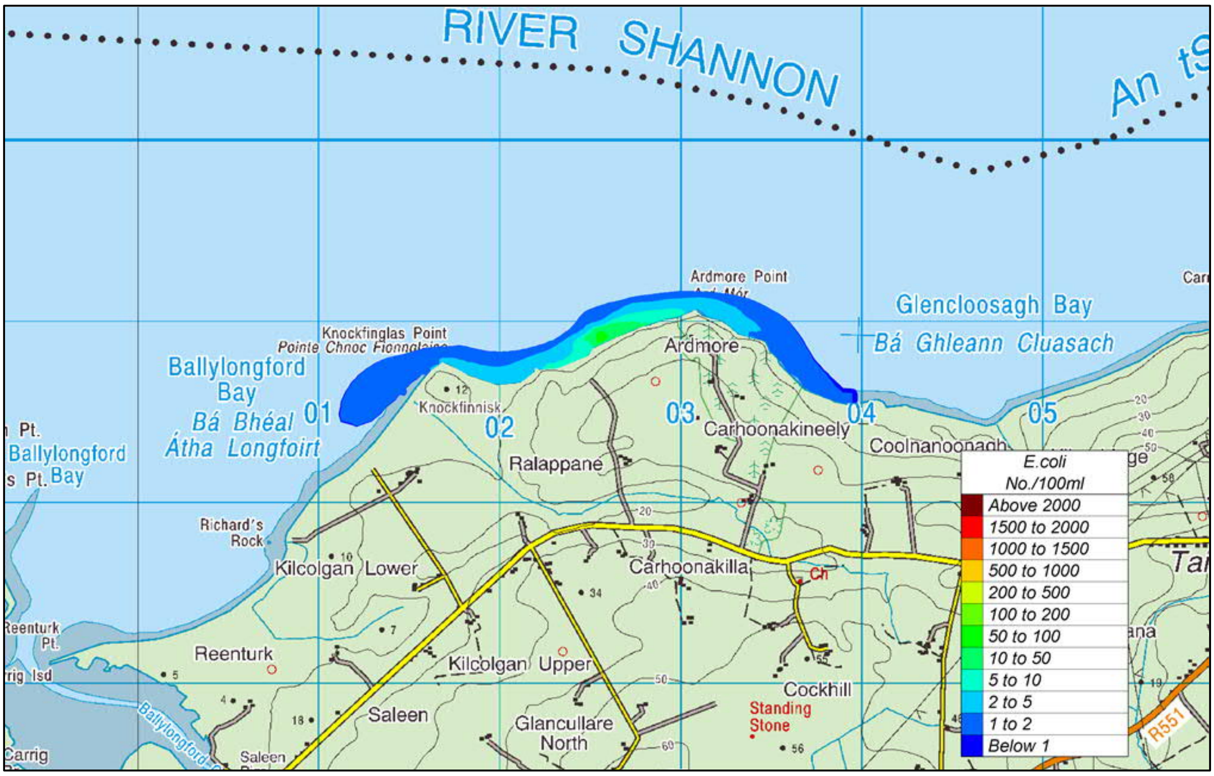

Figure 7A-21 Predicted Average *E.coli* Concentration (No./ 100ml) Envelope over 15 days for Spring-neap-spring Tide Simulation

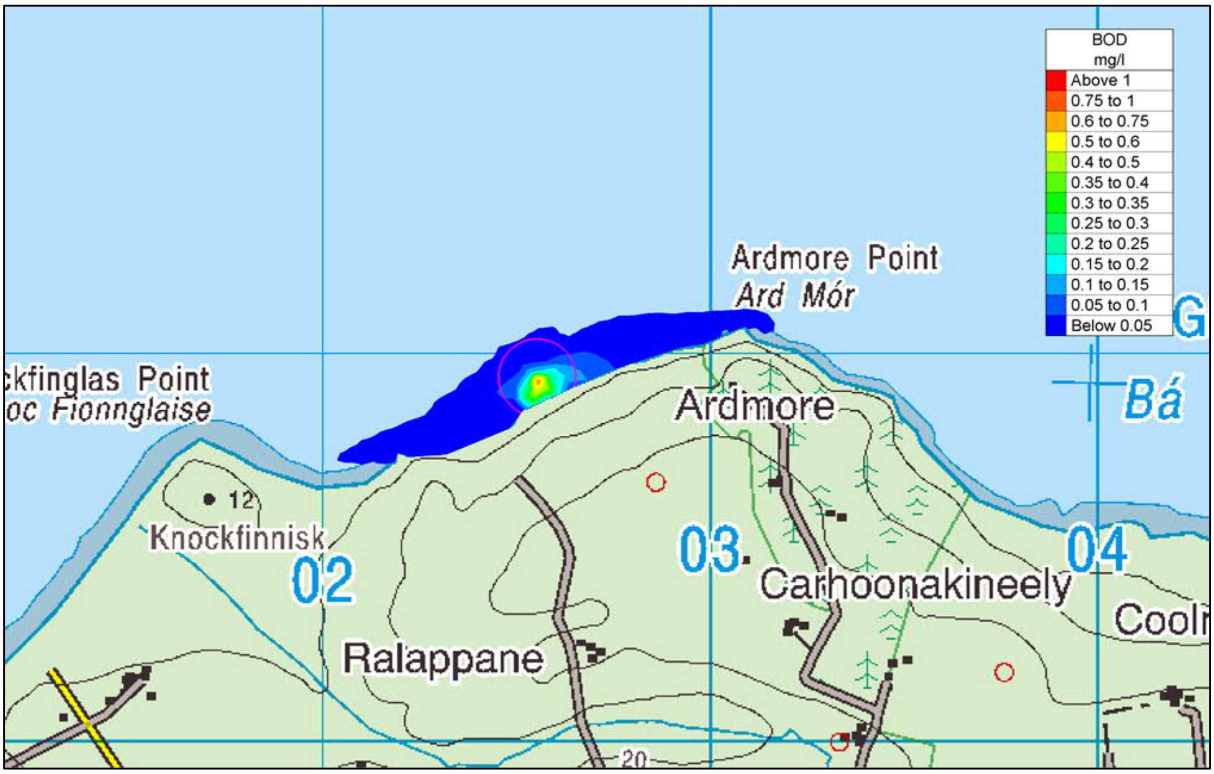

Figure 7A-22 Predicted Maximum BOD concentration (mg/l) Envelope over 15 days for Spring-neap-spring Tide Simulation

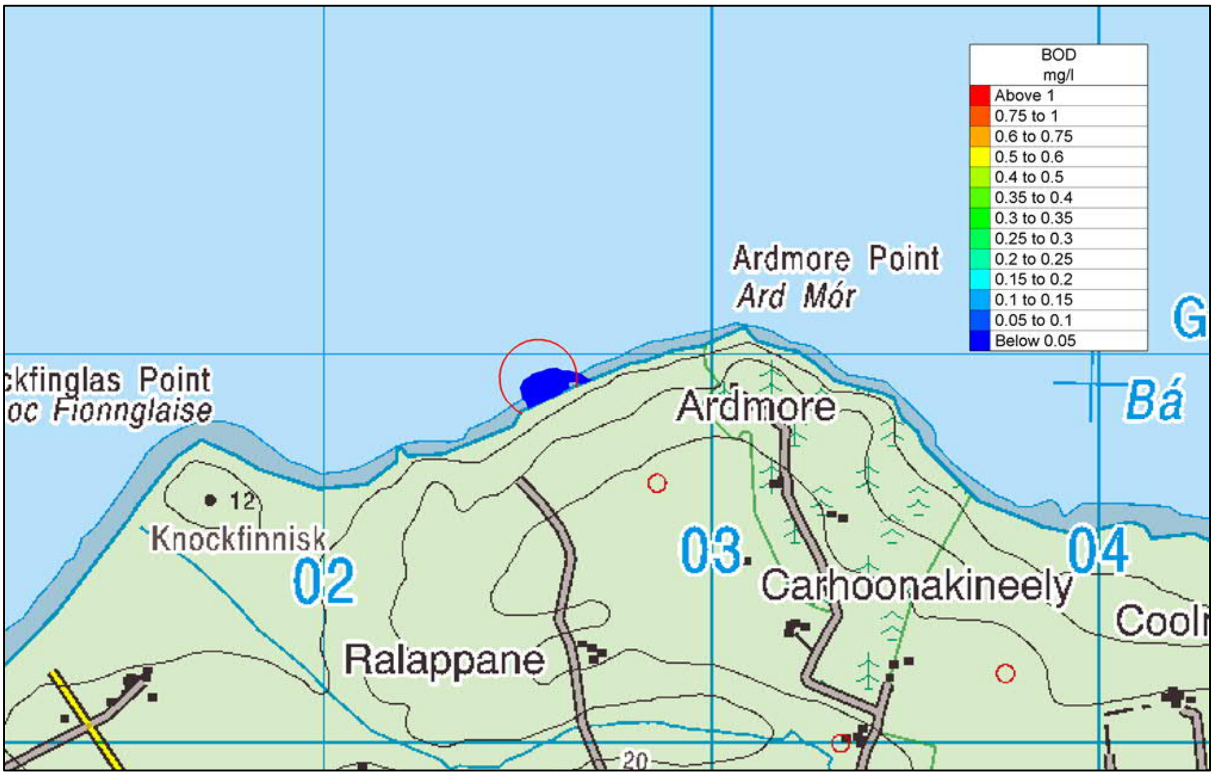

Figure 7A-23 Predicted Mean BOD Concentration (mg/l) Envelope over 15 days for Spring-neap-spring Tide Simulation

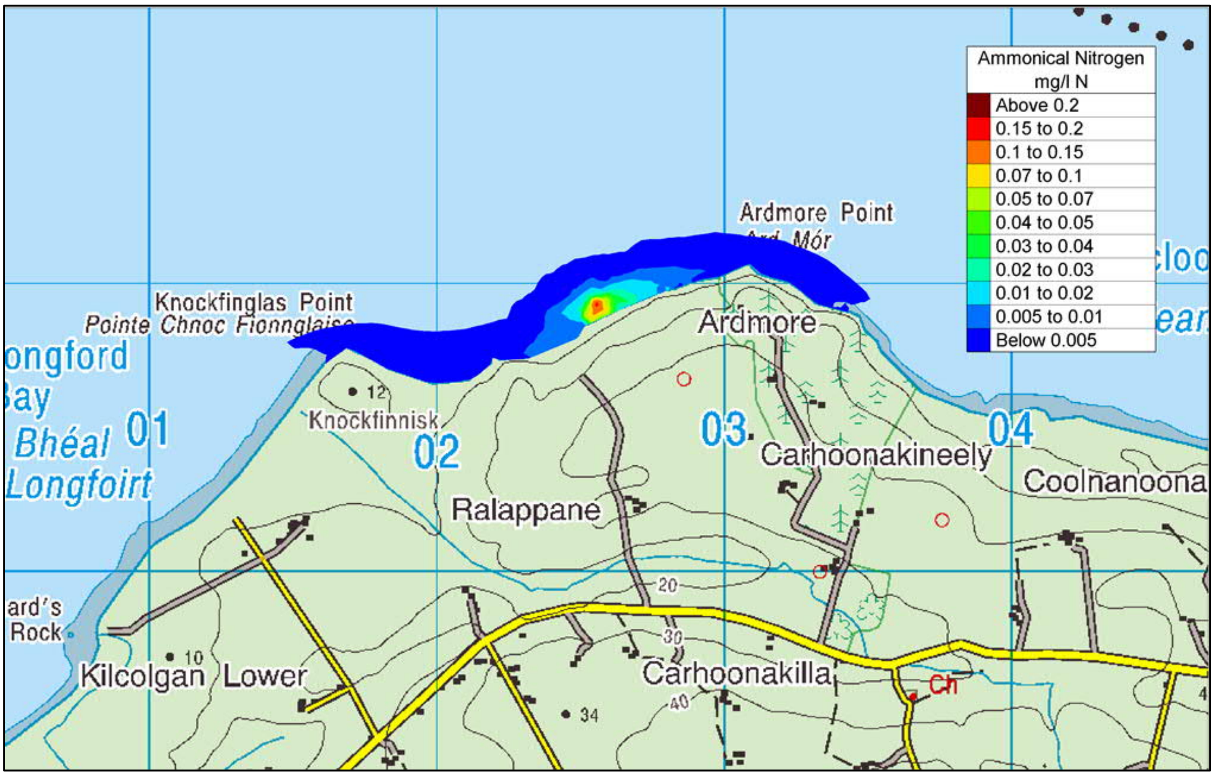

Figure 7A-24 Predicted Maximum Ammoniacal Nitrogen Concentration (mg/l N) Envelope over 15 days for Spring-neap-spring Tide Simulation

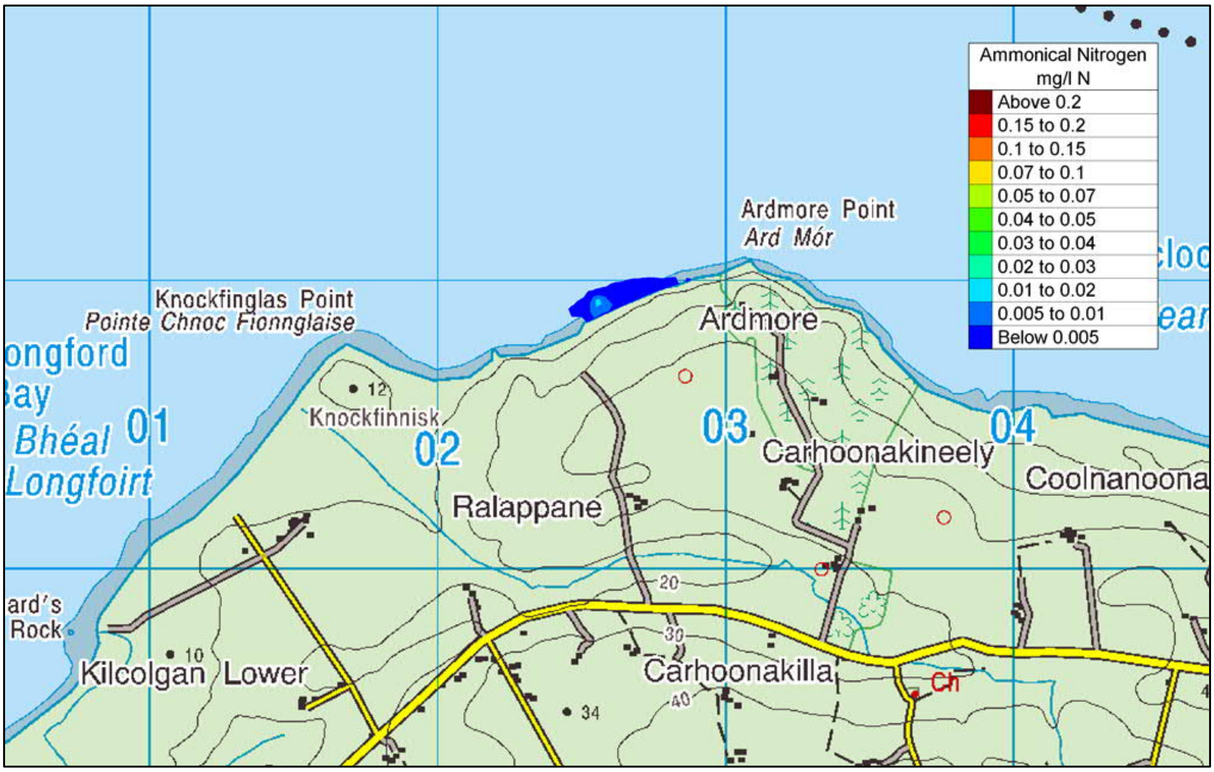

Figure 7A-25 Predicted Mean Ammoniacal Nitrogen Concentration (mg/l N) Envelope over 15 days for Spring-neap-spring Tide Simulation

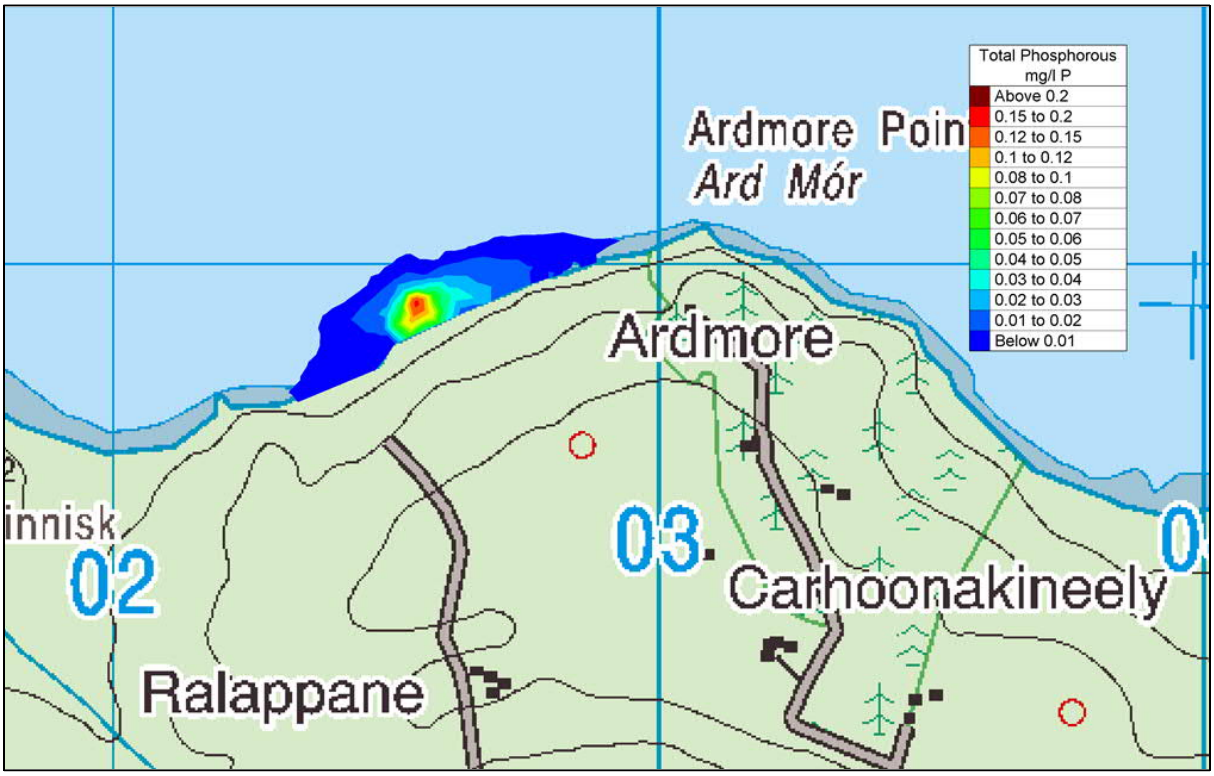

Figure 7A-26 Predicted Maximum Total Phosphorous Concentration (mg/l P) Envelope over 15 days for Spring-neap-spring Tide Simulation

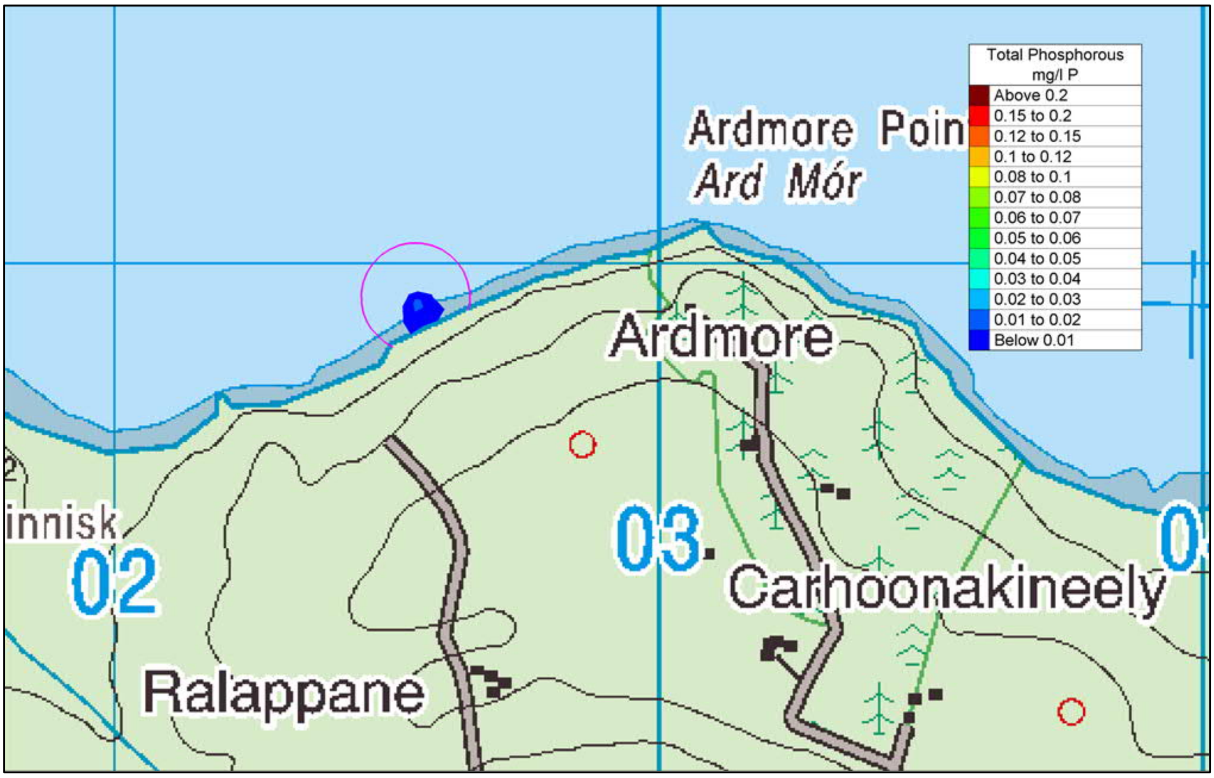

Figure 7A-27 Predicted Mean Total Phosphorous Concentration (mg/l P) Envelope over 15 days for Spring-neap-spring Tide Simulation

7A.5.11 Impact Mechanism 9. Introduction of Invasive Species

7A.5.11.1 Relevant Receptors

- Habitats;
- Marine Mammals; and
- Fish.

7A.5.11.2 Assessment

Impact mechanism 9 is associated with the operation phase.

Invasive non-native plant and animal species are a significant threat to biodiversity worldwide. 'Non-native species' are the equivalent of 'alien species' as used by the Convention of Biological Diversity16. It refers to a species, subspecies or lower taxon, introduced by human action outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce. An invasive non-native species is any non-native animal or plant that has the ability to spread causing damage to the environment. Alien species that become invasive are considered to be main direct drivers of biodiversity loss across the globe. Invasive species are non-native species that can cause harm to the natural ecology of an area, often by out-competing native species.

Ballast water which is used by commercial vessels to control trim, draft and stability is widely recognised as one of the key dispersal mechanisms for marine invasive species. These species can affect the ecological balance of their new regions by outcompeting native species or otherwise impacting native ecosystems. Established protocols to manage the use of ballast water and the risk of introduction and spread of marine invasive species is provided in Section 7A.7.4 below.

7A.5.11.3 Conclusion

Without the implementation of mitigation potential impacts are predicted to **negative**, **significant** and **long-term**.

Strict adherence to protocols will ensure there is no significant risk of environmental impact from the introduction and spread of marine invasive species is managed.

[16] Convention on Biological Diversity. Invasive Alien Species. https://www.cbd.int/invasive/. Accessed 10/01/2017.

7A.5.12 Impact Mechanism 10. Accidental Large Scale Oil or LNG Spill

7A.5.12.1 Assessment

Impact mechanism 10 is associated with the operation phase.

The likelihood of large-scale oil and LNG spills due to accidents and vessel collision during operations at the Proposed Development is regarded as remote, while the risk of accidental small spillages of pollutants (including fuels, hydrocarbons, oils etc.) is considered to be low.

Specifically, the assessment of likelihood of release events from the Proposed Development are set out in the following

- Marine Navigation Risk Assessment, which was prepared by the Shannon Foynes Port Company (see Appendix A2-2 of EIAR Vol. 4).
- Quantitative Risk Assessment (QRA) and associated Major Accidents to the Environment (MATTE) submitted to the HSA as part of the planning application (see Appendix A2-5, Vol. 4).
- EIAR for the Proposed Development submitted ABP as part of the planning application
- OCEMP (see provided in Appendix A2-4, Vol. 4).

Additionally, the operation of the Proposed Development will be controlled and regulated by the following bodies:

- Environmental Protection Agency;
- Commission for Regulation of Utilities;
- Health and Safety Authority;
- KCC; and
- The Shannon Foynes Port Company.

However, in consultation with Shannon Foynes Port Company and the Shannon Estuary Anti-Pollution Team (SEAPT), Shannon LNG has prepared an Oil and Hazardous and Noxious Substances (HNS) Spill Plan Development Framework (see Appendix A2-6 of EIAR Vol. 4). This document describes the graduated and tiered response process to fulfil these obligations and to provide a robust and coordinated response to release incidents in the unlikely event they should occur. The developed plans will follow international best practice guidelines of the International Maritime Organization (IMO), The Society of International Gas Tanker and Terminal Operators (SIGTTO), and International Petroleum Industry Environmental Conservation Association (IPIECA) while taking into account relevant Irish legislative and regulatory approval requirements. In particular the plans will follow the requirements made within the National Maritime Contingency Plan Oil and HNS Spills 2019 (NCP) and the National Framework for the Management of Major Emergencies. The plans will be developed to cover both In-Land (onshore) and Marine based releases and shall cover the Construction and Operational Phases of the Proposed Project. Key objectives and the format of the Oil and HNS Spill Plan Oil and how the plan relates to the National Contingency Plan (NCP) are described in Section 7A.6.

The development has (provisional to project go-ahead) been accepted as member of the Shannon Estuary Anti-Pollution Team (SEAPT). Membership of SEAPT will enable the development to interface directly with the approved Shannon Estuary Oil/HNS Plan and access additional response equipment to augment that held within the terminal (see Section 7A.7.5 for further details).

LNG is stored on the FSRU and LNGC site as a liquefied gas and when released to its surroundings it vaporises rapidly to form natural gas, leaving no residue. LNG (methane and other light hydrocarbons) is classed under the COMAH Regulations as ‘Liquefied Flammable Gasses’. As LNG and natural gas are not toxic to the environment, hazards are associated with exposure to low temperatures from an LNG release (cryogenic burns), or fires if a release of LNG or natural gas is ignited. Environmental receptors at risk are flora and fauna.

The MATTE assessment determined that thermal radiation from jet fires and flash fires will not affect the NHA and onshore cSAC to the west of the Site. LNG Pool fires on the sea surface could lead to thermal radiation effects at the NHA and onshore SAC to the west of the Site. The frequency of these events have been calculated within the Safeti QRA Model and are at most 3.7 x 10^{-6} per year (once in 270,270 years) at the closest point of the onshore SAC. This frequency is considered to be very low. It should be noted that the 5 kw/m^2 thermal radiation intensity is below that which would lead to a fire and therefore recovery from this type of event would be less than three years. Modelling indicates that the jet and pool fire contours of 5kW/m^2 reach areas of the estuary that forms part of the SAC and SPA close to the jetty/terminal. While harm to birds present on the estuary surface close to the Proposed Development may be possible in the event of a fire, bird surveys have identified that there are no significant populations of bird species in the vicinity of the Proposed Development site. Based on the definition of a MATTE jet fires and LNG pool fires are not considered credible MATTE events. All of the MATTE events identified are considered to be low frequency and consequently low risk.

Based on the assessments described above, the likelihood of major accident is predicted to be remote and therefore does not pose a significant risk to habitats or species within or in the vicinity of the Proposed Development site.

7A.5.12.2 Conclusion

Based on the assessments described above, the risk of major accident is predicted to be remote and therefore are not an issue to habitats or species within or in the vicinity of the Proposed Development site.

The potential impact of small-scale accidental spillages is predicted to be **negative**, **significant** and **medium-term.**

With the implementation of mitigation impact of small-scale accidental spillages is predicted to be **not significant.** It should be noted that releases of pollution will be contained and cleaned up immediately. Remediation measures will be carried out in the unlikely event of pollution of the marine environment.

7A.5.13 Climate Change and Biodiversity

The EU Commission guidance document on integrating climate change and biodiversity into environmental impact assessment (EU Commission, 2013) aims to improve the way in which climate change and biodiversity are integrated into Environmental Impact Assessment. Key principles specified by the document when considering impacts include the following:

- Consider climate change at the outset;
- Analyse the evolving environmental baseline trends;
- Take an integrated approach;
- Seek to avoid biodiversity and climate change effects from the start;
- For biodiversity, EIA should focus on ensuring ‘no net-loss’;
- Assess alternatives that make a difference in terms of climate change and biodiversity;
- Use ecosystem-based approaches and green infrastructure as part of the project design and/ or mitigation measures; and
- Assess climate change and biodiversity synergies and cumulative effects which can be significant.

The potential effects from the Proposed Development on climate have been specifically addressed by Chapter 15 – Climate. No significant interactions between the effects on biodiversity resulting from this development and climate change have been identified.

7A.5.14 Decommissioning

As described in Chapter 02 – Project Description, the Proposed Development is expected to have a design life of 50 years, but this could be extended by maintenance, equipment replacement and upgrades or by the transition of the site to use hydrogen capability (which would be subject to a future planning application).

During decommissioning, measures would be undertaken by the Applicant to ensure that there would be no significant, negative environmental effects during the decommissioning phase. The decommissioning plan would incorporate measures to satisfy all regulatory requirements and to achieve targeted environmental goals. The decommissioning measures would have to be implemented to the satisfaction of the relevant consenting authorities.The impact of decommissioning will be **temporary** and **not significant** following the implementation of standard mitigation measures.

7A.6 Cumulative Impacts

The cumulative impacts of the Proposed Development and nearby consented projects in the vicinity of the Proposed Development are discussed below. A planning search of granted and pending planning applications made within the vicinity of the Proposed Development site is presented in Chapter 04 – Energy and Planning Policy.

7A.6.1 Summary of Schemes Considered in Cumulative Impact Assessment

7A.6.1.1 LNG Pipeline, Data Centre Campus and Power Transmission

LNG Pipeline

Permission was granted in 2009 for a pipeline to connect the Proposed Development to the existing national gas network near Foynes, Co. Limerick. The application was accompanied by an EIAR. No significant residual effects were identified to the marine environment in the EIAR for the LNG pipeline.

Following the implementation of good practice standard construction environmental measures and the CEMP for the Proposed Development as detailed, **no significant** cumulative effects on marine biodiversity will result.

Data Centre Campus

A Data Centre Campus is to be constructed to the west of the Proposed Development. This will be subject to its own EIAR and planning application.

220 kV and Medium Voltage (10/ 20 kV) Power Transmission Systems

An application to connect to the national electrical transmission network via a 220 kV high voltage connection was submitted to EirGrid in September 2020. An offer has yet to be received. It is expected that the high voltage connection will run 5 km east under the L1010 road to the ESBN/ EirGrid Kilpaddoge 220 kV substation.

The LNG Terminal may need to be operational before the Power Plant and/ or 220 kV high voltage grid connection are completed or operational. Therefore, the LNG Terminal design will also require an onsite substation and a separate medium voltage (10/ 20 kV) connection, from the existing Electricity Supply Board Networks (ESBN)/ EirGrid Kilpaddoge substation. This will be used as a back-up electricity system when the Power Plant is undergoing maintenance.

The medium voltage (10/ 20 kV) and 220 kV power connections will be constructed in parallel with the Proposed Development but will be subject to separate planning design and planning applications.

Construction Impact

If works associated with these three schemes (described above) in close proximity to the Proposed Development are concurrent with works at the Proposed Development, there is potential for cumulative impacts and effects on marine biodiversity features. Should this situation arise, construction activities will be planned and phased, in consultation with the construction management team for the STEP.

The implementation of best practice standard construction environmental measures and the OCEMP for the Proposed Development as detailed, no significant cumulative effects on biodiversity will result.

Discharges from both this project and the Proposed Development are governed by strict limits to ensure compliance with quality standards. **No long-term cumulative impact** on water quality will occur.

Operational Impacts

No cumulative operational impact will occur.

7A.6.1.2 Cross Shannon 400 kV Cable Project

If the sediment plumes associated with the Cross Shannon 400 kV Cable Project overlap plumes generated due to the installation of piles, there is potential that combined sediment deposition depths could exceed the threshold for impact to habitats and associated faunal communities.

As discussed in section 3.4.3, OSPAR Commission (OSPAR 2008, 2009) outline that benthic fauna can survive rapid sediment deposition up to depths of 100mm, while negative impacts to marine life are only expected when sediment deposition depths exceed 150mm.

While the sediment plumes generated due to the installation of piles (see Figure 7A-33) overlap the sediment plumes generated by the Cross Shannon 400 kV Cable Project (see Figure 7A-34), the combined sediment deposition depths do not exceed the threshold identified in OSPAR (2008, 2009) for impacts to habitats and associated faunal communities; consequently it is predicted that significant negative in-combination effect will not occur.

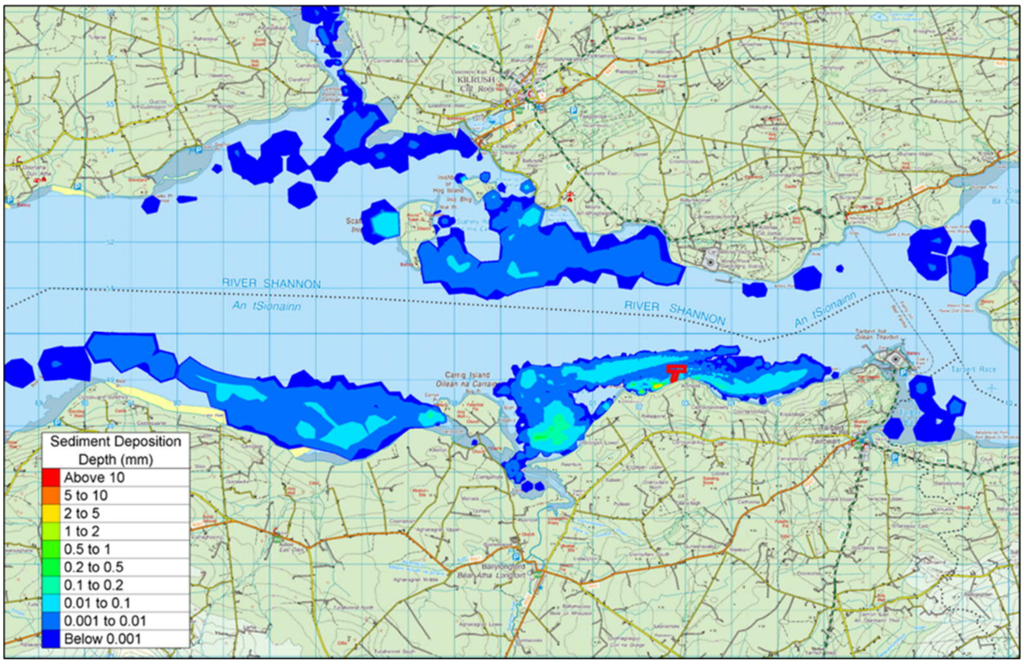

Figure 7A-28 Marine Community Types Identified within Annex I Habitats in Relation to the Modelled Sediment Plume Associated with Sediment Generated by Piling

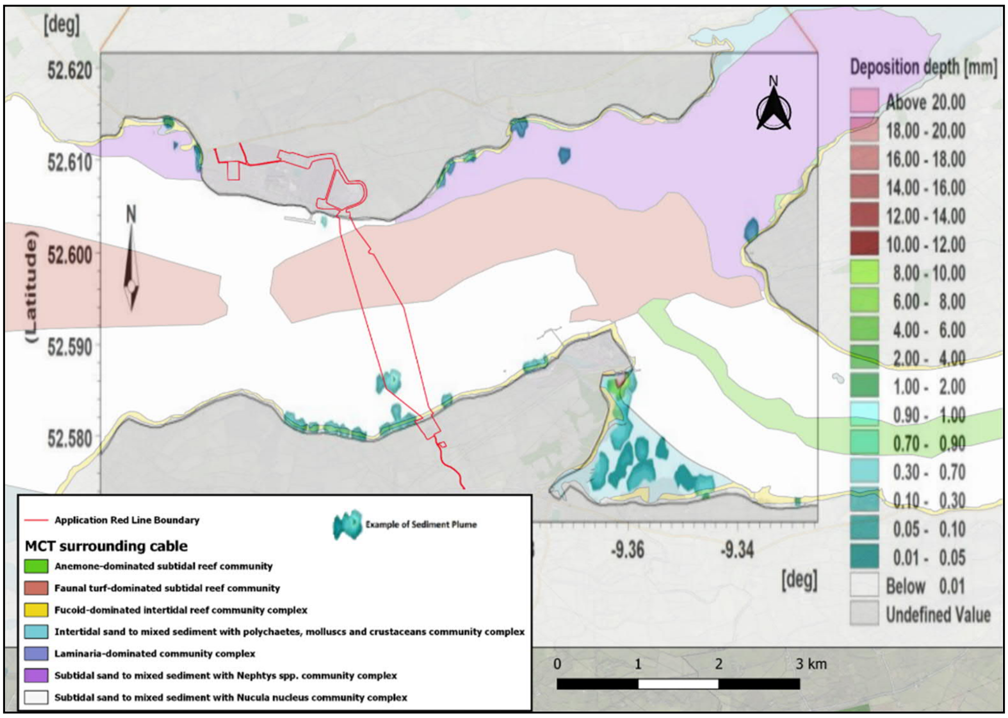

Figure 7A-29 Marine Community Types Identified within Annex I Habitats in Relation to the Modelled Sediment Plume for Trenching Activities Proposed for the Cross Shannon 400 kV Cable Project (Mott McDonald, 2019)

7A.7 Mitigation and Monitoring Measures

7A.7.1 Construction Mitigation Measures and Best Practice

This will take into account measures presented in the OCEMP regarding construction activities including any that are required to ensure no significant release of pollutants, sediment laden water, runoff chemicals or other waste material pollution into the nearby habitats, watercourses and waterbodies.

Measures will include standard construction best practice used to manage the risk of potential for loss of hydrocarbons such as diesel and hydraulic fluids. Careful supervision of construction operations and general construction practice will reduce the risk from impacts so that the likelihood of impacts is best described as low.

At a minimum the oil spill response equipment will include the following: absorbent mats, waste- bags, oil splash goggles, gloves and vinyl or rubber shoe covers to protect the user from the harmful effects of the spilled material.

Imported backfill material will be washed (cleaned) to remove fines and checked for invasive species before use.

Imported material to be used backfill will be stored on the site; measures to avoid the release of sediment will be implemented (including silt fences).

Clean (washed) rock material will be used as rock protection to minimise the risk of introducing fine materials.

The implementation of general construction practice will ensure that the likelihood of pollution in a well-equipped, maintained and managed construction site is low.

7A.7.2 Underwater Noise Mitigation

To mitigate potential impact to marine mammal species Shannon LNG will implement relevant impact mitigation and monitoring measures in relation to marine mammals as outlined in DAHG Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (DAHG, 2014).

7A.7.2.1 NPWS 2014 Required Mitigation

- **Pre-start Observation:** Marine mammal observation period of 30 minutes minimum prior to start (or re-start after a break of 30 minutes) of any impact piling and any drilling;
- **Start delay due to observation:** A gap of at least 30 minutes required between last observation of a marine mammal and start of operations;
- **Observation zone:** The observation zone is 1000 m for impact piling and 500 m for drilling (thus impact piling likely to require > 1 marine mammal observer);
- **Commence in daylight only:** Impact piling and drilling can only start in daylight conditions when visual monitoring can take place (*i.e.* when wind/ wave conditions mean observation is possible: NPWS guidance recommends 'sea conditions for effective visual monitoring by MMOs are WMO Sea State 4 (≈Beaufort Force 4 conditions) or less';
- **Soft-start:** For any source, including equipment testing, exceeding 170 dB re: 1µPa @1 m an appropriate ramp-up procedure (*i.e.* 'soft-start') must be used. This should be a minimum of 20 minutes and no longer than 40 minutes;
- **Continuity:** Once piling or drilling has started it can continue into darkness and does not need to stop even if marine mammals are seen in the observation zone (in fact, an MMO is not required once the sound generating activity starts though continued observation can be beneficial for unexpected breaks or down-time as the 30 minute observation period can start immediately;
- **Marine mammal observer:** MMOs must be dedicated to and engaged solely in monitoring an operator's implementation of the NPWS technical guidance. A sufficient number of MMO personnel must be assigned to ensure that the role is performed effectively. Avoidance of observer fatigue is essential; and
- **MMO training:** Use trained and experienced marine mammal observers – the guidance states this should be a visual observer who has undergone formal marine mammal observation and distance estimation training (JNCC MMO training course or equivalent) and also has a minimum of 6 weeks full-time marine mammal survey experience at sea over a 3-year period in European waters.

7A.7.2.2 Additional Mitigation

- **Piling activities:** No simultaneous impact piling;
- **Continuity between activities:** Pile installation will require a combination of techniques including impact piling, vibratory piling and drilling requiring breaks in activity as equipment is changed. Where an activity progresses to a lower sound level activity – i.e. from impact piling to vibratory piling or drilling, and the break between activities is less than 30 minutes a new period of observation is not required, and activities can be considered to be continuous;
- **Additional seasonal observation for bottlenose dolphin:** For any impact piling taking place during August, an additional MMO will be present at Moneypoint to undertake additional observations for mother-young dolphin pairings. There is known presence of neonatal bottlenose dolphin in the estuary between July and September, peaking in August, and though numbers are low there is potential for presence in the region of the Proposed Development. There will be full communication between the Moneypoint MMO and the construction team to ensure no impact piling commences until animals have moved away from a 1000 m radius observation zone (ensuring the full width of the estuary is observed in August);
- **Mitigation measures during blasting:** Whilst all blasting is land based there will be propagation of sound into the underwater environment. Thus, the standard mitigation measures for blasting will be adopted as a precautionary measure – qualified MMO, a 1000 m observation zone and an

observation period of 30 minutes. As only single blasts will take place in each event (not a series), a soft-start is not included; and

- **Monitoring:** The marine mammal monitoring programme, currently being undertaken by the Irish Whale and Dolphin Group (in the vicinity of the project using CPODs) will be continued into the construction phase for the validation of predictions (based on observations from other studies – see impact assessment) that any animals displaced from an area return after the construction activity stops.

7A.7.3 Invasive Species Surveys

A post consent verification invasive species survey will be undertaken within the Proposed Development boundary by a competent ecologist to determine if invasive species listed under Part 1 of the Third Schedule of S.I No. 477 of 2011 have established in the area in the period between pre-planning and post consent. In the event that invasive species are identified within the works area a site-specific Invasive Species Management Plan will be developed and implemented by a competent specialist on behalf of the Contractor. In addition, in order to comply with Regulations 49 and 50 of the European Communities (Birds and Natural Habitat) Regulations (2011) the appointed Contractor will ensure biosecurity measures are implemented throughout the construction phase to ensure the introduction and translocation of invasive species is prevented. The appointed Environmental (Ecological) Clerk of Works (ECoW) will carry out a toolbox talk which will identify invasive species and will also implement biosecurity measures such as the visual inspection of vehicles for evidence of attached plant or animal material prior to entering and leaving the works area.

To ensure the spread of invasive species is avoided a ‘Check, Clean, Dry’ protocol will be undertaken by the appointed ECoW with all equipment, machinery and vehicles entering and leaving the Proposed Development boundary.

7A.7.4 Ballast Management

Ballast water for the FSRU and LNGC would be managed in accordance with the vessels Ballast Water Management Plan in accordance with Flag State requirements, Shannon Foynes Port Company operating procedures and the provisions of section 34 of the Sea Pollution (Miscellaneous Provisions) Act 2006 referencing the International Convention for the Control and Management of Ships' Ballast Water and Sediments, which entered into force in September 2017.

The FSRU would initially arrive at the Terminal full of LNG and therefore would not be carrying ballast. Ballasting of vessels within the River Shannon is a routine practice and the FSRU would take on ballast water from the river once in operation. There is, therefore, no risk of extra marine invasive species being introduced to the River Shannon from FSRU ballast water. LNGCs also would arrive full of LNG and with no ballast water. The LNGC’s would take in ballast water in accordance with routine practice.

7A.7.5 Pollution Mitigation and Response Protocols

HNS Spill Plan

The primary objectives of Oil and Hazardous and Noxious Substances (HNS) Contingency Plans under the framework are:

- To assess the pollution risk from operations and ensure sufficient preventative and response measures are in place to ensure the risk of a pollution incident ‘as low as reasonably practicable’ (ALARP);
- To ensure the safety of employees, contractors, response personnel and the community/ members of the public throughout the response to a pollution incident:
- To detail the internal and external notification processes and set-in motion practices for an integrated efficient pollution response;
- To ensure the timely mobilisation of resources, both personnel and equipment, to combat a pollution incident within the geographical scope of this plan;

- To have in place actions and procedures to ensure the response to a pollution incident is both timely and effective in mitigating any adverse impact on vulnerable socio-economic and environmental receptors; and
- To be compliant with regulatory and best practice guidance on pollution preparedness and response.

In accordance with the requirements of the National Contingency Plan (NCP) Standard Operation Procedure 05, the Plan is developed around the five operational phases of the core document:

- Phase 1 – Discovery and Notification, Evaluation, Identification and Activation;
- Phase 2 – Development of an Action Plan;
- Phase 3 – Action Plan Implementation;
- Phase 4 – Response Termination and Demobilisation;
- Phase 5 – Post Operations, Documentation of Costs/ Litigation; and

The Oil and HNS Spill Plan is presented in Appendix A2-6, Vol. 4).

The Shannon Estuary Anti-Pollution Team

The Shannon Estuary Anti-Pollution Team (SEAPT) is a Mutual Aid Group and the primary response organisations for oil and HNS spills within the Shannon Estuary. The SEAPT consists of the Shannon Foynes Port Company, Kerry, Limerick and Clare Local Authorities and commercial and industrial entities operating within the Shannon Estuary. SEAPT was initiated to form a unified coordinated response to pollution incidents on the Shannon Estuary. SEAPT is a members' organisation. Members contribute annually to maintain equipment, carry out exercises and training and purchase new and replacement equipment. SEAPT holds a significant stockpile of equipment. This equipment is available to respond to any pollution incident or threat thereof. The Proposed Development would also be able to avail of spill dispersion modelling capability held by SEAPT. SEAPT are also the custodians of the Shannon Estuary Oil/ HNS Contingency Plan developed in accordance with the NCP and approved by the Irish Coast Guard. Shannon LNG Limited has consulted extensively with SEAPT and the intention is to join the SEAPT organisation on successfully receiving development consents and prior to commencement of the construction phase. The development has (provisional to project go-ahead) been accepted as a member of the SEAPT. Membership of SEAPT will enable the development to interface directly with the approved Shannon Estuary Oil/ HNS Plan and access additional response equipment to augment that held within the Terminal. Through the membership process, the development will additionally be contributing to the on-going development and strengthening of the SEAPT organisation.

Incident Response

The development will manage the response to any Tier 1 (Local – within the capability of the operator onsite) and Tier 2 (Regional – beyond the in-house capability of the operator) incident for any pollution on the water within their area of jurisdiction with the full cooperation and integration of the response with the Shannon Foynes Port, the SEAPT mutual aid group which includes the three local authorities of Kerry, Clare and Limerick and other agencies as appropriate. However, the developed plans will identify realistic Tier 1 and Tier 2 scenarios and the resources required to effectively respond to and mitigate these. The plans will further describe any escalation to Tier 3 (requiring national resources) and as discussed above, interface with the National Marine Oil/ HNS Spill Contingency Plan. A training and exercising program forms part of the plans. The completed plans will be submitted to the Irish Coast Guard and EPA for appropriate approvals.

7A.8 Do Nothing Scenario

A significant proportion of marine habitats and associated flora and fauna have been modified from their natural state by human activity. In the absence of Proposed Development, it is expected that the marine environment would largely remain under the same management regimes. No significant changes are likely to occur, in the 'do nothing' scenario.

7A.9 Residual Impacts

Table 7A-17 below provides a summary of table of residual risk of impact to marine ecology associated with each impact mechanism.

Impact Mechanism 1 Release of Pollutants During Construction
The release of pollutants during construction has the potential to impact water quality, habitats, fish and marine mammals. In sufficient quantities pollutant released during the construction phase have the potentially to impact water quality, contaminate the seabed sediments, and directly impact flora and fauna. Standard construction best practice mitigation measures to prevent release of sediments, chemical and pollutants during construction will ensure there is no significant risk of impact to receptors.

Impact Mechanism 2 Release of Spoil during Piling
Given the scale of piling operations significant releases of spoil will not occur and there is no significant risk of impact to environment impact. Mitigation and monitoring measures are not required.

Impact Mechanism 3 Underwater Noise
The relevant receptors are marine mammals and fish.

To mitigate potential impact to marine mammal species during the construction phase Shannon LNG will implement relevant impact mitigation and monitoring measures in relation to marine mammals as outlined in DAHG Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (DAHG, 2014). The mitigation is summarised in Section 7A.7.2.1 above. To further ensure no potential impact to marine mammal Shannon LNG will also implement the additional mitigation outlined in Section 7A.7.2.2 above.

Given the scale of construction piling operations the area within fish mortalities and/ or mortal injuries could occur is relatively small. Consequently, the overall fish population could not be impacted. Mitigation and monitoring measures are not required.

Impact Mechanism 4 Seabed Habitat Loss
The installation of construction piles for the jetty structures foundations and, the installation of a trenched water outfall across the shoreline into the Shannon estuary will result in negligible loss of habitats relative to the total area of the habitats and will not result in significant effects. The minor, almost imperceptible, effects are reversible with recovery following decommissioning of the project.

Impact Mechanism 5 Vessel Physical Disturbance and Collision Injury
The receptors relevant are marine mammals. The presence of the slow moving project vessels will not significantly increase the level of vessel activity and disturbance in the area or increase the risk of collisions. It is concluded that will be no significant impact to marine mammals. Mitigation and monitoring measures are not required.

Impact Mechanism 6 Discharge of Treated Cooled Seawater
Given the minor insignificant relative local change in chlorine level and water temperature, there will be no significant environmental effects to habitats, marine mammals or fish species. Mitigation and monitoring measures are not required.

Impact Mechanism 7 Entrainment and Impingement of Fauna by the FSRU Seawater System
The seawater system has been designed to minimise possible intake of marine organisms including adult macrocrustaceans and fish larvae and juveniles. While some planktonic and larval forms of will be entrained and impinged, there will be no significant impacts. Mitigation and monitoring measures are not required.

Impact Mechanism 8 Discharge of Wastewater and Power Plant Process Heated Water Effluent
Water quality parameters satisfy the permissible limits set out in the surface water regulations and will not impact the water quality status of the receiving Shannon Estuary waters. Consequently, it can be concluded there will be no significant environmental impact.

Impact Mechanism 9 Introduction of Invasive Species
Established protocols to manage the use of ballast water and the risk of introduction and spread of marine invasive species are detailed in Section 7A.7.4.

Impact Mechanism 10 Accidental Large Scale Oil or LNG Spill

Mitigation measures specifically designed to minimise the risk of spills and the introduction of contaminants to the Shannon Estuary will ensure the environmental risk is managed. Mitigation measures are detailed in detailed in Section 7A.7.5.

Potential Impact to Aquaculture Activities

Aquaculture activity in the SAC and SPA relates to the production of shellfish (oysters and mussels). The main aquaculture activity involves the cultivation of Pacific oysters (*Crassostrea gigas*) on trestles in intertidal areas. The mussel culture includes subtidal suspended (longlines) and bottom culture. The majority of the sites are contained in inner Poulnasherry Bay where aquaculture activity has been carried out for many years. There are aquaculture applications in outer Poulnasherry Bay and there are existing and proposed aquaculture activities in the Carrigaholt, Rinevella, Ballylongford/Bunaclugga and Aughinish/ Foynes areas of the Shannon Estuary. In addition, there are three areas within the Shannon Estuary covered by Fishery Orders. While these Orders do not come under the remit of the Department of Agriculture, Food and Marine, they are included as part of the in-combination assessment.

Impact mechanisms associated with the Proposed Development that have potential to directly impact water quality and indirect impact to aquaculture activities is Impact Mechanism 8. Wastewater discharge and Power Plant Process Heated Water Effluent. Hydrodynamic and dispersion modelling study concluded that change to water quality parameters are within permissible limits set out in the surface water regulations and will not impact the water quality status of aquaculture areas. Consequently, it can be concluded there will be no significant impact.

7A.10 Summary

Impacts on the marine ecological environment as a result of the Proposed Development are summarised as follows:

The marine elements of the Proposed Development overlap with the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA. The OCEMP implemented will contain the construction best practice standards and measures regarding pollution prevention. Following implementation of mitigation measures there will be no adverse impacts on designated sites overlapping with the elements of the project.

During the construction phase Shannon LNG will implement relevant impact mitigation and monitoring measures in relation to marine mammals to ensure no potential impact to marine mammal.

The loss of habitat due to the installation of construction piles and, the trenched water outfall is negligible, and will not result in significant effects. The minor, almost imperceptible, effects are reversible with recovery following decommissioning of the project.

The release of spoil during piling operations will not result in significant environment impact.

The presence of the project vessels will not significantly increase the level of vessel activity and disturbance in the area or increase the risk of collisions with marine mammals.

The release of treated cooled seawater will not result in significant environmental impacts

There will be an insignificant loss of fauna due to entrainment and impingement on seawater system FSRU seawater system.

Wastewater and Power Plant process heated water effluent will not impact the water quality status of the receiving Shannon Estuary waters.

Implementation of established ballast water management protocols and measures will manage the risk of the introduction and spread of marine invasive.

Environmental risk of spills and the release of contaminants will be managed by implementation established protocol and mitigation.

Table 7A-17 Summary

Proposed Development Stage	Aspect/ Impact Assessed	Receptor (greatest importance)	Impact Quality	Impact Significance (Prior to Mitigation)	Impact Duration and Frequency	Mitigation and Monitoring Measures (the Proposed Development design embedded environmental controls and all mitigation and monitoring measures detailed herein are included in the OCEMP)	Significance rating (Following Mitigation)	EIAR Chapter Reference
Construction Phase	Impact Mechanism 1 Release of pollutants during construction	Marine habitats of the Lower River Shannon cSAC)	Negative	Significant	Short-term	Standard construction best practice mitigation measures to prevent release of sediments, chemical and pollutants during construction (see Section 7A.7.1 and the OCEMP included in Appendix A2-4, Vol. 4).	Not significant	Section 7A.5.3
Construction Phase	Impact Mechanism 1 Release of pollutants during construction	Marine Mammals (including Bottlenose dolphin species of the Lower River Shannon cSAC)	Negative	Significant	Short-term	Standard construction best practice mitigation measures to prevent release of sediments, chemical and pollutants during construction (see Section 7A.7.1 and the OCEMP included in Appendix A2-4, Vol. 4).	Not significant	Section 7A.5.3
Construction Phase	Impact Mechanism 1 Release of pollutants during construction	Fish populations of estuary including fish of the Lower River Shannon cSAC)	Negative	Significant	Short-term	Standard construction best practice mitigation measures to prevent release of sediments, chemical and pollutants during construction (see Section 7A.7.1 and the OCEMP included in Appendix A2-4, Vol. 4).	Not significant	Section 7A.5.3
Construction Phase	Impact Mechanism 2 Release of spoil during piling	Marine Mammals (including Bottlenose dolphin species of the Lower River Shannon cSAC)	Negative	Not Significant	Short-term	None	-	Section 7A.5.4
Construction Phase	Impact Mechanism 2 Release of spoil during piling	Marine Mammals (including Bottlenose dolphin species of the Lower River Shannon cSAC)	Negative	Not Significant	Short-term	None	-	Section 7A.5.4
Construction Phase	Impact Mechanism 2 Release of spoil during piling	Fish populations of estuary including fish of the Lower River Shannon cSAC)	Negative	Not Significant	Short-term	None	-	Section 7A.5.4

Construction Phase **and** Operation Phase	Impact Mechanism 3 Underwater noise	Fish of the Lower River Shannon cSAC)	Negative	Not Significant	Short-term	None	-	Section 7A.5.5
Construction Phase	Impact Mechanism 3 Underwater noise	Marine Mammals (including Bottlenose dolphin species of the Lower River Shannon cSAC)	Negative	Significant	Medium-term	Chapter 07A summarises standard mitigation required to minimise the risk potential impact to marine mammal species as outlined in DAHG, 2014: • Marine mammal observation period of 30 minutes minimum prior to start (or re-start after a break of 30 minutes) of any impact piling and any drilling; • A gap of at least 30 minutes required between last observation of a marine mammal and start of operations; • The observation zone is 1000 m for impact piling and 500 m for drilling (thus impact piling likely to require > 1 marine mammal observer); • Impact piling and drilling can only start in daylight conditions when visual monitoring can take place (i.e. when wind/ wave conditions mean observation is possible: NPWS guidance recommends ‘sea conditions for effective visual monitoring by MMOs are WMO Sea State 4 (≈Beaufort Force 4 conditions) or less’; • For any source, including equipment testing, exceeding 170 dB re: 1µPa @1 m an appropriate ramp-up procedure (i.e. ‘soft-start’) must be used. This should be a minimum of 20 minutes and no longer than 40 minutes; • Once piling or drilling has started it can continue into darkness and does not need to stop even if marine mammals are seen in the observation zone (in fact, an MMO is not required once the sound generating activity starts though continued observation can be beneficial for unexpected breaks or down-	Not significant	Section 7A.5.5

time as the 30 minute observation period can start immediately;

- MMOs must be dedicated to and engaged solely in monitoring an operator's implementation of the NPWS technical guidance. A sufficient number of MMO personnel must be assigned to ensure that the role is performed effectively. Avoidance of observer fatigue is essential; and
- Use trained and experienced marine mammal observers – the guidance states this should be a visual observer who has undergone formal marine mammal observation and distance estimation training (JNCC MMO training course or equivalent) and also has a minimum of 6 weeks full-time marine mammal survey experience at sea over a 3-year period in European waters.

Additional mitigation measures to be implemented include:

- No simultaneous impact piling (i.e. two rigs operating at the same time);
- Pile installation will require a combination of techniques including impact piling, vibratory piling and drilling requiring breaks in activity as equipment is changed. Where an activity progresses to a lower sound level activity – i.e. from impact piling to vibratory piling or drilling, and the break between activities is less than 30 minutes a new period of observation is not required, and activities can be considered to be continuous;
- For any impact piling taking place during August, an additional MMO will be present at Moneypoint to undertake additional observations for mother-young dolphin pairings. There is known presence of neonatal bottlenose dolphin in the estuary between July and September, peaking in August, and though numbers are low there is potential for presence in the region of the Proposed Development. There will be full

						communication between the Moneypoint MMO and the construction team to ensure no impact piling commences until animals have moved away from a 1000 m radius observation zone (ensuring the full width of the estuary is observed in August); • Whilst all blasting is land based there will be propagation of sound into the underwater environment. Thus, the standard mitigation measures for blasting will be adopted as a precautionary measure – qualified MMO, a 1000 m observation zone and an observation period of 30 minutes. As only single blasts will take place in each event (not a series), a soft-start is not included; and • The marine mammal monitoring programme, currently being undertaken by the Irish Whale and Dolphin Group (in the vicinity of the project using CPODs) will be continued into the construction phase for the validation of predictions (based on observations from other studies – see impact assessment) that any animals displaced from an area return after the construction activity stops.		
Construction Phase **and** Operation Phase	Impact Mechanism 4 Seabed habitat loss	Annex I habitats 1130 Estuaries and 1170 Reefs of the Lower River Shannon cSAC	Negative	Not Significant	Reversible Effects	Negligible loss of habitat pending decommissioning of the development and natural recolonisation of reinstatement of the affected habitat areas.	Not significant	Section 7A.5.6
Construction Phase **and** Operation Phase	Impact Mechanism 5 Vessel physical disturbance and collision injury	Marine Mammals (including Bottlenose dolphin species of the Lower River Shannon cSAC)	-	Not Significant	-	None	-	Section 7A.5.7
Operation Phase	Impact Mechanism 6	Habitats of the Lower River Shannon cSAC)	-	Not Significant	-	None	-	Section 7A.5.8

	Discharge of treated cooled seawater							
Operation Phase	Impact Mechanism 6 Discharge of treated cooled seawater	Marine Mammals (including Bottlenose dolphin species of the Lower River Shannon cSAC)	-	Not Significant	-	None	-	Section 7A.5.8
Operation Phase	Impact Mechanism 6 Discharge of treated cooled seawater	Fish populations of estuary including fish of the Lower River Shannon cSAC)		Not Significant	-	None	-	Section 7A.5.8
Operation Phase	Impact Mechanism 7 Entrainment and impingement of fauna by the FSRU seawater system	Fish and crustacean species of the estuary (including fish species of the Lower River Shannon cSAC)	Negative	Not Significant	-	None	-	Section 7A.5.9
Operation Phase	Impact Mechanism 8 Discharge of Wastewater and Power Plant Process Heated Water Effluent	Habitats (including marine habitats of the Lower River Shannon cSAC)	Negative	Not Significant	Long-term	None	-	Section 7A.5.10
Operation Phase	Impact Mechanism 8 Discharge of Wastewater and Power Plant Process Heated Water Effluent	Marine Mammals (including Bottlenose dolphin species of the Lower River Shannon cSAC)	Negative	Not Significant	Long-term	None	-	Section 7A.5.10
Operation Phase	Impact Mechanism 8 Discharge of Wastewater and Power Plant	Fish populations of estuary including fish of the Lower River Shannon cSAC)	Negative	Not Significant	Long-term	None	-	Section 7A.5.10

	Process Heated Water Effluent						
Operation Phase	Impact Mechanism 9 Introduction of invasive species	Negative	Significant	Long-term	Before and after use, all relevant equipment will be thoroughly cleaned using Virkon Aquatic to guard against the spread of fish viruses, bacteria, fungi, and moulds. All water used in the cleansing, testing or disinfection of structures or machinery shall be rendered safe prior to discharge, particularly any chlorinated water. A post consent verification invasive species survey will be undertaken within the Proposed Development boundary by a competent ecologist. the appointed Contractor will ensure biosecurity measures are implemented throughout the construction phase to ensure the introduction and translocation of invasive species is prevented. The appointed ECoW will carry out a toolbox talk which will identify invasive species and will also implement biosecurity measures such as the visual inspection of vehicles for evidence of attached plant or animal material prior to entering and leaving the works area. To ensure the spread of invasive species is avoided a 'Check, Clean, Dry' protocol will be undertaken by the appointed ECoW with all equipment, machinery and vehicles entering and leaving the Proposed Development boundary.	Not significant	Section 7A.5.11
Operation Phase	Impact Mechanism 10 Accidental large scale oil or LNG spill	Negative	Significant	Medium-term	Established protocols to manage the risk of accidental spill and potential environmental impact.	Not significant	Section 7A.5.12

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CHAPTER 07B
Terrestrial Ecology

Shannon LNG Limited
August 2021

Shannon Technology and Energy Park
Environmental Impact Assessment Report

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7.B Terrestrial Ecology

7B.1 Introduction

DixonBrosnan Environmental Consultants were commissioned to assess the potential impacts of a proposed Liquefied Natural Gas (LNG) Terminal and a Power Plant on terrestrial and freshwater aquatic ecology. DixonBrosnan previously assessed the potential impacts of the proposed Shannon LNG Terminal (LNG Terminal) on terrestrial and aquatic ecology. As part of that process, the entire site, including the area now intended for the Proposed Development, was surveyed in 2006/ 2007 and 2011/ 2012.

This chapter describes and evaluates the habitats within the Proposed Development site along with their representative flora and fauna in order to describe and assess the impacts that will result from the proposed LNG Terminal and Power Plant. The chapter follows the structure and protocols detailed in the Environmental Protection Agency's Draft Guidelines on the information to be contained in *Environmental Impact Assessment Reports* (EPA, 2017).

A detailed description of the project is provided in Chapter 02 – Project Description and construction activities are described in detail in appendices to Chapter 02 i.e., Appendix A2-4 Outline Construction Environmental Management Plan (OCEMP), Appendix A2-7 Construction Equipment Onsite. Chapter 05 – Land and Soils and Chapter 06 – Water address the changes in hydrology and hydrogeology which can have an impact on ecology. Chapter 07A addresses the potential impacts on the marine and estuarine ecology. Noise impacts are addressed in Chapter 08 – Airborne Noise and Groundborne Vibration. Underwater noise modelling (by Vysus Group) (VG)) is presented in Appendix A7A-3, Vol. 4.

7B.2 Competent Expert

Carl Dixon MSc (Ecology) is a senior ecologist who has over 20 years' experience in ecological and water quality assessments. He also has experience in mammal surveys, bat surveys, invasive species surveys and ecological supervision of large-scale projects. Projects in recent years include the Waste to Energy Facility Ringaskiddy, Shannon LNG Project, supervision of the Fermoy Flood Relief Scheme, Skibbereen Flood Relief Scheme, Upgrade of Mallow WWTP Scheme, Douglas Flood Relief Scheme, Great Island Gas Pipeline and Arklow Bank Wind Park Phase 2.

7B.3 Methodology

7B.3.1 Overview

This assessment is based on surveys of the Proposed Development site (Refer to Figure F2-1, Vol. 3). The Proposed Development includes a Liquefied Natural Gas (LNG) Terminal and a Power Plant. A review of desktop data was also carried out to identify potential ecological issues (Sections 7B.3.3 and 7B.3.4). In addition to surveys conducted in 2006/ 2007 and 2011/ 2012, additional ecological surveys were carried out between 2019 and 2021 to inform this Environmental Impact Assessment Report (EIAR) Dates of ecological surveys are included in Table 7B-1.

7B.3.2 Relevant Legislation

Flora and fauna in Ireland are protected at a national level by the Wildlife Act 1976, as amended, and the European Communities (Birds and Natural Habitats) Regulations 2011. They are also protected at a European level by the EU Habitats Directive (92/ 43/ EEC) and the EU Birds Directive 2009/ 147/ EC.

Under this legislation, sites of nature conservation importance are designated in order to legally protect faunal and floral species and important/ vulnerable habitats. The relevant categories of designation are as follows:

- Special Areas of Conservation (SACs) are designated under the European Communities (Birds and Natural Habitats) Regulations 2011 to comply with the EU Habitats Directive (92/ 43/ EEC);
- Special Protection Areas (SPAs) are designated under the EU Birds Directive (79/ 409/ EEC) amended in 2009 as Directive 2009/ 147/ EC; and

- Natural Heritage Areas (NHAs) and proposed Natural Heritage Areas (pNHAs) are listed under the Wildlife (Amendment) Act, 2000, as amended. A NHA is designated for its wildlife value and receives statutory protection. A list of pNHAs was published on a non-statutory basis in 1995, but these have not since been statutorily designated. Consultation with the NPWS is still required if any development is likely to impact on a pNHA.

7B.3.2.1 Relevant European Legislation

- Council Directive 92/ 43/ EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (The Habitats Directive);
- Directive 2009/ 147/ EC of the European Parliament and of the Council on the conservation of wild birds (The Birds Directive);
- Directive 2000/ 60/ EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (The Water Framework Directive); and
- Directive 2006/ 44/ EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life (The Fish Directive (consolidated)).

7B.3.2.2 Relevant Irish Legislation

- Wildlife Act 1976 as amended by Wildlife Act 1976 (Protection of Wild Animals) Regulations 1980, Wildlife (Amendment) Act 2000, Wildlife (Amendment) Act 2010, Wildlife (Amendment) Act 2012, European Communities (Wildlife Act, 1976) (Amendment) Regulations 2017 (The Wildlife Act);
- European Communities (Conservation of Wild Birds) Regulations 1985 (S.I. No. 291/ 1985) as amended by S.I. No. 31/ 1995 (The Wild Birds Regulations);
- European Communities (Natural Habitats) Regulations 1997 (S.I. No. 94/ 1997 as amended by S.I. No. 233/ 1998 and S.I. No 378/ 2005) (The Habitats Regulations);
- Fisheries (Consolidation) Act, 1959 (as amended) (The Fisheries Act);
- European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477/ 2011) (The Habitats Reguations); and
- The Flora (Protection) Order 2015 (S.I. No. 356/ 2015).

7B.3.3 Sources of Information

A desktop study was carried out to collate the available information on the local ecological environment. The purpose of the desktop study was to identify features of ecological value occurring within the Proposed Development site and those occurring in proximity to it. A desktop review also allows the key ecological issues to be identified early in the assessment process and facilitates the planning of surveys. Sources of information utilised for this report include the following:

- National Parks and Wildlife Service (NPWS), 2021;
- Environmental Protection Agency (EPA), 2021;
- National Biodiversity Data Centre (NDBC), 2021;
- Bat Conservation Ireland, 2021;
- Birdwatch Ireland, 2021;
- British Trust for Ornithology (BTO), 2021;
- National Biodiversity Action Plan 2017-2021 (NPWS 2017);
- Kerry Co. Council (KCC, 2019) *Council Climate Change Adaptation Strategy 2019-2024;*
- KCC (2008) *Biodiversity Action Plans 2008-2012;* and
- KCC (2015) *County Development Plan 2015 – 2021*.

7B.3.4 Guidance

This chapter of the EIAR follows the *Environmental Protection Agency's Draft Guidelines on the information to be contained in Environmental Impact Assessment Reports* (EPA, 2017). It also takes account of the *Draft Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment* (Department of Environment, Community and Local Government, August 2018), *Chartered Institute of Ecology and Environmental Management Guidelines on Ecological Impact Assessment in the UK and Ireland, 2nd edition* (CIEEM 2016) and *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, Version 1.1* (CIEEM, 2019). Reference was also made to the following key documents where relevant:

- *Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/ 92/ EU as amended by 2014/ 52/ EU)* (European Union, 2017);
- *Guidance on integrating climate changes and biodiversity into environmental impact assessment* (EU Commission 2013);
- *Guidelines for Assessment of Ecological Impacts of National Road Schemes* (National Roads Authority 2009) (*for habitat assessment)*;
- *Best Practice Guidance for Habitat Survey and Mapping* (Heritage Council, 2011);
- *A Guide to Habitats in Ireland* (Fossitt, 2000);
- *Guidelines for the treatment of Badgers prior to the construction of National Road Schemes. National Roads Authority, Dublin* (National Roads Authority (NRA) 2005a);
- *Best Practice Guidelines for the Conservation of Bats in the Planning of National Road Schemes* (NRA 2005b);
- *Guidelines for the treatment of bats during the construction of national road schemes (National Roads Authority* (NRA 2005c);
- *Guidelines for the protection and preservation of trees, hedgerows and scrub prior to, during and post construction of national road schemes*. (NRA 2006);
- *Guidelines for the treatment of Otters prior to the construction of National Road Schemes (National Roads Authority* (NRA 2008);
- *Bird Census Techniques* Bibby, C.J., Burgess, N.D., Hill, D.A. & Mustoe, S.H. (2000); and
- *Bird Monitoring Methods - a Manual of Techniques for Key UK Species*. Gilbert, G., Gibbons, D.W. & Evans, J. (1998).

7B.3.5 Field Surveys

This assessment is based on surveys at the Proposed Development site (Figure F2-1 of Volume 3). The Proposed Development comprises of two main components i.e., a Power Plant (described in Section 2.4.1) and a LNG Terminal (described in Section 2.4.2 of Chapter 02 – Project Description).

Ecological survey work was previously carried out at the Proposed Development site in 2006/ 2007 and 2011/ 2012. These surveys informed the Environmental Impact Assessments (EIA) for the previous planning applications. Therefore, a large volume of background information about the site is available. Additional ecological surveys were carried out between 2019 and 2021 to inform this Environmental Impact Assessment Report (EIAR).

7B.3.5.1 Habitat Surveys

Habitats were mapped according to the classification scheme outlined in the Heritage Council publication *A Guide to Habitats in Ireland* (Fossitt, 2000) and following the guidelines contained in *Best Practice Guidance for Habitat Survey and Mapping* (Heritage Council, 2011). Habitats were cross referenced with Habitats Directive Annex I habitats. Dates of the main habitat surveys are included in Table 7B-1. During these surveys the site was also surveyed for invasive species and rare floral species (Wyse *et al*., 2016; Stace 2019). It is noted that a considerable number of site visits were carried during the overall assessment process including winter bird surveys, breeding bird surveys, aquatic surveys and mammal surveys (Refer

Table 7B-1). Observations in relation to habitats made during these site visits are included in the habitat descriptions where relevant.

Table 7B-1 Survey Types and Survey Dates for 2019 to 2021 Surveys

Survey Type	Survey Dates
Habitat Survey	22nd July 2019, 27th July 2019, 10th April 2020, 30th May 2020, 1st July 2021
Badger Survey	General surveys: 22nd July 2019, 27th July 2019, 10th April 2020, 30th May 2020 and 22nd April 2021 Bait marking surveys: 8th January 2019, 24th January 2019, 26th January 2019, 30th January 2019, 3rd February 2019, 4th February 2019, 5th February 2019, 6th February 2019, 9th February 2019, 11th February 2019,13th March 2019, 16th March 2019, 20th March 2019, 23rd March 2019, 31st March 2019 and 10th April 2019. Trail camera: 24th January to 10th April 2019 and 28th January to 30th March 2021
Bat Survey	9th September 2020, 26th May 2021, 27th May 2021, 14th June 2021, 30th June 2021, 13th July 2021, 14th July 2021, 20th July 2021
Otter Survey	General surveys: 22nd July 2019, 27th July 2019, 10th April 2020, 30th May 2020, 22nd April 2021, 1st July 2021 Trail Camera Surveys: 24th January to 10th April 2019 and 28th January to 30th March 2021
Breeding Bird Survey	31st March 2019, 22nd July 2019, 27th July 2019, 10th April 2020, and 30th May 2020
Estuarine Bird Survey	Winter surveys: 18th October 2018, 22nd November 2018, 29th November 2018, 12th December 2018, 18th December 2018, 21st January 2019, 24th January 2019, 18th February 2019, 20th February 2019, 15th March 2019, 21st March 2019, 21st October 2019, 25th October 2019, 15th November 2019, 19th November 2019, 3rd December 2019, 9th December 2019, 22nd January 2019, 30th January 2020, 23rd February 2020, 24th February 2020, 31st March 2020. Summer surveys: 28th May 2021, 30th June 2021, 19th July 2021, 20th July 2021
Aquatic Survey	22nd April 2021

7B.3.5.2 Badger

Badger *Meles meles* bait marking and activity surveys were carried out at the Proposed Development site between January 2019 and April 2019 (Refer to

Table 7B-1). Bait marking surveys were based on Scottish Natural Heritage methods (SNH 2003) and following guidelines from the National Roads Authority (NRA 2006a). Potential habitat such as grassland and scrub to a minimum of 150m from the site boundary were systematically checked for signs of Badger activity or habitation. These signs include the presence of main, annex, subsidiary, and outlier setts, foraging evidence (e.g. snuffle holes), latrines, access runs and trails, hairs caught on wires and bushes, tracks, and prints. Trail camera surveys were also carried out in the periods from 24th January to 10th April 2019 and 28th January to 30th March 2021. Further details on Badger survey methods are included in Appendix A7B-1 of Volume 4.

7B.3.5.3 Bats

Bat activity surveys were conducted within the Proposed Development site under suitable weather conditions on several dates outlined in

Table 7B-1. Dusk activity surveys commenced at 15 minutes before sunset and ended a minimum of two hours after sunset (Collins 2016). The primary purpose of bat surveys was to assess usage of structures and habitats, located within or in close proximity, to the site boundary. Activity surveys were also carried out to identify foraging and/ or commuting routes across the site (i.e. hedgerows/ treelines, coastal habitats, Ralappane Stream etc.) within the Proposed Development site boundary. All buildings located within the planning boundary were surveyed during daytime, as well as two other buildings to the west of the Proposed Development site. Further details on bat survey methods are included in Appendix A7B-1 of Volume 4.

7B.3.5.4 Otter

Watercourses, drainage channels and coastal habitats were assessed on a number of dates between 2019 and 2021 for signs of Otter *Lutra lutra* (Refer to Table 7B-1 for dates). Observations relating to Otter that were made during other surveys, such as estuarine and breeding bird surveys, were also recorded where relevant. Otter survey methodology followed guidance outlined in NRA (2008) and included searches for breeding or resting sites within 150m of the Proposed Development site boundary. Trail cameras were utilised along the stream and along the coast to assess usage patterns. Other evidence of Otter, including spraints, footprints, or feeding remains, was also recorded where present. Further details on Otter survey methods are included in Appendix A7B-1 of Volume 4.

7B.3.5.5 Breeding Birds

The breeding bird survey was based on the BTO Common Bird Census (CBC) methodology and Breeding Bird Survey (BBS) (Gilbert *et al.* 1998 and Bibby *et al*. 2000) which aims to capture a snapshot of breeding bird activity within the survey area. The survey area focused on terrestrial habitats within the planning boundary. Breeding bird surveys were carried out over five days at outlined in

Table **7B-1**.

The Proposed Development site was walked so that all habitats within 50 m of all potential nesting features were surveyed. The ornithological surveyor slowly walked through the site, stopping at regular intervals to scan with binoculars and to listen for bird calls or song. Birds were identified by sight and song. All species seen or heard in the survey area and immediate environs were recorded including those in flight. Visits were made during favourable weather conditions.

All species encountered during the survey were mapped and coded using standard BTO species codes and activity recorded using the BTO codes for breeding evidence. In an effort to minimise potential disturbance, no attempts were made to locate nests as observed behaviours are generally sufficient to determine probable or confirmed breeding. The conservation status of birds was also recorded. Bird species listed in Annex I of the Birds Directive are considered a conservation priority. Certain bird species are listed by BirdWatch Ireland as Birds of Conservation Concern in Ireland (BOCCI). These are bird species suffering declines in population size. BirdWatch Ireland and the Royal Society for the Protection of Birds have identified and classified these species by the rate of decline into Red and Amber lists (Gilbert *et al*. 2021). Red List bird species are of high conservation concern and the Amber List species are of medium conservation concern. Green listed species are regularly occurring bird species whose conservation status is currently considered favourable.

Further details on breeding bird survey methods are included in Appendix A7B-2 of Volume 4.

7B.3.5.6 Estuarine Birds

Winter bird surveys were carried out from four vantage points overlooking the Shannon Estuary to the west and east of the Proposed Development site in 2018/ 2019 and 2019/ 2020. Additional surveys were carried out in the summer of 2021 with two additional vantage points added to the east of the Proposed Development site. The vantage point locations for the winter bird counts are shown in Figure 7B-11.

The survey methodology was based on that used by the British Trust for Ornithology (BTO), Wetland Bird Survey (WeBS) and also that for the Irish Wetland Bird Survey (I-WeBS), as outlined in Gilbert *et al.* (1998) and the low tide waterbird surveys (Lewis and Tierney 2014). The winter bird survey was undertaken using 8.5×45 binoculars and a Swarovski ATX30-70x95 spotting scope. Sixty-minute counts were undertaken at each survey location at either high tide, mid tide and low tide.

Dates of winter bird surveys are included in

Table **7B-1** and further details on survey methods are included in Appendix A7B-3 of Volume 4.

7B.3.5.7 Aquatic Surveys

Aquatic Services Unit (ASU) carried out a fisheries assessment of the Ralappane Stream on 4th October 2006. Quantitative electro-fishing was undertaken at 3 x 30 m stretches of the stream within the Proposed Development site. Stop nets were placed upstream and downstream to isolate each stretch as it was being fished; in each case, three times using the depletion fishing method.

Aquatic Services Unit also carried out a macro-invertebrate survey and a fisheries assessment of the stream on 4th October 2006. The stream was sampled using kick-sampling methodology. Two 1-minute kick samples (combined as one composite) were taken at each site. Each sample was collected in areas of moderate to shallow, swift current in coarse substrate usually comprising small to large stones and cobbles.

A macro-invertebrate survey of the Ralappane Stream was carried out by DixonBrosnan on 22nd April 2021. The macro-invertebrate samples from the stream were assessed in terms of water quality using the biotic index system used by the Environmental Protection Agency (EPA) in its on-going monitoring of biological quality in Irish rivers. The index assigns a score to a given site depending on the relative proportion of pollution sensitive and pollution tolerant organisms present.

Further details of the macro-invertebrate survey are included in Appendix A7B-4 of Volume 4.

7B.3.6 Consultation

Consultations were carried out with statutory and non-statutory bodies. Letters were received from IFI (13th April 2021) and NPWS DAU (26th April 2021). Of particular relevance to terrestrial biodiversity were consultations held with IFI and NPWS; the comments raised are presented below.

The following extracts from the NPWS letter are relevant to the current chapter i.e. Terrestrial Biodiversity. Biodiversity is also addressed in Chapter 07A – Marine Biodiversity and to the Natura Impact Statement (NIS) which accompanies this planning application. Full details of the NPWS letter are included in Chapter 07A Table 7A-3.

7B.3.6.1 LNG FRSU Terminal

- *Any increase in the risk of oil spills from increased ship traffic need to be fully assessed;*
- *Effect of the lighted jetty on bird mortality during poor weather condition, based on evidence from monitoring of jetties elsewhere;*
- *Effect of pile-driving on estuarine birds: The seasonal timing and type of pile driving needs to be clearly described, and its impact of estuarine birds assessed. Unless adequate data is already available, a two-year survey of bird use of the estuary within 2 km of the proposed jetty and FSRU infrastructure is recommended, with a year being the minimum requirement;* and
- *Modelling of pool fires and accidents: The impact of shipping accidents and pool fires on estuarine and sea-birds needs to be assessed. Although there is a good safety record for LNG ship transport, nevertheless it is recommended that such risks are formally modelled (e.g. Woodward & Pitbaldo (2010) . The feasibility of bird surveys at and on each side of the sip lane within the SPA need to be established and if feasible such data is recommended to be collected.*

7B.3.6.2 Power Plant at Ralappane

- *If any indirect effects are likely, a re-assessment of the small lagoon near the land bank site, for typical lagoonal species, is recommended; in particular the protected species Lamprothamnium papillosum;* and
- *A re-assessment of the use of the terrestrial and shore development area by Otter needs to be carried out.*

7B.3.6.3 Powerlines Exporting Electricity

- *It is understood that an underground cable is the preferred means of exporting electricity. However, if powerlines remain an option then the impact on birds dispersing between different parts of the SPA need to be assessed, with particular reference to mortality and/ or electrocution.*

7B.3.6.4 White-tailed Sea Eagles

- *There is a current release site for white-tailed sea eagles, under Phase II of the White-tailed Sea Eagles Reintroduction Project, within 7 km of the Proposed Development, and the potential impact on recently-released young eagles needs to be assessed. This species is particularly susceptible to powerline collision and electrocution.*

7B.3.6.5 Protected Mammals

- *A re-assessment of the use of the terrestrial and shore development area by the strictly protected species, Otter needs to be carried out*; and
- *Use of the terrestrial development site by dispersing and migrating bats also needs re assessment.*

7B.3.7 Limitations and Assumptions

Extensive survey work was carried out over several years at the Proposed Development site using a range of standard methodologies. However, there were difficulties in mapping areas of Badger territory and other species in third party lands outside the control of the Applicant. It can be difficult to determine territory size in Badger populations particularly where they may include multiple landholdings. Therefore, in this case a conservative approach was adopted in determining impact on Badger social groups.

7B.4 Baseline Environment

7B.4.1 Description of Existing Site

The Proposed Development will be located on the Shannon Estuary, 4.5 km from Tarbert and 3.5 km Ballylongford in Co. Kerry. The site for the Proposed Development is 52 ha (including the marine area). The Shannon Landbank on which the Proposed Development site is located has a total area of 243 ha.

The Proposed Development site consists primarily of improved agriculturally grassland, which runs along the southern shore of the Shannon estuary. The Proposed Development site boundary is shown in Figure 7B-3. The shoreline in this general area is relatively sheltered and composed of shingle or low earthen cliffs. The land within the site is primarily used for grazing or hay/ silage. The type of grassland varies considerably with topography and includes areas of wet grassland particularly in the northwest section of the Proposed Development site. The lower section of the Ralappane Stream forms the western boundary of the Proposed Development site. To the west of the Proposed Development site boundary, this stream forms a tidal creek and dense reed beds adjoin parts of its lower reaches near its discharge to into the Shannon Estuary. Lands in the eastern part of the site include large, well-drained fields and here the area is more intensively farmed.

7B.4.2 Designated Sites

7B.4.2.1 European Sites

Special Areas of Conservation (SACs) and candidate SACs (cSACs) are protected under the Habitats Directive and the European Communities (Birds and Natural Habitats) Regulations 2011, as amended. Special Protection Areas (SPAs) are protected under the Birds Directive 2009/ 147/ EC and European Communities (Birds and Natural Habitats) Regulations 2011, as amended. Collectively, these sites are referred to as Natura 2000 or European sites.

Table 7B-2 Natura 2000 sites within 15 km radius of Proposed Development Site

Site	Code	Distance from Proposed Development site Boundary (at closest point)
Special Area of Conservation (SAC) and candidate SAC (cSAC)		
Lower River Shannon cSAC	002165	0 km
Moanveanlagh Bog SAC	002351	12.4 km south
Tullaher Lough and Bog SAC	002343	14.0 km northwest
Special Protection Area (SPA)		

River Shannon and River Fergus Estuaries SPA	004077	0 km
Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	004161	10.0 km south
Natural Heritage Areas (NHAs) and Proposed Natural Heritage Areas (pNHAs)		
Ballylongford Bay pNHA	001332	Approximately 80 m west
Tarbert Bay pNHA	001386	2.1 km southeast
Bunnaruddee Bog NHA	001352	5.9 km south

The Proposed Development site boundary partially overlaps the Lower River Shannon candidate Special Area of Conservation (cSAC) (Site code 002165) (NPWS 2012a) and the River Shannon and River Fergus Estuaries Special Protection Area (SPA) (Site code 004077) (NPWS 2012b). Marine habitats which overlap with the Lower River Shannon cSAC are discussed in Chapter 07A – Marine Biodiversity and in the NIS.

Three other Natura 2000 sites are located within a 15 km radius of the Proposed Development i.e., Moanveanlagh Bog SAC (002351) (12.4 km south) and Tullaher Lough and Bog SAC (Site code: 002343) (14.0 km northwest) and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Site code: 004161) (10.0 km south). The location of SACs and SPAs within a 15 km radius are listed in Table 7B-2 and illustrated in Figure 7B-1 and Figure 7B-2..

The Lower River Shannon cSAC (Site code: 002165) overlaps with the Proposed Development site (Figure 7B-3). This very large site stretches along the Shannon valley from Killaloe in Co. Clare to Loop Head/ Kerry Head, a distance of approximately 120 km. The site thus encompasses the Shannon, Feale, Mulkear and Fergus estuaries, the freshwater lower reaches of the River Shannon (between Killaloe and Limerick), the freshwater stretches of much of the Feale and Mulkear catchments and the marine area between Loop Head and Kerry Head. The site is designated for a wide range of Annex I marine, coastal, freshwater aquatic and terrestrial habitats, while Annex II species for which the site is designated include marine mammals, diadromous fish species and freshwater aquatic species.

Moanveanlagh Bog SAC (Site code: 002351), located 12.4 km south of the Proposed Development is situated in Co. Kerry approximately 6 km east of Listowel, mainly within the townlands of Carhooeara and Bunagarha. The site comprises a raised bog that includes both areas of high bog and cutover bog. The site is a designated for Annex I habitats [7110] Raised Bog (Active)*, Degraded raised bogs still capable of natural regeneration [7120] and Depressions on peat substrates of the Rhynchosporion [7150].

Tullaher Lough and Bog SAC (Site code: 002343), which is located 14.0 km northwest of the Site, is a diverse site comprising of raised bog (including areas of high bog and cutover bog), wet grassland, improved grassland, scrub woodland, alkaline fen and lake. It is bounded to the east by the Doonbeg to Moyasta road, to the west by a local road, to the north by bog tracks and to the south by a conifer plantation. The site is a designated for Annex I habitats [7110] Raised Bog (Active)*, Degraded raised bogs still capable of natural regeneration [7120], Transition mires and quaking bogs [7140] and Depressions on peat substrates of the Rhynchosporion [7150].

River Shannon and River Fergus Estuaries SPA (Site code: 004077), which overlaps with part of the Proposed Development site (Figure 7B-3) includes the estuaries of the River Shannon and River Fergus form the largest estuarine complex in Ireland. The site comprises the entire estuarine habitat from Limerick City westwards as far as Doonaha in Co. Clare and Dooneen Point in Co. Kerry. The site has vast expanses of intertidal flats which contain a diverse macroinvertebrate community which provides a rich food resource for the wintering birds. Salt marsh vegetation frequently fringes the mudflats and this provides important high tide roost areas for the wintering birds. Elsewhere in the site the shoreline comprises stony or shingle beaches. The site is designated for the following species: Cormorant *Phalacrocorax carbo*, Whooper Swan *Cygnus cygnus*, Light bellied Brent Goose *Branta bernicla hrota*, Shelduck *Tadorna tadorna*, Wigeon *Anas penelope*, Teal *Anas crecca*, Pintail *Anas acuta*, Shoveler *Anas clypeata*, Scaup *Anas marila*, Ringed Plover *Charadrius hiaticula*, Golden Plover *Pluvialis apricaria*, Grey Plover *Pluvialis squatarola*, Lapwing *Vanellus vanellus*, Knot *Calidrus canutus*, Dunlin *Calidris alpina*, Black-tailed Godwit *Limosa limosa*, Bar-tailed Godwit *Limosa laponica*, Curlew *Numenius arquata*, Redshank *Tringa totanus*, Greenshank *Tringa nebularia* and Black-headed Gull *Larus ridibundus*. The site is also designated for wetlands.

Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA (Site code: 004161), which is located 10 km south of the Proposed Development site, is a very large site centred on the borders between the counties of Cork, Kerry and Limerick. The site is skirted by the towns of Newcastle West, Ballydesmond, Castleisland, Tralee and Abbeyfeale. The SPA is designated for Hen Harrier *Circus cyaneus*.

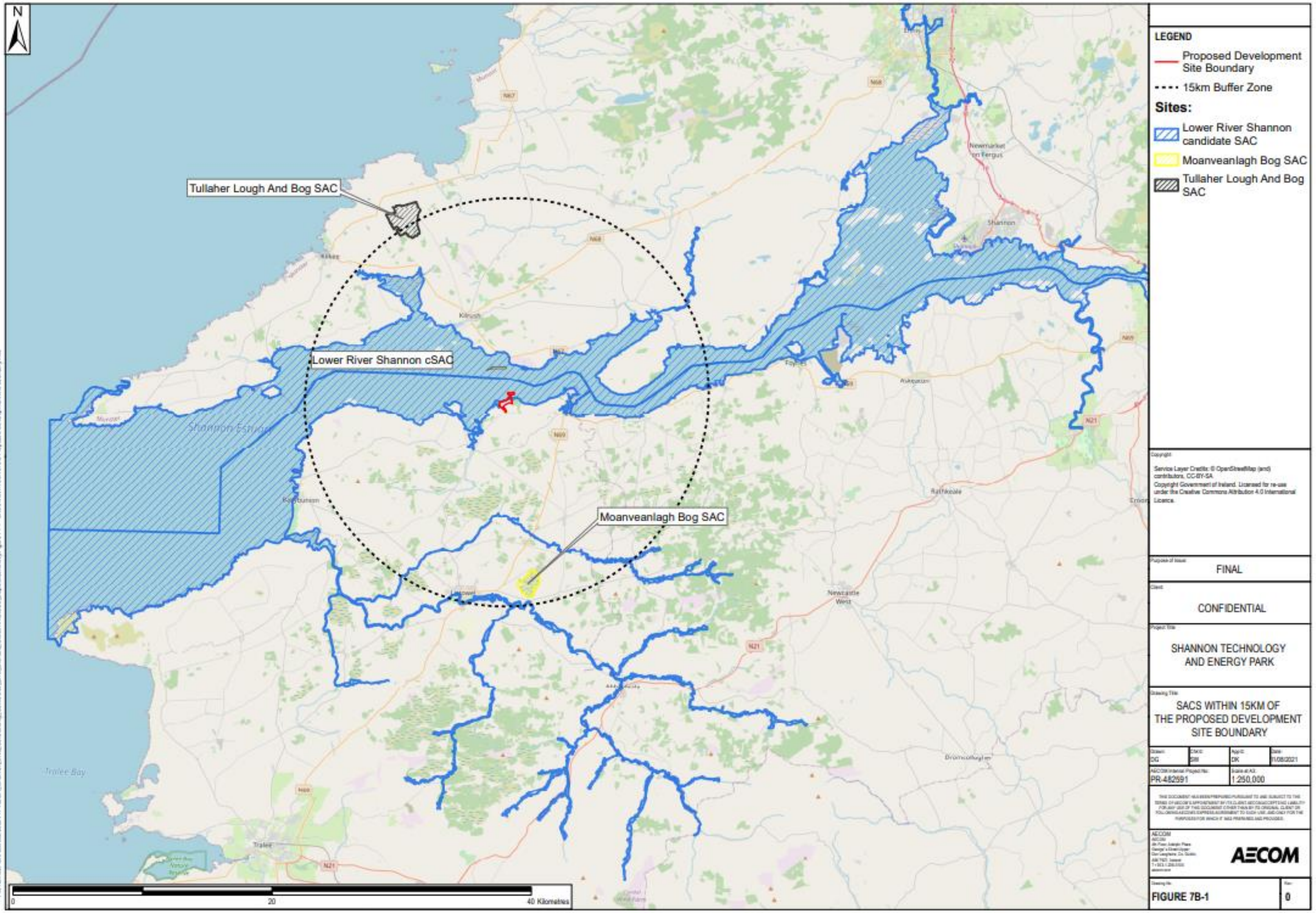

Figure 7B-1 Special Areas of Conservation within 15 km radius of the Site

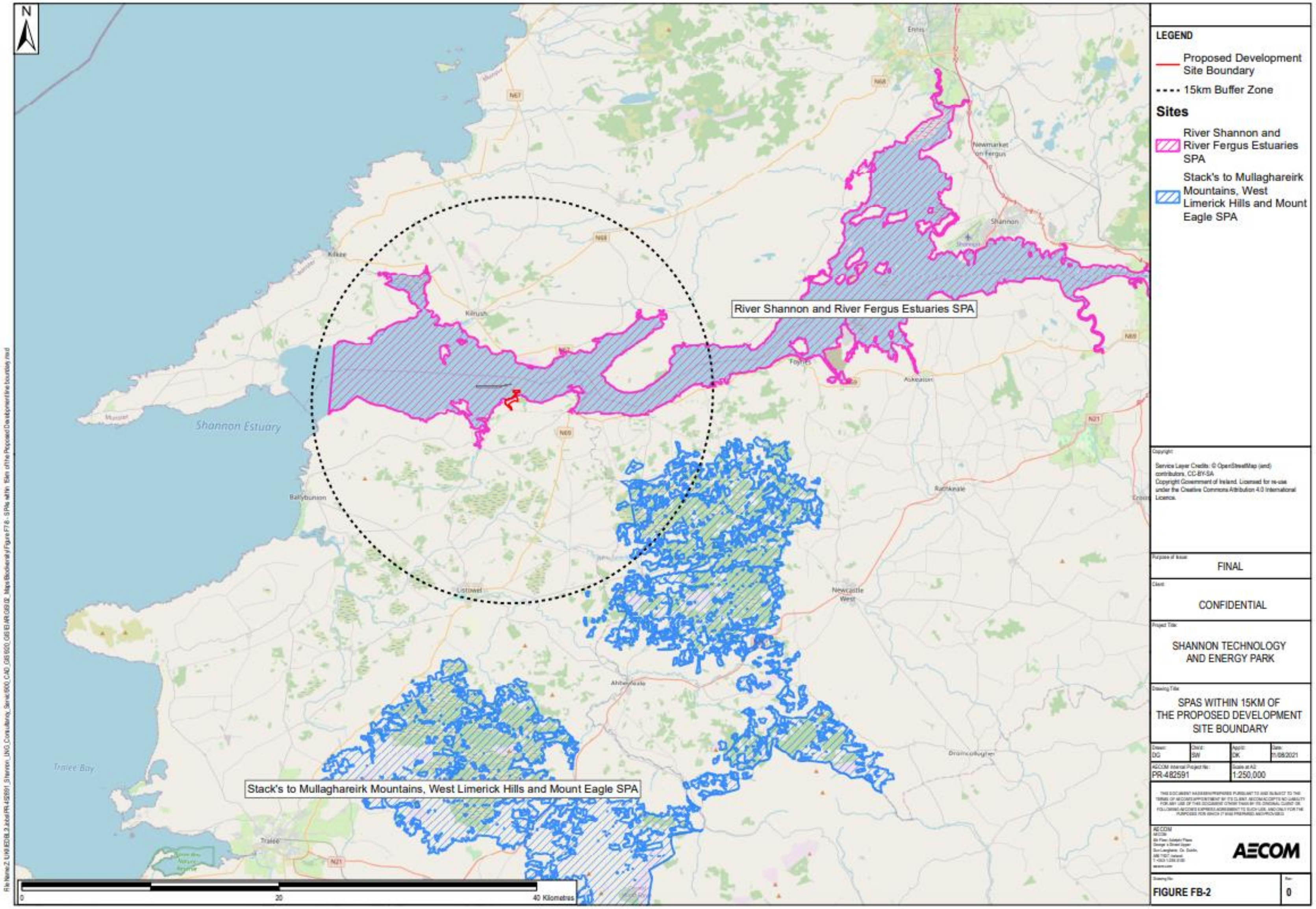

Figure 7B-2 Special Protection Areas (SPAs) within 15 km radius of the Site

Figure 7B-3 Proposed Development Site and Overlapping Natura 2000 Sites

Potential impacts on designated Natura 2000 sites (SAC/ cSAC/ SPA) are specifically addressed in *Shannon Technology and Energy Park Screening Statement for Appropriate Assessment and Natura Impact Statement Volume 1 – Main Report* which has been submitted as part of this application. This report concluded the following:

Following a comprehensive evaluation of the potential direct, indirect and cumulative impacts on the conservation features in light of their Conservation Objectives, it has been concluded that with the construction and operation of the Proposed Development will have no adverse effect on the River Shannon and River Fergus Estuaries SPA.

Following a comprehensive evaluation of the potential direct, indirect and cumulative impacts on the conservation features in light of their Conservation Objectives, it has been concluded that with the construction and operation of the Proposed Development will have no adverse effect on the Lower River Shannon cSAC.

7B.4.2.2 National Sites

Natural Heritage Areas (NHA) and proposed Natural Heritage Areas (pNHA) are national designations under the Wildlife Act 1976, as amended. A NHA is designated for its wildlife value and receives statutory protection. A list of proposed NHAs (pNHAs) was published on a non-statutory basis in 1995, but these have not since been statutorily proposed or designated.

NHAs and pNHAs located in the vicinity of the Proposed Development site are listed in Table 7B-2 and illustrated in Figure 7B-4 and Figure 7B-5. Habitats (marine and/ or terrestrial) within the site do not overlap with any NHA/ pNHA.

Ballylongford Bay pNHA (site code 1332) is located west of Knockfinglas Point. It includes the wetland area along the Ralappane Stream to the west of the Proposed Development site and the adjacent heathland and the salt marsh further west of the site. This pNHA is an inlet on the southern side of the Shannon Estuary and runs northwards from the town of Ballylongford in Co. Kerry. The scientific interest of the bay lies in the large concentrations of waterfowl that feed on the mudflats. The Ballylongford Bay pNHA makes up a valuable part of the Shannon Estuary.

Tarbert Bay pNHA (site code 001386) is also located within the Shannon Estuary. Tarbert Bay is a sandy intertidal bay fringed by saline vegetation, which is best developed at Tarbert Village. Some deciduous woodland is included in the pNHA and this comes down to the estuary edge in places. The site is important for a wintering waterfowl and is part of the large Shannon- Fergus estuarine complex.

The importance of the Shannon estuary is underlined by its designation as a Special Protection Area and both Ballylongford Bay pNHA and Tarbert Bay pNHA overlap with the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA.

The Proposed Development site is potentially hydrologically connected to both these pNHAs via the Shannon Estuary. Further details on indirect impacts to the Ballylongford Bay pNHA are included in Chapter 06 – Water. Given the distance from the Tarbert Bay pNHA (2.1 km) and the dilution available within the Shannon Estuary no significant impact on this pNHA are predicted to occur. No significant connection with any other NHA/ pNHA has been identified.

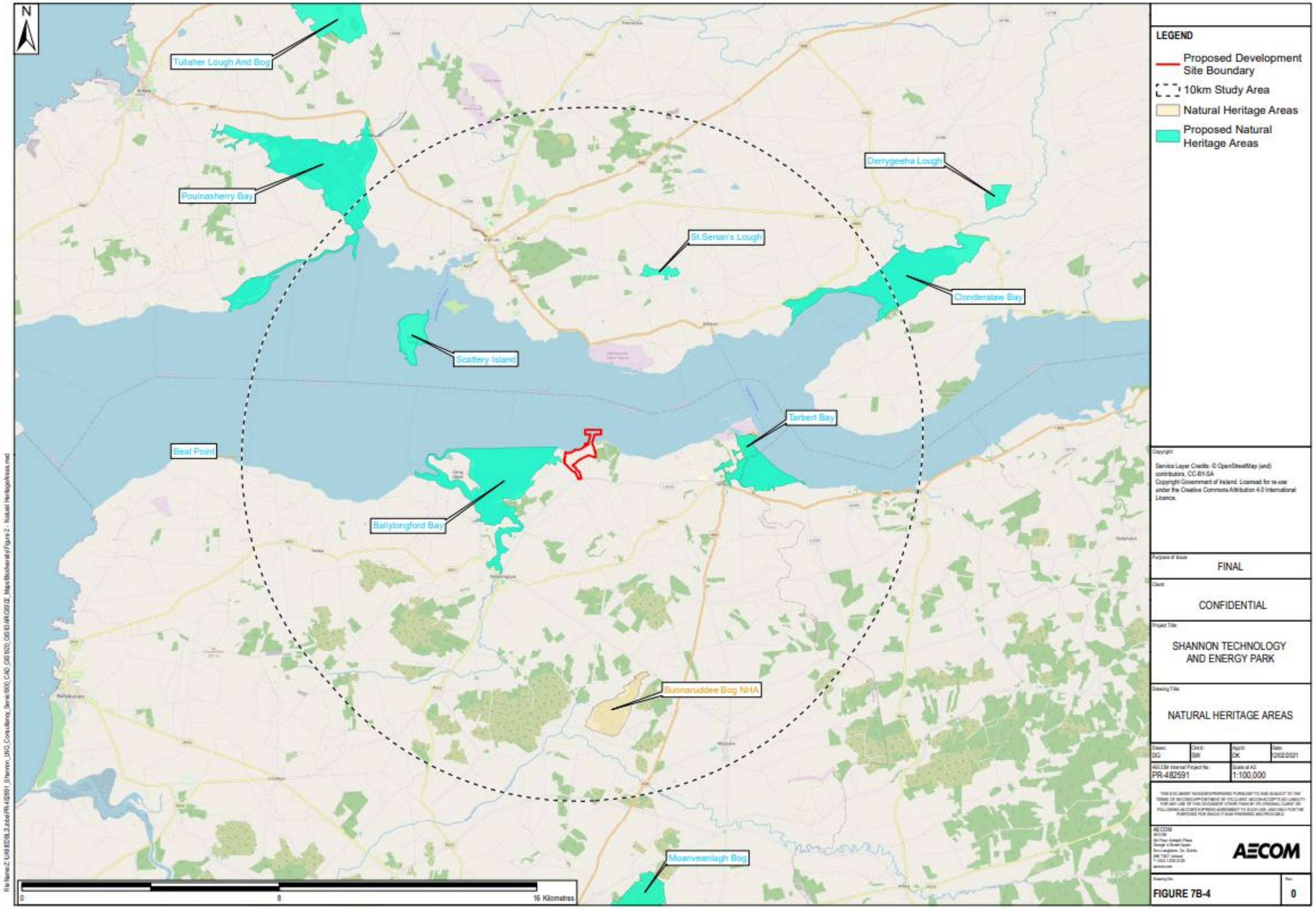

Figure 7B-4 Natural Heritage Areas (NHAs) and Proposed Natural Heritage Areas (pNHAs) in vicinity of Proposed Development

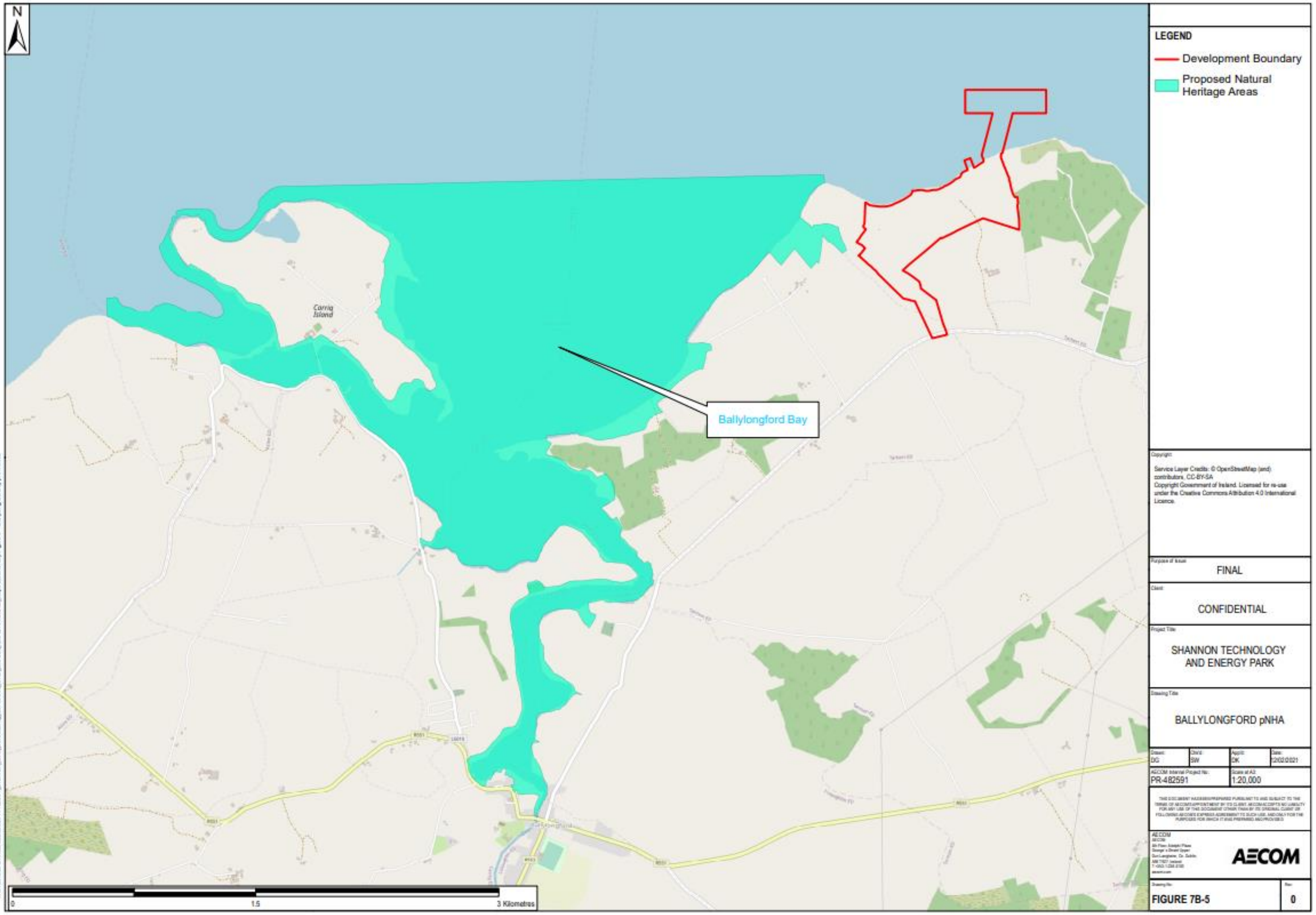

Figure 7B-5 Ballylongford Bay pNHA Relative to Proposed Development Site

7B.4.3 Habitats

Habitat mapping was carried out in line with the methodology outlined in the Heritage Council Publication, *Best Practice Guidance for Habitat Survey and Mapping* (Heritage Council, 2011). The terrestrial and aquatic habitats within the Proposed Development site boundary were classified using the classification scheme outlined in the Heritage Council publication *A Guide to Habitats in Ireland* (Fossitt, 2000) and cross referenced with Annex I Habitats where required. The survey results are representative of the habitats within the application site and include the dominant and characteristic species of flora.

No rare plant species were recorded within the Proposed Development site boundary during the site survey and given the common nature of the habitats within the Proposed Development area, are unlikely to occur. A full list of plant species recorded during site surveys is included in Appendix A7B-5 of Volume 4. Site photographs are included in Appendix A7B-6 of Volume 4.

A current overview of habitats recorded within the Proposed Development site boundary is outlined in the habitat maps included in Figure 7B-6.

Habitats recorded within the Proposed Development site boundary and their ecological value are detailed in Table 7B-3. The ecological value of habitats has been defined using the classification scheme outlined in the Guidelines for Assessment of Ecological Impacts of National Road Schemes (NRA 2009) which is included in Appendix A7B-7 of Volume 4 of this EIAR. It should be noted that the value of a habitat is site specific and will be partially related to the amount of that habitat in the surrounding landscape.

- Habitats that are considered to be good examples of Annex I and Priority habitats are classed as being of International or National Importance;
- Semi-natural habitats with high biodiversity in a county context and that are vulnerable, are considered to be of County Importance;
- Habitats that are semi-natural, or locally important for wildlife, are considered to be of Local Importance (higher value); and
- Sites containing small areas of semi-natural habitat or which maintain connectivity between habitats are considered to be of Local importance (lower value).

Figure 7B-6 Terrestrial and Freshwater Habitats within the Proposed Development Site Boundary

Table 7B-3 Terrestrial and Freshwater Habitats Recorded within Proposed Development Site Boundary

Habitat	Comment	Ecological Value (NRA Guidelines)*
Wet grassland GS4/ Improved agricultural grassland GA1	Several fields within Proposed Development site boundary Refer to Section 7B.4.3.1 for detail.	Local importance (Lower value)
Improved Agricultural grassland GA1	Several fields within Proposed Development site boundary Refer to section 7B.4.3.2 for detail	Local importance (Lower value)
Hedgerows WL1/ Treelines WL2	Located within Proposed Development site boundary. Refer to section 7B.4.3.3 for detail	Local importance (Higher value)
Sedimentary Sea Cliffs CS3	Located along the northern site boundary, a small area of this habitat overlaps with the proposed jetty location. This habitat overlaps the Lower River Shannon cSAC boundary, therefore it has been categorised as of international importance, however it is noted that this is not a qualifying habitat for the cSAC. Refer to section 7B.4.3.4 for details.	International importance
Eroding River FW1	The Ralappane Stream passes through the southern boundary of the site before running outside the western planning boundary to its confluence with the Shannon Estuary. Refer to section 7B.4.3.5 for details	Local importance (Higher value)
Drainage ditches FW4	Drainage ditches flow along hedgerows at a number of locations within the site. Refer to section 7B.4.3.6 for details	Local importance (Lower value)
Scrub WS1	Patchy distribution within the Proposed Development site boundary. Not shown of Figure 7B-6. Refer to 7B.4.3.7 for detail.	Local importance (Higher value)

* Refer to Appendix A7B-7 of Volume 4 of this EIAR. *Guidelines for Assessment of Ecological Impacts of National Road Schemes*

7B.4.3.1 Wet Grassland GS4/ Improved Agricultural Grassland GA1

This habitat consists of areas of pasture dominated by Yorkshire-Fog *Holcus lanatus*, Creeping Bent *Agrostis stolonifera*, Soft Rush *Juncus effusus* and Yellow Flag *Iris pseudacorus*. It generally occurs where ground is waterlogged either due to topography or due to low intensity agricultural management i.e., blocked drains. Within the Proposed Development site, wet grassland grades into improved agricultural grassland where reseeding has occurred, and rye grass becomes abundant in the sward. Species noted include Perennial Ryegrass *Lolium perenne*, Meadow Foxtail *Alopecurus pratensis*, Timothy *Phleum pratense* and Sweet Vernal-Grass *Anthoxanthum odoratum*. Associated herbaceous species include Creeping Buttercup *Ranunculus repens*, Cuckoo Flower *Cardamine pratensis*, Silverweed *Potentilla anserina*, Chickweed *Stellaria media*, Ribwort Plantain *Plantago lanceolata*, Curled Dock *Rumex crispus*, Angelica *Angelica sylvestris* and Horsetail *Equisetum* spp..

7B.4.3.2 Improved Agricultural Grassland GA1

The drier portions of the site are dominated by improved agricultural grassland which is a very common habitat type in the Irish countryside. Larger fields are located to the east of the Proposed Development site and these areas are more intensively managed with lower species diversity. Rye-grasses dominate the sward and other common grasses include meadow-grasses, Timothy, Sweet Vernal-grass and Yorkshire-fog.

7B.4.3.3 Hedgerows WL1/ Treelines WL2

The Proposed Development site is dominated by a managed agricultural landscape of fields bounded by defined hedgerows and treelines, which support a variety of species. Included within this category are sections of earth banks (BL2) and stonewalls (BL1) which also occur on field boundaries in conjunction with hedges and tree lines. Where hedges are sheltered they are generally denser; hedges exposed to wind are less dense with Hawthorn *Crateagus monogyna* often dominant. Other tree species noted include Elm *Ulmus glabra*, Blackthorn *Prunus spinosa*, Holly *Ilex aquifolium*, Willow *Salix* spp and Alder *Alnus glutinosa*. Climbing plants include Ivy *Hedera helix*, Honeysuckle *Lonicera periclymenum* and Dog- Rose *Rosa canina*. Grass and herbaceous understory species include Yarrow *Achillea millefolium*, Lords-and- Ladies *Arum maculatum*, Common Knapweed *Centauria nigra*, Cleavers *Galium aparine*, Herb-Robert Geranium roberianum, Hogweed *Heracleum mantegazzianum*, Bluebell *Hyacinthoides non-scripta*, False Oat- Grass *Arrhenatherum elatius*, Cock's-Foot grass *Dactylus glomerata*, Red Fescue *Festuca rubra*, False Brome *Brachypodium sylvaticum*, Meadow Foxtail, Yorkshire-Fog, Timothy and Sweet Vernal-Grass. Hedges provide nesting and foraging habitat and function as wildlife corridors.

7B.4.3.4 Sedimentary Sea Cliffs CS3

Sedimentary sea cliffs (CS3) occurs along sections of the boundary between the Shannon Estuary and the Proposed Development site. These cliffs run approximately from the Ralappane Stream in the west to the eastern boundary. However, only a small section of this habitat occurs within the Proposed Development site boundary. This category includes steep to almost vertical coastal cliffs that are formed primarily of unconsolidated material. The cliffs within the Proposed Development site is composed of glacial till and is subject to erosion making it unstable and difficult for plants to colonise.

The cliffs within the Proposed Development site boundary are relatively low and largely unvegetated. The top of the cliff is dominated by common scrub species such as Bramble and improved agricultural grassland. Although this habitat type is loosely linked with the Annex I habitat ‘vegetated sea cliffs of the Atlantic and Baltic coasts 1230’ which is a qualifying habitat for the Lower River Shannon cSAC, the cliffs within the Proposed Development site are not an example of this Annex I habitat and are not considered of high ecological value.

7B.4.3.5 Eroding River FW1

The Ralappane Stream runs through the southern area of the Proposed Development site before flowing northwards to its confluence with the Shannon Estuary. With the exception of a small section near the southern boundary of the Proposed Development site, this stream is located outside the Proposed Development site boundary. The section of the Ralappane Stream within the Proposed Development site is representative of the habitat type Eroding river FW1. The stream supports a macroflora dominated by Lesser Water-Parsnip *Berula erecta*, Fool’s Watercress *Apium nodiflorum* and Common Starwort *Stellaria graminea*. Hemlock Water Dropwort *Oenanthe crocata* also occurs. There is some tidal influence in the lower reaches of the river, outsite the Proposed Development site boundary, and here the river is classified as Tidal River CW2. The lower section of this watercourse, which is outside the Proposed Development site boundary is included in the Ballylongford pNHA and the Lower Shannon cSAC.

7B.4.3.6 Drainage Ditch FW4

Several drainage ditches cross the southern portion of the Proposed Development site, generally flowing in a west or northwest direction. The drainage ditches along the access road all ultimately drain to a single watercourse, namely the Ralappane Stream. It is noted that, with the exception of D3 (Refer to Section 6.5.8.2 in Chapter 06 – Water), all drainage ditches are dry during the summer months. Therefore, they do not support fish and do not provide significant foraging habitat for Otter. Surrounding vegetation consists of typical riparian and field flora including Rushes *Juncus* spp., Willow, Alexanders *Smyrnium olusatrum*, Stinging Nettles *Urtica dioica,* Water Crowsfoot *Ranunculus aquatilis*, Pondweeds *Potamogeton* spp and Water Starwort *Callitriche* spp.

7B.4.3.7 Scrub WS1

Scrub habitat has a patchy distribution within the Proposed Development site boundary. Scrub has begun to encroach around the margins of grassland habitats from adjoining hedgerow habitat. The main species recorded in these areas are Hawthorn, Bramble *Rubus fruticosa* and Gorse *Ulex europaeus*. Along the Ralappane Stream scrub species include Goat Willow *Salix caprea*.

7B.4.3.8 Habitats Outside the Proposed Development Site

The Lower River Shannon cSAC and Ballylongford Bay pNHA are located to the north and west of the Proposed Development site, as well as overlapping within marine habitats (refer to Figure 7B-3 and Figure 7B-5). These sites support a variety of important habitats and species, both terrestrial and aquatic. A number of terrestrial qualifying habitats for the Lower River Shannon cSAC are located to the west of the Proposed

Development site i.e. Atlantic Salt Meadows (1330), Mediterranean Salt Meadows (1410), Perennial Vegetation on Stony Banks (1220), Estuaries (1130) and Coastal Lagoons (1150). Estuarine and coastal qualifying habitats are discussed further in Chapter 07A – Marine Biodiversity.

A number of notable terrestrial and freshwater habits are located outside the planning boundary. These include:

- Lagoon and saline lakes CW1. A brackish lagoon (CW1) occurs to the west of the Proposed Development site. This habitat comprises a small lake of impounded brackish water that is separated from the sea by banks of shingle. Tidal influence is much reduced by this physical barrier which fluctuates on a daily and seasonal basis, depending on tides and inputs of freshwater. Surveys carried out by Minerex in 2007 confirmed that this habitat is not hydrologically connected to the Proposed Development site (*Hydrological and hydrogeological impact assessment of the Proposed Shannon LNG Terminal at Ballylongford, Co. Kerry* (Minerex 2007)).
- Reed and large sedge swamps FS1. A large area of reedbed dominated by Common Reed *Phragmites australis* occurs to the west of the Ralappane Stream. This reed bed is species poor and dominated by Common Reed. This area, which is outside the Proposed Development site boundary, is included within the Ballylongford pNHA and Lower River Shannon cSAC. Surveys carried out by Minerex in 2007 confirmed that this habitat is not hydrologically connected to the Proposed Development site (*Hydrological and hydrogeological impact assessment of the Proposed Shannon LNG Terminal at Ballylongford, Co. Kerry* (Minerex 2007)).
- Lower salt marsh CM1. Along the lower reaches of Ralappane Stream a typical saltmarsh zonation occurs. It is subject to periodic tidal influence and comprises only small areas of pioneer and low-mid marsh. This area, which is outside the boundary of the Proposed Development site, is included within the Ballylongford pNHA. Lower salt marsh is allied to four types of salt marsh habitat listed in Annex I of the Habitats Directive (habitat codes 1310, 1320, 1330 and 1420) however correspondence is not exact. This habitat has deteriorated in quality in recent years. Surveys carried out by Minerex in 2007 confirmed that this habitat is not hydrologically connected to the Proposed Development site (*Hydrological and hydrogeological impact assessment of the Proposed Shannon LNG Terminal at Ballylongford, Co. Kerry* (Minerex 2007)).
- Conifer plantation WD4. A mature Sitka Spruce *Picea sitchensis* coniferous forestry plantation is located to the east of the Proposed Development site.

These habitats are located outside the Proposed Development site boundary and there will be no direct or indirect impacts on these habitats as a result of the Proposed Development.

7B.4.4 Mammals

The following mammals were recorded during the 2019-2021 sites surveys; Badger, Otter, Mink *Mustela lutreola,* Fox *Vulpes vulpes*, Irish Hare *Lepus timidus,* Common Pipistrelle *Pipistrellus pipistrellus,* Soprano Pipistrelle *Pipistrellus pygmaeus* and Leisler's Bat *Nyctalus leisleri.* During the 2006/ 2007 and 2011/ 2012 surveys Irish Hare, Fox, Otter, Badger and Common Pipistrelle were recorded. Full details of mammal surveys are included in Appendix A7B-1 of Volume 4.

7B.4.4.1 Badgers

Badger bait marking surveys were carried out at the Proposed Development site in 2007, 2011 and 2019. Bait marking surveys can be extremely useful for establishing the limits of Badger social group territories (SNH 2003). Bait-marking techniques rely upon the fact that Badgers mark the boundaries of their territories with dung pits (or aggregations of these, known as 'latrines'). These are regularly maintained by a large proportion of the Badger social group, although most of the marking activity is thought to be undertaken by the adult males. Full details of bait marking survey methods and results are included in Appendix A7B-1 of Volume 4.

Extensive surveying was carried out by DixonBrosnan for Badgers in 2007 following the discovery of three separate Badger setts; two within the overall Proposed Development site and one immediately outside the eastern boundary. The location of these setts is shown in Appendix A7B-1 of Volume 4. A site visit on 28 November 2011 ascertained that these three setts remained in place and activity levels remain similar to those recorded in 2007. The two setts (Sett 1 and Sett 3) are respectively located east and south-west of the overall Proposed Development site boundary. Sett 2, which was located within the site boundary was a much smaller sett, which had developed on a disused track. Signs of activity were recorded at this sett in 2011. It was concluded in 2011 that a possible sett nominated as Sett 2a in 2007 was not used by Badger. It was noted that the results of the survey may have been distorted by site clearance works (during the 2011 surveys) and in particular by unseasonably dry weather which may have impacted on feeding patterns and use of latrines.

An assessment of the 2007 bait marking survey was carried out prior to the implementation of the 2019 survey. Results from the 2007 survey were tentative and were considered uncertain due to agricultural works during the survey period and particularly dry weather. No such issues were recorded during the 2019 bait marking survey and results from this more recent survey are considered more reliable. The primary purpose of the bait marking survey in 2019 was to more accurately determine the status of Sett 1 and Sett 2 which are located within the Proposed Development site boundary.

The results of the bait marking survey which was carried out in 2019 are considered conclusive and provide a relatively clear picture of Badger usage patterns. A number of latrines were located which contained coloured pellets which illustrates the distribution of Badger social groups. Bait marking was carried out as outlined in Table 7B-4.

Table 7B-4 Bait Marking Survey 2019

Sett	Description of sett	Colour of pellets
Sett 1	Outlier sett located inside the Proposed Development site boundary	Blue pellets
Sett 2	Subsidiary sett located within the Proposed Development site boundary	Yellow pellets
Sett 3	Very large main sett located outside the Proposed Development site boundary	Red pellets
Sett 4	Main sett located outside the Proposed Development site boundary	White pellets

Based on the results of the 2019 bait marking survey, it was concluded that Sett 3 and Sett 2 belong to the same social group and that Sett 2 is a subsidiary sett (Sett 3 is the main sett). As expected, uptake of bait was high at Sett 3 as this is a large main sett. Uptake of bait was much lower at Sett 2, which was expected as this is a smaller subsidiary sett. The presence of yellow and red pellets in latrines indicates that these setts are linked as the main and subsidiary sett of the same social group. An overview of Badger sett distribution from the 2019 survey is provided in Figure 7B-7.

At Sett 1 which is located just inside the Proposed Development site boundary, bait update was much larger in 2007 but showed relatively low levels of activity in 2019. Following identification of a large sett (Sett 4) outside the Proposed Development site boundary, white and blue pellets were identified in Sett 4 latrines indicating that Sett 1 and Sett 4 are linked, with Sett 4, the main sett (outside the site boundary) and Sett 1 (within the eastern boundary) an outlier sett with very limited usage.

Figure 7B-7 Badger Latrine with Recorded Pellets and Sett Locations

Following the 2019 surveys it was concluded that two main Badger setts occur near the Proposed Development site, namely Sett 3 and Sett 4. However, neither sett will be directly impacted by the Proposed Development. Bait marking surveys indicate that Sett 2 is a subsidiary sett and the main sett for this social group is Sett 3, which will be unaffected by the Proposed Development. Sett 1 which has contracted since initial surveys in 2007, now consists of one unused sett entrance and on outlier sett just within the site boundary. It is noted that neither of the main setts (Sett 3 and Sett 4) will be impacted by the Proposed Development and exclusion of the Badgers from outlier and subsidiary setts (Sett 1 and Sett 2) is a viable option in relation to the Proposed Development.

Overall, the Proposed Development site is of Local importance (Higher value) for Badger.

7B.4.4.2 Bats

Night-time bat emergence surveys and transect surveys as well as daytime building surveys and were carried out within the Proposed Development site boundary in April 2007, September 2020, May 2021, June 2021 and July 2021. Full details of survey methods and results are included in Appendix A7B-1 of Volume 4.

The hedgerows and treelines, grassland areas, shoreline and river corridor around the Proposed Development site may be used by bats for feeding, however no trees were recorded which could potentially support bat roosts were noted in the 2007 site surveys. Within the Proposed Development site boundary, a disused farmstead (Location B in Figure 7B-8) was surveyed in 2007 via a standard bat detector survey. A small number of Common Pipistrelle (<20) were recorded at this location. This indicated that these disused farmstead buildings supported a small summer bat roost. A small derelict building was located closer to the shoreline west of the Proposed Development site boundary (Location D Figure 7B-8). However, this building lacked the crevices and spaces which would make it suitable as roosting sites for bats and the presence of bat roosts at this location is considered highly improbable.

Bats spend much of the winter in torpor at hibernation sites although they will rouse on warmer nights to drink, forage and expel waste products. Bats can change hibercula depending on weather conditions. In general winter roosting sites have a constant temperature and high humidity (Collins, 2016) and are often in basements or underground cellars. The buildings within the Proposed Development site and in immediate proximity to it, are in an advanced state of disrepair and drafty in winter with extreme fluctuations in temperature. There are no cellars or underground structures associated with these buildings. Therefore, no potential winter roosting habitat for bats will be affected.

All buildings and structures were resurveyed in 2020 and 2021 (Table 7B-1). No buildings with significant potential to support bats were recorded within the Proposed Development site boundary during the 2020 or 2021 bat surveys. A disused farmhouse within the Proposed Development site boundary (Location B in Figure 7B-8) has a heavy growth of ivy and is drafty due to an absence of windows or doors. Three Common Pipistrelle, one Soprano Pipistrelle and One Leisler's Bat were recorded foraging in the vicinity of this building on two nights in July 2021. However, no bats were recorded emerging from the building. Following a daytime visual search, it was concluded that Location B is of low potential roost value for bats as no signs of bat usage (i.e. staining, dropping etc.) were recorded. A pillbox (Location C in Figure 7B-8) close to the Shannon Estuary lacks suitable crevices for bats. Overall, the buildings within the Proposed Development site boundary are considered of low suitability as potential bat roosts (Potential Roost Feature (PRF)) under the guidelines set out in '*Bat Surveys for Professional Ecologists: Good Practice Guidelines (3rd end)*' (Collins 2016).

A derelict farmhouse, part of a complex of farm buildings (Location A, in Figure 7B-8) which are outside the Proposed Development site boundary, was previously assessed in 2007 and a small colony of Common Pipistrelle (<20) was recorded. Although this building is outside the Proposed Development site boundary, this farmstead was re-surveyed in September 2020. Approximately eight Common Pipistrelle bats were recorded emerging from the disused farmhouse with a slate roof and feeding activity post emergence was recorded around the building complex. A second farm building within the same farm complex was also surveyed in September 2020. Although feeding activity by Common Pipistrelle was recorded in proximity to this building, no bats were recorded emerging from it during the 2020 bat survey. Both buildings are considered moderate PRFs Collins (2016).

No trees of potential value as bat roosts were recorded within the Proposed Development site boundary during the 2020-2021 bat surveys.

Surveys along internal hedgerows/ treelines, cliffs, scrub, reed bed and stream habitat found small numbers of bats foraging/ commuting in these areas. Three bat species were recorded i.e., Common Pipistrelle, Soprano Pipistrelle and Leisler's Bat during bat surveys. The majority of registrations were along hedgerow habitat bordering agricultural grassland. Three Common Pipistrelle, one Soprano Pipistrelle and one Leisler's Bat were recorded foraging along the cliff habitat at Ardmore Point. One Common Pipistrelle was recorded foraging over the reed bed habitat to the west of the Proposed Development site. Internal hedgerows and scrub within the Proposed Development site are considered to have moderate suitability for commuting and foraging bats under the guidelines set out Collins (2016).

Overall, the Proposed Development site is Local importance (Higher value) for bats. Common Pipistrelle, Soprano Pipistrelle and Leisler's Bat were recorded foraging within the Proposed Development site but no roosting sites were recorded. It is noted that no Myotis bats (light-sensitive species) were recorded.

Figure 7B-8 Bat Survey Locations

7B.4.4.3 Otter

Full details of survey methods and results are included in Appendix A7B-1 of Volume 4. Otter is a qualifying interest for the Lower River Shannon cSAC and impacts on Otter are discussed further in the NIS which accompanies this planning application. An overview of the lands in the vicinity of the Proposed Development site boundary which were surveyed for Otter are shown in Figure 7B-9.

Initial Otter surveys were carried out in January 2007 with a more intensive survey for natal holts carried out in March 2007. These surveys indicated that the Ralappane Stream to the west of the Proposed Development site is used by Otter. A well-worn Otter track was recorded running alongside the tidal section of the stream. Along its length there were several sprainting sites. A path was also observed where Otter cross into the large reed bed to the west of the Proposed Development site boundary. A survey was carried out to locate any potential resting areas/ holts or natal holts along the stream. The survey did locate one obvious holt/ resting area at the base of an over-mature willow on the riverbank. It is noted that this holt/ resting area is outside the Proposed Development site boundary (Refer to Figure 7B-9).

A further survey was carried out an area of dense, impenetrable scrub vegetation in September 2007 (*Specialised Otter survey at Ballylongford, Co. Kerry,* DixonBrosnan, 2007). This survey used remote surveillance methods (Infra-red system to trigger a stationary camera) to determine if Otter were using this particular area. No evidence of Otter was recorded within this area which is located outside the Proposed Development site boundary (See Figure 7B-9 for location).

A DixonBrosnan Otter survey in 2011 did not find evidence of Otter along the Ralappane Stream or along the Shannon Estuary shoreline of the Proposed Development site and no evidence was recorded to indicate that resting site recorded in 2007/ 2008 was still being utilised. There was no obvious track running alongside the stream and no spraint sites were recorded. There was sufficient indentation in the grass margin of the stream to suggest some possible sporadic usage. The results of the 2011 suggested that whilst Otter were possibly using the Ralappane Stream and the Shannon Estuary shoreline sporadically, at the time of the survey this habitat was not of high value Otter.

In October 2019 an Otter sprainting site was recorded along the tidal section of the Ralappane Stream outside the western Proposed Development site boundary. An Otter was recorded foraging along the Shannon Estuary shoreline near Knockfinglas Point and to the west of the Proposed Development site. Otter was also recorded foraging at the lagoon to the west of the Proposed Development site in October 2019. In January 2020 an Otter was also recorded moving along a field bordering the Shannon Estuary approximately 900m west of the Proposed Development site. It is noted that no signs of Otter were recorded along the upper reaches of the Ralappane Stream within the Site boundary or along any of the drainage ditches within the Proposed Development site during any of the surveys between 2007 and 2021.

In June 2019, trail cameras recorded two adult Otter close to the confluence of the Ralappane Stream and the Shannon Estuary, outside the Proposed Development site boundary (Refer to Figure 7B-9). Otter are generally solitary and therefore the presence of two adults may be indicative of breeding behaviour. However, no holts were recorded within 150m of the Proposed Development site.

Overall, the Proposed Development site is of Local Importance (Higher value) for Otter. Otter was recorded in the vicinity of the Proposed Development site but there are no records of Otter within the site boundary.

Figure 7B-9 Otter Survey Results

7B.4.4.4 Other Terrestrial Mammals

Nine other species of terrestrial mammal have been recorded within R04, the grid square within which the Proposed Development site is located (NBDC). Five of these are protected under the Wildlife Act 1976, as amended, namely Red Squirrel *Sciurus vulgaris*, Fallow Deer *Dama dama*, Irish Hare *Lepus timidus subsp. hibernicus*, Sika Deer *Cervus nippon* and Hedgehog *Erinaceus europaeus*.

Red Squirrel

Red Squirrel is known to occur in the wider area (NBDC records). The closest record of Red Squirrel in approximately 1 km southeast of the Proposed Development site at Cockhill, Tarbert in 2017. However, no signs of Red Squirrel were recorded during site surveys and given there is no valuable woodland habitat within the Proposed Development site for this species. The site is of negligible local ecological value for Red Squirrel.

Hedgehog

No signs of Hedgehog were recorded during site surveys, although they are likely to use hedgerows and treelines within the Proposed Development site boundary. The site of Local importance (Lower value) for Hedgehog.

Irish Hare

Irish Hare was recorded within the Proposed Development site boundary during the 2011 surveys, although not in the 2007 surveys. Two Hares were recorded foraging in grassland at the southeast of the Proposed Development site on the 22nd of April 2021. A single Hare was also recorded along the shoreline to the east of the Proposed Development site boundary on the 21st January 2019. (Figure 7B-10). The Proposed Development site of Local importance (Lower value) for Irish Hare.

Fallow Deer

No sign of Fallow Deer was recorded during the surveys within the Proposed Development site boundary and habitats present are suboptimal for this species. The Proposed Development site is of negligible local ecological value for Fallow Deer.

Sika Deer

No sign of Sika Deer was recorded during the surveys within the Proposed Development site boundary and habitats present are suboptimal for this species. The Proposed Development site is of negligible local ecological value for Sika Deer.

Figure 7B-10 Other Species Recorded within Proposed Development Site

7B.4.5 Amphibians and Reptiles

7B.4.5.1 Amphibians

According to records held by the NBDC, Common Frog *Rana temporaria* and Smooth Newt *Lissotriton vulgaris* are the only amphibians recorded within grid square R04, the grid square in which the Proposed Development site is located.

A single Common Frog was recorded in wet grassland near the west of the site on the 22 April 2021 (Figure 7B-10). No other amphibian species were recorded during site surveys. The Proposed Development site is of Local importance (Higher value) for Common Frog.

7B.4.5.2 Reptiles

Common Lizard *Lacerta vivipera* has been recorded within R04 on two occasions, however the most recent record dates back to 1976. No sign of Common Lizard was recorded during site surveys. The Proposed Development site is of negligible value for reptiles. No habitats of particular significance for this species will be affected by the Proposed Development.

7B.4.6 Birds

7B.4.6.1 Breeding Birds

The NBDC online database lists 128 species of bird recorded within grid square R04. Of these species, a number are listed under Annex I of the Birds Directive and are Red Listed Birds of Conservation Concern in Ireland (Gilbert *et al.* 2021). Corncrake *Crex crex*, Grey Partridge *Perdix perdix*, Curlew *Numenius arquata*, Barn Owl *Tyto alba* and Yellowhammer *Emberiza citrinella* have historically bred within 10 km of the Proposed Development site (Sharrock 1976, Gibbons *et al.* 1993). However, the proposed site does not contain suitable habitat for breeding Curlew, Barn Owl or Grey Partridge. A national survey of breeding Hen Harriers in Ireland in 2016, recorded no evidence of breeding Hen Harriers in the 10 km grid square containing the Proposed Development (Ruddock *et al.* 2016). It is noted that a juvenile (Ringtail) Hen Harrier was recorded over the reed bed habitat to the west of the Proposed Development site in July 2021 (19th July 2021). However, there is no high value foraging or suitable breeding habitat for this species within the Proposed Development site boundary and there are no records of breeding Hen Harrier within 10 km of the site boundary. Given the habitats within the Proposed Development site, it is of negligible value for breeding Hen Harrier and of low potential value for foraging Hen Harrier.

Breeding bird surveys were carried out at the Proposed Development site in March 2019, July 2019, April 2020 and May 2020. Full details of this survey are included in Appendix A7B-2 of Volume 4.

A total of 37 bird species were recorded during breeding bird surveys, the majority of which are common farmland and woodland edge species. Green List species were recorded primarily along field boundaries and included Woodpigeon *Columba palumbus*, Blackbird *Turdus merula*, Song thrush *Turdus philomelos*, Wren *Troglodytes troglodytes* and Great tit *Parus major*.

Breeding birds of conservation concern recorded during the site surveys are included in Table 7B-5. One Annex I species, Little Egret *Egretta garzetta*, was recorded during site surveys. It is noted that Little Egret was recorded within the salt marsh habitat which is located outside the Proposed Development site boundary. Four red-listed species were recorded in the 2019/ 2020 surveys i.e., Meadow Pipit *Anthus pratensis*, Merlin *Falco columbarius,* Quail *Coturnix coturnix* and Stock Dove *Columba oenas* (Gilbert *et al.* 2021). A single Woodcock *Scolopax rusticola*, a Red List species, was also recorded on a trail camera recording during January 2020, although no sign of this species was recorded during breeding surveys. A male Quail was recorded within wet grassland at the Proposed Development site on one occasion. However, no signs of breeding were recorded and this is likely to be a migrant species passing through the Proposed Development site. Merlin was recorded foraging to the east of the Proposed Development site, near coniferous forestry in July 2019. However, no signs of breeding Merlin were recorded within the Proposed Development site boundary.

Eleven Amber List species were recorded. A number of these species such as Skylark *Alauda arvensis* and Linnet *Carduelis cannabina* as well as the Red List species Snipe *Gallinago gallinago*, Meadow Pipit and Quail are under threat due to intensification of agricultural practices as they rely on less intensively manged agricultural grassland habitat. Less intensively managed agricultural land and wet grassland at the Proposed

Development site provides valuable habitat for these species. It is noted that Snipe were not recorded during the breeding bird surveys but were recorded on a number of occasions during winter bird surveys at the Proposed Development site. They could potentially breed in wet grassland or less intensely managed agricultural grassland at the west of the Proposed Development site. Snipe have recently been moved from Amber List to the Red List species of conservation concern due to a significant drop in their breeding numbers.

It is noted that four juvenile White-Tailed Sea Eagles *Haliaeetus albicilla* have been released in the Tarbert area to date and a further eight birds are scheduled for release in 2021 (Allan Mee, personal communication). White-tailed Sea Eagle have a foraging range of up to 250 km^2 (Evans *et al.* 2011). No signs of this species were recorded during any of the site surveys. The terrestrial habitats within the Proposed Development site do not provide breeding or foraging habitat for White-tailed Sea Eagle, however they could potentially forage along the Shannon Estuary in the vicinity of the site.

There are a number of Red List and Amber List species breeding and foraging within the Proposed Development site. Overall, the Proposed Development site is of Local Importance (Higher value) for birds of conservation concern and Local importance (Higher value) for other breeding birds. Sandwich Tern *Thalasseus sandvicensis*, an Annex I (and Amber List) species was recorded foraging within intertidal waters to the west of the Proposed Development site in summer 2021 (Refer to Section 7B.4.6.2 for detail). Sandwich Tern and Common Tern *Sterna hirundo* breed within the Shannon Estuary at Rat Island, approximately 33 km northeast of the Proposed Development site. Common Tern, which were not recorded during any site survey, also breed at Sturamus Island 24 km east of the Proposed Development site (Hannon *et al*. 2007; Natura 2012). However, there are no breeding tern colonies in the vicinity of the Proposed Development site. Although White-tailed Sea Eagle were not recorded, given the foraging range of this species and the release of birds within 7 km of the Proposed Development site, the site has been classified as Local importance (Lower value) for this Annex I species.

Table 7B-5 Birds of Conservation Concern Recorded during Site Surveys

Species		Breeding Status	Estimated number of territories within site boundary	Conservation Status: Annex I of Birds Directive or Red/ Amber List*
Black-headed Gull	*Larus ridibundus*	Possible	0	Amber List
Herring Gull	*Larus argentatus*	Possible	0	Amber List
House sparrow	*Passer domesticus*	Probable	1	Amber List
Linnet	*Carduelis cannabina*	Probable	1	Amber List
Little egret	*Egretta garzetta*	Possible	0	Annex I
Mallard	*Anas platyrhynchos*	Confirmed	0	Amber List
Meadow pipit	*Anthus pratensis*	Possible	2-3	Red List
Merlin	*Falco columbarius*	Possible	0	Red List
Quail	*Coturnix coturnix*	Non-breeding	0	Red List
Sand Martin	*Riparia riparia*	Possible	0	Amber List
Shelduck	*Tadorna tadorna*	Possible	0	Amber List
Skylark	*Alauda arvensis*	Possible	1	Amber List
Starling	*Sturnus vulgaris*	Possible	2	Amber List
Stock dove	*Columba oenas*	Probable	1	Red List
Swallow	*Hirundo rustica*	Confirmed	2	Amber List
Willow warbler	*Phylloscopus trochilus*	Possible	1	Amber List
Woodcock	*Scolopax rusticola*	Non-breeding	0	Red List

7B.4.6.2 Estuarine Birds

As detailed in Section 7B.4.2, the terrestrial habitats within the Proposed Development site are adjacent to the River Shannon and River Fergus Estuaries SPA. The River Shannon and River Fergus Estuaries SPA is an internationally important site that supports an assemblage of over 20,000 wintering waterbirds. The SPA holds internationally important populations of four species, i.e., Light-bellied Brent Goose, Dunlin, Black-tailed Godwit and Redshank. In addition, there are 17 species that have wintering populations of national importance. The site also supports a nationally important breeding population of Cormorant. Of particular note is that three of the species which occur regularly are listed on Annex I of the E.U. Birds Directive, i.e., Whooper Swan, Golden Plover and Bar-tailed Godwit.

The proposed jetty extends into the SPA boundary (Figure 7B-3). Winter bird surveys were conducted from four vantage points to the east and west of the Proposed Development site on the southern shores of the Shannon Estuary between Richard's Rock and Ardmore Point (Figure 7B-11). Initially the survey focused on three points (Points A, B and C). A fourth site was added in February of 2019 (Point D). During summer 2021 two additional points (Point E and F) were added to the east of the Proposed Development site and surveys at all six points were extended in the summer months (May to July 2021).

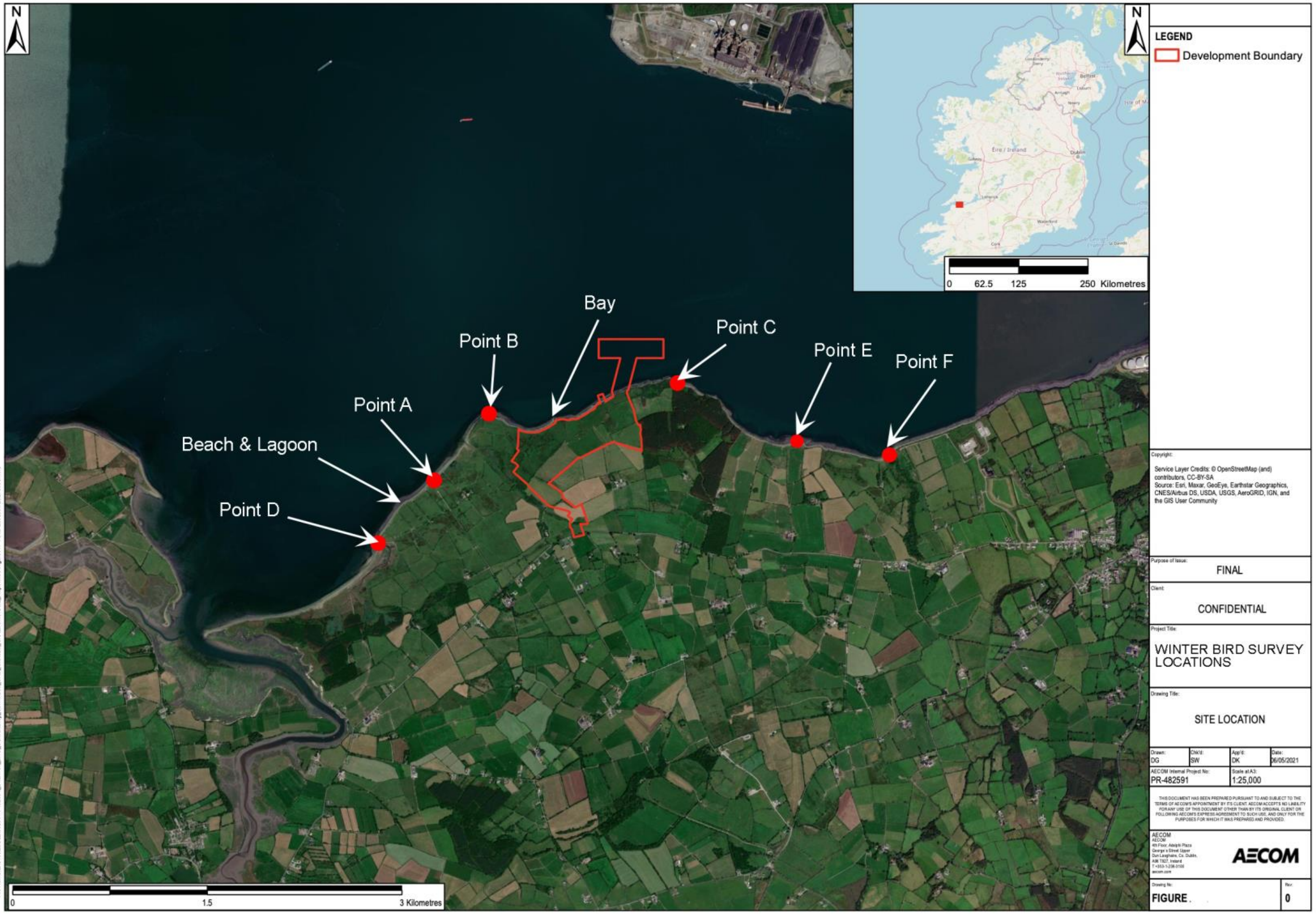

Figure 7B-11 Estuarine Bird Survey Locations

Winter bird surveys within the Shannon Estuary were carried out in 2006/ 2006, 2011/ 2012, 2018/ 2019 and 2019/ 2020. Summer bird surveys were conducted in 2021. Full details of estuarine bird surveys are included in Appendix A7B-3 of Volume 4 and within the NIS which accompanies this application.

Cork Ecology conducted six surveys at monthly intervals between October 2006 and March 2007 at Points A, B and C. On each visit, three bird counts were made over the coastal waters between Knockfinglas Point and Ardmore Point. A total of 29 waterfowl species were recorded during counts over the coastal waters. Two species listed on Annex I of the EU Birds Directive (79/ 409/ EEC) i.e. Red-throated Diver *Gavia stellata* and Great Northern Diver *Gavia immer*, were recorded during the 2006/2007 winter bird surveys. Both species were regularly recorded in low numbers from Point A (Refer to Figure 7B-11). No nationally or internationally important numbers of birds were recorded during the 2006/ 2007 winter bird surveys. Ten SCI species for the SPA were recorded during the 2011/ 2012 surveys i.e., Black-headed Gull, Cormorant, Curlew, Dunlin, Lapwing, Redshank, Ringed Plover, Scaup, Teal and Wigeon. During the 2006/ 2007 winter bird surveys, peak bird numbers were recorded from Point A.

Further bird surveys were carried out by DixonBrosnan in the period 2011-2012 from Points A, B and C along the shoreline of the Shannon Estuary. The Annex I bird species Great Northern Diver and Whooper Swan were recorded during these 2011/ 2012 site surveys. Great Northern Diver was recorded in the area around Knockfinglas point. Whooper Swan was recorded within the lagoon to the west of the Proposed Development site. No nationally or internationally important numbers of birds were recorded during the 2011/ 2012 winter bird surveys. Eight SCI species for the SPA were recorded during the 2011/ 2012 surveys i.e. Whooper Swan, Cormorant, Teal, Ringed Plover, Lapwing, Curlew, Redshank and Black-headed Gull. During the 2011/ 2012 winter bird surveys, peak bird numbers were recorded from Point A.

As part of the current application DixonBrosnan carried out winter bird surveys 2018-2020 from Points A, B and C, as well as Point D from February 2019. Surveys were carried out at all six points (Points A-F) in summer 2021. A total of 33 bird species were recorded during the 2018/ 2019 and 2019/ 2020 winter bird counts. Four Annex I species were recorded i.e. Great Northern Diver, Red-throated Diver, Golden Plover and Little Egret. Fourteen of the 21 SCI species for the River Shannon and River Fergus Estuaries SPA were recorded during the 2018-2021 surveys including Cormorant, Wigeon, Shelduck, Teal, Light-bellied Brent Goose, Ringed Plover, Golden Plover, Grey Plover, Lapwing, Dunlin, Curlew, Redshank, Greenshank and Black-headed Gull. During the summer 2021 surveys a total of 20 species were recorded. This included three species which had not been recorded during winter surveys i.e., Sandwich Tern, Whimbrel *Numenius phaeopus* and Water Rail *Rallus aquaticus*. Three SCI species were recorded during summer 2021 i.e., Cormorant, Curlew and Shelduck.

During the 2018/ 2019 survey, peak numbers were recorded in December (3rd December 2018). During the 2019/ 2020 survey, peak numbers were recorded in February (22nd February 2020). While the peak numbers by month varied between the two survey seasons, the species diversity by month was consistent between both survey seasons. Peak bird numbers were recorded during low tides, with 260 Dunlin and 100 Light-bellied Brent Goose recorded at Point D (west of the Proposed Development site) during low tide. In general, the largest density of birds was recorded from Point D, which was added to the survey area in 2019. Lowest bird numbers and species diversity were recorded during the summer months.

The proposed jetty location is between Point B and Point C (refer to Figure 7B-11). Point B is located at Knockfinglas Point to the west of the Proposed Development site. Low numbers of gulls, diving birds, and waders were recorded here during both low and high tide surveys. A flock of 64 Black-headed Gull and 23 Turnstone *Arenaria interpres* were recorded loafing on the water at high tide. Within the Bay adjacent to Point B, only three wading bird species were recorded and in small numbers i.e. Curlew (peak number 10) and Turnstone (peak number 23), Oystercatcher *Haematopus ostralegus* (peak number 9).

Point C is located at Ardmore Point to the east of the Proposed Development site. This overlooks slightly deeper waters than the other survey points with limited intertidal habitats. Gulls and divers were regularly recorded at this site, albeit in small numbers. Few waders were recorded here, likely due to the limited foraging habitat present; Oystercatcher (peak number 5), Curlew (peak number 2) and Redshank (peak number 4) and Turnstone (peak number 7). Small numbers of duck species i.e., Mallard *Anas platyrynchos* (peak number 2) and Wigeon (peak number 12), were recorded here at low tide.

The grassland habitats near the north-western boundary of the Proposed Development site may serve as high tide foraging locations for terrestrial foraging waders such as Curlew, Lapwing and Golden Plover. It is noted that flocks of Curlew were recorded foraging on wet grassland within the Proposed Development site during the 2007/ 008, 2018/ 2019 and 2019/ 2020 winter bird surveys (max. 78 individuals in January 2008). Snipe were also recorded in wet grassland habitats during the 2018/ 2019 and 2019/ 2020 winter bird surveys. Curlew and Snipe, which are Red List species of Conservation Concern (Gilbert *et al.* 2021), were the only terrestrial foraging wading birds recorded within the Proposed Development site. No other wading birds were recorded on terrestrial habitats within the Proposed Development site.

The deeper waters of the estuary provide foraging grounds for seabirds and divers including Black Guillemot *Cepphus grylle*, Common Guillemot *Uria aalge*, Great Crested Grebe *Podiceps cristatus*, Great Northern Diver and Razorbill *Alca torda*. These birds generally occurred in small numbers at both high and low tides.

The estuarine bird survey area has small areas of shingle and gravel shores, shingle beach and boulders shores with limited exposed mudflat at low tide. The stretch of the shore between Point A and Point E has low value for wading birds and this is reflected in the low numbers of these species recorded here. Few SCI birds were recorded between Point B and Point C (the proposed jetty location) and with the exception of a flock of 123 Black-headed Gull in December 2018, were recorded in low peak numbers Cormorant (4), Curlew (10) Greenshank (1), Whimbrel (1) and Wigeon (10). Point D, approximately 1 km west of the Proposed Development site, is closer to an area of intertidal mudflats along Ballylongford Creek. Bird numbers and diversity were notably higher at Point D compared to Points A, B or C. This would suggest that the habitats to the west of the Proposed Development site are likely to provide the valuable intertidal habitats which are lacking within the survey area.

The peak number of benthic foraging divers were recorded feeding within deeper waters of the survey area including Great Northern Diver (4), Red-throated Diver (2) and Great Crested Grebe (11) as well as other piscivorous species such as Cormorant (4), Shag *Phalacrocorax aristotelis* (5) and Sandwich Tern (3). The majority of sightings were from Point A although a number of these species were recorded between Point B and Point C and the peak numbers were as follows: Great Northern Diver (3), Great Crested Grebe (2), Red-throated Diver (2), Cormorant (4). No Shag or Sandwich Tern were recorded foraging within the intertidal waters at the Proposed Development site. While peak numbers of birds were generally recorded to the west of the survey area, the waters around the proposed jetty location are also regularly used by small numbers of piscivorous and diving birds. The foraging distribution of these birds is highly influenced by water depth and tidal conditions. Many of these species however exhibit a widespread coastal distribution during winter, utilising shallow nearshore waters to a greater degree at certain times (e.g., storms, driving onshore winds).

Part of the Proposed Development site overlaps with the River Shannon and River Fergus Estuaries SPA and SCI birds use the waters in the vicinity of the site. However, no birds were recorded in nationally or internationally important numbers. It is noted that an extensive survey of the Shannon Estuary found that bird species richness within the SPA was generally correlated with intertidal habitat area (MKO 2019). MKO noted that the Proposed Development site had limited intertidal foraging habitat and subsequently very low numbers of birds.

Overall, the Proposed Development site is of County importance for Annex I species, Local importance (Higher value) for SCI species and Local importance (Higher value) for non-SCI wintering/ estuarine birds.

7B.4.7 Fish

Aquatic Services Unit carried out a fisheries assessment of the Ralappane Stream on 4 October 2006. The characteristics/ locations of the sites and the species detected are shown in Table 7B-6.

A resurvey of the stream was not considered necessary in 2011. However, a visual examination of the stream did not record any signs of a significant deterioration in water quality such as odour, siltation or excessive algae development.

Table 7B-6 Fisheries Assessment – Survey Locations

Site	Location	Species Captured
Site F1	Located in sluggish water in the lower reach of the stream about 120m upstream from the seashore.	1 stone loach (*Nemacheilus barbatus*)
Site F2	Site 2 was situated about 1 field due north of the southern farmyard	2 sticklebacks (*Gasterosteus aculeatus*) and 3 Eels (*Anguilla anguilla*)
Site F3	Site 3 was located due east of the same farmyard.	20 stickleback (*Gasterosteus aculeatus*) and 1 eel (*Anguilla anguilla*)

Small numbers of fish were caught during the electrofishing survey and only three species were detected. Two species (Stone Loach *Nemacheilus barbatus* and European Eel *Anguilla anguilla*) were found in low numbers with higher numbers of Stickleback *Gasterosteus aculaeatus* recorded. European Eel is listed by the International Union for Conservation of Nature (IUCN) as a critically endangered species, with numbers in catastrophic decline. No salmonids were recorded. This could be due to the short length of the stream, low flows, lack of available spawning substrate or due to debris and marginal vegetation blocking migration routes through the stream. There is no evidence to indicate that the stream has significant spawning habitat or is generally of high value for fish. It is noted that European Eel and Stickleback were also observed within the stream during kick sampling carried out by DixonBrosnan in April 2021 (Refer to Appendix A7B-4 of Volume 4).

Small numbers of fish use the stream, and no Annex II species were recorded. However, European Eel which is critically endangered, was recorded within the stream. Overall the Ralappane Stream is of Local importance (Higher value) for fish species.

7B.4.8 Aquatic Invertebrates

The results of the ASU survey are outlined in Table 7B-7 and the location of sampling sites shown in Figure 7B-12. Water chemistry monitoring within the Ralappane Stream is discussed in Chapter 06, Section 6.5.10.3. This section notes that the analytical results indicate that surface waters at the Proposed Development site are locally impacted by some minor water quality issues.

Table 7B-7 Kick Sampling Results 2006

Site	GPS	Characteristics	Q Value
Stream Site 1	Strandline Stream Outlet R01525 48553	The mainstream flowed to the estuary across the boulder-cobble-gravel shoreline Here the channel, without banks, was 2.5m wide and 15-20cm deep flowing swiftly and turbulently over the substrate of smooth boulders cobbles gravel and fine gravel. The water was quite turbid, presumably due to re-suspended shore sand. Conductivity was recorded at 491µS/cm. The substrate was largely plant-free except for green alga *Enteromorpha. sp.*	Not assigned due to tidal influence
Stream Site 2	GR (R10860 48268)	The stream flows over boulder cobble and coarse sand; and is largely plant-free. The channel is about 0.7m wide and 0.37m deep with a moderate to swift laminar flow. The overgrown banks were dominated by bramble, with an understorey of rushes and nettles. The channel is very shaded with vertical banks of about 0.6m.	Q4

Stream Site 3	This site is upstream of Site 2 at R01965 48180	The right bank was heavily overgrown with bramble and hawthorn, while the left bank had low elm suckers backed by marshy grassland. The channel was 1m wide and 0.28m deep in heavy shade. The substrate comprised boulders, cobbles, gravel and coarse sand in a moderate to swift flow. The substrate was plant free. The water was colored and had a conductivity of 309 µS/cm.	Q4

The Ralappane Stream has a fairly typical mix of taxa, but numbers of Mayfly *Ephemeroptera* spp were low and stoneflies *Plecoptera* spp were absent. This may indicate a marginal degree of water quality impairment although; a Q-value of Q4 (unpolluted) was assigned. A value of Q3-4 (slightly polluted) might also have been assigned, especially to Site 3 as there were relatively more oligochaetes and leeches at this location.

An aquatic survey of the Ralappane Stream was undertaken by DixonBrosnan on the 22 April 2021. Biological sampling was carried out at each station using the kick-sampling technique as described by Clabby *et al* (2001).

The Ralappane Stream arises approximately 3.5 km south-east of the Proposed Development site and passes through a landscape dominated by intensive agriculture with blocks of planted woodland, before discharging to the estuary. Although there are sections with a natural riffle-glide flow pattern, sections of the stream have been straightened and deepened leading to sluggish flows and a soft substrate. Three sampling stations were selected along the Ralappane Stream as shown below on Figure 7B-12. Further detail on the sample locations including instream conditions and surrounding vegetation is included in the report *Biological Assessment of Ralappane Stream, Ballylongford, Co. Kerry 2021* (DixonBrosnan, 2021) which is included in Appendix A7B-4 of Volume 4.

Figure 7B-12 Aquatic Sampling Locations

Macro-invertebrates found at each site were identified down to the lowest taxon required for the determination of Q value. All three sites were assigned a Q value of 3 which is indicative of a degree of water quality impairment and the most sensitive species (Group A) were absent from all three sites. No sites achieved the target of good status (Q4) water quality, as specified under the Water Framework Directive (2000/ 60/ EC).

Site 1 and 2 adjoin intensive grassland with cattle drinking points evident within this section of the watercourse. Site 3 adjoins wet grassland which is less intensively managed, and diversity was generally higher at site 3.

The results from chemical analysis of water samples were not indicative of significant water quality impairment; however it is noted that cattle drinking points have the potential to cause significant localised nutrient enrichment in small streams where dilution is limited. European Eel and Stickleback were noted within the watercourse which is considered highly unlikely, given its limited size, to support salmonids. No salmonids were recorded during the fish stock assessment in 2006.

Overall the Ralappane Stream is of Local importance (Lower value) for invertebrate species.

7B.4.9 Invasive Species

The Birds and Natural Habitats Regulations 2011 (SI 477 of 2011), section 49(2) prohibits the introduction and dispersal of species listed in the Third Schedule, which includes Japanese Knotweed (*Fallopia japonica*), as follows: 'any person who plants, disperses, allows or causes to disperse, spreads or otherwise causes to grow [….] shall be guilty of an offence.'

A survey for invasive species was carried out in conjunction with habitat surveys and any observations of invasive species made during other surveys were recorded. No third schedule invasive species were recorded within the planning boundary (Wildlife Act 1976, as amended) or any High impact or Medium impact invasive species as classified by the NBDC were recorded within the Proposed Development site.

7B.4.10 Other Species

In 2007 (9th September 2007) a specialised Lepidopteran survey was carried out following consultation with the NPWS. A Robinson pattern moth trap was placed at the reed bed adjacent to the Ralappane Stream to the west of the Proposed Development site and was run and supervised overnight. This reed bed is included in the Lower River Shannon Special Area of Conservation (Site Code 002165) and is outside the Proposed Development site boundary. Other habitats in the immediate surroundings include wet grassland and agriculturally improved grassland with unmanaged hedgerows. No specialised survey was carried out for butterflies and day flying moths. However, a variety of species were recorded during general survey work in 2006 and 2007. Overall, no Lepidopteran species of particular rarity were recorded, although some of the moth species did have specialised or localised distributions (Table 7B-8, Table 7B-9). The prevalence of the Wainscot moths i.e. Smokey wainscot *Leucania impure*, Striped wainscot *Leucania pudorina*, Large Wainscot *Arenostola pygmina*. is largely related to the presence of their food plants in the area including coarse grasses, sedges and in particular Common Reed.

Table 7B-8 Moth Species Recorded during 2007 Reed Bed Survey

Common Name	Latin Name	Notes
Canary shouldered thorn	*Deuteronomos alniaria*	Distributed throughout Ireland. Its primary food plants are Birch and Willow
August thorn	*Deuteronomos quercinaria*	Distributed throughout Ireland. Its primary food plants are Hawthorn and Willow.
Smokey wainscot	*Leucania impura*	Widely distributed. Primary foodplants are grasses.

Common Name	Latin Name	Notes
Striped wainscot	*Leucania pudorina*	Recorded from Galway, Cork and Kerry. Its foodplant is Common Reed
Large Wainscot	*Arenostola pygmina*	Fens and marshy ground. Foodplants sedges and Marram Grass Ammophila spp..
Pink barred sallow	*Citria lutea*	Throughout Ireland. Food plants sallow and Birch *Betula* spp..
Frosted orange	*Gortyna flavago*	Throughout Ireland. Local. Foodplants thistles *Cirsium* spp. and burdock *Arctium* spp..
Rosy rustic	*Gortyna micarea*	Widespread coastal species. Foodplant roots of dock *Rumex* spp. etc.
Large yellow underwing	*Noctua pronuba*	Common. Foodplant grasses.
Copper underwing	*Amphipyra pyramidea*	Widespread; mainly a woodland species. Foodplants various tree and shrub species including Birch, Willow and Hawthorn.
Angle shades	*Phlogophora meticulosa*	Widespread, common. Main foodplants dock, Groundsel *Senecio vulgaris* etc.
Crimson ear	*Hudraecia crinanensis*	Widespread. Foodplant Yellow Iris *Iris pseudacorus.*
Autumn green carpet	*Chloroclysta miata*	Widespread. Foodplants willow and Alder *Alnus* spp..
Brimstone moth	*Opisthograptis luteolata*	Numerous and widespread. Foodplant Hawthorn etc.

Table 7B-9 Butterflies and Day-flying Moth Species Recorded during Site Survey

Common Name	Latin Name	Notes
Small tortoiseshell	*Aglais urticae*	Widely distributed in Ireland, although abundance varies. Highly mobile and can be seen in many habitats.
Meadow brown	*Maniola jurtina*	Widely distributed in Ireland and common in fields, roadsides and woodland.
Painted lady	*Vanessa cardui*	Found in a number of locations around Ireland. Main foodplants thistles and nettle

Common Name	Latin Name	Notes
Red admiral	*Vanessa atalanta*	Widespread and highly mobile. Main foodplant nettle and hop.
Five spotted burnet moth	*Zygaena trifolii*	Locally distributed, and occupies damp meadows, marshes and sea cliffs.
Common blue	*Polyommatus icarus*	Widespread and common. Foodplants include Bird's foot trefoil Lotus corniculatus, Black Medick. Medicago lupulina and White Clover Trifolium repens.
Ringlet	*Aphantopus hyperantus*	Widespread. Main foodplants Cock's-foot *Dactylis glomerata*, Common Couch Elymus repens, and meadow grasses.
Green veined white orange tip	*Pieris napi*	Distributed throughout Ireland. Charlock *Sinapis arvensis*, Cuckooflower *Cardamine pratensis*, Watercress *Nasturtium officinale*.
Small white	*Pieris rapae*	Found throughout most of Ireland. Main foodplants crucifers *Brassicaceae* spp., nasternium *Tropaeolum* spp. and Wild Cabbage *Brassica oleracea*.
Large white	*Pieris brassicae*	Distributed throughout most of Ireland. Foodplant mainly crucifers, nasternium.
Small heath	*Coenonympha pamphilus*	Found in a number of areas around Ireland. Main foodplants bents *Agrostis* spp. and fescues *Festuca* spp..

In 2007 (30 August 2007), terrestrial and aquatic invertebrates were collected from several habitats within and adjoining the reedbed site. Terrestrial invertebrates were collected by sieving dead plant material, breaking up tussocks of vegetation, trampling a small area of soil splashing water margins to disturb invertebrates. Aquatic invertebrates were collected with a pond net whilst disturbing the substratum and marginal and emergent vegetation. Invertebrates were identified to species level where possible. These were mainly terrestrial and aquatic beetles,

Twenty-six species of terrestrial beetles were recorded. Most of these are common and widespread species, frequently occurring wherever suitable habitat exists. Two species of rove beetle recorded that are uncommon in Ireland. *Quedius fumatus* is noted by Anderson (1997) as widespread but local, in moss and damp litter in wooded swamps. *Philonthus fumarius* is also a species of damp litter in fens and marshes. Anderson (1997) mentions one relatively recent record of this species for the Northern Ireland and Johnson and Halbert (1902) regarded the species as very local in Ireland as a whole.

Amongst the thirteen aquatic beetle species recorded three are restricted to brackish water habitats. *Ochthebius punctatus* and *Enochrus bicolor* are locally common in brackish water all around the coast of Ireland and Great Britain. *Ochthebius viridus* is uncommon and sparsely distributed around the coast of Ireland. Only four species of mollusc were recorded and all are common and widespread in Ireland.

Overall, the reed bed supported a good diversity of beetle species although this is limited by the homogeneous nature of reed stands and the lack of standing water on the site. Other small areas of habitats on the site i.e. the stands of Willow *Salix sp.* and the area of putrid pools contained three uncommon beetle species which are restricted to a particular habitat and have a limited distribution in Ireland which makes the site of some ecological interest.

A search of NBDC records recorded one notable species within 2 km of the Proposed Development site (R04J and R04E) i.e., *Ochthebius (Ochthebius) viridis* which was recorded during the reed bed surveys.

During the 2018 to 2021 surveys within the Proposed Development site boundary, no rare or notable species were observed within the Proposed Development site boundary. Whilst no site is without invertebrate interest, it is considered highly unlikely, given the habitat types within the site boundary, that the Proposed Development site would support any protected, rare or uncommon invertebrate species and no specialised surveys were considered necessary.

7B.5 Assessment of Impact and Effect

7B.5.1 Likely Significant Effects

Annex III of the amended Directive 2014/ 52/ EU requires that the EIAR should assess:

- The magnitude and spatial extent of the impact (for example geographical area and size of the population likely to be affected);
- The nature of the impact;
- The transboundary nature of the impact;
- The intensity and complexity of the impact;
- The probability of the impact;
- The expected onset, duration, frequency and reversibility of the impact;
- The cumulation of the impact with the impacts of other existing and/ or approved projects; and
- The possibility of effectively reducing the impact.

Potential effects of the construction, operational and decommissioning phases of Proposed Development on terrestrial and aquatic biodiversity include:

- Potential Effects on Terrestrial and Aquatic Habitats;
- Potential Effects on Badgers;
- Potential Effects on Bats;
- Potential Effects on Otter;
- Potential Effects on Other Mammals;
- Potential Effects on Birds;
- Potential Effects on Fish;
- Potential Effects on Other Species;
- Potential effects on Air Quality;
- Potential Effects from Non-native Invasive Species;
- Potential Effects on Climate Change and Biodiversity;
- Potential Effects from Accidents; and
- Potential Effects of Decommissioning.

7B.5.2 Impact Assessment

7B.5.2.1 Potential Impacts

When describing changes/ activities and impacts on ecosystem structure and function, important elements to consider include positive/ negative, extent, magnitude, duration, frequency and timing, and reversibility.

Section 3.7 of the *Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports'*, (EPA 2017) provides standard definitions which have been used to classify the effects in respect of ecology. This classification scheme is outlined below in Table 7B-10**.**

Table 7B-10 EPA Impact Classification

Impact Characteristic	Term	Description
Quality	Positive	A change which improves the quality of the environment.
	Neutral	No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error.
	Negative	A change which reduces the quality of the environment.
Significance	Imperceptible	An effect capable of measurement but without significant consequences.
	Not Significant	An effect which causes noticeable changes in the character of the environment but without significant consequences
	Slight	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.
	Moderate	An effect that alters the character of the environment in a manner consistent with existing and emerging trends.
	Significant	An effect, which by its character, magnitude, duration or intensity alters a sensitive aspect of the environment.
	Very Significant	An effect which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment.
	Profound	An effect which obliterates sensitive characteristics.
Duration and Frequency	Momentary Effects	Effects lasting from seconds to minutes.
	Brief Effects	Effects lasting less than a day.
	Temporary Effects	Effects lasting less than a year.
	Short-term	Effects lasting one to seven years.
	Medium-term	Effects lasting seven to fifteen years.
	Long-term	Effects lasting fifteen to sixty years.
	Permanent	Effects lasting over sixty years.
	Reversible Effects	Effects that can be undone.
	Frequency	Describe how often the effect will occur. (once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, monthly, annually)
	Irreversible	When the character, distinctiveness, diversity, or reproductive capacity of an environment is permanently lost.
	Residual	Degree of environmental change that will occur after the proposed mitigation measures have taken effect.
	Synergistic	Where the resultant effect is of greater significance than the sum of its constituents.
	'Worst Case'	The effects arising from a development in the case where mitigation measures substantially fail.

7B.5.2.2 Determining Impact Significance

According to the EPA (2017), significance of effects is usually understood to mean the importance of the outcome of the effects and is determined by a combination of objective (scientific) and subjective (social) concerns.

The EPA further notes that:

'*While guidelines and standards help ensure consistency, the professional judgement of competent experts plays a role in the determination of significance. These experts may place different emphases on the factors involved. As this can* *lead to differences of opinion, the EIAR sets out the basis of these judgements so that the varying degrees of significance attributed to different factors can be understood*'.

With this in mind, the geographic frame of reference applied to determining impact significance by the NRA (2009) in Ireland and CIEEM (2019) in Ireland and the UK, has been adopted in this report in tandem with the EPA's qualitative significance criteria. Table 7B-11 compares the qualitative versus geographic approaches to determining the significance of effects.

Table 7B-11 Equating the Definitions of Significance of Effects Using a Geographic vs. Qualitative Scale of Reference

Geographic Scale of Significance (NRA, 2009; CIEEM, 2019)	Qualitative Scale of Significance of Effects (EPA 2017)
Negligible or Local Importance (Lower Value). No significant effects predicted to significant ecological features.	**Imperceptible**. An effect capable of measurement but without significant consequences. **Not significant**. An effect which causes noticeable changes in the character of the environment but without significant consequences.
Local Importance (Higher Value), County, National, Regional, or International.	**Slight/ Moderate/ Significant/ Very Significant/ Profound** i.e. effects can be slight, moderate, significant, very significant, or profound at Local scale, subject to the proportion of the local population/ habitat area affected.

The geographic frame of reference can be a good fit to assessments of biodiversity impacts because it allows clear judgements to be made about the scale of significance, with reference to published estimates for the population size of a given species at county, national and/ or international scales or areas of habitats at such scales.

The proportion of a known feature impacted at county scale (i.e., 1% of the known or estimated population in a given county) is measurably different from that impacted at national scale (i.e., 1 % of the known or estimated national population).

A non-geographic qualitative approach can be a poor fit to assessments of biodiversity, since the definitions provided for the different qualitative terms do not relate to measurable units of space such as a county or national boundary. For instance, a significant effect is defined by the EPA as '*an effect which, by its character, magnitude, duration or intensity alters a sensitive aspect of the environment without affecting its sensitivities*', whilst a very significant effect is that which '*by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment'*.

7B.5.2.3 Summary Valuation of Significant Terrestrial Ecology Features

As per the impact assessment methodology outlined in Section 7B.5.2.2, significant ecological features are considered to be those valued at Local Importance (Higher Value) or higher as per NRA (2009) and CIEEM (2019) definitions. Table 7B-12 summarises all significant ecological features identified within the Zone of Influence of potentially significant impacts.

It is noted that direct and indirect impacts on marine/ intertidal habitats within the Lower River Shannon cSAC and River Shannon and River Fergus Estuaries SPA are discussed in Chapter 07A – Marine Biodiversity and the NIS. Indirect impacts on these sites, as well as the Ballylongford Bay pNHA, via water discharges are also discussed in Chapter 06 – Water.

Table 7B-12 Summary Valuation of Significant Terrestrial Ecological Features and Identification of Features Scoped Out From the EIA

Feature		Highest Value within Zone of Influence	At risk of significant impact	Scoped into terrestrial ecology assessment
	Lower River Shannon cSAC	International	Yes	Yes

Feature		Highest Value within Zone of Influence	At risk of significant impact	Scoped into terrestrial ecology assessment
Designated sites	River Shannon and River Fergus Estuaries SPA	International	Yes	Yes
	Ballylongford Bay pNHA	National	Refer to Chapter 06	No
	Other National Sites	National	No	No
Habitats	Wet grassland GS4/ Improved agricultural grassland GA1	Local importance (Lower value)	Yes	Yes
	Improved Agricultural grassland GA1	Local importance (Lower value)	Yes	Yes
	Hedgerows WL1/ Treelines WL2	Local importance (Higher value)	Yes	Yes
	Sedimentary Sea Cliffs CS3	International importance	Yes	Yes
	Scrub WS1	Local importance (Higher value)	Yes	Yes
	Eroding River FW1	Local importance (Higher value)	Yes	Yes
	Drainage ditches FW4	Local importance (Lower value)	Yes	Yes
Terrestrial mammals	Badger	Local Importance (Higher Value)	Yes	Yes
	Bats (Common Pipistrelle, Soprano Pipistrelle, Leisler)	Local Importance (Higher Value)	Yes	Yes
	Otter	Local Importance (Higher Value)	Yes	Yes
	Red Squirrel, Fallow Deer, Sika Deer, Red Fox, Mink	Negligible	No	No
	Hedgehog, Irish Hare	Local importance (Lower value)	Yes	Yes
Amphibians	Common Frog	Local importance (Higher Value)	Yes	Yes
Reptiles	Common Lizard	Negligible	No	No
Birds	SCI birds (River Shannon and River Fergus Estuaries SPA)	Local importance (Higher Value)	Yes	Yes
	Annex I species (Great Northern Diver, Red-throated Diver, Little Egret, Golden Plover, Sandwich Tern)	County importance	Yes	Yes
	Red list bird species (Non SCI) (Meadow Pipit, Merlin, Stock Dove, Quail, Oystercatcher, Snipe, Razorbill)	Local importance (Higher Value)	Yes	Yes

Feature		Highest Value within Zone of Influence	At risk of significant impact	Scoped into terrestrial ecology assessment
	Amber list bird species (Several)	Local importance (Higher Value)	Yes	Yes
	Other breeding birds (Several)	Local importance (Higher Value)	Yes	Yes
	Annex I (White-tailed Sea Eagle)	Local importance (Lower value)	Yes	Yes
	Annex I (Hen Harrier)	Negligible value	No	No
Aquatic species	Fish (Stickleback, Eel, Stone Loach)	Local importance (Higher value)	Yes	Yes
	Aquatic invertebrates	Local importance (Lower value)	Yes	Yes
Other species	Invertebrates	Negligible	No	No

7B.5.3 Construction Phase

In the absence of mitigation measures, construction phase impacts have the potential to remove a range of habitats and disturb or displace protected species throughout the estimated 32 month duration of construction. Significant potential impacts to terrestrial biodiversity include habitat loss, noise and visual disturbance (including lighting) to protected fauna species, and the potential for suspended solids or other contaminants to be carried into local watercourses, particularly following topsoil stripping and bridge construction.

It is noted that main sources of noise and vibration associated with the construction of the Proposed Development are the piling rigs used in the construction of the jetty and blasting within onshore habitats. Piling works will take place around the offshore elements i.e., jetty and FRSU at the northeast of the Proposed Development site. Piling works offshore have the potential to generate above ground and underwater noise. Jetty works will take place 24 hours a day 6 days a week. Vibration levels are expected to be highest during blasting operations, however these will be carefully managed. No more than three blasts are envisaged to occur in any given day and associated noise and vibration levels will be transient and very short lived. Excluding the jetty construction works construction works will take place during normal daytime hours.

Three watercourse crossing are required within the Proposed Development site i.e. a bridge over the Ralappane Stream and two culverts on drainage ditches. Direct impacts on Ralappane Stream will be avoided through the use of the single span bridge for the stream crossing and no instream works will be carried out. Two drainage ditches, which do not have the potential to support fish, in the southwest section of the Proposed Development site will be culverted (Section 2.4.4.2 of Chapter 02 – Project Description). The proposed crossings of the watercourses within the Proposed Development have been adequately sized to have a minimal impact on the current hydraulic regime in the area. This section, which presents potential construction phase impacts for the Proposed Development alone, should be read in conjunction with summary tables of potential impacts (Table 7B-15).

7B.5.3.1 Terrestrial and Freshwater Habitats

The Proposed Development site layout is shown on Figure 7B-3. The majority of habitats and flora in this area will be removed during the construction phase. Potential impacts on terrestrial habitats, are included in Table 7B-13. As noted in Section 7B.4.2.1, a small area of terrestrial habitat along the shoreline overlaps with the Lower River Shannon cSAC i.e., Sedimentary sea cliffs CS3. Potential impacts on habitats within the Lower River Shannon cSAC are discussed in the NIS.

It should be noted that the value of a habitat is site specific and will be partially related to the amount of that habitat in the surrounding landscape. The classification scheme, used in Table 7B-10 and Table 7B-11 for the value of habitats and the impacts on them, is detailed in the NRA publication *Guidelines for assessment of ecological impacts of National Road Schemes* (Appendix A7B-7 of Volume 4). Predicted impacts on habitats within the Proposed Development site in the absence of mitigation are detailed in Table 7B-13.

Table 7B-13 Impact on Habitats within Proposed Development Site Boundary

Habitat type	Approximate extent within the site (ha or linear km)	Maximum extent habitat loss during construction	Habitat value	Impacts
Wet grassland GS4/ Improved agricultural grassland GA1	7.41 ha	7.41 ha	Local importance (Lower value)	The majority of the Proposed Development site will be developed and a high proportion of this habitat will be completely removed. **Negative, slight, long-term at local level.**
Improved agricultural grassland GA1	31.2 ha	31.2 ha	Local importance (Lower value)	Most of the Proposed Development site will be developed and a high proportion of this habitat will be completely removed. **Negative, slight, long-term at local level.**
Hedgerows (WL1)/ Treelines (WL2)	4.9 km	4.9 km	Local importance (Higher Value)	Most of the Proposed Development site will be developed and a high proportion of this habitat will be completely removed. **Negative, moderate, long-term at local level.**
Sedimentary sea cliffs CS3	100 m	100 m	International importance	The development of the offshore elements will result in the removal of a small area of this habitat. This habitat is located within the Lower River Shannon cSAC However, this is not an example of the Annex I qualifying habitat vegetated sea cliff 1230. **Negative, significant, long-term at local level.**
Scrub WS1	Small, scattered distribution (not measurable)	Small, scattered distribution (not measurable)	Local importance (Higher Value)	Small areas of scrub will be removed. **Negative, slight, long-term at local level.**
Eroding river FW1	137 m (approximately)	0 m	Local importance (Higher Value)	A single-span bridge will cross the Ralappane Stream at the site entrance. While no instream works are

Habitat type	Approximate extent within the site (ha or linear km)	Maximum extent habitat loss during construction	Habitat value	Impacts
				proposed, this may lead to bank destabilisation. Indirect impacts on water quality through the generation of excessive silt levels or spillage of cement or hydrocarbons during construction. **Negative, moderate, short-term at local level.**
Drainage ditch FW4	600 m (approximately)	80 m	Local importance (Lower Value)	Two drainage ditches at the southwest of the site will be culverted. This will lead to minor habitat loss. Indirect impacts on water quality through the generation of excessive silt levels or spillage of cement or hydrocarbons during construction. **Negative, slight, long-term at local level.**

7B.5.3.2 Badger

Two main Badger setts occur in proximity to the Proposed Development site, namely Sett 3 and Sett 4. However, neither sett will be directly impacted by the Proposed Development. Bait marking surveys indicate that Sett 2 is a subsidiary sett and the main sett for this social group is Sett 3, which will be unaffected by the Proposed Development. Sett 1 which has contracted since initial surveys in in 2007, now consists of one unused sett entrance and is an outlier sett just within the site boundary. Sett 1 is linked to the main sett, Sett 4 which is located to the east of the Proposed Development site.

During construction two smaller setts (Sett 1 and Sett 2) which are located within the Proposed Development site boundary will be removed. Neither of the main setts (Sett 3 and Sett 4) will be impacted by the Proposed Development and exclusion of the Badgers from subsidiary or outlier setts is a viable option. Piling and blasting works will take place within 150 m of Sett 1. This has the potential to create significant disturbance to Sett 1 and/ or block or damage tunnels that radiate from the entrance to the sett, leading to Badger injury or mortality. Construction works close to breeding setts can cause serious disturbance to Badgers and mortality of cubs. All other setts are a significant distance from vibration impacts. It is noted that a range of measures will be adopted during the blasting stage of the construction phase to minimise the impact of air overpressure as far as practicable. Given the distance from Badger setts overpressure and vibration impacts from blasting will not be significant.

The development of the Proposed Development site will result in a net loss of foraging habitat within agricultural grassland. Conservatively it is estimated that this will be greater than 25% habitat loss within the territories of both social groups. Where loss of habitat is likely to be greater than 25%, the impact may be considered as significant on the affected social group (NRA 2005a). Furthermore, Badgers may be killed or injured by road traffic as they attempt to access their feeding areas. However, given that the recommended speed limit at the Proposed Development site is 15 km/hr, there is unlikely to be any significant impact from traffic fatalities within the site.

During construction Badgers are likely to remain *in situ* and continue to use existing territories. However, the reduction in territory size is likely to create a contraction in the size of both social groups. It is noted that no Badger latrines were recorded in the large agricultural fields as the southeast of the Proposed Development site, so this habitat may not be critical within their foraging territories. A net loss of grassland foraging habitat will therefore be a long-term impact of the Proposed Development but given the alternative resources available both Badger territories will remain extant.

Impacts to Badgers during the construction phase in the absence of mitigation will be **negative, significant** and **long-term** at a local geographic level.

7B.5.3.3 Bats

No buildings with significant potential to support bats were recorded within the Proposed Development site boundary. A small bat roost of Common Pipistrelle was recorded in a disused farm building to the southwest of the Proposed Development site boundary (Location A Figure 7B-8). This building will not be removed as part of the Proposed Development. No trees with potential to support bat roosts were recorded within the Proposed Development site boundary and no other buildings of value for bats will be affected. Two structures (Location B and Location C Figure 7B-8) within the Proposed Development site boundary will be removed as part of the Proposed Development, however neither supports bats.

While direct impacts to bat roosting sites will be avoided, the removal of treelines and hedgerows will result in a reduction in foraging resources within the Proposed Development site (Table 7B-13). Linear features within the Proposed Development site boundary, including hedgerows, treelines, cliffs and scrub, have moderate suitability as foraging/ commuting areas, to link roost sites to foraging areas and facilitate the dispersal of bats into the wider landscape. Small numbers of Common Pipistrelle, Soprano Pipistrelle and Leisler's Bat were recorded foraging along these habitats at the Proposed Development site. During construction all internal hedgerows/ treelines as well as scrub and a small area of cliff habitat will be removed. In the absence of mitigation, the construction phase of the Proposed Development will result in the long-term loss of moderate value bat foraging and commuting habitat. However, given the availability of similar habitat in the immediate vicinity and the relatively low numbers of bats recorded at the Proposed Development site, there is unlikely to be any fragmentation impacts or loss of connectivity within the wider landscape.

Noise and lighting onshore during construction has the potential to significantly impact foraging habitats of Common Pipistrelle and Soprano Pipistrelle. Construction works within terrestrial habitats will be confined to daytime hours and therefore disturbance from lighting during onshore construction works will be minimal. However, jetty works will take place over a 24-hour period and lighting along the coast has the potential to disrupt foraging bats in this area, particularly Leisler's Bat. Bat foraging along the coastline near the jetty location may also be disrupted by increase disturbance and lighting i.e. Common and Soprano Pipistrelle and Leisler's Bat. Lighting deters some bat species, in particular Myotis species, from foraging. No Myotis species were recorded within the Proposed Development site or along the coastline to the north of the site. Pipistrelle species appear to be more tolerant of light and disturbance (Speakman 1991; Stones *et al.* 2009; Haffner 1986). It is also noted that Leisler's Bats will opportunistically feed on such insect gatherings in lit areas (Bat Conservation Ireland 2010). This exposed section of coastline does not appear to provide valuable bat foraging habitat, with small numbers of Common Pipistrelle, Soprano Pipistrelle and Leisler's Bat using this area.

Overall, the loss of semi-natural habitat and increased lighting and disturbance during construction will reduce the feeding area available for bats. The impact on foraging bats will be **negative, moderate** and **medium term** at a local geographic level.

Migratory Bats

While the migratory movements have long been known and described (Popa-Lisseanu and Voight 2009), recent advances in research methods as well as the increase in perceived threats from offshore infrastructure such as windfarm has led to increase in research on the topic (Ahlen *et al.* 2009, Hutterer *et al.* 2005, McGuire *et al.* 2011, McGuire *et al.* 2013 and Popa-Lisseanu *et al*. 2012). Bat migration is a relatively uncommon phenomenon with less than 3% of bats understood to be migratory and only 12 species worldwide for which long-distance movements of more than 1000 km have been recorded (Bisson *et al.* 2009).

The key reason why fewer species of bat migrate than birds, relates to the ability of bats to sustain torpor in hibernation which gives bats the option of hibernating in response to lack of insect prey during the winter months. Most temperate bats that migrate do so to travel to hibernation sites with optimum conditions for surviving the winter. Many species of bats e.g., Less Horseshoe Bats and Myotis bats hibernate underground in systems that offer consistent microclimates in winter and characteristically undertake relatively short migrations to hibernation sites. Long-distance migrants are typically tree roosting species that are offered insufficient protection from extreme cold during hibernation and migrate to climates that are mild in the winter (Popa-Lisseanu and Voight 2009). Further detail on bat migration is included in Appendix A7B-1 of Volume 4.

Following an extensive review of the available literature no evidence of bat migration along the Shannon Estuary was found. Bat Conservation Ireland confirmed that there are no records of bat migration along the Shannon Estuary or in the vicinity of the Proposed Development site (personal communication Conor Kelleher). All bat surveys at the Proposed Development site found very low numbers of common bat species along the coastal habitats. Leisler's Bat is a migratory bat species. While is it noted that a small number of Leisler's bat was recorded along the coastline in June 2021, this bat was exhibited foraging behaviour (repeating same flight path for 20 minutes). No records of migratory bats were recorded during site surveys. No risk to migratory bats has been identified from the construction phase of the Proposed Development.

7B.5.3.4 Otter

Otter activity was recorded west of the Proposed Development site along the lower reaches of the Ralappane Stream. No signs of Otter were recorded in the eastern section of the site where shoreline works are proposed or on the section of the Ralappane Stream where bridge is proposed. No breeding holts were recorded during surveys.

There is no evidence of Otter usage upstream of the tidal section of the Ralappane Stream (or drainage ditches) and given its limited size this small watercourse is unlikely to be a critical foraging resource for this species. The bridging works could potentially indirectly affect existing fish stocks via impacts on water quality. However, it is noted that this stream is small with limited fish stocks and it is unlikely to be a significant source of prey for Otter. The drainage ditches do not support fish species, are unlikely to provide significant breeding habitat for Common Frog and have negligible value for Otter foraging. Construction works which will result in a minor, temporary loss of potential low quality Otter foraging habitat.

During the construction phase it is expected that there will be considerable disturbance of the site, particularly during blasting and piling works. However, the disturbance will be centred to the east of the Proposed Development site, a significant distance from the areas of Otter activity. While there may be some short-term displacement of Otter, this increased noise and disturbance during the construction phase is unlikely to significantly impact on Otter due to their ability to move away from and/ or adapt to short-term disturbance. No adverse impacts on Otter from underwater noise have been identified.

It is noted that onshore construction works will primarily take place during daytime hours which will avoid the largely nocturnal foraging habits of Otter. Jetty works will take place over 24 hours. However, it is noted that all records of Otter were over 1 km from the jetty works area.

Chapter 07A notes that impacts on fish stocks from piling vibration (Section 7.5.5) , entrainment (Section 7.5.9) or changes in water quality (Section 7.5.3, Section 7.5.4) will be negative and not significant. However, the loss of wet grassland within the Proposed Development site, where frogs are known to occur, may lead to a small loss of prey availability for Otter (Section 7B.5.3.6). While frogs use this habitat, it is limited in extent and is unlikely to support a significant population of Common Frog (only one was observed within the site boundary), and this habitat is unlikely to be a significant foraging area for Otter.

Overall, it is expected that effects on Otter will be **negative, not significant** and **long-term** at a local geographic level in the absence of mitigation.

7B.5.3.5 Other Terrestrial Mammals

The only other protected mammal species (Wildlife Act 1976 (as amended)) which was recorded within the Proposed Development site during 2018-2021 surveys was Irish Hare. While there were no confirmed field signs (or trail camera recordings) of Hedgehog observed during site surveys, this species is nocturnal, and field signs are less frequently observed than for other mammals. Given the mix of habitats onsite they are very likely to be present.

The habitats to be affected are common and there is no evidence to indicate that the Proposed Development areas are of particular value for these species in the context of the surrounding countryside. Effects on these species during construction due to loss of habitat, increased noise and disturbance and lighting are predicted to be **negative, not significant** and **temporary** at a local geographic level in the absence of mitigation.

7B.5.3.6 Amphibians

One Common frog was recorded in grassland at the west of the Proposed Development site. Small numbers of frog are likely to utilise this habitat within the Proposed Development site. In the absence of mitigation, construction works could lead to habitat loss as well as direct mortality or injury during vegetation clearance. The impact on this species during construction will be **negative, moderate** and **long-term** at a local geographic level.

7B.5.3.7 Birds

Breeding Birds

The most significant impacts on breeding birds will be direct impacts during the construction phase through habitat loss, fragmentation and modification. The majority of hedgerows, treelines, scrub areas, grasslands and disused farm buildings within the construction area of the site will be lost during the course of construction. This will result in loss of connectivity with the wider environment, as well as loss of habitat for birds. During the construction phase it is expected that there will be indirect impacts with considerable disturbance of the site, particularly during blasting and piling works. The duration of works (approximately 32 months) means that works will overlap with two breeding bird seasons. This is likely to displace foraging and breeding birds from the Proposed Development site. During construction works, noise levels will fall off quickly outside the Proposed Development site boundary even during peak construction works (Refer to Appendix A7B-3, Vol. 4). Given the mobile nature of birds, the common nature of habitats within the site and the availability of alternative foraging habitat in the immediate vicinity, the impact from disturbance will be moderate during the construction phase at a local level. There are no trees suitable for breeding Cormorant within the Proposed Development site and there are no recorded roosting sites within 10 km of the Proposed Development site (NPWS 2012c). No seabirds breed in the vicinity of the Proposed Development site and there will be no impact on breeding seabirds during the construction phase.

Several territories of breeding birds of conservation concern including the Red List species i.e. Meadow Pipit and Snipe, as well as Amber List species Skylark, House Sparrow, Linnet, Starling *Sturnus vulgaris,* Stock Dove and Willow Warbler *Phylloscopus trochilus* will be removed during the construction phase (Gilbert *et al.* 2021). While displaced birds are likely to use alternative grassland and hedgerow/ treeline habitats in the vicinity, intensification of agriculture and the loss of suitable grassland habitats is a significant threat to these species. In the absence of mitigation, potential impacts include disturbance and injury to eggs, young and nests, and long-term loss of potential nesting sites and foraging habitat. Assuming several pairs of each Red List and Amber List species are impacted, this would not be a significant impact on the local population. The impact on breeding birds of conservation concern is likely to be **negative, moderate** and **long-term** at a local level due to loss of breeding territories.

Several birds of conservation concern forage within, but breed outside the site i.e. Black-headed Gull, Herring Gull *Larus argentatus*, Little Egret, Mallard, Merlin, Quail, Sand Martin *Riparia riparia*, Shelduck, Woodcock and Swallow *Hirundo rustica.* The Annex I species White-tailed Sea Eagle could also potentially forage within subtidal habitats at the Proposed Development site. On the basis of short-term disturbance impacts during construction the impact birds of conservation concern which forage within but breed outside the Proposed Development site is likely to be **negative, not significant** and **short-term** at a local level.

Several territories of many common Green List bird species (Blackbird, Great Tit, Wren etc.) will be removed. In the absence of mitigation, potential impacts include disturbance and injury to eggs, young and nests, and long-term loss of potential nesting sites and foraging habitat. The impact on Green List bird species will be **negative, imperceptible**, and **long-term** at a local level.

Estuarine Birds

From a species conservation viewpoint, the most significant potential impact arising from the Proposed Development will be the loss of individuals of a rare or uncommon species. The following rare/ uncommon bird species were recorded during winter and summer surveys of estuarine habitats:

- Three Annex I listed species, Red-throated Diver, Great Northern Diver and Sandwich Tern, were recorded in the inshore waters bordering the Proposed Development as well as the Red List species Razorbill;
- The Annex I (and Red List) species Golden Plover was recorded over 2 km from site within intertidal mudflats. This species does not use habitats in the vicinity of the Proposed Development site and will not be impacted by construction works;
- The Annex I species Little Egret was recorded west of the Proposed Development site, foraging on the shoreline and within salt marsh habitat. Seven other Red List species i.e., Curlew, Dunlin, Grey Plover, Lapwing, Oystercatcher, Redshank and Snipe were recorded foraging on intertidal habitats to the west of Proposed Development site. It is noted that Dunlin, Grey Plover and Lapwing forage at least 1 km from the Proposed Development site and will not be impacted by construction works;
- Two of these Red List species, Curlew and Snipe, were regularly recorded feeding in agricultural/ wet grassland within the Proposed Development site during the winter months; and
- Fourteen of the 21 SCI species for the River Shannon and River Fergus Estuaries SPA were recorded within the survey area including Cormorant, Wigeon, Shelduck, Teal, Ringed Plover, Golden Plover, Grey Plover, Lapwing, Dunlin, Curlew, Redshank, Greenshank and Black-headed Gull. Further details on the impact of the Proposed Development on the SPA and SCI birds are discussed in the NIS which accompanies this application.

Potential impacts on estuarine birds during the construction phase include habitat loss due to the construction of the jetty, land-based construction noise and visual disturbance (including lighting), underwater noise and changes in prey availability due to a deterioration in water or via fish mortality during vibration from piling works. Further detail on potential impacts on estuarine birds is discussed in Appendix A7B-3 of Volume 4 and the NIS which accompanies this application.

There are no significant areas of mudflat or sandflat habitat within the Proposed Development site and no habitat which could support large numbers of wading birds or waterfowl. The intertidal habitats encountered are typical of cobbly rocky shores in Ireland being dominated by *Pelvetia canaliculata*, *Fucus* sp. and *Ascophyllum nodosum* (Chapter 07A). The intertidal waters of the proposed jetty location provides foraging habitat for small numbers of diving birds including two Annex I species i.e., Red-throated Diver and Great Northern Diver as well as Cormorant and Great Crested Grebe. Sandwich Tern, also an Annex I species could potentially forage here, although none were recorded foraging inshore. These species could potentially lose foraging habitat during construction due to seabed habitat loss following placement of the jetty piling (163m² of subtidal habitat). However, given the low numbers of birds using the Proposed Development site, the availability of alternative foraging habitat in the immediate vicinity and the foraging range of diving birds within the estuary, no significant impact from habitat loss will occur. Whilst the amount of foraging habitat available to foraging birds will be very slightly reduced during the construction of the Proposed Development, this does not represent critical foraging habitat for seabirds or shorebirds and this will not have a significant impact on the overall numbers of birds within the Shannon Estuary.

The potential for release of pollutants and increased sedimentation (plumes) from piling works to impact on water quality and subsequently on fish and invertebrate numbers is discussed in the Chapter 07A Section 7.5.4. This concluded that in the absence of mitigation, spills of hydrocarbons and chemicals can give rise to tainting of fish or, if large enough, fish kills and invertebrate kills. Given the scale and temporary nature of piling works any elevated turbidity would be limited spatially and temporally to the immediate project area and consequently there is no risk of significant effects. While there may be small overlap between wetland foraging habitats for birds and sediment deposition plumes, given the small numbers of birds foraging in this area and the localised nature of the plume, there will be no significant impact on intertidal or subtidal foraging birds.

Chapter 07A notes that impacts on fish stocks from piling vibration (Section 7.5.5), entrainment (Section 7.5.9) or changes in water quality (Section 7.5.3, Section 7.5.4) will be negative and not significant following mitigation. Impacts on marine habitats from sedimentation and/ or release of pollutants during construction are predicted to be not significant, and therefore no impacts on macro-invertebrate populations are predicted to occur. Mitigation measures to prevent release of sediments, chemical and pollutants during construction are detailed in Section 7.7. Therefore, there will be no significant impact to estuarine birds from loss of prey species during the construction phase due to piling vibration, entrainment, accidental spills, pollution or sedimentation.

As noted in Section 7B.4.6.2, very small numbers of wading birds were recorded foraging along the shoreline in the vicinity of the jetty. Noise contour modelling has been carried out for peak construction noise, i.e., when site clearance, enabling works, piling and heavy civil engineering operations related to the Terminal are expected to occur concurrently (see Appendix A7B-3 in Volume 4). The noise contour model illustrates that during construction noise levels will attenuate quickly outside the immediate piling works. Noise levels of 70 dB and above are regularly cited within the literature as being the threshold beyond which disturbance to estuarine bird species can be predicted to occur (Cutts *et al.* 2013). In the absence of mitigation, significant noise levels i.e., >70dB will be confined to a small area of subtidal waters and shoreline in the immediate vicinity of the jetty. Based on disturbance distances calculated by Cutts *et al.* (2013), visual disturbance impacts for wading birds will be confined to the shoreline within 300m of the jetty works and given the small numbers of birds foraging in this area, the impacts of visual disturbance will not be significant. Therefore, during peak construction works, where high-level noise levels and visual disturbance will occur in the vicinity of the jetty works area, a very small number of wading birds would be temporarily displaced and this would not have a significant impact on overall numbers of birds foraging within the estuary.

Diving birds, such as Red-throated Diver and Great Northern Diver, are generally regarded as highly sensitive to disturbance (Furness *et al.* 2013)). Small numbers of these species forage in the vicinity of the jetty (peak numbers of 2 Red-throated Diver and 3 Great Northern Diver within 500m of jetty). However, disturbance impacts for these species can extend up to 1.2 km (Red-throated Diver (750m ± 437m)). Using a conservative approach and extending the displacement area to 2 km, few Great Northern Diver (peak n=4) and Red-throated Diver (peak n=2) forage within this area. The worst-case scenario will be that construction works will temporarily displace up to 0.06-0.07% of the flyaway population of Great Northern Diver (5,100-6,300) and 0.0004-0.0009% of Red-throated Diver (216,000-429,000) (Burke *et al*. 2018). In a worst-case scenario, a small number of these species will be displaced during construction works. However, it should be noted that other seabirds and diving birds are relatively flexible with respect to habitat use (Garthe and Hüppop 2004; Furness and Wade 2012), and show significantly lower disturbance distances e.g. Black Guillemot (417m ± 186m), Great Crested Grebe (308m ± 248m), Cormorant (258m ± 215m), Lesser Black-backed Gull (157m ± 105mm), Herring Gull (133m ± 83m) and Black-headed Gull (84m ± 70m). Sandwich Tern as also regarded as to have low behavioural sensitivity to disturbance (Furness *et al.* 2013). While estuarine birds may temporarily avoid water in the immediate vicinity of construction, these species are likely to readily forage in other areas within the estuary during peak construction works.

Higher numbers of birds were recorded to the west/ southwest of Knockfinglas Point, over 1 km from the onshore construction area, although none in nationally or internationally important numbers. During construction the Proposed Development will be visible within the Shannon Estuary (and SPA), but the topography of the coastline largely hides works from shoreline habitats to the west of the Knockfinglas Point (Appendix A10-1 Photomontages). Noise levels west of Knockfinglas Point will be <40dB(A) during peak construction works (Appendix A7B-3). Given the distance involved, the topography of the shoreline and predicted noise levels, there will be no disturbance impacts to birds west of Knockfinglas Point during construction works.

Disturbance from artificial lighting used during the construction phases could potentially cause disruption to birds foraging within the Shannon Estuary. It is noted that artificial light may have a positive impact on waterbirds in intertidal habitats by enhancing the efficiency of nocturnal foraging (Dwyer *et al.* 2013) and may also reduce predation risk to roosting birds (cf. Gorenzel and Salmon, 1995). However, in the absence of mitigation, lighting during construction may cause displacement of birds foraging in the vicinity of the jetty works.

Although lethal effects of hard underwater noise, such as blasting and pile driving are well-known on cetaceans and fish, the effects of hard underwater sound on seabirds has been the focus of limited studies. Bird species most likely to be vulnerable to underwater sound are those that forage by diving after fish or shellfish i.e., Red-throated Diver, Great Northern Diver, Razorbill, Cormorant, Shag, Black Guillemot, Common Guillemot and Great Crested Grebe. Several gull species were recorded in the vicinity of offshore works in higher densities as well as small numbers of Sandwich Tern in offshore waters, but they feed at the surface only, and are considered the least vulnerable to underwater noise. Based on noise predictions modelled by Vysus Group (Refer to Appendix A7A-3 of Volume 4), the most significant source of noise during construction would be from piling works. Underwater noise during piling works would be significantly below the threshold for mortality or injury in diving birds (Refer to NIS for further detail). As described in Section 7B.3.5.6, small numbers of diving birds were recorded in the vicinity of the proposed offshore works area.

The presence of the large construction machinery is likely to make the waters around the jetty unattractive to seabirds and diving birds and these birds are unlikely to forage in the immediate vicinity of construction works (Garthe and Hüppop 2004; Topping and Peterson 2011; Furness and Wade 2012). Underwater noise is likely to lead to a temporary displacement of a small number of birds foraging in the vicinity of the jetty works. However, given the small numbers of birds using this area no significant impacts are predicted to occur to seabirds during construction.

The impact on SCI birds, including wading and diving birds, from disturbance/ displacement during construction as well as accidental release of pollutants will be negative, slight and short-term at an international level in the absence of mitigation.

The impact on Annex I species i.e. Red Red-throated Diver, Great Northern Diver and Sandwich Tern from disturbance/ displacement during construction as well as accidental release of pollutants will be negative, slight and short-term at a county level in the absence of mitigation.

The impact on other estuarine species from disturbance/ displacement during construction as well as accidental release of pollutants will be **negative, slight** and **short-term** at a local level in the absence of mitigation.

7B.5.3.8 Fish

Stickleback and European Eel were recorded within the Ralappane Stream in 2021, and Stone Loach, was also recorded in 2006. There is no evidence to indicate that the stream has significant spawning habitat or is generally of high value for fish and it is of insufficient size to be of value for salmonids or lamprey species.

The removal of hedgerow/ treeline vegetation along the Ralappane Stream may reduce cover and foraging opportunities for fish. During construction, potential impacts on water quality could arise from mobilised suspended solids as well as spillage of fuels, lubricants, hydraulic fluids and cement from construction plant. In the absence of appropriate mitigation measures, site stripping, earthworks and material stockpiles associated with the construction could potentially give rise to a high degree of solids washout which could discharge into the local drainage network and the Ralappane Stream. Bank destabilisation during bridge construction could lead to increased risk of bank collapse and silt generation. Silt generated during the construction phase could potentially interfere with spawning of Stone Loach and Stickleback smothering spawning gravels and deposited eggs and newly hatched larvae. If sufficient quantities of silt enter local watercourses it could potentially settle on the bottom, smothering benthic flora, ultimately affecting faunal feeding and breeding sites.

It is noted that piling works are confined to marine habitats and any impacts to fish from underwater noise/ vibration associated with piling works are addressed in Chapter 07A – Marine Biodiversity. This concluded that since the distance within which fish mortalities and/ or mortal injuries could occur is relatively small, the overall fish population could not be impacted. Blasting works are confined to the east of the site and given the distance from the Ralappane Stream, no impacts on fish within the stream from vibration will occur. Potential effects of water quality are discussed in Chapter 06 – Water. The impact of construction works on the fish in the absence of mitigation will be **negative, not significant** and **short-term** at a local geographic level.

7B.5.3.9 Aquatic Invertebrates

If sufficient quantities of silt enter the Ralappane Stream, this could potentially settle on the bottom, smothering aquatic invertebrates. The Proposed Development site is of Local importance (Lower value) for aquatic invertebrates. Impacts during the construction phase will be **not significant** and **short-term** at a local geographic level.

7B.5.3.10 Spread of Invasive Species

As noted in Section 7B.4.9, no invasive species were recorded within the Proposed Development site. All excavated material will be used onsite and no import of soil is expected. Therefore, no impacts from the spread of invasive species during the construction phase is expected to occur.

7B.5.3.11 Air Quality

The primary concern in relation to air quality arises from the possible deposition of dust from construction operations on vegetation, within watercourses or protected habitats i.e. Lower River Shannon cSAC/ River Shannon, River Fergus Estuaries SPA and Ballylongford Bay pNHA. It is noted that the majority of the SAC/

SPA within 50 m of the Proposed Development site boundary is tidal estuary and should dust deposit beyond the site boundary, it is likely to be washed away naturally. Construction works will be located a significant distance from the Ballylongford Bay pNHA and no impacts are predicted to occur to habitats in the pNHA. No rare species or habitat which are sensitive to air quality impacts are located within the Proposed Development site. In the absence of mitigation, the impact from dust deposition on terrestrial, freshwater and estuarine habitat will be **not significant** and **short-term** at a local geographic scale.

7B.5.4 Operation Phase

7B.5.4.1 Proposed Development Features and Types of Impact

The Proposed Development would be operational 24 hours a day, seven days a week. In the absence of mitigation measures, significant operation phase impacts could include light spill onto retained vegetation outside the Proposed Development site boundary (it is assumed that all habitats within the site would be removed) used for feeding or breeding by protected species. Lighting of water around the jetty dock will also be required to detect spillage and possibly unauthorized craft. Disturbance to protected species could occur from noise or vibration associated with vehicles, shipping and human use of the operational site. The presence of the jetty within the estuary could lead to collision mortality effects to birds and bats. The new jetty may also change the habitats and micro-habitats present in the immediate area.

It is noted that an application to connect to the national electrical transmission network was submitted to EirGrid in September 2020 under the Enduring Connection Policy 2 (ECP2) process. As part of this grid connection application, Shannon LNG Limited made a specific connection method request for underground cabling, in lieu of overhead lines. Given the expressed preference for underground cabling by the Applicant, and the resistance of the Applicant to overhead powerlines, no assessment of collision risk to birds from overhead powerlines is required.

The operational impacts would affect ecological receptors over many decades subject, to the lifetime of the Proposed Development. The Proposed Development is expected to have a design life of 50 years, but this could be extended by maintenance, equipment replacement and upgrades or by the transition of the site to use hydrogen capability. This section, which presents potential operation phase impacts for the Proposed Development alone, should be read in conjunction with summary tables of potential impacts (Table 7B-15).

7B.5.4.2 Terrestrial and Freshwater Habitats

A detailed Flood Risk Assessment (FRA) concluded that with the exception of crossings of the watercourses for the access road, there is no development proposed within either Flood Zone ‘A’ or Flood Zone ‘B’ and therefore the Proposed Development will have a **negligible** impact on the existing flood regime within and around the site (Refer to Appendix A6-3 of Volume 4).

The proposed crossing/ culverting of the stream/ drainage ditches within the Proposed Development have been designed to have a minimal impact on the existing hydraulic regime within the Proposed Development site and downstream in the Ralappane Stream.

Combined stormwater flows and treated sanitary effluent and process effluent from the Proposed Development will be discharged directly to the Shannon Estuary below low tide level. There will be no direct discharges to surface water and no impact on freshwater habitats during the operational phase.

7B.5.4.3 Badger

The removal of subsidiary/ outlier setts could potentially have a long-term impact on social structure on Badgers in the vicinity of the Proposed Development site, even though both main setts will continue to exist outside the site boundary. However, Badgers are expected to continue using semi-natural habitats close to the site boundary. Increased activity and human presence, noise, fencing and additional lighting may disturb or displace Badger from retained foraging habitats once the Proposed Development site is operational. Badgers are nocturnal and as activity and noise levels will generally be lower at night, Potential impacts on Badgers during operation are predicted to be **negative, significant** and **long-term** at a local level in the absence of mitigation.

7B.5.4.4 Bats

Increased activity and human presence, noise and artificial lighting may impact and disturb or displace bats during the operational phase of the Proposed Development, including light spill onto previously unlit boundary habitats and the Shannon Estuary.

Lighting around the coastline near the jetty and at the Power Plant during the operational phase means that bat foraging in this area is likely be reduced or absent. Lighting deters some bat species, in particular Myotis species, from foraging. No Myotis species were recorded within the Proposed Development site or along the coastline to the north of the site. Pipistrelle species appear to be more tolerant to light and disturbance (Speakman 1991; Stones *et al.* 2009; Haffner 1986). It is also noted that Leisler’s bats will opportunistically feed on such insect gatherings in lit areas (Bat Conservation Ireland 2010).

While the LNG Terminal will be manned for round-the-clock service for operations and maintenance purposes, planned maintenance activities will predominantly be conducted during daytime. Lighting levels will meet national and international engineering standards as a minimum, including a lighted area around the dock to detect spillage and unauthorised craft. However, given the small numbers of bats which forage along the exposed coastline, the impacts on local bat populations during operation will not be significant. Bats are likely to continue to forage in dark areas within the Proposed Development site although less frequently than previously.

Operational lighting and activity will lead to the loss of low value foraging habitats for bats. Impacts to bats during operation are predicted to be **negative, slight** and **long-term** at a local level in the absence of mitigation.

7B.5.4.5 Otter

Increased activity and human presence, noise and artificial lighting may impact and disturb or displace Otter during the operational phase of the Proposed Development, including light spill onto previously unlit boundary habitats and the Shannon Estuary. Badly designed lighting could displace Otter from nearby habitats and create a barrier to connectively in the wider area. It is noted that the jetty trestle will be elevated above the foreshore to allow access for walkers and wildlife and there will be no physical barrier to Otter movement along the shoreline.

Outdoor lighting at the Proposed Development site will be designed to minimise the potential for light spill. While the LNG Terminal will be manned round-the-clock for operations and maintenance purposes, planned maintenance activities will predominantly be conducted during daytime. Lighting levels will meet national and international engineering standards as a minimum, including a lighted area around the dock to detect spillage and unauthorised craft. It is noted that while Otter activity is centred to the west of the Proposed Development site away from the Proposed Development site buildings and jetty, given the importance of the Shannon Estuary for Otter, it cannot be ruled out that Otter forage in the vicinity of the proposed jetty location. If Otter were excluded from this area during operation due to disturbance and/ or lighting, this could potentially impact on Otter foraging range and numbers within the Shannon Estuary.

Otter are largely nocturnal and can habituate to human disturbance (Chanin, 2003). It is known that Otters use man-made structures for holting in addition to excavations (Natural England, 2006). For example, these would include the underneath of bridges or jetties, where secluded areas are created. Such areas can be prominent resting areas and thus fall under the 'couch' category. There are several examples of Otter usage around busy industrial structures in Ireland including at the IOWR facility in Corkbeg Island where Otter regularly forage and rest in the vicinity of the oil tanker docks (Macklin 2018) and at the jetty in the Ringaskiddy Port in Cork (RPS 2015). Reid *et al*. (2013) also found that Otter regular use bridges as sprainting sites. Manmade structures in nearshore areas e.g., ports, docks, jetties, canals, coastal protection can create additional habitat for a range of marine species including fish, invertebrates and algae. Brandl *et al.* (2017) found that artificial marine habitats, including dock pilings and jetties, can harbour diverse, regionally characteristic assemblages of vertebrates that follow macroecological patterns that are well documented for natural habitats. Toft *et al.* (2004) found significantly higher density of juvenile salmonid species around overwater structures in comparison to the surrounding natural habitat. The location of the new jetty along the Shannon Estuary is likely to create additional couch and sprainting sites for Otter, as well as additional foraging habitat during the operational phase.

Given Otter’s ability to habituate to disturbance, their known usage of similar industrial sites around Ireland, the operational lighting design for the Proposed Development site, and the largely nocturnal habits of Otter, impacts to Otter during operation are predicted to be negative, not significant and long-term at a local level in the absence of mitigation.

7B.5.4.6 Other Mammals

Increased activity and human presence, noise, fencing and additional lighting may disturb or displace other mammal species such as Hedgehog and Irish Hare from favoured foraging habitats during the operational phases of the Proposed Development. However, given the availability of similar habitat in the vicinity and the mobile nature of these species, potential impacts on other mammals during operation are predicted to be **negative, slight** and **long-term** at a local level.

7B.5.4.7 Amphibians

Wet grassland habitat, where Common Frog has been recorded, will absent from the Proposed Development site during operation. In the absence of mitigation there will be no suitable habitat for Common Frog within the Proposed Development site. However, it is noted that wet grassland habitat is common outside the Proposed Development site boundary and frogs are likely to use alternative habitat in the absence of mitigation. The impact on this species will be **negative, slight** and **long-term** at a local geographic level.

7B.5.4.8 Birds

Terrestrial Birds

Following habitat removal during construction a number of Red List species i.e. Meadow Pipit and Snipe, as well as Amber List species Skylark, House Sparrow, Linnet, Starling, Stock Dove and Willow Warbler will be displaced and are no longer likely to use the Proposed Development site. This will also be the case for a number of common bird species, as hedgerow and grassland habitats will be absent from the majority of the site during operation. Birds of conservation concern which nest outside the site, but forage within the site e.g., Merlin and Sand Martin and occasionally Quail and Woodcock are unlikely to forage at the site due to the absence of semi-natural habitats. However, given the availability of similar habitat in the immediate vicinity, birds are likely to readily breed and/ or forage in adjoining habitats.

Visible human presence in previously undisturbed areas and increased noise and lighting may prevent birds from nesting or foraging in retained habitats within or adjacent to the Proposed Development site. In areas where nesting habitat is retained within the Proposed Development site, operational lighting may impact on breeding birds. Night-length can be very important for birds, as it can determine the onset of the breeding season and migration. Artificial lighting can induce hormonal, physiological and behavioural changes that initiate breeding in birds (Lofts and Merton 1968). Timing of singing and sleep are also strongly affected by light pollution (Kempenaers *et al.,* 2010; Da Silva *et al*. 2014; Raap *et al*. 2015), and such changes are suggested to have physiological consequences (Dominoni *et al.* 2016). The Power Plant will have area lighting installed on a down angle to cover the facility and the car parking areas while minimizing impact to surrounding neighbours. The height of the proposed light columns has been kept to a minimum throughout the Proposed Development site and light columns will be fitted with focused luminaires to avoid glare, sky glow and light spill. This will minimise any physiological impacts on birds using adjoining habitats.

The impact on birds of conservation concern which breed within the Proposed Development site is likely to be negative, moderate and long-term at a local level due to disturbance and/ or displacement of bird species including Meadow Pipit, Stock Dove, House Sparrow, Linnet, Skylark, Starling, Swallow, Willow Warbler.

The impact on birds of conservation concern which forage within but breed outside the Proposed Development site is likely to be negative, not significant and long-term at a local level due disturbance and/ or displacement i.e., Black-headed Gull, Herring Gull, Mallard, Sand Martin, Shelduck, Merlin, Quail, White-tailed Sea Eagle and Woodcock. It is noted that gull and tern species could potentially use the jetty for roosting and nesting during the operational phase, as they do in a number of ports throughout Ireland (RPS 2015, RPS 2017).

The impact on common bird species is likely to be **negative, slight** and **long-term** at a local level due disturbance and/ or displacement.

Estuarine Birds

Potential impacts on estuarine birds during the operational phase include disturbance due to increased land-based visual, lighting and noise disturbance (from human activity and shipping activity), increased underwater noise, physical disturbance and collision injury from ship traffic and a reduction in of prey availability due to changes in water quality resulting from wastewater discharges or entrainment/ impingement by the cooling system. The presence of the jetty could also potentially create a collision risk for bird species.

As noted in Section 7B.3.5.6, very small numbers of birds were recorded foraging along the shoreline and intertidal habitats in the vicinity of the proposed jetty. Noise contour modelling was carried out for two operational scenarios where peak noise levels are predicted (Appendix A7B-3 of Volume 4). These models illustrate that, noise levels will attenuate quickly outside the immediate Power Plant and jetty locations. Noise levels in the absence of mitigation are predicted to be below 65dB LAeq along the shoreline and outside the immediate FRSU location. This represents a moderate level of noise disturbance to which birds are likely to become habituated to over time (Cutts *et al*. 2013). Wading birds and waterfowl foraging along the shoreline are likely to habituate to the regular nature of the noise and disturbance associated with the jetty and shipping activity and continue to forage here, albeit potentially in smaller numbers than previously. In the absence of mitigation, outside subtidal/ intertidal habitats in the immediate vicinity of the Proposed Development site, noise levels within the estuary will be below 55dB(A) throughout the operational phase and will not cause significant disturbance impacts to estuarine birds.

During operation the Proposed Development will be visible within the Shannon Estuary (and SPA), but the topography of the coastline largely hides works from shoreline habitats to the west of the Knockfinglas Point, where larger bird numbers have been recorded. Along the shoreline in the immediate vicinity of the jetty, visual disturbance from shipping traffic and human activity has the potential to displace wading birds, waterfowl and seabirds. Species-specific disturbance responses to ship traffic vary considerably. Divers for example are generally regarded as highly sensitive to disturbance, while gulls and terns are the most tolerant. As described in Section 7B.5.3.7, of the species known to occur near the Proposed Development site, diving species such as Red-throated Diver and Great Northern Diver are the most sensitive to disturbance. While there is some evidence that Great Northern Diver may be able to habituate to shipping disturbance (Gittings *et al.* 2015), it is likely that these species will largely avoid the area during operational activity. However, both species occurred in very low numbers in the vicinity of the jetty. Other bird species which were recorded in the vicinity of the Proposed Development site (Black-headed Gull, Greenshank Wigeon, Curlew, Oystercatcher, Cormorant, Great Crested Grebe) are considerably more tolerant to disturbance and have been shown to habituate to visual (and noise) disturbance (Garthe and Hüppop 2004; Furness and Wade 2012; Cutts *et al*. (2013); Fliessbach *et al.* 2019). As discussed in Section 7B.5.4.5, the jetty structure may increase the availability of prey for piscivorous bird species as well as roosting sites for gulls. Seabirds are known to effectively forage and breed in the vicinity of busy ports throughout Ireland (RPS, 2012, 2014, 2017). While Great Northern Diver and Red-throated Diver may be displaced in small numbers during operation, other species are likely to continue to use the site throughout operational activities.

As discussed in Section 7B.5.3.7, bird species most likely to be vulnerable to underwater sound are those that forage by diving after fish or shellfish. Based on noise predictions modelled by Vysus Group, all activity during operation will be significantly below noise thresholds for mortality or injury in diving birds (Refer to Appendix A7A-3 of Volume 4). This assessment also determined that the FSRU alone, or the offloading scenario will only exceed the ambient noise within 0.5-1 km. As described in Section 7B.3.5.6, small numbers of diving birds were recorded within 1 km of the proposed offshore works area. Therefore, while underwater noise is likely to lead to a temporary displacement of a small number of birds foraging in the vicinity of the jetty works, given the small numbers of birds using this area no significant impacts are predicted to occur to seabirds during operation.

Disturbance from artificial lighting used during the operational phases could potentially cause disruption to estuarine birds. Lighting levels will meet national and international engineering standards as a minimum, including a lighted area around the dock to detect spillage and unauthorised craft. The Power Plant will have area lighting installed on a down angle to cover the facility and the car parking areas while minimizing impact to surrounding areas. The height of the proposed light columns has been kept to a minimum throughout the Proposed Development site, and light temperatures reviewed to minimise the content of blue light. L light columns will be fitted with focused luminaires to avoid glare, sky glow and light spill to the estuary. Modelling of light spillage from the jetty and Power Plant show that outside the immediate lit areas of the jetty, light spillage onto the estuary will be minimal (Figure F2-7 of Volume 3). It is noted that artificial light may have a positive impact on waterbirds in intertidal habitats by enhancing the efficiency of nocturnal foraging (Dwyer *et al.* 2013) and may also reduce predation risk to roosting birds (cf. Gorenzel and Salmon, 1995). While there may be short-term impacts from operational lighting, in the medium to long term birds are likely to habituate to additional lighting and foraging rates will return to pre-construction levels. Therefore, while lighting in the immediate vicinity of the jetty will increase, this will not have a significant on bird numbers or distribution of birds within the Shannon Estuary.

While entrainment has the potential to impact on small numbers of juvenile fish, no significant impact on fish numbers is predicted to occur and therefore there will be no impact on prey availably for foraging birds. Wastewater discharges will not impact on water quality or invertebrate and fish abundance in the estuary (Chapter 07B, Section 7.5.10). The Proposed Development will no impact on prey availability for estuarine birds during the operational phase.

Collision risk associated with built structures is highest amongst ‘heavy wing loading’ species such as geese and swans. It is also increased where birds undertake daily migrations during the hours of dusk and dawn to foraging and roosting locations. Within the Shannon Estuary, species most at risk are Whooper Swan and Light-bellied Brent Goose, and to a lesser extent Cormorant. The risk of diurnal collision for other bird species is not considered to be significant due to the small size and/ or agile flight ability of these species. It is also noted that the lattice structure of the jetty means that smaller birds can also fly beneath the structure.

The proposed jetty will be 364 m and +9 m high. It is noted that similar structures along the southern shores of the Shannon Estuary at Tarbert and Foynes do not appear to pose any current collision risk to birds. Observations on overflying birds at the proposed jetty location as well as to the east and west of this area confirmed that there were no commuting routes for heavy wing loading birds along this stretch of coastline or within 1 km east or west of the site. On one occasion, two Whooper Swans were observed flying close to the jetty area (Point B), 100-250 m offshore at a height of between 25-50 m. However, this flight height is significantly above the height of the jetty platform (9m OD). Cormorants are likely to fly in the vicinity of the proposed jetty during foraging and commuting flights. Blew *et al.* (2008) in a study of a Swedish windfarm found that resident cormorants will effectively avoid collision with wind turbines. Furthermore, cormorants are known to effectively forage and breed in the vicinity of busy ports throughout Ireland (RPS, 2012, 2014, 2017) and their risk of collision with the jetty structure is not significant.

Lighting of structures at night has been shown to increase the risk of bird collision and collision rates have been found to increase with increased lighting (Evans Ogden 2002, Zink and Eckles 2010). Migratory bird species are at an increased risk of collision at night, with collisions occurring during nocturnal migration, particularly in areas with strong levels of artificial light. Migrating birds can be diverted from their flight path by excessive light and collide with lit structures. (Winger *et al.* 2019; Arnold and Zink 2011). While the linear nature of the Shannon Estuary is likely to provide a flight path for nocturnal migrants, bird migration altitudes are likely to be between 2,000-6,000m (Lindstrom *et al.* 2021). As can be seen from Appendix A10-1 Photomontages (see Volume 4), the lighting of the jetty along the southern shore of the Shannon Estuary is not excessive. The levels of light of the Proposed Development within the Shannon Estuary means the risk of the jetty lighting at night diverting nocturnal migrants is not significant and no significant impact on nocturnal migrating birds is predicted to occur.

While bird collision is a well-documented phenomenon, it should be noted that following an extensive review of the available literature no studies were found which recorded bird collision with jetties, during day or night (piers, wharfs, marinas etc). Given the low risk of collision with jetty structures, the lattice design of the jetty, the location of the jetty outside commuting routes for heavy wing loading birds and the lighting design measures at the site, no significant risk of collision has been identified and no impact on birds due to collision is predicted to occur.

As noted in Section 7B.5.4.5, manmade structures in nearshore areas e.g., ports, docks, jetties, canals, coastal protection can create additional habitat for a range of marine species including fish, invertebrates and algae. The location of the new jetty along the Shannon Estuary is likely to create additional roosting sites for gulls, terns and Cormorant and as well as increased foraging opportunities for fish eating species such as Cormorant.

The impact on SCI birds, including wading and diving birds, from operational activities is predicted to be negative, slight and long-term at an international level in the absence of mitigation.

The impact on Annex I species i.e., Red-throated Diver, Great Northern Diver and Sandwich Tern from operational activities is predicted to be **negative, slight** and **long-term** at a county level in the absence of mitigation.

The impact on other estuarine species during operational is predicted to be **negative, slight** and **long-term** at a local level in the absence of mitigation.

7B.5.4.9 Fish

Combined stormwater flows and treated sanitary effluent and process effluent from the Proposed Development will be discharged directly to the Shannon Estuary below low tide level. There will be no direct discharges to surface water during the operational phase and no impact on freshwater habitats. There will be no significant impacts on fish during the operational phase.

7B.5.4.10 Aquatic Invertebrates

Combined stormwater flows and treated sanitary effluent and process effluent from the Proposed Development will be discharged directly to the Shannon Estuary below low tide level. There will be no direct discharges to surface water features during the operational phase and no impact on freshwater habitats. There will be no significant impacts on freshwater aquatic invertebrates during the operational phase.

7B.5.4.11 Other Species

No significant impacts on other species during the operational phase have been identified.

7B.5.4.12 Air Quality

The operation of the Proposed Development will include a number of sources with emissions to air associated with combustion plant, to generate heat and power for onsite activity. Emissions to air associated with such plant vary with the type of plant and its purpose, the thermal capacity of the plant and the fuel used to enable combustion.

Following UK EA guidance, pollutants and averaging periods at human health and nature conservation receptors reported were considered be not significant (Refer to Chapter 08 – Air Quality, Section 8.6.1). For the normal operational scenario, impacts at the closest sensitive receptors are not to the extent that operation of the Proposed Development would cause a risk of an exceedance of an Air Quality Standard or Environmental Assessment Level, nor will it increase total pollutant concentrations to the extent that it would constrain future development of the area. No significant impacts from operational air emissions are predicted to occur.

7B.5.4.13 Climate Change and Biodiversity

The EU Commission guidance document on integrating climate change and biodiversity into environmental impact assessment (EU Commission, 2013) aims to improve the way in which climate change and biodiversity are integrated into Environmental Impact Assessment.

An assessment of the impact of the Proposed Development on climate change is included in Chapter 15 – Climate. This assessment looked at the influence of climate change to the Project-related impacts to neighbouring sensitive receptors. Technical specialists used the climate change projections to examine if there were any changes to either the likelihood or severity of impact to their receptors, however no combined impacts were identified. This assessment also looked at the influence of climate change to the Proposed Development itself, particularly its physical and functional aspects. Any identified vulnerabilities were found to be sufficiently mitigated against by aspects of the design, particularly aspects of flood design such as drainage systems and building/ infrastructure heights that take sea level rise into account. It is noted that biodiversity enhancement planting will be provided within the Proposed Development site, which will also minimise any impact of the Proposed Development on climate change and biodiversity.

In the absence of any significant impacts of the Proposed Development on sensitive neighbouring receptors no significant interactions between the effects on biodiversity resulting from this development and climate change have been identified.

7B.5.4.14 Accidents

The likelihood of large-scale oil and LNG spills due to accident during operations and vessel collision at the Proposed Development is regarded as remote, while the risk of accidental small spillages of pollutants (including fuels, hydrocarbons, oils etc.) is considered to be low.

Specifically, the assessment of likelihood of release events from the Proposed Development are set out in the following:

- Marine Navigation Risk Assessment, which was prepared by the Shannon Foynes Port Company (see Appendix A2-2, Vol. 4);
- Quantitative Risk Assessment (QRA) and associated Major Accidents to the Environment (MATTE) submitted to the HSA as part of the planning application (see Appendix A2-5, Vol. 4);
- EIAR for the Proposed Development submitted ABP as part of the planning application; and
- OCEMP (see provided in Appendix A2-4, Vol. 4).

Additionally, the operation of the Proposed Development will be controlled and regulated by the following bodies:

- Environmental Protection Agency;
- Commission for Regulation of Utilities;
- Health and Safety Authority;
- KCC; and
- The Shannon Foynes Port Company.

However, in consultation with Shannon Foynes Port Company and the Shannon Estuary Anti-Pollution Team (SEAPT), Shannon LNG has prepared an Oil and Hazardous and Noxious Substances (HNS) Spill Plan Development Framework (see Appendix A2-6, Vol. 4). This document describes the graduated and tiered response process to fulfil these obligations and to provide a robust and coordinated response to release incidents in the unlikely event they should occur. The developed plans will follow international best practice guidelines of the International Maritime Organization (IMO), The Society of International Gas Tanker and Terminal Operators (SIGTTO), and International Petroleum Industry Environmental Conservation Association (IPIECA) while taking into account relevant Irish legislative and regulatory approval requirements. In particular the plans will follow the requirements made within the National Maritime Contingency Plan Oil and HNS Spills 2019 (NCP) and the National Framework for the Management of Major Emergencies. The plans will be developed to cover both In-Land (onshore) and Marine based releases and shall cover the Construction and Operational Phases of the Proposed Project. Key objectives and the format of the Oil and HNS Spill Plan Oil and how the plan relates to the National Contingency Plan (NCP) are described in Section 7.6.5.

The development has (provisional to project go-ahead) been accepted as member of the Shannon Estuary Anti-Pollution Team (SEAPT). Membership of SEAPT will enable the development to interface directly with the approved Shannon Estuary Oil/HNS Plan and access additional response equipment to augment that held within the terminal (refer to Chapter 07A Section 7.6.5 for further details)

LNG is stored on the FSRU and LNGC site as a liquefied gas and when released to its surroundings it vaporises rapidly to form natural gas, leaving no residue. LNG (methane and other light hydrocarbons) is classed under the COMAH Regulations as 'Liquefied Flammable Gasses'. As LNG and natural gas are not toxic to the environment, hazards are associated with exposure to low temperatures from an LNG release (cryogenic burns), or fires if a release of LNG or natural gas is ignited. Environmental receptors at risk are flora and fauna.

The MATTE assessment determined that thermal radiation from jet fires and flash fires will not affect the NHA and onshore cSAC to the west of the Site. LNG Pool fires on the sea surface could lead to thermal radiation effects at the NHA and onshore cSAC to the west of the Site. The frequency of these events have been calculated within the Safeti QRA Model and are at most 3.7 x 10-6 per year (once in 270,270 years) at the closest point of the onshore cSAC. This frequency is considered to be very low. It should be noted that the 5 kw/m^2 thermal radiation intensity is below that which would lead to a fire and therefore recovery from this type of event would be less than three years. Modelling indicates that the jet and pool fire contours of 5 kW/m^2 reach areas of the estuary that forms part of the cSAC and SPA close to the jetty/terminal. While harm to birds present on the estuary surface close to the Proposed Development may be possible in the event of a fire, bird surveys have identified that there are no significant populations of bird species in the vicinity of the Proposed Development site (see Section 7.3.6.2). Based on the definition of a MATTE jet fires and LNG pool fires are not considered credible MATTE events. All of the MATTE events identified are considered to be low frequency and consequently low risk.

Based on the assessments described above, the risk of major accident is predicted to be very low and therefore does not pose a significant risk to habitats or species within or in the vicinity of the Proposed Development site.

7B.5.5 Decommissioning

As described in Chapter 02 – Project Description, the Proposed Development is expected to have a design life of 50 years, but this could be extended by maintenance, equipment replacement and upgrades or by the transition of the site to use hydrogen capability (which would be subject to a future planning application). It is expected that it would be a condition of the industrial emissions licence for the Proposed Development that a closure and residuals management plan, including a detailed decommissioning plan, be submitted to the EPA for their approval.

Decommissioning activities will include, as a minimum:

- All wastes at the facility at time of closure will be collected and recycled or disposed of by an authorised waste contractor, as appropriate;
- Utilities will be drained of all potential pollutants such as lubricating oils or sealed to prevent leakage if being moved offsite or recused elsewhere;
- All raw materials, oils, fuels, etc. onsite at the time of closure will be returned to the supplier, or collected and recycled or disposed of by an authorised waste contractor, as appropriate,
- All buildings and equipment will be decontaminated, decommissioned and demolished in accordance with a phased demolition plan, and either sold for reuse or recycled, or disposed of by an authorised waste contractor, as appropriate. In general, specialist equipment, pipelines and storage tanks will be sold for reuse, where possible, or disposed of offsite;
- Roadways to be broken up and removed and security fences dismantled;
- All hazardous and non-hazardous process substances to be removed;
- All roads and hardstanding areas to be removed and recycled or disposed of by an authorised waste contractor, as appropriate;
- Landscaped will be reinstated in accordance with a landscape reinstatement plan; and
- On completion of safe decommissioning of equipment, the potable water, fire water and electrical power supplies could be disconnected, and removed or abandoned in place.

When operations have ceased, and assuming confirmation from the monitoring programme that all emissions have ceased, it is expected that there would be no requirement for long-term aftercare management at the Proposed Development site.

During decommissioning, measures would be undertaken by the Applicant to ensure that there would be no significant, negative environmental effects during the decommissioning phase. The decommissioning plan would incorporate measures to satisfy all regulatory requirements and to achieve targeted environmental goals. The decommissioning measures would have to be implemented to the satisfaction of the EPA. As the terrestrial site of the Proposed Development is generally of relatively low habitat and species value, the impact of decommissioning will be **temporary** and **not significant** following the implementation of standard mitigation and monitoring measures.

7B.6 Cumulative Impacts

The cumulative impacts of the Proposed Development and nearby consented projects in the vicinity of the Proposed Development are discussed below. A planning search of granted and pending planning applications made within the vicinity of the Proposed Development site is presented in Chapter 04 – Energy and Planning Policy.

7B.6.1 Summary of Schemes Considered in Cumulative Impact Assessment

7B.6.1.1 LNG Pipeline

Permission was granted in 2009 for a pipeline to connect the Proposed Development to the existing national gas network near Foynes, Co. Limerick. The application was accompanied by an EIAR. No significant residual effects were identified to hydrogeology and surface water in the EIAR for the LNG pipeline.

Potential cumulative impacts for terrestrial fauna could occur in the vicinity of the Proposed Development site, if the adjacent pipeline route contained rare habitats or valuable habitats for rare species. Habitats recorded within this section of the pipeline route were common. No signs of terrestrial mammals were recorded within 1 km of the Proposed Development site. A small number of the Red List species Meadow Pipit were recorded within this area, however given the availability of alternative grassland habitat in the immediate vicinity, no in-combination impact on this species is predicted to occur.

Given the location of these projects (in areas of relatively low habitat and species value), together with the implementation of good practice standard construction environmental measures and the OCEMP for the Proposed Development as detailed, no significant cumulative effects on biodiversity will result.

Data Centre Campus

A Data Centre Campus is to be constructed to the west of the Proposed Development. This will be subject to its own EIAR and planning application.

220 kV and Medium Voltage (10/ 20 kV) Power Transmission Network

An application to connect to the national electrical transmission network via a 220 kV high voltage connection was submitted to EirGrid in September 2020. An offer has yet to be received. It is expected that the high voltage connection will run 5 km east under the L1010 road to the Electricity Supply Board Networks (ESBN)/ EirGrid Kilpaddoge 220 kV substation.

The LNG Terminal may need to be operational before the Power Plant and/ or 220 kV high voltage grid connection are completed or operational. Therefore, the LNG Terminal design will also require an onsite substation and a separate medium voltage (10/ 20 kV) connection, from the existing ESBN/ EirGrid Kilpaddoge substation. This will be used as a back-up electricity system when the Power Plant is undergoing maintenance.

The medium voltage (10/ 20 kV) and 220 kV power connections will be constructed in parallel with the Proposed Development but will be subject to separate planning design and planning applications.

7B.6.1.2 Construction Impact

If works associated with these three schemes (described above) in close proximity to the Proposed Development site are concurrent with the bulk excavation works at the Proposed Development, there is potential for cumulative impacts and effects on terrestrial ecology features. Should this situation arise, construction activities will be planned and phased, in consultation with the construction management team for the Shannon Technology and Energy Park.

The implementation of best practice standard construction environmental measures and the OCEMP for the Proposed Development as detailed, no significant cumulative effects on biodiversity will result.

If works are concurrent with the bulk excavation works on the Proposed Development site, there is potential for cumulative disturbance effects, as the sites are located close to each other. Should this situation arise, construction activities will be planned and phased, in consultation with the construction management team for the scheme.

Discharges from both this project and the Proposed Development are governed by strict limits to ensure compliance with quality standards. No long-term cumulative impact on water quality will occur.

Given the location of these projects (in areas of relatively low habitat and species value), together with the implementation of good practice standard construction environmental measures and the OCEMP for the Proposed Development as detailed, no significant cumulative effects on biodiversity will result.

7B.6.1.3 Operational Impacts

Potential impacts from consented development elsewhere, combined with the potential impacts of the Proposed Development, could result in increased disturbance to sensitive fauna.

Potential effects to terrestrial biodiversity from the Proposed Development range from significant to negligible and mitigation measures proposed to manage and control potential impacts during operation would further reduce the magnitude and significance of effects.

Potential impacts primarily relate to disturbance impacts from increase noise, activity and lighting at the site. The site is located in a largely rural area with little or no disturbance. Therefore, the cumulative operational effect of the Proposed Development and other consented or potential developments on terrestrial biodiversity is considered to be **imperceptible**.

7B.7 Mitigation and Monitoring Measures

7B.7.1 Construction

The mitigation and monitoring measures have been drawn up in line with current best practice and include an avoidance of sensitive habitats at the design stage and mitigation measures will function effectively in preventing significant ecological impacts. The following mitigation and monitoring measures will be implemented.

7B.7.1.1 General Mitigation and Monitoring Measures

An OCEMP has been prepared (included in Appendix A2-4 of Volume 4). The OCEMP contains the construction mitigation and monitoring measures, which are set out in this EIAR and the NIS. This will have particular emphasis on the protection of habitats and species of the cSAC, SPA and pNHA which adjoin the site.

These sites (cSAC, SPA and pNHA) are by definition internationally/ nationally important for their habitats and/ or the species they support. It is essential that all construction staff, including all sub-contracted workers, be notified of the boundaries of these Natura 2000 sites and be made aware that no construction waste of any kind (rubble, soil, etc.) is to be deposited in these protected areas and that care must be taken with liquids or other materials to avoid spillage.

Mitigation and monitoring measures (of relevance in respect of any potential ecological effects) will be implemented throughout the project, including the preparation and implementation of detailed method statements. The works will incorporate the relevant elements of the guidelines outlined below:

- *Control of water pollution from construction sites. Guidance for consultants and contractors (C532). CIRIA.* Masters-Williams et al (2001); and
- *Control of water pollution from linear construction projects. Technical guidance (C648). CIRIA.* Murnane, *et al.* (2006).

All personnel involved with the Proposed Development will receive an onsite induction relating to construction and operations and the environmentally sensitive nature of European sites and to re-emphasise the precautions that are required as well as the precautionary measures to be implemented. Site managers, foremen and workforce, including all subcontractors, will be suitably trained in pollution risks and preventative measures.

All staff and subcontractors have the responsibility to:

- Understand the importance of avoiding pollution onsite, including noise and dust, and how to respond in the event of an incident to avoid or limit environmental impact;
- Respond in the event of an incident to avoid or limit environmental impact;
- Report all incidents immediately to the project manager and the Environmental (Ecological) Clerk of Works (ECoW);
- Monitor the workplace for potential environmental risks and alert the site manager if any are observed; and

- Co-operate as required, with site inspections.

As part of the assessment of the required construction mitigation, best practice construction measures which will be implemented for the Proposed Development were considered. A summary of the measures relevant to hydrology are provided as follows and are in accordance with Construction Industry Research and Information Association (CIRIA) guidance – *Control of Water Pollution from Construction Sites, Guidance for Consultants and Contractors* (Masters-Williams *et al*. 2001). Further detail is provided in Chapter 05 – Land and Soils, Chapter 06 – Water, Chapter 09 – Airborne Noise and Groundborne Vibration and in the OCEMP included in Appendix A2-4 of Volume 4.

7B.7.1.2 Water Quality

Details of water quality mitigation and monitoring measures are included in Chapter 06 – Water and in the OCEMP included in Appendix A2-4 of Volume 4.

7B.7.1.3 Bridge and Culvert Construction

Bridge construction on the Ralappane Stream will use a single span, pre-cast concrete bridge near the southern boundary of the Proposed Development site. Two drainage ditches within the Proposed Development site will be culverted. In addition to the general measures described above, the following specific mitigation measures will be implemented for crossing of the Ralappane Stream and drainage ditch:

- Works will comply with The IFI's *Guidelines on protection of fisheries during construction works in and adjacent to waters* (IFI, 2016);
- No instream works will take place in the Ralappane Stream;
- Appropriate silt control measures such silt barriers (e.g. straw or silt fence) will be employed where required;
- Construction activities will be undertaken during daylight hours only. This will ensure that there is potential for undisturbed fish passage at night. The works will be temporary and will not create a significant long-term barrier to fish movement;
- An appropriate native grass seed mix as determined by the ECoW based on ground conditions, will be utilised to re-vegetate any disturbed areas along the bank of the Ralappane Stream; and
- Although no Common Frog were observed in drainage ditches within the Proposed Development site boundary, they will be surveyed prior commencement of site works by the ECoW as a precautionary measure. Any Common Frog, if recorded, will be moved to suitable habitat in the wider landscape under licence from NPWS.

7B.7.1.4 Noise

The employment of good construction management practice, as described in the OCEMP and in Chapter 09 – Airborne Noise and Groundborne Vibration, will minimise the risk of adverse impacts from the noise and vibration during the construction phase.

Mitigation and monitoring measures will be employed to ensure that potential noise and vibration impacts at nearby sensitive receptors due to construction activities are minimised. The preferred approach for controlling construction noise is to reduce source levels where possible, but with due regard to practicality.

The OCEMP will be updated by the contractor, prior to construction, to include any specific conditions attached to the approval and other specific construction information, but will at a minimum, include the measures described in Chapter 09, Section 9.8.

7B.7.1.5 Lighting

Lighting associated with the Proposed Development site works could cause disturbance/ displacement of fauna. If of sufficient intensity and duration, there could be impacts on reproductive success.

Site lighting will typically be provided by tower mounted temporary portable construction floodlights. The floodlights will be cowled and angled downwards to minimise spillage to surrounding properties. Lighting mitigation measures will follow *Bats & Lighting Guidance Notes for: Planners, engineers, architects and developers* (Bat Conservation Ireland, 2010). The following measures will be applied in relation to construction works lighting:

- Lighting will be provided with the minimum luminosity necessary for safety and security purposes. Where possible, lighting will be restricted to the working area and using the cowl and angling noted above, will minimise overspill and shadows on sensitive habitats outside the construction area; and
- During construction, lighting will be positioned and directed so that it does not to unnecessarily intrude on adjacent ecological receptors and structures used by protected species. The primary area of concern is the potential impact at the cSAC/ SPA boundary, the Ralappane Stream as well as hedgerows, treelines. With the exception of the jetty dock, there will be no directional lighting focused towards these areas and cowling and focusing lights downwards will minimise light spillage.

7B.7.1.6 Protection of Habitats

The Wildlife Act 1976, as amended, provides that it is an offence to cut, grub, burn or destroy any vegetation on uncultivated land or such growing in any hedge or ditch from 1st March to 31st August. Exemptions include the clearance of vegetation in the course of road or other construction works or in the development or preparation of sites on which any building or other structure is intended to be provided. If works are carried out during the breeding season, a pre-construction survey will be carried out by the ECoW and if birds are detected appropriate mitigation measures will be implemented. Where possible, vegetation will be removed outside of the breeding season and in particular, removal during the peak-breeding season (April-June inclusive) will be avoided. This will also minimise the potential disturbance of breeding birds outside of the Proposed Development site boundary.

Particular care will be taken at the boundary between the Proposed Development site and the cSAC, SPA and pNHA so that construction activities do not cause damage to habitats in this area. These habitats will be securely fenced off early in the construction phase. The fencing will be clearly visible to machine operators.

The Ralappane Stream runs from the Proposed Development site through the cSAC and pNHA to the estuary, it is important that construction activities do not result in pollution of this watercourse, either through siltation, which interferes with water flow, vegetation growth and aquatic fauna, or pollution (e.g. chemical). Refer to Chapter 06 Section 6.10 for further details on mitigation and monitoring measures for water.

To prevent incidental damage by machinery or by the deposition of spoil during site works, hedgerow, tree and scrub vegetation which are located in close proximity to working areas will be clearly marked and fenced off to avoid accidental damage during excavations and site preparation. The ECoW will specify appropriate protective fencing where required.

Habitats that are damaged and disturbed will be reinstated and landscaped once construction is complete. Disturbed areas will be seeded or planted using appropriate native grass or species native to the areas where necessary. Details on landscaping are included in Figure F2-4 in Volume 3. Natural regeneration of vegetation will also occur.

There will be a defined working area which will be fenced off with designated haul routes to prevent inadvertent damage to adjoining habitats.

Tree root systems can be damaged during site clearance and groundworks. Materials, especially soil and stones, can prevent air and water circulating to the roots. No materials will be stored within the root protection area/ dripline of trees earmarked for retention. The ECoW will specify appropriate protective fencing where required.

7B.7.1.7 Badgers

This will require exclusion of Badgers from subsidiary/ outlier setts, however in both instances both social groups of Badgers would be expected to continue to use their main setts.

Badger sett tunnel systems can extend up to approximately 20 m from sett entrances. Therefore, no heavy machinery should be used within 30m of Badger setts (unless carried out under licence); lighter machinery (generally wheeled vehicles) should not be used within 20 m of a sett entrance; light work, such as digging by hand or scrub clearance should not take place within 10 m of sett entrances.

During the breeding season (December to June inclusive), none of the above works should be undertaken within 50 m of active setts nor blasting or pile driving within 150 m of active setts.

Affected Badger setts will be clearly marked and the extent of bounds prohibited for vehicles clearly marked by fencing and signage.

The most recent surveys show that the two main Badger setts are located outside of the Proposed Development site boundary and the two setts to be directly affected are subsidiary setts. The bait marking survey indicates that the setts are linked as follows:

- Sett 4 (main sett) is located to the east of the Proposed Development. Sett 1 is located within the Proposed Development site boundary. These setts are used by the same social group; and
- Sett 3 (main sett) is located to the east of the Proposed Development. Sett 2 is located within the Proposed Development site boundary. These setts are used by the same social group.

The presence of alternative setts within the particular social group's territory is required to ensure that excluded Badgers are able to relocate to a suitable alternative refuge. The objective is to allow the Badgers to remain within their territory, even though a portion of their current territory may be lost as a result of a particular development. There is a standard methodology which can be utilised to exclude Badgers from setts

A methodology for the exclusion of Badgers from affected setts and displacement of Badgers to artificial setts is outlined in the National Roads Authority publication *Guidelines for the Treatment of Badgers Prior to the Construction of National Road Schemes* (NRA 2005a). Detailed mitigation and monitoring measures including method statements will be agreed with the NPWS prior to implementation as part of a licence application.

Prior to the commencement of works, setts will be surveyed by the ECoW to determine current usage patterns.

Exclusion of Badgers from any currently active sett will only be carried out during the period of July to November (inclusive) in order to avoid the Badger breeding season.

In the instance of disused setts or setts verified as inactive, and to prevent their reoccupation, the entrances may be lightly blocked with vegetation and a light application of soil (soft blocking). The purpose of soft-blocking is to confirm that an apparently inactive sett is not occupied by Badgers. If all entrances remain undisturbed for approximately five days, the sett should be destroyed immediately using a mechanical digger, under the supervision of the licensee. Should there be any delay in sett destruction, the soft-blocked entrances should be hard-blocked and the sett destroyed as soon as possible, again under the supervision of the licensee. Hard-blocking is best achieved using buried fencing materials and compacted soil with further fencing materials laid across and firmly fixed to blocked entrances and surrounds

Where field signs or monitoring reveal any suggestion of current or recent Badger activity at any of the sett entrances, the sett requires thorough evacuation procedures.

Inactive entrances may be soft and then hard-blocked, as described for inactive setts, but any active entrances should have one-way gates installed (plus proofing around sides of gates) to allow Badgers to exit but not to return. The gates should be tied open for three days prior to being set to exclude. Sticks should be placed at arm's length within the gated tunnels to establish if Badgers remain within the sett.

Gates should be left installed, with regular inspections, over a minimum period of 21 days (including period with gates tied open) before the sett is deemed inactive. Any activity at all will require the procedures to be repeated or additional measures taken. Gates might be interfered with by other mammals or members of the public - hence the importance of regular exclusion monitoring visits. Sett destruction should commence immediately following the 21-day exclusion period, provided that all Badgers have been excluded.

Badgers will often attempt to re-enter setts after a period, and if gates are left in place for any long period, they may attempt to dig around them or even create new entrances and tunnels into the sett system.

Where an extensive sett is involved, an alternative method of evacuating Badgers is to erect electric fencing around the sett (ensuring all entrances are included) with one-way Badger-gates installed within the electric fence at points where the fence crosses Badger paths leading to and from the sett. The exclusion should again take place over a minimum period of 21 days before sett destruction; this monitoring period would be contingent upon no Badger activity being observed within the fenced area. Fencing may not be practical in many situations due to the topography or the terrain – and can be difficult to install effectively. If no activity is observed, then the sett may be destroyed, under supervision by the ECoW under licence.

The destruction of a successfully evacuated Badger sett may only be conducted under the supervision of qualified and experienced personnel under licence from the NPWS. The possibility of Badgers remaining within a sett must always be considered; suitable equipment should be available on hand to deal with Badgers within the sett or any Badgers injured during sett destruction.

Destruction is usually undertaken with a tracked 12-25 tonne digger, commencing at approximately 25m from the outer sett entrances and working towards the centre of the sett, cutting approximately 0.5 m slices in a trench to a depth of 2 m. Exposed tunnels may be checked for recent Badger activity, with full attention paid to safety requirements in so doing. The sett should be destroyed from several directions, in the above manner, until only the central core of the sett remains.

Once it is ensured that no Badgers remain, the core may then also be destroyed and the entire area back-filled and made safe. Sett excavation should, preferably, be concluded within one working day, as Badgers may re-enter exposed tunnels and entrances.

A report detailing evacuation procedures, sett excavation and destruction, and any other relevant issues should be submitted to the NPWS, in fulfilment of usual wildlife licence conditions.

Construction activities within the vicinity of affected setts may commence once these setts have been evacuated and destroyed under licence from the NPWS. Where affected setts do not require destruction, construction works may commence once recommended alternative mitigation measures to address the Badger issues have been complied with.

Badger access points will be provided to allow Badgers to access the development area once complete See NHBS, 2021 or similar. Gates will be placed within fences along the western, eastern and southern boundaries to maximise potential usage by the different social groups that occur within this area.

Monitoring of Badger setts will be carried out during construction works and a five-year post-construction monitoring programme will be implemented.

7B.7.1.8 Bats

During the site works, general mitigation measures for bats will follow the National Road Authority's '*Guidelines for the Treatment of Bats during the Construction of National Road Schemes*' NRA (2005c) and *'Bat Mitigation Guidelines for Ireland: Irish Wildlife Manuals, No. 25*' (Kelleher, C. & Marnell, F. (2006)). These documents outline the requirements that will be met in the pre-construction (site clearance) stage to minimise negative effects on roosting bats, or prevent avoidable effects resulting from significant alterations to the immediate landscape.

A Common Pipistrelle colony was recorded in a farm building southwest of the Proposed Development site. This building will not be affected. No bat roosts were recorded within the site boundary. Mitigation measures will be agreed with the National Parks and Wildlife Service prior to any demolition works and will include the following.

Two buildings within the Proposed Development site will be demolished as part of the development. No signs of bats were recorded within these buildings. However, as a precautionary measure, the following measures will be implemented prior to and/ or during demolition:

- In all cases immediately in advance of demolition a bat specialist will undertake an examination of the building. If bats are present at the time of examination it is essential to determine the nature of the roost (i.e. number, species, whether it is a breeding population) as well as its exact location;
- If bats are recorded in buildings earmarked for demolition, special mitigation measures to protect bats will be put in place and a license to derogate from the conservation legislation will be sought from the NPWS;
- The contractor will take all required measures to ensure works do not harm individuals by altering working methods or timing to avoid bats, if necessary; and
- If roosting habitat for bats is removed, replacement habitat will be provided.

A number of trees will be removed prior to construction. Although mature trees with the potential of be of value as bat roosts are absent from the site, the following precautionary measures will be implemented.

- The bat specialist will work with the contractor to ensure that the loss of trees is minimised and that trees earmarked for retention are adequately protected;
- Tree-felling will ideally be undertaken in the period September to late October/ early November. During this period bats are capable of flight and may avoid the risks of tree-felling if proper measures are undertaken;
- Felled trees will not be mulched immediately. Such trees will be left lying several hours and preferably overnight before any further sawing or mulching. This will allow any bats within the tree to emerge and avoid accidental death. The bat specialist will be on-hand during felling operations to inspect felled trees for bats. If bats are seen or heard in a tree that has been felled, work will cease and the local NPWS Conservation Ranger will be contacted;
- Tree will be retained where possible and no 'tidying up' of dead wood and spilt limbs on tree specimens will be undertaken unless necessary for health and safety;
- Treelines outside the Proposed Development area but adjacent to it and thus at risk, will be clearly marked by a bat specialist to avoid any inadvertent damage;
- During construction directional lighting will be employed to minimise light spill onto adjacent areas. Where practicable during night-time works, there will be no directional lighting focused towards watercourses or boundary habitats and focusing lights downwards will be utilised to minimise light spillage;
- If bats are recorded by the bat specialist within any trees no works will proceed without a relevant derogation licence from the NPWS; and
- As a biodiversity enhancement measure it is proposed that bat boxes will be put up within the Proposed Development site. It is proposed that eight bat boxes will be located within the overall site (see Wildcare, 2021 for box proposed or similar). The boxes will be erected by the ECoW taking into account landscape plans, vehicle movements and lighting.

As noted in Section 7B.7.1.5, lighting mitigation measures will follow *Bats & Lighting Guidance Notes for: Planners, engineers, architects and developers* (Bat Conservation Ireland, 2010).

All mitigation measures including detailed method statements will be agreed with the NPWS prior to commencement of works, which could affect any bat populations onsite.

7B.7.1.9 Otter

No signs of Otter or Otter holts were noted within 150 m of the Proposed Development site however Otter was recorded along the Ralappane Stream and to the west of the Proposed Development site. A detailed pre-construction survey will be carried out no more than 10-12 months prior to the commencement of construction works to confirm the absence of Otter holts within 150 m of the Proposed Development site.

If Otter holts are recorded at that time, the ECoW will determine the appropriate means of minimising effects i.e. avoidance, moving works, timing of works etc. If required the ecologist will obtain a derogation licence from the NPWS, to facilitate licenced exclusion from the breeding or resting site in accordance with a plan approved by the NPWS.

Any holts found to be present will be subject to monitoring and mitigation as set out in the NRA publication *Guidelines for the Treatment of Otter prior to the Construction of National Road Schemes* (2008). If found to be inactive, exclusion of holts may be carried out during any season. No wheeled or tracked vehicles (of any kind) will be used within 20m of active, but non-breeding, Otter holts. Light work, such as digging by hand or scrub clearance will also not take place within 15m of such holts, except under licence. The prohibited working area associated with Otter holts will be fenced and appropriate signage erected. Where breeding females and cubs are present no evacuation procedures of any kind will be undertaken until after the Otters have left the holt, as determined by the ECoW. Breeding may take place at any season, so activity at a holt must be adjudged on a case-by-case basis. On occasion, Otter holts may be directly affected by the scheme. To ensure the welfare of Otter, they must be evacuated from any holts present prior to any construction works commencing. The exclusion process, if required, involves the installation of one-way gates on the entrances to the holt and a monitoring period of 21 days to ensure the Otters have left the holt prior to removal.

7B.7.1.10 Common Frog

A visual search of the wet grassland habitat and drainage ditches to be removed will be carried out in the days prior to commencement of works and any frogs will be removed to alternative wet grassland habitat elsewhere within the landholding. This will be carried out under licence from the NPWS and under supervision of the ECoW.

7B.7.1.11 Birds

Breeding Birds

No signs of nesting birds were recorded in disused farm buildings during the 2018-2021 surveys. However, prior to demolition buildings will be checked for nesting Swallows (and other birds). If nesting birds are recorded, all demolition operations will be carried out between October and March, when birds have finished breeding.

As noted in Section 7B.7.1.6, where possible, vegetation will be removed outside of the breeding season and in particular, removal during the peak-breeding season (April-June inclusive) will be avoided. This will also minimise the potential disturbance of breeding birds outside of the Proposed Development site boundary.

As a biodiversity enhancement measure ten bird nesting boxes (various types) will be located within the Proposed Development site boundary at locations specified by the ECoW. It is noted that provision of woodland planting and the use of more diverse grassland planting will provide additional nesting and feeding sites for birds, particularly as these habitats mature.

Estuarine Birds

A detailed method statement will be drawn up by the ECoW and agreed with the NPWS prior to commencement of works. The method statement will specify the timing of blasting operations and the need, if any, for ecological supervision.

As noted in Chapter 07A Section 7.7.2 a soft-start will be required for piling works or any source, including equipment testing, exceeding 170 dB re: 1µPa @1m an appropriate ramp-up procedure (i.e. ‘soft-start’) must be used. This should be a minimum of 20 minutes and no longer than 40 minutes.

7B.7.1.12 Biodiversity and Landscaping Plans

Details of the landscaping plan for the Proposed Development are included in Figure F2-4 in Volume 3. This includes detailed areas of native woodland and native scrub habitat as well as native grassland planting.

The woodland planting mix will be dominated by native species including Scots Pine *Pinus sylvestris*, Willow, Pedunculate Oak *Quercus robur* and Sessile Oak *Quercus petraea*, Alder, Rowan *Sorbus* spp. and Crab Apple *Malus* spp.. The woodland edge planting mix will include Hazel *Corylus* spp., Hawthorn, Blackthorn, Elder *Sambucus* spp. and Holly Ilex spp.. The objective of these elements is to create natural, multi-layered woodland habitat which will be of local ecological value and has the potential to support native flora and fauna. A linear strip of woodland along the southern boundary will help to maintain connectivity (east to west) between habitats in the wider landscape.

Additional native specimen trees (Willow, Wild Cherry *Prunus avium*, Rowan, Whitebeam *Sorbus subg. Aria* and Silver Birch) will be planted on peripheral areas such as the road edge and administration area.

As detailed in Figure F2-4 in Volume 3 a native wildflower/ grass mix will be utilised to provide a more diverse sward which is of higher ecological value for invertebrates and birds. Perennial Rye Grass or other vigorous amenity/ agricultural grass species will not be utilised as they tend to over-dominate the sward and reduce overall biodiversity. The final grassland/ wildflower mix for same will be specified by the ECoW based on final ground conditions including alkalinity, fertility and moisture levels.

Based on the seed mix utilised and on prevailing ground conditions, the ECoW will specify the management regime, including weed control and mowing regime, necessary to maximise biodiversity and habitat value.

Five insect nesting boxes suitable for *Hymenoptera* spp. (bees and wasps) will be put in place within the site boundary as a biodiversity enhancement measure.

7B.7.1.13 Invasive Species

Prior to the commencement of construction works an invasive species survey will be undertaken within the Proposed Development boundary by a competent ecologist to determine if invasive species listed under Part 1 of the Third Schedule of S.I No. 477 of 2011 have established in the area in the period between pre-planning and post consent. In the event that invasive species are identified within the works area a site-specific Invasive Species Management Plan will be developed and implemented by a competent specialist on behalf of the Contractor. In addition, in order to comply with Regulations 49 and 50 of the European Communities (Birds and Natural Habitat) Regulations (2011) the appointed Contractor will ensure biosecurity measures are implemented throughout the construction phase to ensure the introduction and translocation of invasive species is prevented. The appointed ECoW will carry out a toolbox talk which will identify invasive species and will also implement biosecurity measures such as the visual inspection of vehicles for evidence of attached plant or animal material prior to entering and leaving the works area.

7B.7.2 Operations

During the operational phase the site environmental management system will address management of potentially contaminating materials such as fuel, lubricating oils, solvent, etc. and ensure such material is appropriately controlled, in accordance with regulatory requirements and industry best practice.

The drainage design for the Power Plant will consider the magnitude of the changes in infiltration and runoff characteristics and the significance of potential impacts at the wetland. Further details on operational water management are included in Chapter 06 – Water.

Lighting shall be provided in plant areas where safe access and safe conditions for work activities is required at night. Lighting will also be required on the water around the jetty dock to detect spillage and possibly unauthorized craft. The onshore receiving facilities would have area lighting installed on a down angle to cover the LNG Terminal and Power Plant. The terminals will have a level of lighting sufficient to ensure that all ship/ shore interfaces activities can be safely conducted during periods of darkness. Lighting levels will meet national and international engineering standards as a minimum

The principal mitigation measures required for the development in relation to noise concern selection of equipment, sound containment, and acoustic attenuators, in order to achieve the required limits. The predicted noise levels, as outlined in Chapter 09 – Airborne Noise and Groundborne Vibration are considered to be readily technically achievable using standard methods.

7B.8 Do Nothing Scenario

Most of the habitats to be affected have been significantly modified from their natural state by human activity. In pockets of semi-natural habitats within the Proposed Development site boundary, the general pattern of succession from grassland to scrub to woodland would be expected to continue In the absence of development, it is expected that the lands within the planning boundary would largely remain under the same management regimes. No significant changes to the habitats within the boundary are likely to occur, in the ‘do nothing’ scenario.

7B.9 Residual Impacts

7B.9.1 Habitats

Replacement planting of native tree species within the Proposed Development site will provide alternative forging and commuting habitat for fauna (Refer to Figure F2-4 in Volume 3). This will compensate for some of the habitat loss at the site including hedgerows/ treelines, scrub and grassland habitat.

Table 7B-14 Residual Impacts on Habitats within Proposed Development Site Boundary Following Mitigation

Habitat type	Habitat value	Impacts
Wet grassland GS4	Local importance (Lower value)	**Negative, slight, long-term**
Improved agricultural grassland GA1	Local importance (Lower value)	**Negative, slight, long-term**
Hedgerows (WL1)/ Treelines (WL2)	Local importance (Higher Value)	**Negative, not significant, long-term**
Sedimentary sea cliffs CS3	International importance	**Negative, significant, permanent**
Scrub WS1	Local importance (Higher Value)	**Negative, not significant, long-term**
Eroding river FW1	Local importance (Higher Value)	**Negative, slight, long-term**
Drainage ditch FW4	Local importance (Lower Value)	**Negative, not significant, long-term**

7B.9.2 Badgers

Based on conservative estimates, it is probable that 25% of the feeding territory of both feeding groups will be impacted by the Proposed Development. The reduction in territory size is likely to create a reduction in the size of both social groups. A net loss of grassland foraging habitat will therefore be a long-term impact of the Proposed Development but given the alternative resources available, both Badger territories will remain extant.

Noise modelling which was carried out for peak construction noise at Sett 3 and Sett 4, found that peak noise (LAeq) at Sett 3 would be 49.9dB(A) during daytime works and 32.1 dB(A) during night-time works. At Sett 4 this would be 43.6dB(A) during daytime and 37.1dB(A) during night-time (Refer to Appendix A7B-3, Vol. 4). Therefore, even during peak construction works there will no disturbance impacts to the main Badger setts in the vicinity of the Proposed Development site. During operation noise levels at Sett 3 and Sett 4 will be 35dB(A) for all operational scenarios.

Given the alternative resources available, both Badger territories will remain extant. Impacts to Badgers during the construction phase in following mitigation will be **negative, significant** and **long-term** at a local level.

7B.9.3 Bats

The residual impact of the Proposed Development will include loss of hedgerows/ treelines as well as smaller areas of scrub and cliff habitat which are used as commuting and foraging habitat. Lit areas of the Proposed Development site will be avoided by bats, although they are likely to continue to forage in dark areas. The Proposed Development will result in a net loss of moderate value feeding habitat. Replacement planting of native tree species within the Proposed Development site boundary will provide alternative foraging and commuting habitat for bats. This will also help to shield retained boundary habitats from lighting within the Power Plant and create dark areas for bat foraging. The residual impact of the Proposed Development is expected to be **negative, slight** and **long-term** at a local level on Common Pipistrelle, Soprano Pipistrelle and Leisler's Bat.

7B.9.4 Otter

Otter is known to forage outside the Proposed Development site, but no Otters were recorded within the site boundary. During peak construction works (including jetty works), noise levels along the tidal section of the Ralappane Stream (R8), the closest location to the Proposed Development site where Otter was recorded, will be 58.3 dB(A) during daytime and 36.3dB(A) during night-time (Refer to Appendix A7B-3, Vol. 4). During operation noise levels at R8 will be less than 37dB(A) for all operational scenarios. Therefore, even in during the worst-case scenario for noise, there will no significant disturbance at known Otter foraging sites. There may be some short-term displacement of Otters foraging offshore during the works period. However, this species is tolerant to a high degree of noise and/ or disturbance. Thus, any impacts during the construction phase are expected to be localised, slight and short-term.

Otters in Ireland regularly use manmade habitat such as jetties for foraging and resting and it is noted that the new jetty is likely to provide additional foraging opportunities for Otter. During the operational phase, Otters at the Proposed Development site are likely to adapt successfully to increased disturbance and forage along the artificial reef habitat created by the jetty. The residual impact on Otter will be **not significant** at a local level.

7B.9.5 Other Terrestrial Mammals

Hares are a highly mobile species which can move away from the site of disturbance. There will be a net loss of feeding habitat. The residual impact on Irish Hare is predicted to the **negative, slight** and **long-term** at a local level.

Hedgehog is likely to recolonise newly planted hedgerows/ treelines at the Proposed Development site following the new landscape planting. The residual impact is predicted to the **negative, slight** and **long-term** at a local level.

7B.9.6 Amphibians

Common Frog will no longer use the site following the removal of wet grassland. However, following relocation the residual impact on Common Frog will not be significant.

7B.9.7 Birds

7B.9.7.1 Terrestrial Birds

Breeding birds will be displaced from grassland and boundary habitats at the site. Noise levels within terrestrial habitats during construction are likely to be significant and birds will be displaced during peak construction works. During operation and following the implementation of the landscape plan, woodland edge species are likely to recolonise the new hedgerows/ treelines at the Proposed Development site. Native seeded grassland is likely to provide alterative nesting habitat for ground nesting species such as Meadow Pipit, Skylark and Snipe. The residual impact will be **negative, minor** and **long-term** at a local level.

7B.9.7.2 Estuarine Birds

The numbers of estuarine birds displaced during construction, following mitigation and monitoring measures for noise and lighting, will be minimal. Outside of blasting works, birds are predicted to continue to forage along all areas of the Shannon Estuary outside the immediate working area. According to Cutts *et al.* (2013), a single sudden sound such as blasting will generally cause more disturbance than a constant or regular noise regardless of noise level. The typical response would be for birds to move away from affected areas to less disturbed areas. Birds that remain in the affected area may not forage effectively and this may impact on survival and foraging rates. Blasting works will take place only within terrestrial habitats i.e., grassland on southeast of Proposed Development site. No significant estuarine bird numbers were recorded in the vicinity of the Proposed Development site and given the limited use of blasting and the distance from more valuable bird foraging areas (i.e., west of Knockfinglas Point), no significant impact is predicted to occur to estuarine birds during construction works.

Following mitigation, peak operational noise levels will be 45-55 dB(A) along the along the Shannon Estuary shoreline adjacent to the Proposed Development site. To the east and west of the Proposed Development site, noise levels will be 35-40 dB(A) falling to <35 dB(A) west of Knockfinglas Point (Appendix A7B-3 of Volume 4). In the subtidal waters in the immediate vicinity of the FRSU, noise levels following mitigation will be <65 dB(A). During operation, more sensitive bird species such as Red-throated Diver and Great Northern Diver are likely to avoid foraging in the vicinity of the jetty and ships. Other estuarine bird species are likely to habituate to operational noise and disturbance and continue to forage along the intertidal and sub-tidal habitats. The new jetty is likely to create foraging and roosting opportunities for a number of species including gull and tern species, Cormorant and Shag.

The residual impact on SCI birds will be negative, not significant and long-term at an international level following mitigation.

The residual impact on Annex I species i.e., Red-throated Diver, Great Northern Diver and Sandwich Tern will be **negative, slight** and **long-term** at a county level following mitigation.

The residual impact on other estuarine species will be **negative, not significant** and **long-term** at a local level following mitigation.

7B.9.8 Fish

Residual impacts on water quality are predicted to be **imperceptible**. The impact of residual impact on fish will be **not significant**.

7B.9.9 Aquatic Invertebrates

Residual impacts on water quality are predicted to be **imperceptible**. The impact of residual impact on fish will be **not significant**.

7B.9.10 Other Species

No residual impacts identified.

7B.9.11 Spread of Invasive Species

No residual impacts identified.

7B.9.12 Air Quality

No residual impacts predicted.

Table 7B-15 Summary of Potential impacts from the Proposed Development for Designated Sites, Habitats and Flora

Feature		Highest Value within Zone of Influence	Potential Construction Phase impacts	Significance of Potential Construction-Phase Impact	Potential Operational Phase impacts	Significance of Potential Operational-Phase Impact	Mitigation Proposed	Residual Impact Significance (Construction and Operation)	Cumulative Residual Impact Significance
Designated sites	Lower River Shannon cSAC	International	Direct habitat loss/ Pollution	Refer to NIS	Refer to NIS	Refer to NIS	Refer to NIS	Refer to NIS	Refer to NIS
	River Shannon and River Fergus Estuaries SPA	International	Direct habitat loss/ Pollution	Refer to NIS	Refer to NIS	Refer to NIS	Refer to NIS	Refer to NIS	Refer to NIS
	Ballylongford Bay NHA	National	Pollution	Refer to Chapter 06	Refer to Chapter 06	Refer to Chapter 06	Refer to Chapter 06	Refer to Chapter 06	Refer to Chapter 06
	Other National Sites	National	Not significant	Not significant	Not significant	N/A	N/A	N/A	N/A
Habitats	Wet grassland GS4	Local importance (Lower value)	Direct habitat loss	Local	None	N/A	Yes	Local	Local
	Improved Agricultural grassland GA1	Local importance (Lower value)	Direct habitat loss	Local	None	N/A	Yes	Local	Local
	Hedgerows WL1/ Treelines WL2	Local importance (Higher value)	Direct habitat loss	Local	None	N/A	Yes	Local	Local

Feature		Highest Value within Zone of Influence	Potential Construction Phase impacts	Significance of Potential Construction-Phase Impact	Potential Operational Phase impacts	Significance of Potential Operational-Phase Impact	Mitigation Proposed	Residual Impact Significance (Construction and Operation)	Cumulative Residual Impact Significance
	Sedimentary Sea Cliffs CS3	International importance	Direct habitat loss	Local	None	N/A	No	Local	Local
	Scrub WS1	Local importance (Higher value)	Direct habitat loss	Local	None	N/A	Yes	Local	Local
	Eroding River FW1	Local importance (Higher value)	Pollution	Local	Not significant	N/A	Yes	Not significant	Not significant
	Drainage ditches FW4	Local importance (Lower value)	Direct habitat loss/ Pollution	Local	Pollution	Local	Yes	Local	Local
Fauna	Badger	Local Importance (Higher Value)	Mortality or injury Disturbance/ Displacement/ Loss of foraging habitat/ territory	Local	Disturbance/ displacement from noise and lighting	Local	Yes	Local	Not significant
	Bats (Common Pipistrelle, Soprano Pipistrelle, Leisler)	Local Importance (Higher Value)	Loss of foraging habitat/ Habitat fragmentation/ Disturbance/ Displacement	Local	Disturbance/ displacement from noise and lighting	Local	Yes	Local	Not significant
	Otter	Local Importance (Higher Value)	Loss of foraging habitat/ Disturbance/ Displacement	Local	Disturbance/ displacement from noise and lighting	Local	Yes	Not significant	Not significant

Feature		Highest Value within Zone of Influence	Potential Construction Phase impacts	Significance of Potential Construction-Phase Impact	Potential Operational Phase impacts	Significance of Potential Operational-Phase Impact	Mitigation Proposed	Residual Impact Significance (Construction and Operation)	Cumulative Residual Impact Significance
	Hedgehog, Irish Hare	Local importance (Lower value)	Loss of habitat/ Disturbance/ Displacement	Local	Disturbance/ displacement from noise and lighting	Not significant	Yes	Not significant	Not significant
Amphibians	Common Frog	Local importance (Higher Value)	Mortality or injury during vegetation clearance/ Habitat loss	Local	None	Not significant	Yes	Not significant	Not significant
Birds	Red list bird species (Terrestrial) (Meadow Pipit, Merlin, Stock Dove, Quail)	Local importance (Higher Value)	Mortality or injury, Disturbance/ displacement Direct loss of breeding/foragin g habitat	Local	Disturbance/ displacement	Local	Yes	Local	Not significant
	Amber list bird species (Several)	Local importance (Higher Value)	Mortality or injury Disturbance/ displacement Direct loss of breeding/ foraging habitat	Local	Disturbance/ displacement	Local	Yes	Local	Not significant
	Other breeding birds	Local importance (Higher Value)	Mortality or injury Disturbance/	Local	Disturbance/ displacement	Local	Yes	Local	Not significant

Feature		Highest Value within Zone of Influence	Potential Construction Phase impacts	Significance of Potential Construction-Phase Impact	Potential Operational Phase impacts	Significance of Potential Operational-Phase Impact	Mitigation Proposed	Residual Impact Significance (Construction and Operation)	Cumulative Residual Impact Significance
	(Green list species)		displacement Direct loss of breeding/ foraging habitat						
	Annex I species (Great Northern Diver, Red-throated Diver, Little Egret, Golden Plover, Sandwich Tern)	County importance	Disturbance/ displacement Direct loss of foraging habitat/ Pollution	County	Disturbance/ Displacement/ Collision mortality/ Pollution (reduction in prey availability)	County	Yes	County	Not significant
	SCI birds (River and River Fergus Estuaries SPA	Local importance (Higher Value)	Disturbance/ displacement Direct loss of foraging habitat/ Pollution (reduction in prey availability)	International	Disturbance/ Displacement/ Collision mortality/ Pollution (reduction in prey availability)	International	Yes	Not significant	Not significant
	Non-SCI estuarine birds	Local importance (Higher value)	Displacement Direct loss of foraging habitat/ Pollution (reduction in prey availability)	Local	Disturbance/ Displacement/ Collision mortality/ Pollution	Local	Yes	Local	Not significant

Feature		Highest Value within Zone of Influence	Potential Construction Phase impacts	Significance of Potential Construction-Phase Impact	Potential Operational Phase impacts	Significance of Potential Operational-Phase Impact	Mitigation Proposed	Residual Impact Significance (Construction and Operation)	Cumulative Residual Impact Significance
					(reduction in prey availability)				
Aquatic species	Fish (Including Stickleback, Eel, Stone Loach)	Local importance (Higher value)	Pollution	Local	Pollution	Not significant	Yes	Not significant	Not significant
	Invertebrates	Local importance (Lower value)	Pollution	Local	Pollution	Not significant	Yes	Not significant	Not significant
Other species		Negligible	None	Not significant	None	N/A	N/A	N/A	N/A

7B.10 Summary

The impacts on the ecological environment as a result of the Proposed Development are summarised as follows:

The terrestrial elements of the Proposed Development overlap with the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA. Following mitigation, there will be no adverse impacts on designated sites overlapping with the terrestrial elements of the project. The OCEMP implemented by the Contractor will contain the industry standards and appropriate measures regarding pollution prevention;

Semi-natural habitats within the Proposed Development site will be removed. While replacement habitat will be provided with the Proposed Development site boundary including native woodland, scrub and grassland areas, overall there will be a net loss of semi-natural habitats at the Proposed Development site.

No invasive species were recorded within the Proposed Development site.

No bats were identified roosting in buildings or trees within the Proposed Development site. Three species of foraging and commuting bats were identified using semi-natural habitat, mainly hedgerows. No light sensitive Myotis species were recorded. Lighting design and replacement tree planting will be implemented to minimise impacts on bats.

Two Badger setts will be removed from the Proposed Development site during construction. These are outlier setts and while two Badger social groups will be impacted, Badger are likely to remain extant during operation. However, it is probable that 25% of the feeding territory of both feeding groups will be impacted by the Proposed Development and this reduction in territory size is likely create a contraction in the size of both social groups.

Otter was not recorded within the Proposed Development site, but regularly use areas to the west of the Proposed Development site as well as the Shannon Estuary. Mitigation and design measures will be implemented to ensure that Otter continue to use the site following development including allowing access for Otter (and other species) under the jetty and the retention of habitats to the west of the Proposed Development site will continue to provide habitat for this species.

The site currently includes low value habitat for breeding birds, including a number of birds of conservation concern. Timing of vegetation removal will be scheduled to avoid impacts to breeding birds, whilst replacement planting will reduce the impacts to breeding and nonbreeding birds within the site.

The River Shannon and River Fergus Estuaries SPA supports internationally important numbers of wintering waterbirds. However, the area of the SPA within the Proposed Development site boundary and the SPA to the north of the Proposed Development site, support very small numbers of SCI and non-SCI bird species. While disturbance, particularly piling and blasting, during construction may disturb/ displace a small number of birds in the vicinity of offshore works, there will be no adverse impact to bird numbers within the SPA during construction or operation.

Common Frog has previously been recorded in wet grassland habitat within the Proposed Development site. Wet grassland habitat at the site will be removed. Mitigation measures including removal of this species under licence have been outlined to avoid direct mortality impacts to Common Frog.

No rare invertebrate species were recorded at the Proposed Development site.

A slight County impact on Annex I diving birds i.e. Red-throated Diver and Great Northern Diver is predicted to occur. Assuming successful implementation of mitigation measures as outlined above, all other impacts will not be significant above Local geographic scale of significance.

Table 7B-16 Summary

Proposed Development Stage	Aspect/ Impact Assessed	Existing Environment/ Receptor Sensitivity	Effect/ Magnitude	Significance (Prior to Mitigation)	Mitigation and Monitoring Measures (the Proposed Development design embedded environmental controls and all mitigation and monitoring measures detailed herein are included in the OCEMP)	Residual Impact Significance	EIAR Chapter Reference
Construction	General mitigation and monitoring measures	Low	Not assessed	Not assessed	An OCEMP has been prepared (included in Appendix A2-4 of Volume 4). The OCEMP contains the construction mitigation and monitoring measures, which are set out in this EIAR and the NIS. This will have particular emphasis on the protection of habitats and species of the cSAC, SPA and pNHA which adjoin the Proposed Development site. These sites are by definition internationally/ nationally important for their habitats and the species they support. It is essential that all construction staff, including all sub-contracted workers, be notified of the boundaries of these Natura 2000 sites and be made aware that no construction waste of any kind (rubble, soil, etc.) is to be deposited in these protected areas and that care must be taken with liquids or other materials to avoid spillage. Mitigation and monitoring measures (of relevance in respect of any potential ecological effects) will be implemented throughout the project, including the preparation and implementation of detailed method statements. The works will incorporate the relevant elements of the guidelines outlined below: • *Control of water pollution from construction sites. Guidance for consultants and contractors (C532). CIRIA.* Masters-Williams et al (2001); and • *Control of water pollution from linear construction projects. Technical guidance (C648). CIRIA.* Murnane, *et al.* (2006). All personnel involved with the Proposed Development will receive an onsite induction relating to construction and operations and the environmentally sensitive nature of European sites and to re-emphasise the precautions that are required as well as the precautionary measures to be implemented. Site managers, foremen and workforce, including all subcontractors, will be suitably trained in pollution risks and preventative measures. All staff and subcontractors have the responsibility to: • Work to agreed plans, methods and procedures to eliminate and minimise environmental impacts; • Understand the importance of avoiding pollution onsite, including noise and dust, and how to respond in the event of an incident to avoid or limit environmental impact; • Respond in the event of an incident to avoid or limit environmental impact; • Report all incidents immediately to the project manager and the Environmental (Ecological) Clerk of Works (ECoW); • Monitor the workplace for potential environmental risks and alert the site manager if any are observed; and • Co-operate as required, with site inspections.	Not significant	
Construction	Bridge and culvert construction	Medium	Culverting of two drainage ditches and bridging of Ralappane Stream	Moderate	Bridge construction on the Ralappane Stream will use a single span, pre-cast concrete bridge near the southern boundary of the Proposed Development site. Two drainage ditches within the Proposed Development site will be culverted. In addition to the general measures described above, the following specific mitigation measures will be implemented for crossing of the Ralappane Stream and drainage ditch: • Works will comply with The IFI's Guidelines on protection of fisheries during construction works in and adjacent to waters (IFI, 2016); • No instream works will take place in the Ralappane Stream; • Appropriate silt control measures such silt barriers (e.g. straw or silt fence) will be employed where required; • Construction activities will be undertaken during daylight hours only. This will ensure that there is potential for undisturbed fish passage at night. The works will be temporary and will not create a significant long-term barrier to fish movement; • An appropriate native grass seed mix as determined by the ECoW based on ground conditions, will be utilised to re-vegetate any disturbed areas along the bank of the Ralappane Stream; and	Not significant	7B

					• Although no Common Frog were observed in drainage ditches within the Proposed Development site boundary, they will be surveyed prior commencement of site works by the ECoW as a precautionary measure. Any Common Frog, if recorded, will be moved to suitable habitat in the wider landscape under licence from NPWS.		
Construction	Lighting	Medium	Disturbance and/ or displacement of sensitive fauna	Moderate	Lighting associated with the site works could cause disturbance/ displacement of fauna. If of sufficient intensity and duration, there could be impacts on reproductive success. Site lighting will typically be provided by tower mounted temporary portable construction floodlights. The floodlights will be cowled and angled downwards to minimise spillage to surrounding properties. Lighting mitigation measures will follow Bats & Lighting Guidance Notes for: Planners, engineers, architects and developers (Bat Conservation Ireland, 2010). The following measures will be applied in relation to construction works lighting: • Lighting will be provided with the minimum luminosity necessary for safety and security purposes. Where possible, lighting will be restricted to the working area and using the cowl and angling noted above, will minimise overspill and shadows on sensitive habitats outside the construction area and • During construction, lighting will be positioned and directed so that it does not to unnecessarily intrude on adjacent ecological receptors and structures used by protected species. The primary area of concern is the potential impact at the cSAC/ SPA boundary, the Ralappane Stream as well as hedgerows, treelines. With the exception of the jetty dock, there will be no directional lighting focused towards these areas and cowling and focusing lights downwards will minimise light spillage.	Slight	7B
Construction	Habitats	Medium	Removal of habitat	Slight to moderate	The Wildlife Act 1976, as amended, provides that it is an offence to cut, grub, burn or destroy any vegetation on uncultivated land or such growing in any hedge or ditch from 1st March to 31st August. Exemptions include the clearance of vegetation in the course of road or other construction works or in the development or preparation of sites on which any building or other structure is intended to be provided. If works are carried out during the breeding season, a pre-construction survey will be carried out by the ECoW and if birds are detected appropriate mitigation measures will be implemented. Where possible, vegetation will be removed outside of the breeding season and in particular, removal during the peak-breeding season (April-June inclusive) will be avoided. This will also minimise the potential disturbance of breeding birds outside of the Proposed Development site boundary. Particular care will be taken at the boundary between the Proposed Development site and the cSAC, SPA and pNHA so that construction activities do not cause damage to habitats in this area. These habitats will be securely fenced off early in the construction phase. The fencing will be clearly visible to machine operators. The Ralappane Stream runs from the Proposed Development site through the cSAC and pNHA to the sea, it is important that construction activities do not result in pollution of this watercourse, either through siltation, which interferes with water flow, vegetation growth and aquatic fauna, or pollution (e.g. chemical). Refer to Chapter 06 Section 6.10 for further details on mitigation. Any disturbance to cliff habitat from vehicular access should be minimised and will require a detailed method statement which will be agreed with the NPWS prior to commencement of works To prevent incidental damage by machinery or by the deposition of spoil during site works, hedgerow, tree and scrub vegetation which are located in close proximity to working areas will be clearly marked and fenced off to avoid accidental damage during excavations and site preparation. The ECoW will specify appropriate protective fencing where required. Habitats that are damaged and disturbed will be reinstated and landscaped once construction is complete. Disturbed areas will be seeded or planted using appropriate native grass or species native to the areas where necessary. Natural regeneration of vegetation will also occur. There will be a defined working area which will be fenced off with designated haul routes to prevent inadvertent damage to adjoining habitats. Tree root systems can be damaged during site clearance and groundworks. Materials, especially soil and stones, can prevent air and water circulating to the roots. No materials will be stored within the root protection area/ dripline of trees. The ECoW will specify appropriate protective fencing where required.	Not significant to slight	7B
Construction	Badger	Medium	Sett removal/mortality/injury disturbance and/displacement	Significant	This will require exclusion of Badgers from subsidiary/ outlier setts, however in both instances both social groups of Badgers would be expected to continue to use their main setts.	Significant	7B

Badger sett tunnel systems can extend up to approximately 20 m from sett entrances. Therefore, no heavy machinery should be used within 30 m of Badger setts (unless carried out under licence); lighter machinery (generally wheeled vehicles) should not be used within 20 m of a sett entrance; light work, such as digging by hand or scrub clearance should not take place within 10m of sett entrances.

During the breeding season (December to June inclusive), none of the above works should be undertaken within 50 m of active setts nor blasting or pile driving within 150m of active setts.

Affected Badger setts will be clearly marked and the extent of bounds prohibited for vehicles clearly marked by fencing and signage.

The most recent surveys show that the two main Badger setts are located outside of the Proposed Development site boundary and the two setts to be directly affected are subsidiary setts. The bait marking survey indicates that the setts are linked as follows:

Sett 4 (main sett) is located to the east of the Proposed Development. Sett 1 is located within the Proposed Development site boundary. These setts are used by the same social group.

Sett 3 (main sett) is located to the east of the Proposed Development. Sett 2 is located within the Proposed Development site boundary. These setts are used by the same social group.

The presence of alternative setts within the particular social group’s territory is required to ensure that excluded Badgers are able to relocate to a suitable alternative refuge. The objective is to allow the Badgers to remain within their territory, even though a portion of their current territory may be lost as a result of a particular development. There is a standard methodology which can be utilised to exclude Badgers from setts

A methodology for the exclusion of Badgers from affected setts and displacement of Badgers to artificial setts is outlined in the National Roads Authority publication Guidelines for the Treatment of Badgers Prior to the Construction of National Road Schemes (NRA 2005a). Detailed mitigation measures including method statements will be agreed with the NPWS prior to implementation as part of a licence application.

Exclusion of Badgers from any currently active sett will only be carried out during the period of July to November (inclusive) in order to avoid the Badger breeding season.

In the instance of disused setts or setts verified as inactive, and to prevent their reoccupation, the entrances may be lightly blocked with vegetation and a light application of soil (soft blocking). The purpose of soft-blocking is to confirm that an apparently inactive sett is not occupied by Badgers. If all entrances remain undisturbed for approximately five days, the sett should be destroyed immediately using a mechanical digger, under the supervision of the licensee. Should there be any delay in sett destruction, the soft-blocked entrances should be hard-blocked and the sett destroyed as soon as possible, again under the supervision of the licensee. Hard-blocking is best achieved using buried fencing materials and compacted soil with further fencing materials laid across and firmly fixed to blocked entrances and surrounds

Where field signs or monitoring reveal any suggestion of current or recent Badger activity at any of the sett entrances, the sett requires thorough evacuation procedures.

Inactive entrances may be soft and then hard-blocked, as described for inactive setts, but any active entrances should have one-way gates installed (plus proofing around sides of gates as illustrated) to allow Badgers to exit but not to return. The gates should be tied open for three days prior to being set to exclude. Sticks should be placed at arm’s length within the gated tunnels to establish if Badgers remain within the sett.

Gates should be left installed, with regular inspections, over a minimum period of 21 days (including period with gates tied open) before the sett is deemed inactive. Any activity at all will require the procedures to be repeated or additional measures taken. Gates might be interfered with by other mammals or members of the public - hence the importance of regular exclusion monitoring visits. Sett destruction should commence immediately following the 21-day exclusion period, provided that all Badgers have been excluded.

Badgers will often attempt to re-enter setts after a period, and if gates are left in place for any long period, they may attempt to dig around them or even create new entrances and tunnels into the sett system.

Where an extensive sett is involved, an alternative method of evacuating Badgers is to erect electric fencing around the sett (ensuring all entrances are included) with one-way Badger-gates installed within the electric fence at points where the fence crosses Badger paths leading to and from the sett. The exclusion should again take place over a minimum period of 21 days before sett destruction; this monitoring period would be contingent upon no Badger activity being observed within the fenced area. Fencing may

					not be practical in many situations due to the topography or the terrain – and can be difficult to install effectively. If no activity is observed, then the sett may be destroyed, under supervision by the licensed wildlife expert. The destruction of a successfully evacuated Badger sett may only be conducted under the supervision of qualified and experienced personnel under licence from the NPWS. The possibility of Badgers remaining within a sett must always be considered; suitable equipment should be available on hand to deal with Badgers within the sett or any Badgers injured during sett destruction. Destruction is usually undertaken with a tracked 12-25 tonne digger, commencing at approximately 25 m from the outer sett entrances and working towards the centre of the sett, cutting approximately 0.5 m slices in a trench to a depth of 2 m. Exposed tunnels may be checked for recent Badger activity, with full attention paid to safety requirements in so doing. The sett should be destroyed from several directions, in the above manner, until only the central core of the sett remains. Once it is ensured that no Badgers remain, the core may then also be destroyed and the entire area back-filled and made safe. Sett excavation should, preferably, be concluded within one working day, as Badgers may re-enter exposed tunnels and entrances. A report detailing evacuation procedures, sett excavation and destruction, and any other relevant issues should be submitted to the NPWS, in fulfilment of usual wildlife licence conditions. Construction activities within the vicinity of affected setts may commence once these setts have been evacuated and destroyed under licence from the NPWS. Where affected setts do not require destruction, construction works may commence once recommended alternative mitigation measures to address the Badger issues have been complied with. Badger access points will be provided to allow Badgers to access the development area once complete See (NHBS, 2021 or similar). Gates will be placed within fences along the western, eastern and southern boundaries to maximise potential usage by the different social groups that occur within this area. Monitoring of Badger setts will be carried out during construction works and a five-year post-construction monitoring programme will be implemented.		
Construction	Bats	High	Disturbance/ displacement	Not significant	During the site works, general mitigation measures for bats will follow the National Road Authority's 'Guidelines for the Treatment of Bats during the Construction of National Road Schemes' NRA (2005c) and 'Bat Mitigation Guidelines for Ireland: Irish Wildlife Manuals, No. 25' (Kelleher, C. & Marnell, F. (2006)). These documents outline the requirements that will be met in the pre-construction (site clearance) stage to minimise negative effects on roosting bats, or prevent avoidable effects resulting from significant alterations to the immediate landscape. A Common Pipistrelle colony was recorded in a farm building southwest of the Proposed Development site. This building will not be affected. No bat roosts were recorded within the site boundary. Mitigation measures will be agreed with the National Parks and Wildlife Service prior to any demolition works and will include the following: Two buildings within the Proposed Development site will be demolished as part of the development. No signs of bats were recorded within these buildings. However as a precautionary measure, the following measures will be implemented prior to and/ or during demolition: • In all cases immediately in advance of demolition a bat specialist will undertake an examination of the building. If bats are present at the time of examination it is essential to determine the nature of the roost (i.e. number, species, whether it is a breeding population) as well as its exact location; • If bats are recorded in buildings earmarked for demolition, special mitigation measures to protect bats will be put in place and a license to derogate from the conservation legislation will be sought from the NPWS; • The contractor will take all required measures to ensure works do not harm individuals by altering working methods or timing to avoid bats, if necessary; • If roosting habitat for bats is removed, replacement habitat will be provided; • A number of trees will be removed prior to construction. Although mature trees with the potential of be value as bat roosts are absent from the site, the following precautionary measures will be implemented; • The bat specialist will work with the contractor to ensure that the loss of trees is minimised and that trees earmarked for retention are adequately protected;	Not significant	7B

					• Tree-felling will ideally be undertaken in the period September to late October/ early November. During this period bats are capable of flight and may avoid the risks of tree-felling if proper measures are undertaken; • Felled trees will not be mulched immediately. Such trees will be left lying several hours and preferably overnight before any further sawing or mulching. This will allow any bats within the tree to emerge and avoid accidental death. The bat specialist will be on-hand during felling operations to inspect felled trees for bats. If bats are seen or heard in a tree that has been felled, work will cease and the local NPWS Conservation Ranger will be contacted; • Tree will be retained where possible and no 'tidying up' of dead wood and spilt limbs on tree specimens will be undertaken unless necessary for health and safety; • Treelines outside the Proposed Development area but adjacent to it and thus at risk, will be clearly marked by a bat specialist to avoid any inadvertent damage; • During construction directional lighting will be employed to minimise light spill onto adjacent areas. Where practicable during night-time works, there will be no directional lighting focused towards watercourses or boundary habitats and focusing lights downwards will be utilised to minimise light spillage; • If bats are recorded by the bat specialist within any trees no works will proceed without a relevant derogation licence from the NPWS; and • As a biodiversity enhancement measure it is proposed that bat boxes will be put up within the Proposed Development site. It is proposed that eight bat boxes will be located within the overall site. The boxes will be erected by the ECoW taking into account landscape plans, vehicle movements and lighting. As noted in 7.5.1.5, lighting mitigation measures will follow Bats & Lighting Guidance Notes for: Planners, engineers, architects and developers (Bat Conservation Ireland, 2010). All mitigation measures including detailed method statements will be agreed with the NPWS prior to commencement of works, which could affect any bat populations onsite.		
Construction	Otter	Medium	Disturbance/ displacement	Not significant	No signs of Otter or Otter holts were noted within 150 m of the Proposed Development site. Although Otter were recorded along the Ralappane Stream and to the west of the Proposed Development site. A detailed pre-construction survey will be carried out no more than 10-12 months prior to the commencement of construction works to confirm the absence of Otter holts within 150m of the site. If Otter holts are recorded at that time, the ECoW will determine the appropriate means of minimising effects i.e. avoidance, moving works, timing of works etc. If required the ecologist will obtain a derogation licence from the NPWS, to facilitate licenced exclusion from the breeding or resting site in accordance with a plan approved by the NPWS. Any holts found to be present will be subject to monitoring and mitigation as set out in the NRA publication Guidelines for the Treatment of Otter prior to the Construction of National Road Schemes (2008). If found to be inactive, exclusion of holts may be carried out during any season. No wheeled or tracked vehicles (of any kind) will be used within 20m of active, but non-breeding, Otter holts. Light work, such as digging by hand or scrub clearance will also not take place within 15m of such holts, except under licence. The prohibited working area associated with Otter holts will be fenced and appropriate signage erected. Where breeding females and cubs are present no evacuation procedures of any kind will be undertaken until after the Otters have left the holt, as determined by the ECoW. Breeding may take place at any season, so activity at a holt must be adjudged on a case-by-case basis. On occasion, Otter holts may be directly affected by the scheme. To ensure the welfare of Otters, they must be evacuated from any holts present prior to any construction works commencing. The exclusion process, if required, involves the installation of one-way gates on the entrances to the holt and a monitoring period of 21 days to ensure the Otters have left the holt prior to removal.	Not significant	7B
Construction	Common Frog	Medium	Habitat loss/ mortality/ injury	Moderate	A visual search of the wet grassland habitat to be removed will be carried out in the days prior to commencement of development and any frogs will be removed to alternative wet grassland habitat elsewhere within the landholding. This will be carried out under licence from the NPWS.	Not significant	7B
Construction	Birds	Medium	Habitat loss/ mortality/ injury Mortality or injury, Disturbance/ displacement Direct loss of breeding/ foraging habitat	Not significant to moderate	No signs of nesting birds were recorded in disused farm buildings during the 2018-2021 surveys. However, prior to demolition buildings will be checked for nesting Swallows (and other birds). If nesting birds are recorded, all demolition operations will be carried out between October and March, when birds have finished breeding. As noted in Section 7.7.1.6, where possible, vegetation will be removed outside of the breeding season and in particular, removal during the peak-breeding season (April-June	Not significant	7B

					inclusive) will be avoided. This will also minimise the potential disturbance of breeding birds outside of the Proposed Development site boundary. As a biodiversity enhancement measure ten bird nesting boxes (various types) will be located within the Proposed Development site boundary at locations specified by the ECoW. It is noted that provision of woodland planting and the use of more diverse grassland planting will provide additional nesting and feeding sites for birds, particularly as these habitats mature. A detailed method statement will be drawn up by the ECoW and agreed with the NPWS prior to commencement of works. The method statement will specify the timing of blasting operations and the need, if any, for ecological supervision. As noted in Chapter 07A Section 7.7.2 a soft-start will be required for piling works or any source, including equipment testing, exceeding 170 dB re: 1μPa @1m an appropriate ramp-up procedure (i.e. 'soft-start') must be used. This should be a minimum of 20 minutes and no longer than 40 minutes.		
Construction	Biodiversity and landscaping	Low	Habitat loss	Slight positive	Details of the landscaping plan for the Proposed Development are included in Figure F2-4 in Volume 3. This includes detailed areas of native woodland and native scrub habitat as well as native grassland planting. The woodland planting mix will be dominated by native species including Scots Pine *Pinus sylvestris*, Willow, Pedunculate Oak *Quercus r*obur and Sessile Oak *Quercus petraea*, Alder, Rowan *Sorbus* spp. and Crab Apple *Malus* spp.. The woodland edge planting mix will include Hazel *Corylus* spp., Hawthorn, Blackthorn, Elder *Sambucus* spp. and Holly *Ilex* spp.. The objective of these elements is to create natural, multi-layered woodland habitat which will be of local ecological value and has the potential to support native flora and fauna. A linear strip of woodland along the southern boundary will help to maintain connectivity (east to west) between habitats in the wider landscape. Additional native specimen trees (Willow, Wild Cherry *Prunus avium*, Rowan, Whitebeam *Sorbus subg*. Aria and Silver Birch) will be planted on peripheral areas such as the road edge and administration area. As detailed in Figure F2-4 in Volume 3 a native wildflower/ grass mix will be utilised to provide a more diverse sward which is of higher ecological value for invertebrates and birds. Perennial Rye Grass or other vigorous amenity/ agricultural grass species will not be utilised as they tend to over-dominate the sward and reduce overall biodiversity. The final grassland/ wildflower mix for same will be specified by the ECoW based on final ground conditions including alkalinity, fertility and moisture levels. Based on the seed mix utilised and on prevailing ground conditions, the ECoW will specify the management regime, including weed control and mowing regime, necessary to maximise biodiversity and habitat value. Five insect nesting boxes suitable for Hymenoptera spp. (bees and wasps) will be put in place within the site boundary as a biodiversity enhancement measure.	Slight positive	7B
Construction	Invasive species	Slight	Loss of habitat for native flora	Not significant	Prior to the commencement of construction works invasive species survey will be undertaken within the Proposed Development boundary by a competent ecologist to determine if invasive species listed under Part 1 of the Third Schedule of S.I No. 477 of 2011 have established in the area in the period between pre-planning and post consent. In the event that invasive species are identified within the works area a site-specific Invasive Species Management Plan will be developed and implemented by a competent specialist on behalf of the Contractor. In addition, in order to comply with Regulations 49 and 50 of the European Communities (Birds and Natural Habitat) Regulations (2011) the appointed Contractor will ensure biosecurity measures are implemented throughout the construction phase to ensure the introduction and translocation of invasive species is prevented. The appointed ECoW will carry out a toolbox talk which will identify invasive species and will also implement biosecurity measures such as the visual inspection of vehicles for evidence of attached plant or animal material prior to entering and leaving the works area.	Not significant	7B
Operation	General	Medium	Displacement/ disturbance	Slight	During the operational phase the site environmental management system will address management of potentially contaminating materials such as fuel, lubricating oils, solvent, etc. and ensure such material is appropriately controlled, in accordance with regulatory requirements and industry best practice. The drainage design for the Power Plant will consider the magnitude of the changes in infiltration and runoff characteristics and the significance of potential impacts at the wetland. Further details on operational water management are included in Chapter 06 – Water. Lighting shall be provided in plant areas where safe access and safe conditions for work activities is required at night. Lighting will also be required on the water around the jetty dock to detect spillage and possibly unauthorized craft. The onshore receiving facilities	Not significant	7B

would have area lighting installed on a down angle to cover the LNG Terminal and Power Plant. The terminals will have a level of lighting sufficient to ensure that all ship/ shore interfaces activities can be safely conducted during periods of darkness. Lighting levels will meet national and international engineering standards as a minimum

The principal mitigation measures required for the development in relation to noise concern selection of equipment, sound containment, and acoustic attenuators, in order to achieve the required limits. The predicted noise levels, as outlined in Chapter 09 – Airborne Noise and Groundborne Vibration are considered to be readily technically achievable using standard methods.

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Appendix 3

Hydrodynamic and Dispersion Modelling

Shannon Technology and Energy Park

Hydrodynamic and dispersion modelling
Of proposed development process and effluent discharges

Produced by

AQUAFACT International Services Ltd

for

Shannon LNG Ltd.

August 2021

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Table of Contents

1 INTRODUCTION

1.1 Background

AQUAFACT International Services Ltd. (AQUAFACT) were commissioned by consultants AECOM on behalf of Shannon LNG Ltd. (Shannon LNG) to undertake a 3D hydrodynamic study of the Shannon Estuary as part of the Environmental Assessment for the Shannon Technology and Energy Park development. The proposed development will be located near Ardmore Point located between Tarbert and Ballylongford in County Kerry.

1.2 General Description

The main components of the Shannon Energy Park are:

LNG Terminal

Power Plant

Gas transmission pipeline

The LNG Terminal will comprise

- A floating storage regasification unit (FSRU), which will have an LNG storage capacity of up to 180,000 m^3. The LNG vaporisation process equipment to regasify the LNG to natural gas shall be on-board the FSRU. The heat for LNG regasification shall be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate. Loading of LNG onto the FSRU shall be via a ship-to-ship transfer from another LNG carrier (LNGC) berthed alongside.
- Jetty and access trestle, with the jetty comprising of an unloading platform, mooring dolphins and breasting dolphins.
- Four tugboats moored on the proposed jetty for FSRU and LNG carrier mooring operations.
- Onshore facilities including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator, fire water system.
- An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, gas metering and pressure control equipment. The AGI facilitates the connection of the LNG terminal to the consented 26km Shannon Pipeline.

The Floating Storage Regassification Unit (FSRU) will be moored at a proposed LNG Jetty in the Shannon Estuary, refer to Figure 1.

The proposed on-shore Power Plant will comprise of:

- A flexible modular power plant design with up to three (3) blocks of Combined Cycle Gas Turbines (CCGT), each block with a capacity of *circa* 200 MW for a total installed capacity of up to 600 MW. The multishaft arrangement of the power plant provides fast acting response with very low minimum stable generation and is ideally suited to support increased intermittent renewable generation.

- Each block shall comprise of two (2) gas turbine generators, two (2) heat recovery steam generators and one (1) steam turbine generator and an air-cooled condenser.
- A 120 MW for 1 hour (120 MWhr) Battery energy storage facility (BESS). Due to its very fast response, the BESS supports intermittent renewable generation.

The hydrodynamic assessment documented herein was carried out with particular reference to possible adverse effects on the local flora and fauna. As part of the LNG development, it is intended to abstract seawater from the estuary, chlorinate that water, utilize the water as a source of heat for the LNG regasification onboard the FSRU, extract heat from the water and finally return the cooler water to the estuary.

For the Terminal Plant sanitary effluent (foul water) will be generated at three locations on the site: the workshop /warehouse building, the nitrogen package control room, and the main control room. For the Power Plant sanitary effluent will be generated at the following locations: the administration building, central control/operations building, storage/workshop/canteen building and each turbine building. All sanitary effluent from the development will be pumped or fall by gravity to a wastewater treatment plant (WWTP) on site, which is common to both the LNG Terminal and the power plant. This foul effluent will undergo secondary treatment and discharge to the Shannon Estuary in a marine outfall located close to the shoreline.

As part of this study, a computer based hydrodynamic and water quality model **Telemac** was used to assess the potential changes in water quality and temperature in the receiving waters due to chlorine residual and heated water discharges from the submarine outfall pipe. The purpose of the model simulations, the results of which are presented in this report, is to examine the dispersion pattern and concentration of the discharges from the outfall and to determine if they satisfy regulatory requirements as set out in the surface water regulations.

A description of the numerical model used to carry out the current study and the process of model calibration, are presented in Chapters 2. The results of the hydrodynamic and solute transport model are presented in Chapter 3. These results are discussed in relation to relevant water quality standards and conclusions based on the water quality model study are drawn and presented in Chapter 4.

Figure 1 Location of proposed LNG Terminal with FSRU near Ardmore Point

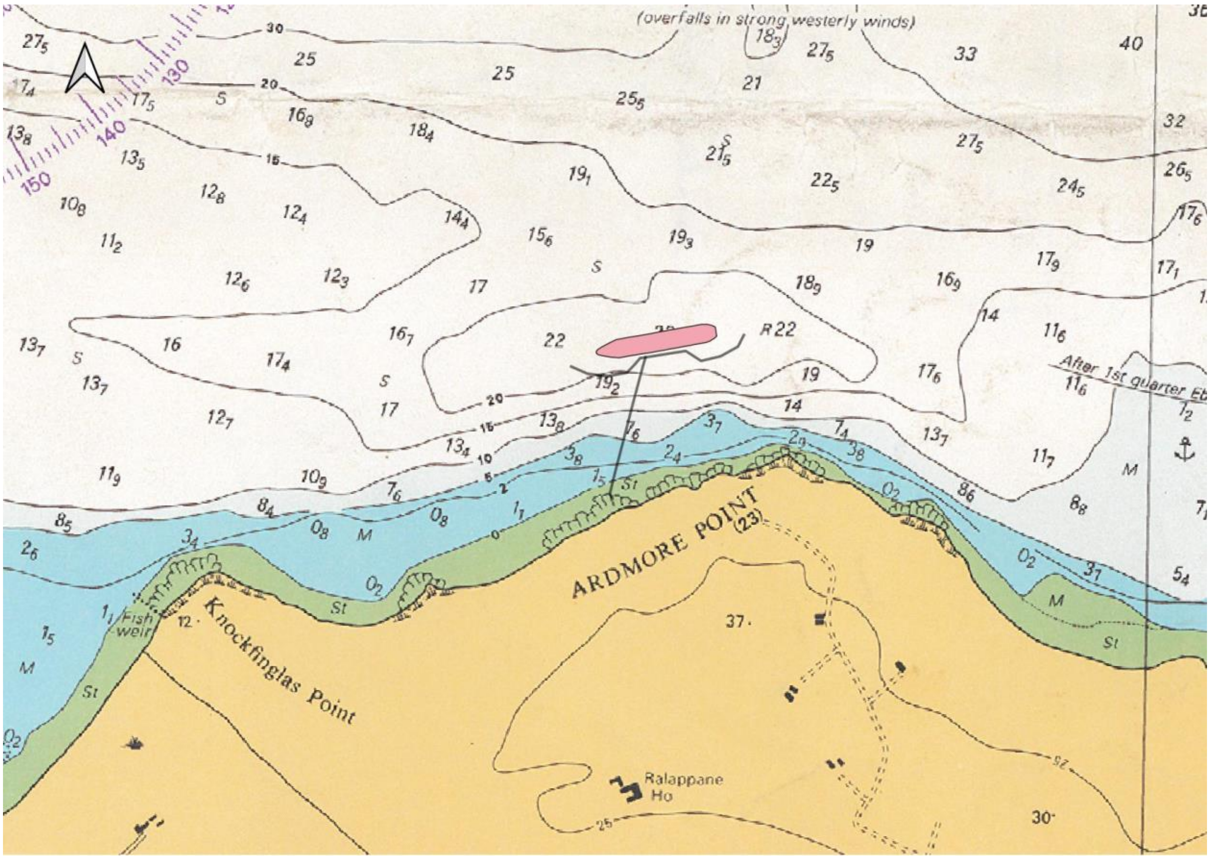

Figure 2 Location of proposed LNG Terminal and FSRU overlain onto admiralty chart

2 MODEL DEVELOPMENT AND HYDRODYNAMICS

2.1 Model Background

The **TELEMAC** system and specifically **Telemac-2D** and **Telemac-3D** modules is the software of choice for modelling the complicated hydrodynamics of the Shannon Estuary off Ballylongford Co. Kerry and particularly given the very high computation refinement required to model accurately the three-dimensional flow in the vicinity of the proposed outfall discharge. **TELEMAC** is a software system designed to study environmental processes in free surface transient flows. It is therefore applicable to seas and coastal domains, estuaries, rivers, and lakes. Its main fields of application are in hydrodynamics, water quality, sedimentology, and water waves.

TELEMAC is an integrated, user friendly software system for free surface waters. TELEMAC was originally developed by Laboratoire National d'Hydraulique of the French Electricity Board (EDF-LNHE), Paris. It is now under the directorship of a consortium of organisations including EDF-LNHE, HR Wallingford, SOGREAH, BAW and CETMEF. It is regarded as one of the leading software packages for free surface water hydraulic applications and with more than 1000 Telemac Installations Worldwide.

The **TELEMAC** system is a powerful integrated modelling tool for use in the field of free-surface flows. Having been used in the context of very many studies throughout the world (several thousand to date), it has become one of the major standards in its field. The various simulation modules use high-capacity algorithms based on the finite-element method. Space is discretised in the form of an unstructured grid of triangular elements, which means that it can be refined particularly in areas of special interest. This avoids the need for systematic use of embedded models, as is the case with the finite-difference method. **Telemac-2D** is a two-dimensional computational code describing the horizontal velocities, water depth and free surface over space and time. In addition, it solves the transport of several tracers which can be grouped into two categories, active and passive, with salinity and temperature being the active tracers that alter density and thus the hydrodynamics.

Telemac-3D is a three-dimensional computational code describing the horizontal and vertical velocities, water depth and free surface over space and time. In addition, it solves the transport of several tracers which can be grouped into two categories, active and passive, with salinity and temperature being the active tracers that alter density and thus the hydrodynamics. It can be set to solve the barotropic (constant non-varying density conditions) and baroclinic pressure conditions where the active tracers of salinity and temperature influence density. The baroclinic approach is required to model the dispersion of cooled water discharge from the FSRU which initially will sink being denser than the ambient water.

The horizontal coordinates are set as Cartesian Coordinates to Irish OS grid and the vertical coordinates are transformed using a "σ" (sigma) vertical coordinate transformation allowing accurate representation of the vertical water column for representation of surface and bottom boundary processes. The bathymetry specified at every finite element node is referenced to Chart Datum which is c. 3m below OS Malin Datum.

2.2 Model Development

A 2-dimensional depth averaged model of the entire Shannon Estuary from Loop head to Corbally weir was developed previously to provide hydrodynamic input for Oil spill simulation by the Shannon-Foynes Harbour Company. This model was run using **Telemac-2d** and had an unstructured finite element mesh of variable density depending on the geometry requirements, the total number of nodes 10,294 and total finite elements 17,980 (representing an estuarine area of 561km^2).

The hydrodynamic output (time varying horizontal U and V velocities and water depth) from this model was used to drive the flow and elevation boundary conditions in a more refined local 3-D model of the middle estuarine reach. The output was also used to provide initial hydrodynamic conditions within the model domain for the simulation start period. This refined model extends from Kilcredaun Point Co. Clare and Kilconly Point Co. Kerry eastward to Mountshannon Co. Clare and Carraunbaur Pt. Co. Limerick. The computation mesh of the local 3-D model is a variable density mesh ranging in node spacing varying horizontally from 30m to 400m with the more refined 30m meshing being limited to the receiving waters near the outfall and intake locations. The vertical discretisation is 15 equal vertical layers using a sigma transformation relationship. The total node number for the 3D model is 74,475 and the total number of elements is 389,340 (Estuarine area 151km^2 and 1,848 million m^3 below chart datum).

The 3-Dimensional local model was developed using detailed bathymetry survey data obtained from the following sources: Irish Hydrodata, the GSI Infomar lidar seabed data and relevant Admiralty Charts for outside the survey areas. This bathymetry was interpolated and mapped to the finite element mesh nodes using mesh generator software refer to figures 3, 4 and 5.

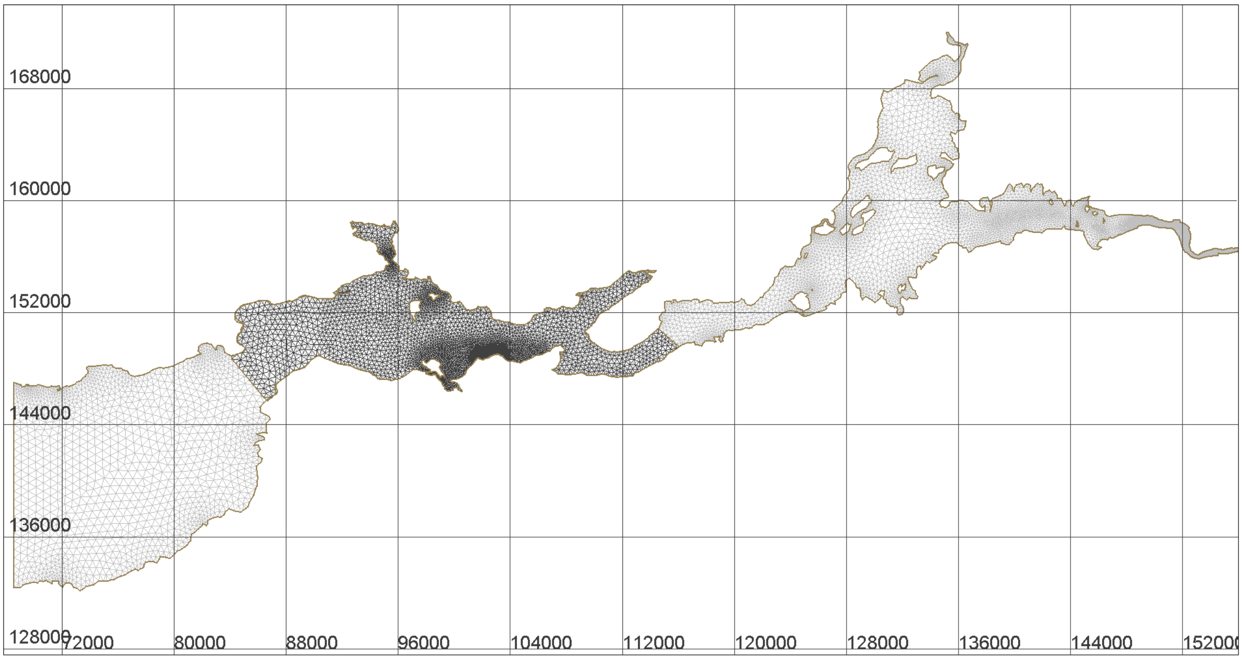

Figure 3 Shannon Estuary and refined LNG model Domain

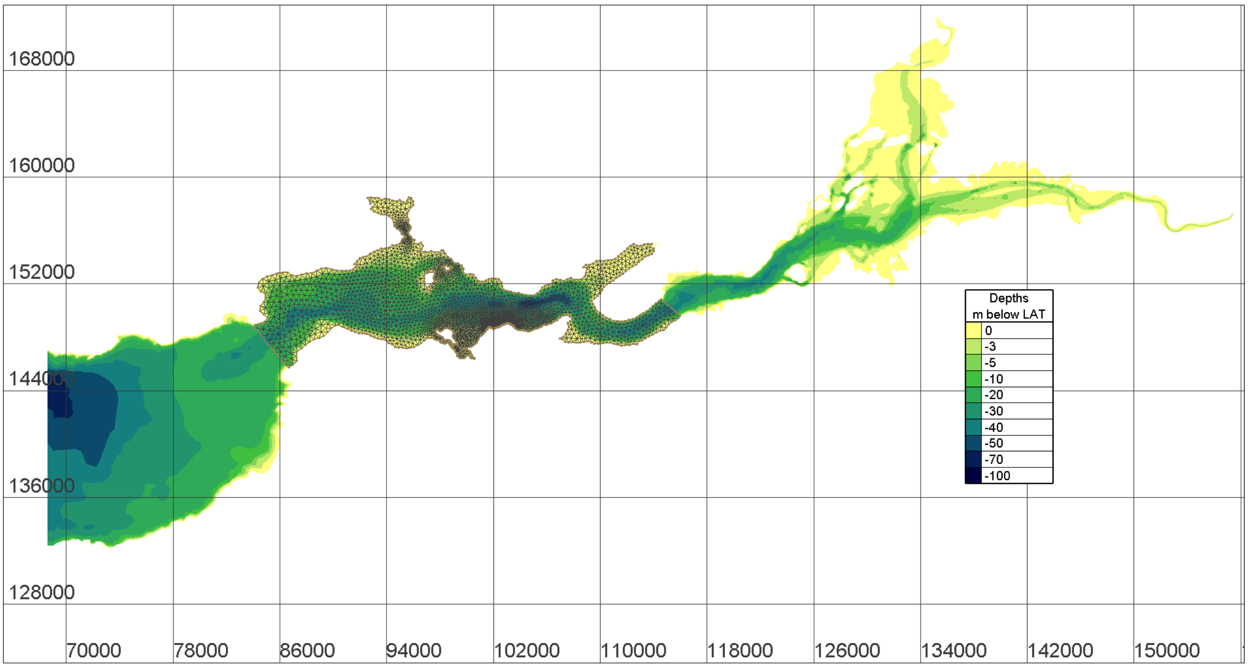

Figure 4 ***Shannon Estuary and refined LNG model Domain***

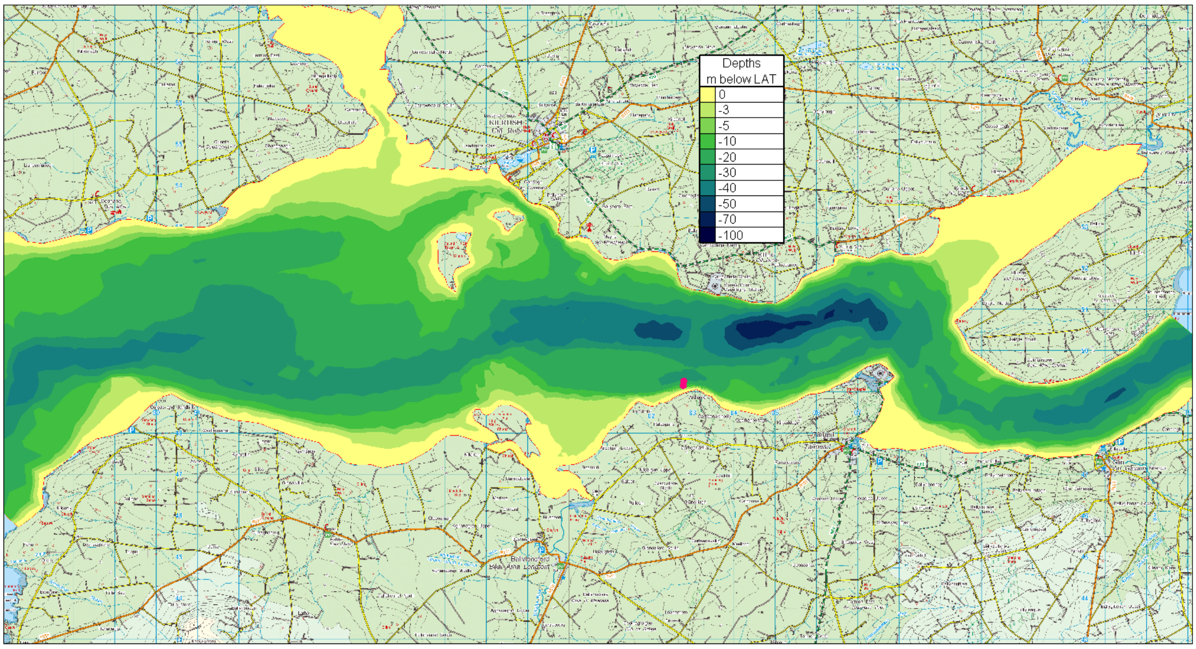

Figure 5 ***Bathymetric Contour Map from GSI lidar, Irish Hydrodata Survey and Admiralty Chart for model Domain.***

Boundary conditions specified are a tidal elevation boundary modelled with a Thompson Radiation condition along the western sea boundary and a flow boundary along the estuarine sea boundary representing the total tidal and fluvial flux from the estuarine area east of the model as computed by the 2-D model of the entire estuary, refer to figure 6. The tidal component of flow through the east boundary far outweighs the fluvial influence from the Shannon and other contributing rivers (Fergus, Maigue, Deal etc.) and is the dominant influence on hydrodynamics in the vicinity of the proposed outfall.

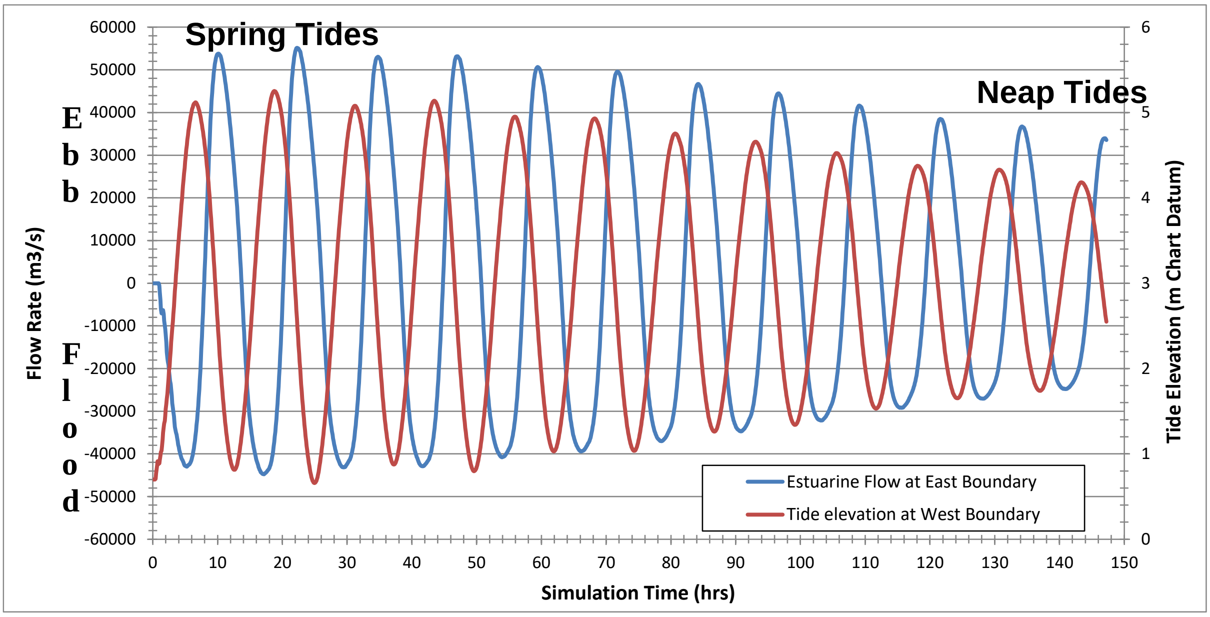

Figure 6 ***Tide and flow boundary hydrographs inputted to 3-D model Simulations***

The first stage consisted of running the hydrodynamic model of the area surrounding Ballylongford to compute the hydrodynamic patterns and tidal elevations within the receiving water for prescribed environmental conditions. The second stage in the study was the calibration of this hydrodynamic model against field data. The solute transport model then uses the output from the hydrodynamic model to compute concentrations of residual chlorine and water temperature.

2.3 Hydrodynamic Simulation Results

The hydrodynamic model was run for mean spring to neap tides to examine the water circulation patterns and the variation of current velocities throughout the receiving estuarine waters. The results from the hydrodynamic model simulations are presented as vertically integrated snapshots in time of velocity vectors at each nodal point of the finite element mesh. The output is presented at eight different stages during the course of spring and neap tidal cycles: (i.e. high water, flood tide flows at 1.5hour intervals, low water and ebb tide flows at 1.5hour intervals). The mean spring and neap tidal ranges specified for these simulation runs were 4.6m and 2.2m respectively.

The current velocities calculated during the tidal cycle are considerably greater on the ebbing (out-going tide) tide than the returning flooding tide, such characteristics are also evident from the Irish Hydrodata 2006 current metering survey. As a result of the smaller tidal range for neaps, the predicted tidal velocities are considerably lower than the corresponding spring tide velocities. The maximum neap tide velocity in the vicinity of the outfall site is approximately 0.6m/s to 0.8m/s (flood and ebb flows), whereas the maximum spring tide velocity is 0.8 to 1.2m/s (flood and ebb flows), refer to Figure 9 (9.1 to 9.8) and 10 (10.1 to 10.8) below. The direction is predominantly rectilinear flowing predominantly east and west across the outfall.

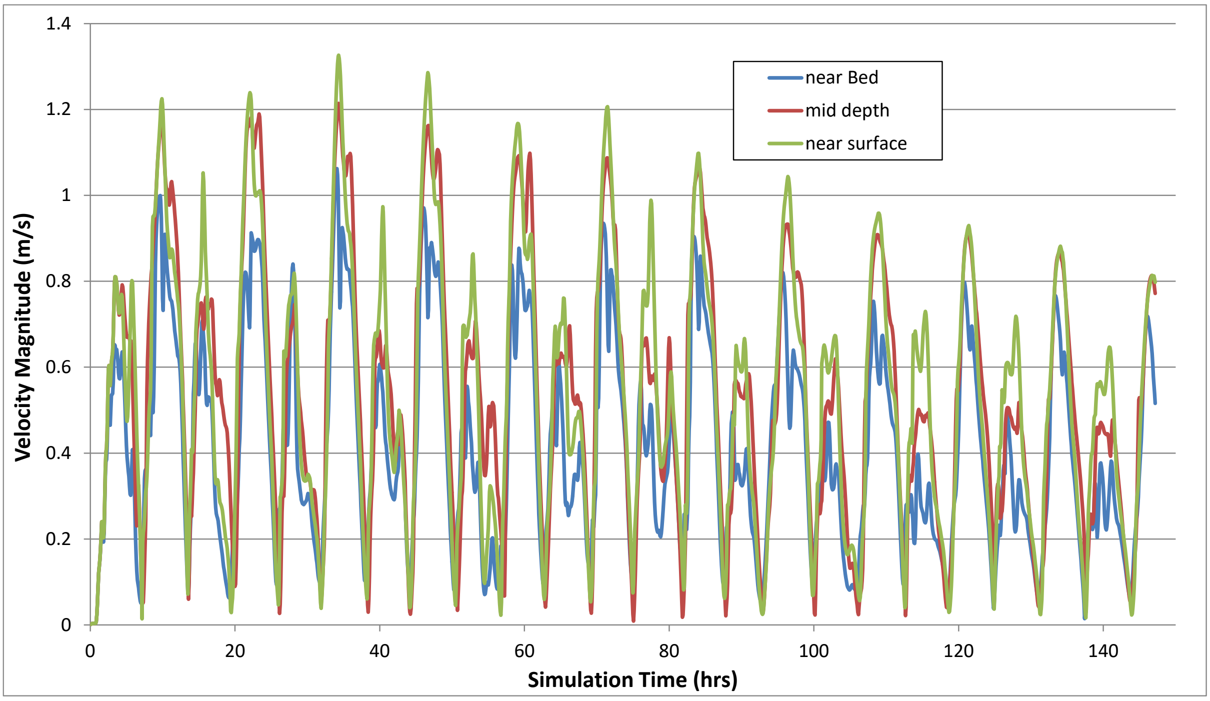

Figure 7 Computed Current Magnitudes at Outfall for layers 2, 6 and 11 (note these compare very well with the Irish Hydro Data 2006 ADCP current Survey information)

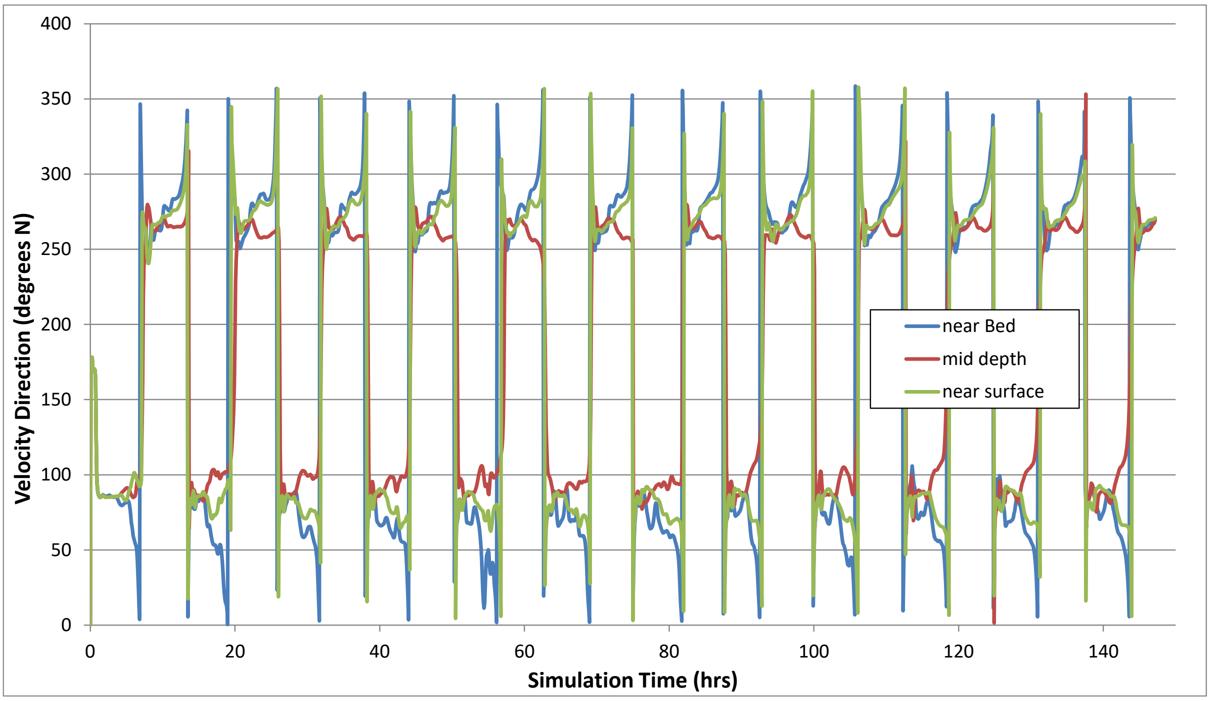

Figure 8 Computed Current Direction at Outfall for layers 2, 6 and 11 (note these compare very well with the Irish Hydro Data 2006 ADCP current Survey information)

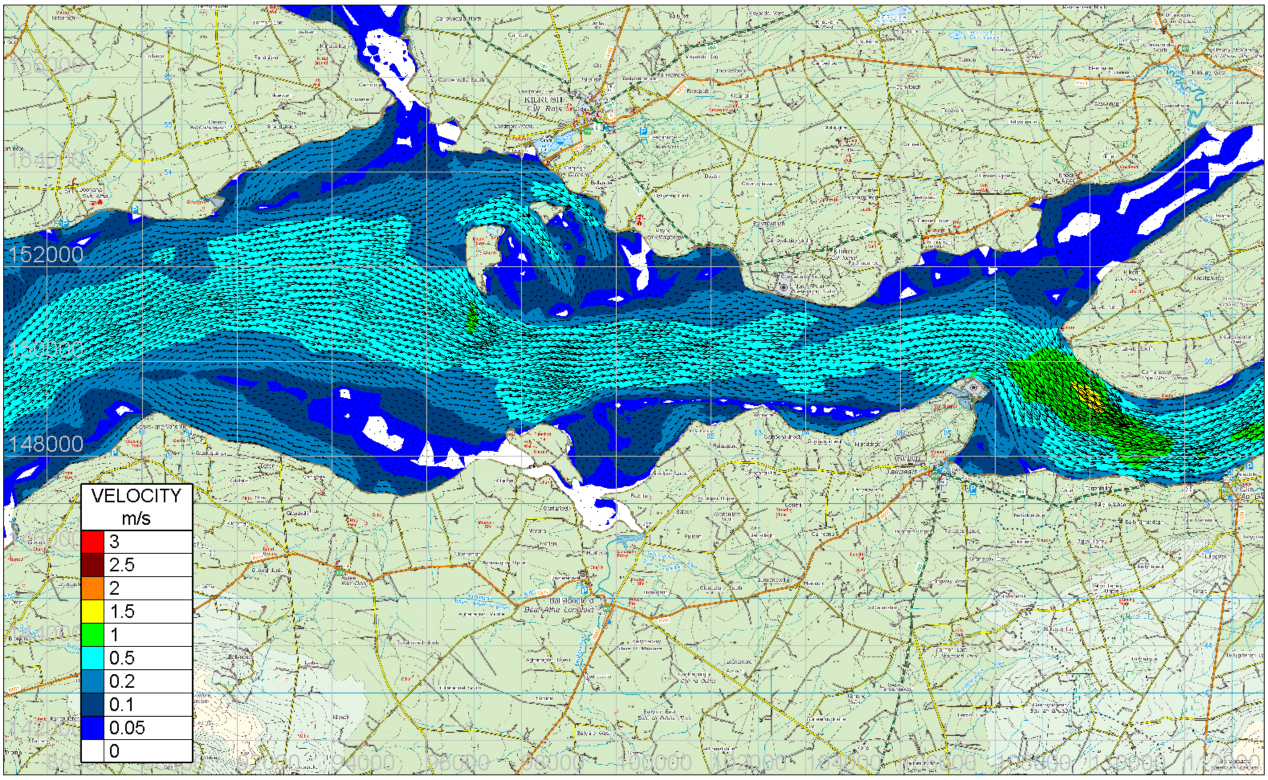

Figure 9.1 Spring tide velocities – High Water (simulation Time 19:00hrs)

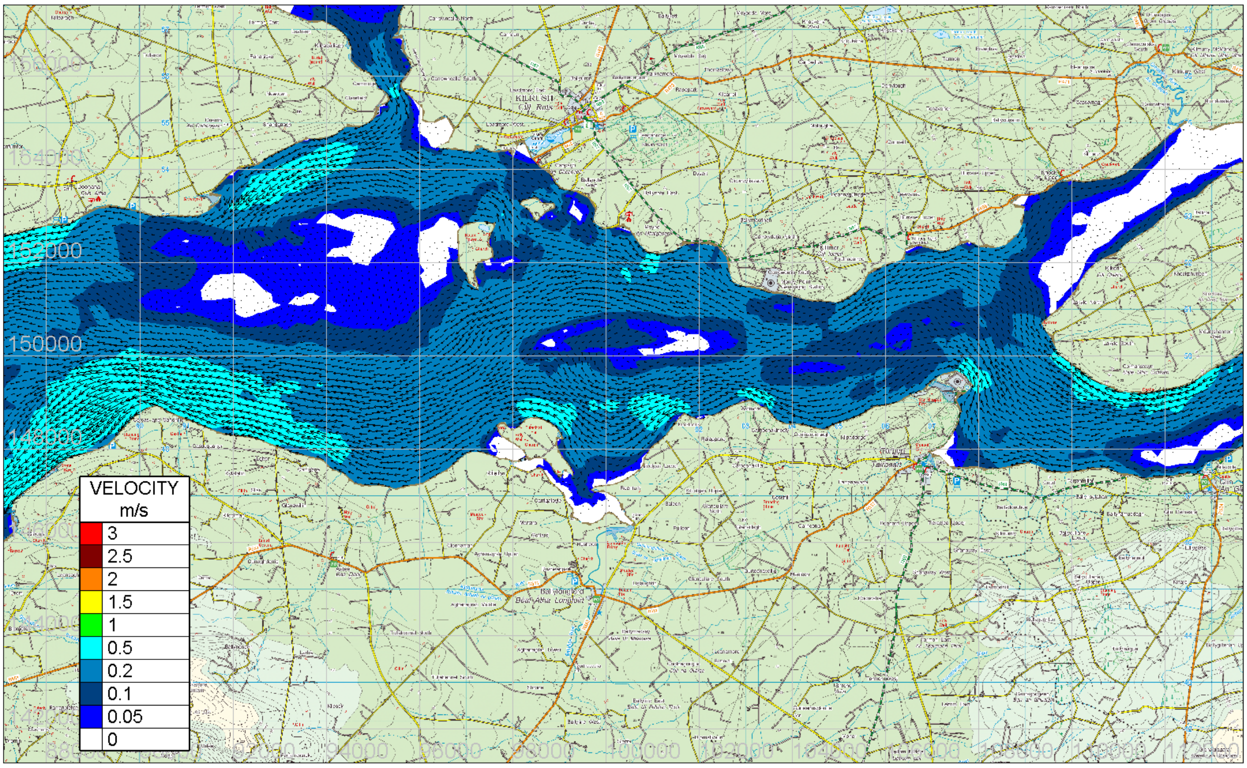

Figure 9.2 Spring tide velocities – 1.55hrs after High Water (simulation Time 20:35hrs)

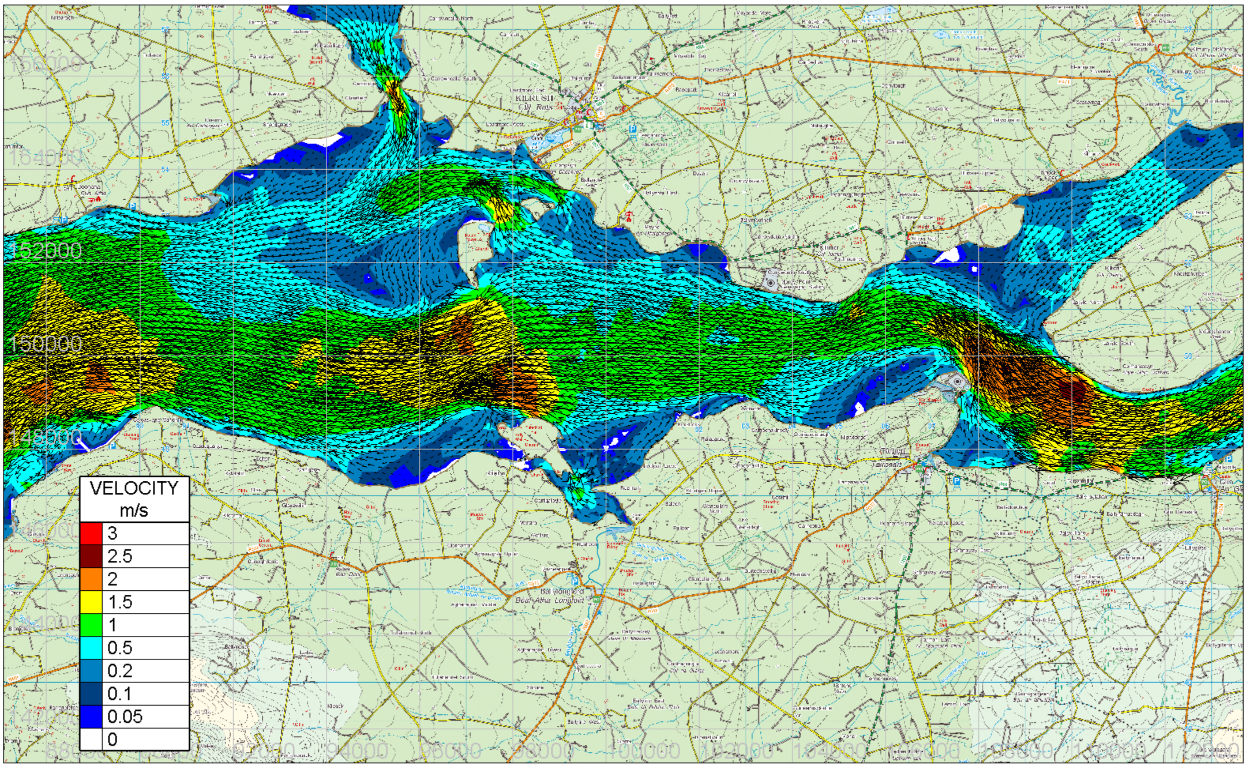

Figure 9.3 Spring tide velocities – Mid-Ebb Flow (simulation Time 22:10hrs)

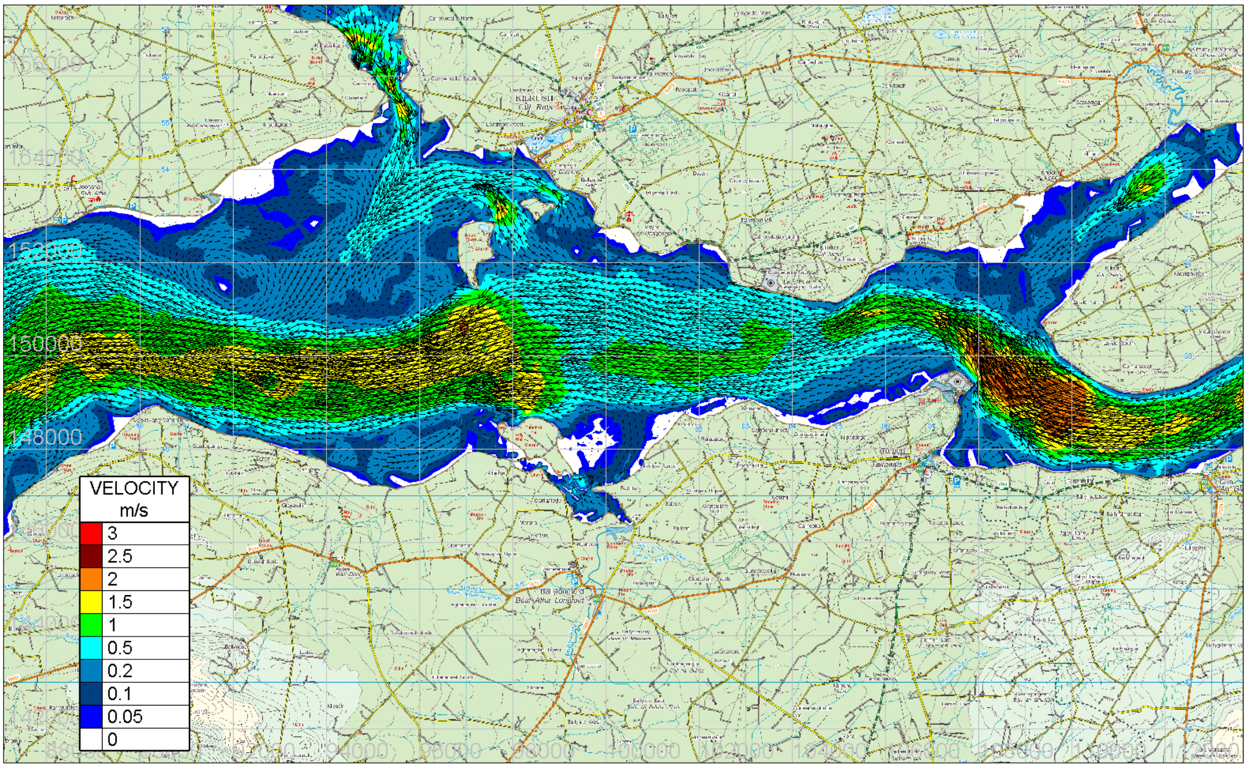

Figure 9.4 Spring tide velocities 1.5hrs before Low Water (Simulation Time 23:40hr)

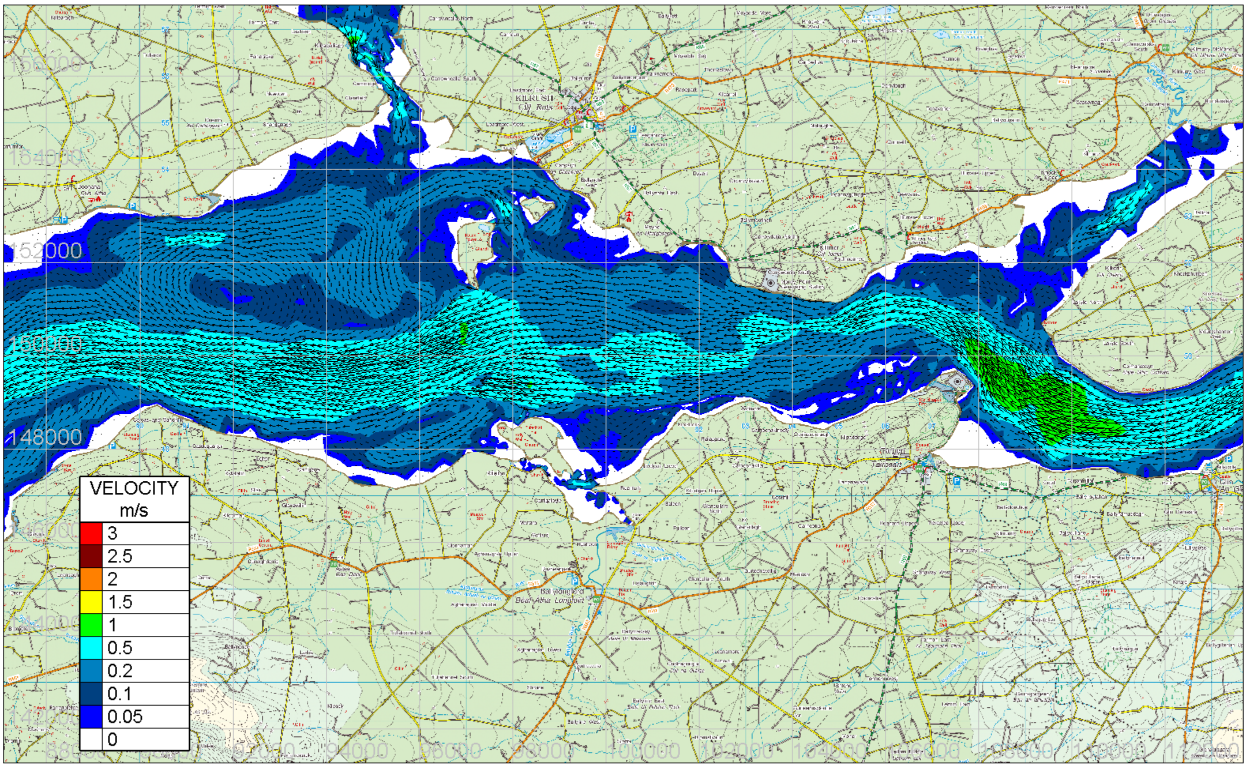

Figure 9.5 Spring tide velocities Low Water (Simulation Time 25:10 hrs)

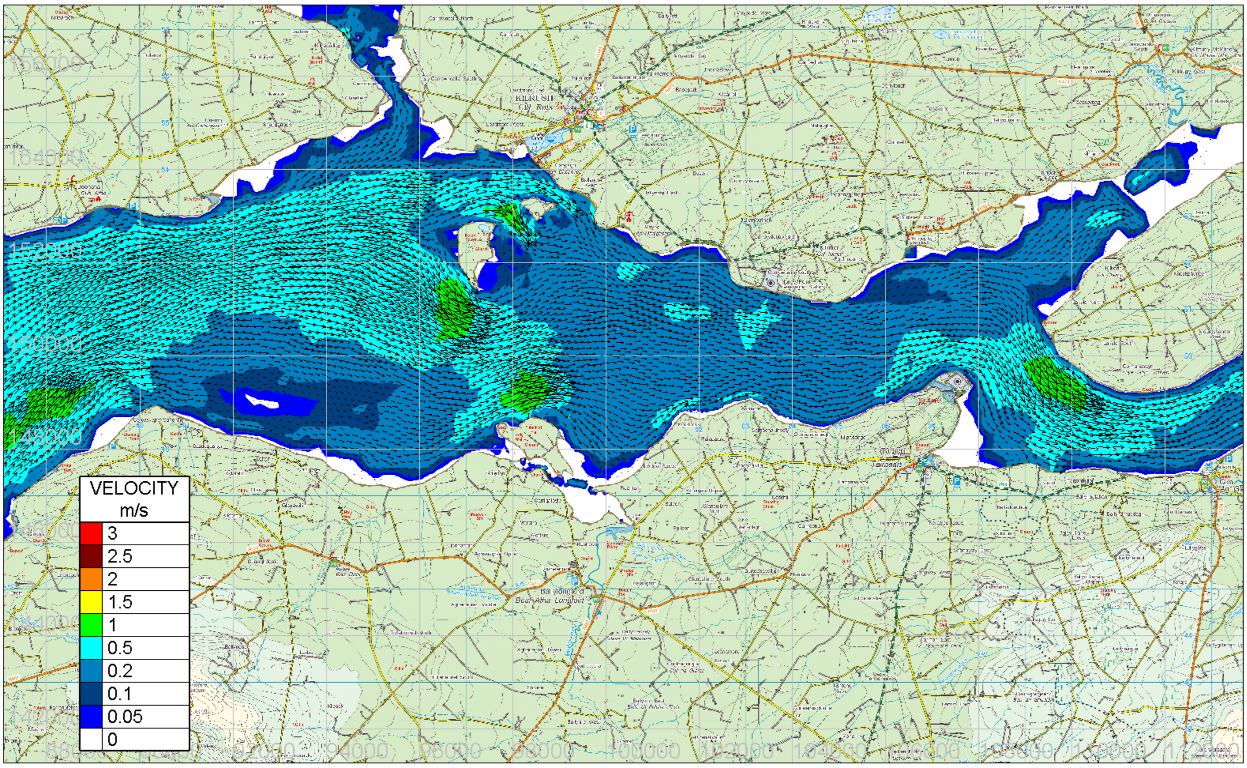

Figure 9.6 Spring tide Velocities 1.5hr after Low Water (Simulation Time 26:40 hrs)

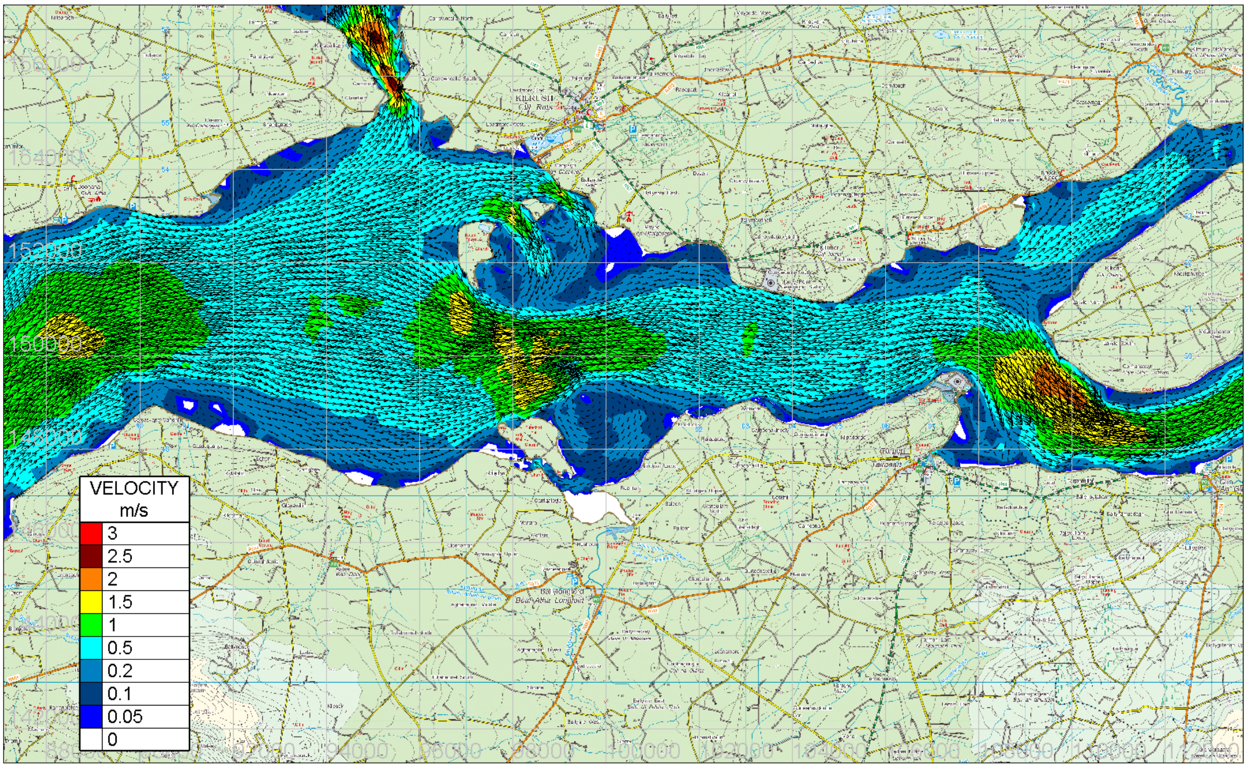

Figure 9.7 Spring tide velocities - Mid Flood (Simulation Time 28:20hrs)

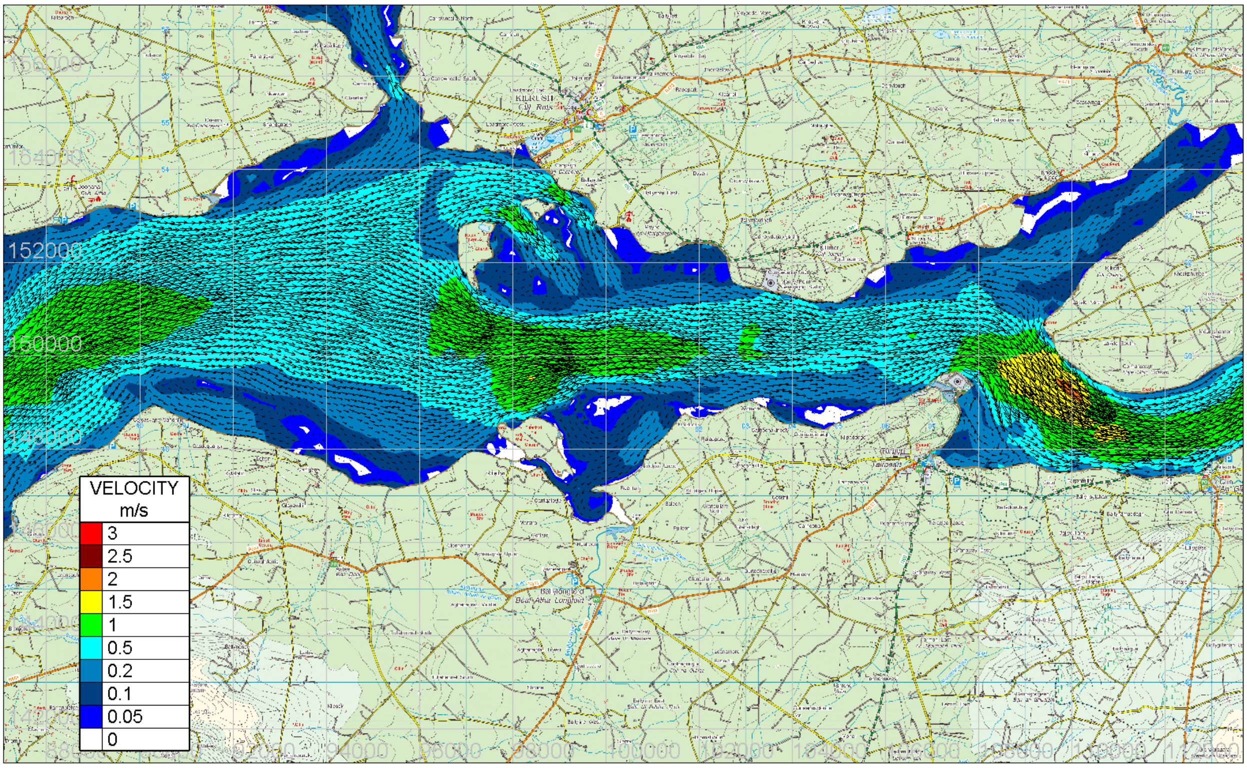

Figure 9.8 Spring tide velocities 1.5hr before High Water (Simulation Time 30:00 hrs)

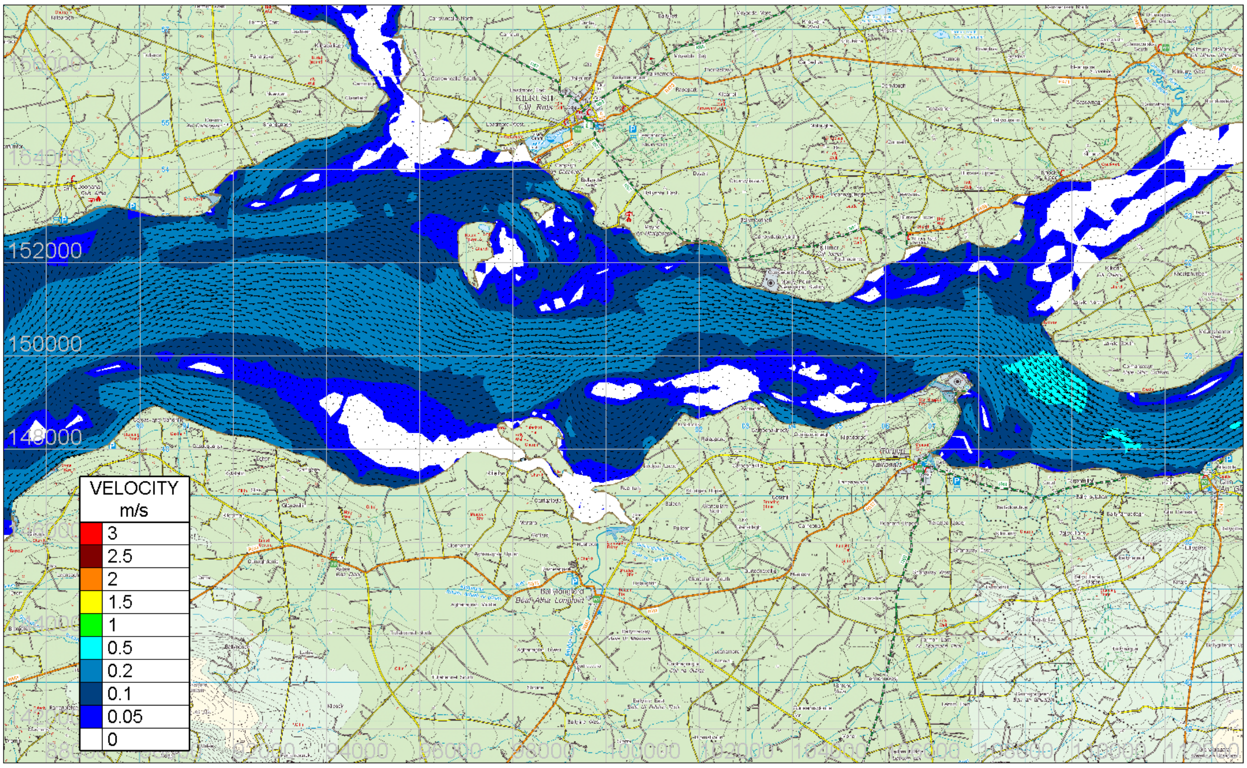

Figure 10.1 Neap tide velocities – High Water (simulation Time 19:00hrs)

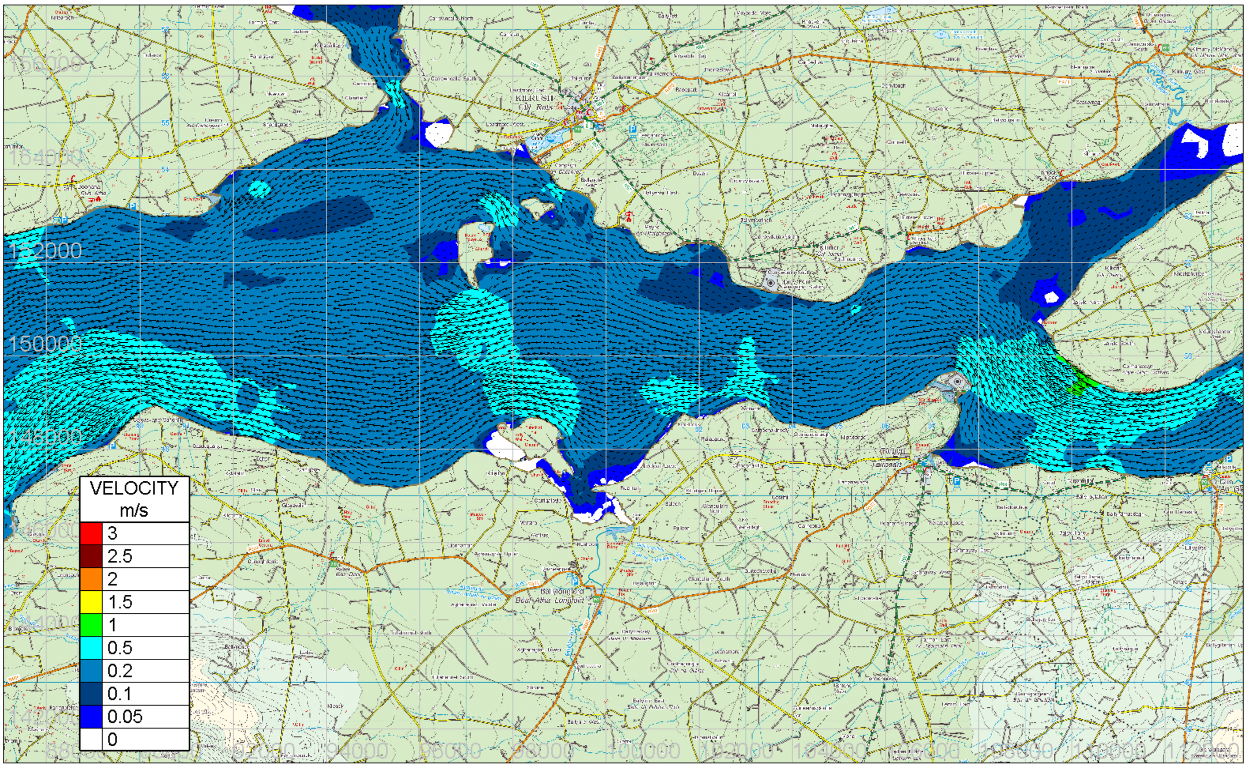

Figure 10.2 Neap tide velocities – 1.55hrs after High Water (simulation Time 20:35hrs)

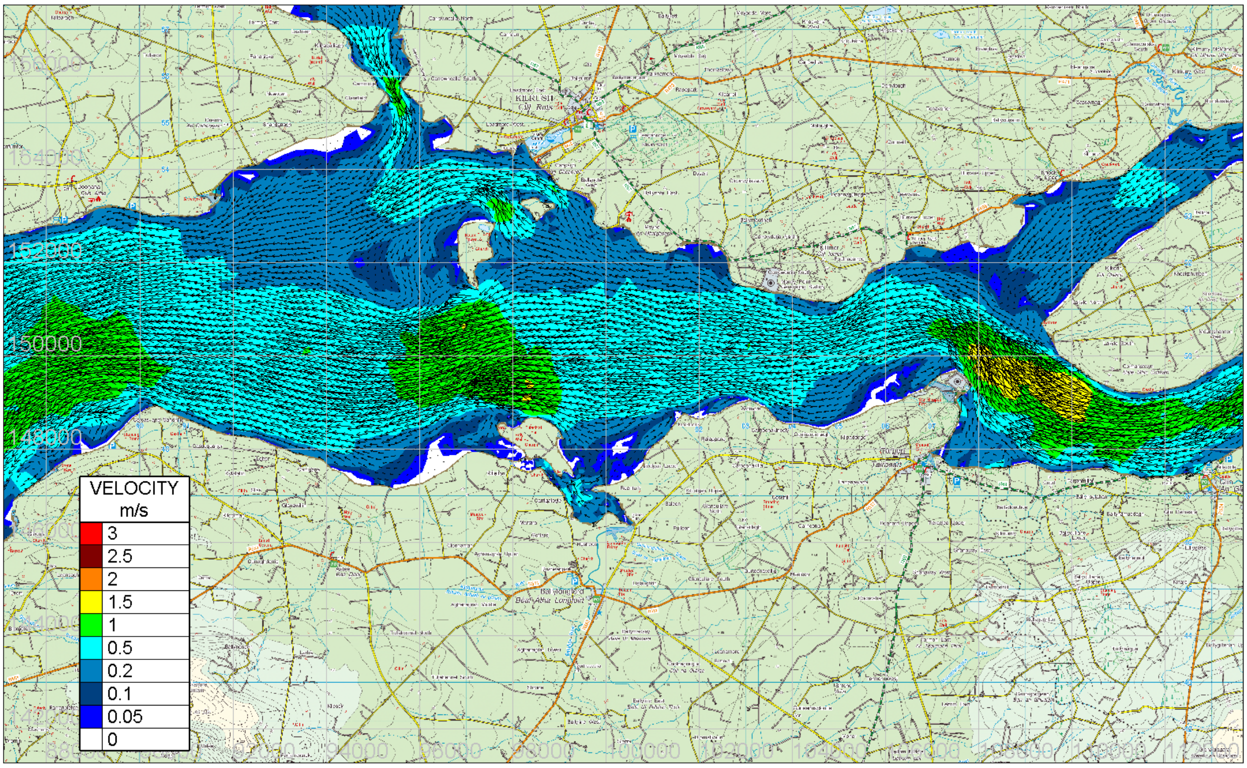

Figure 10.3 Neap tide velocities – Mid-Ebb Flow (simulation Time 22:10hrs)

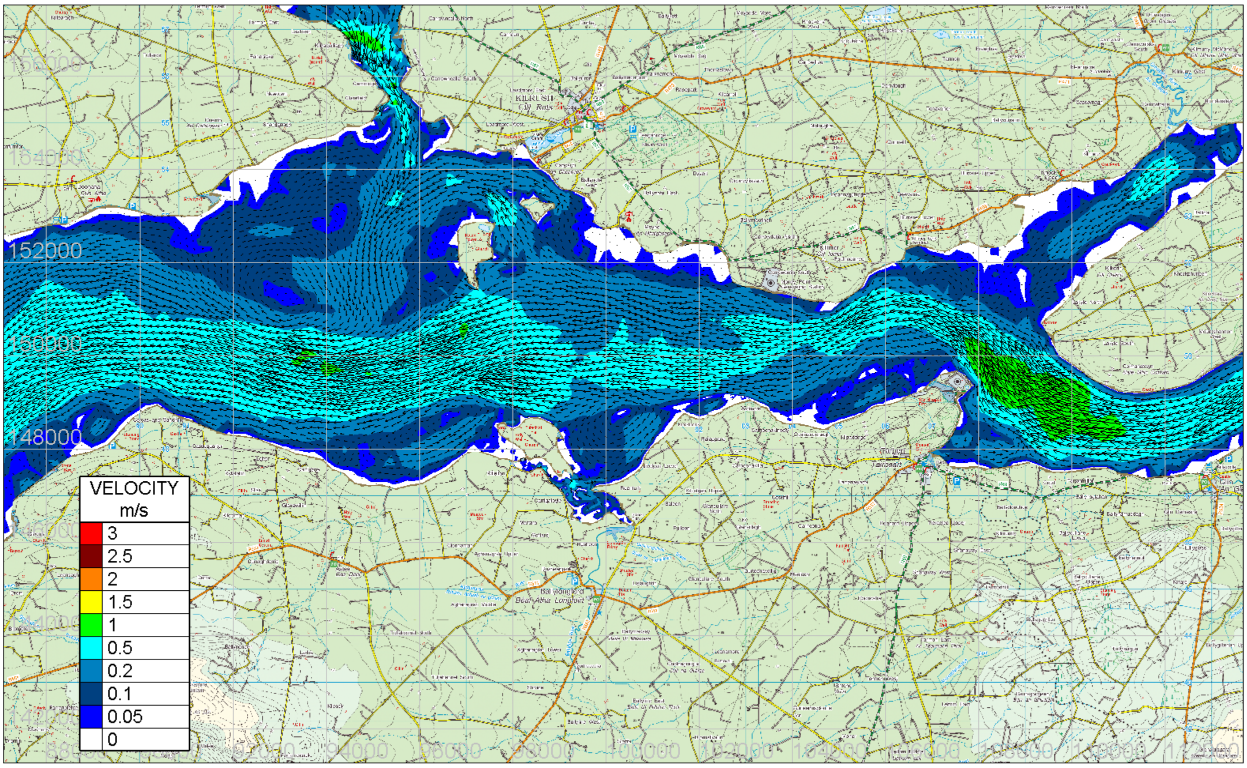

Figure 10.4 Neap tide velocities 1.5hrs before Low Water (Simulation Time 23:40hr)

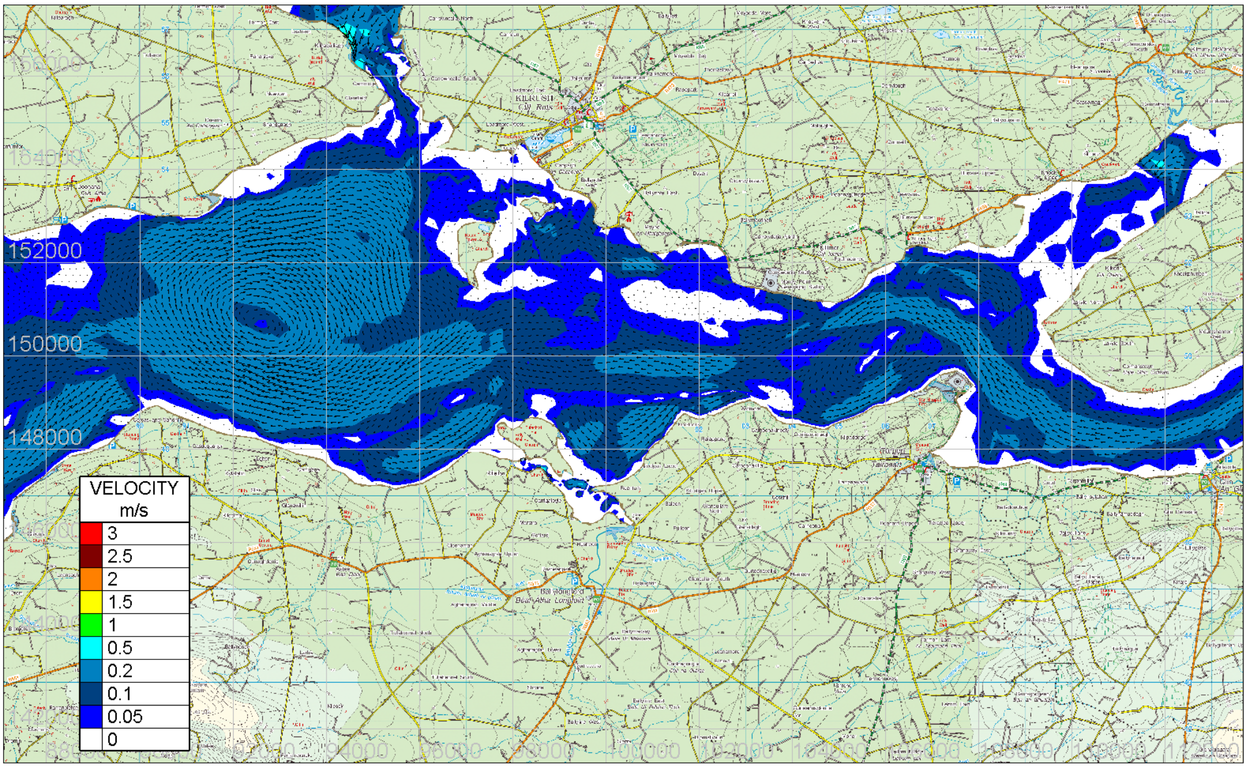

Figure 10.5 Neap tide velocities Low Water (Simulation Time 25:10 hrs)

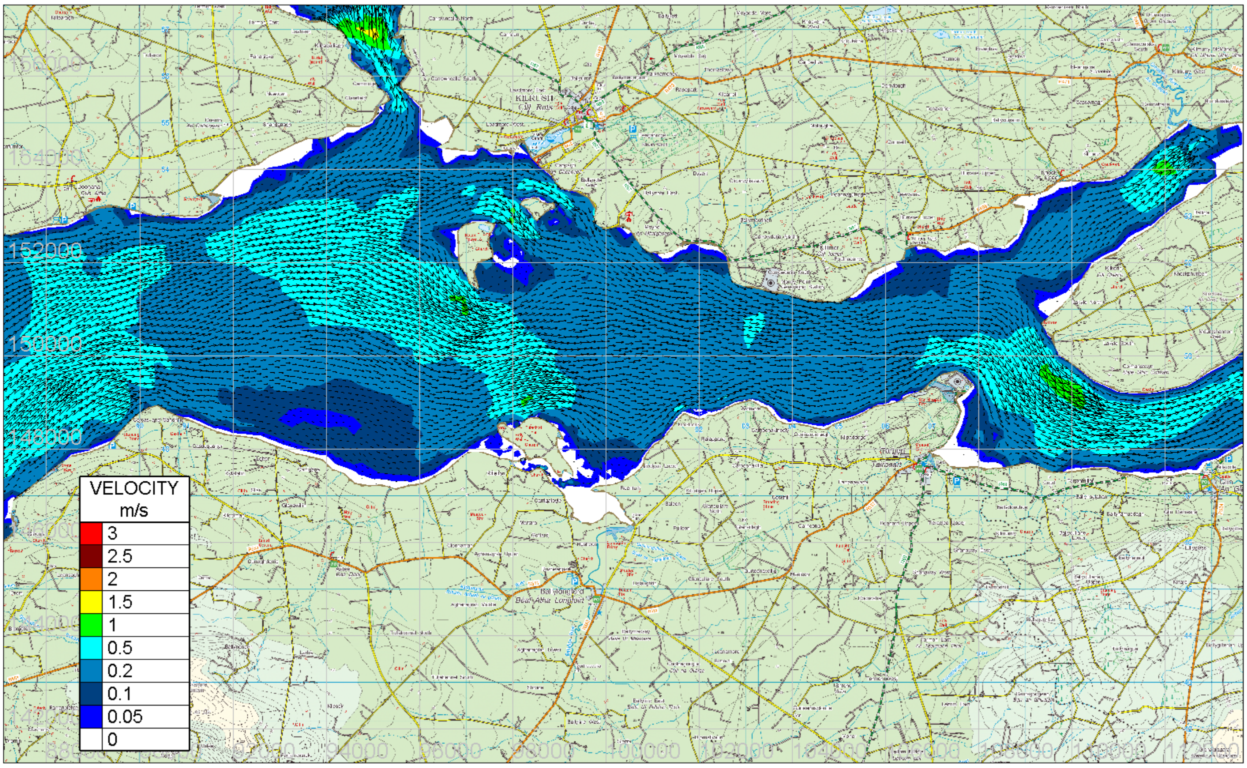

Figure 10.6 Neap tide Velocities 1.5hr after Low Water (Simulation Time 26:40 hrs)

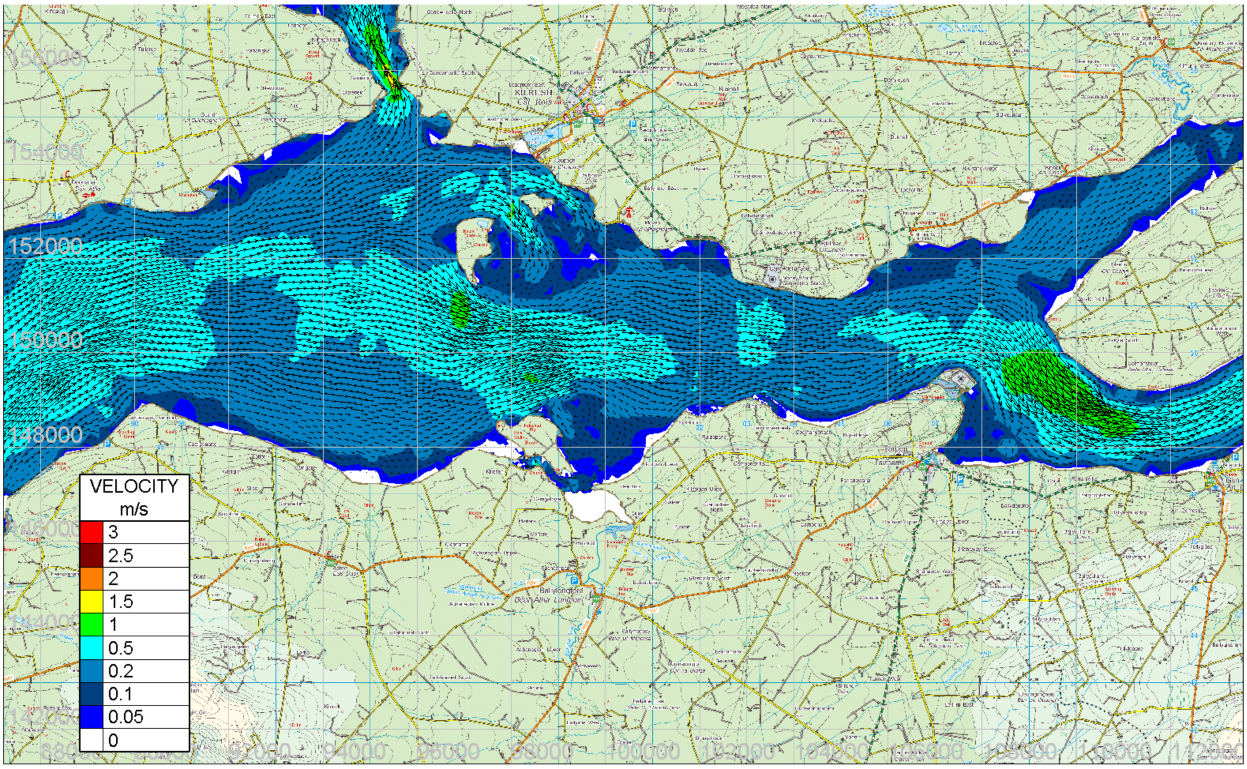

Figure 10.7 Neap tide velocities - Mid Flood (Simulation Time 28:20hrs)

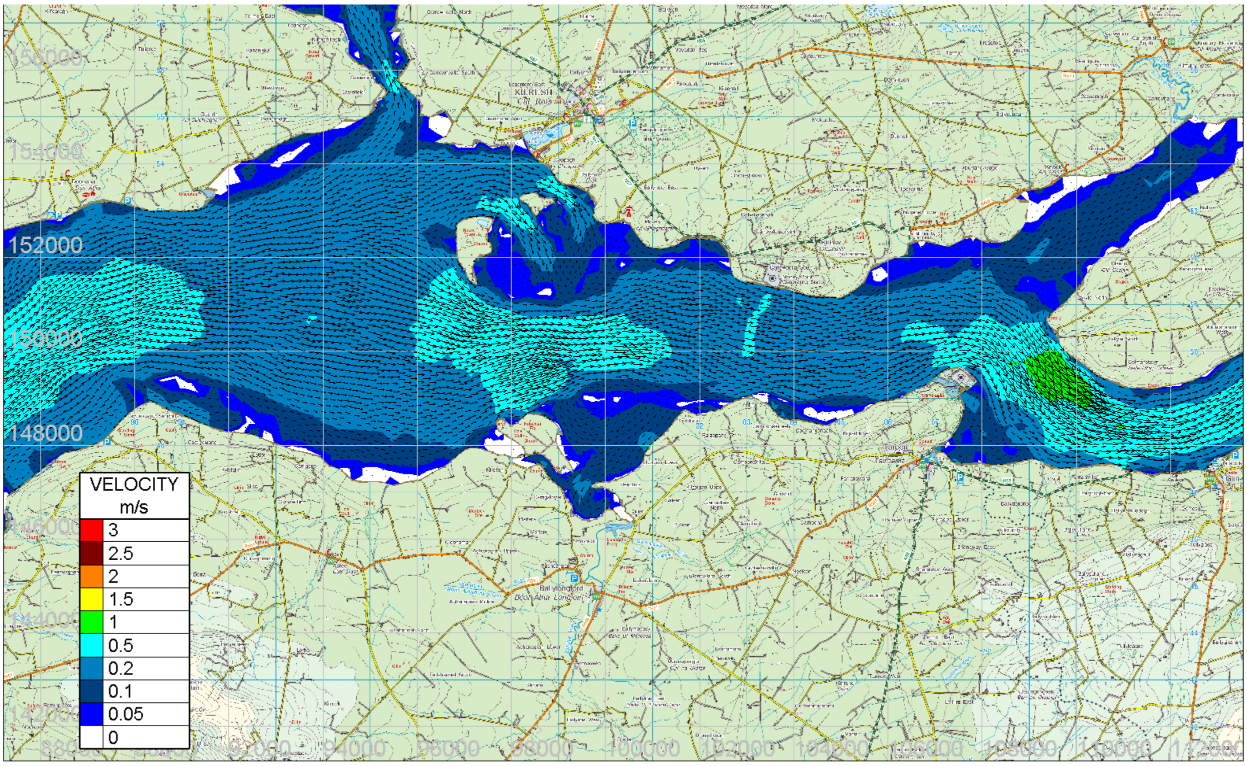

Figure 10.8 Neap tide velocities 1.5hr before High Water (Simulation Time 30:00 hrs)

3 DISPERSION SIMULATIONS AND INPUTS

3.1 Discharge Characteristics

The characteristics of the cooled water to be discharged from the Floating Storage Regasification Unit are shown in table 1. The hydraulic load of 22,000m^3/hr is the peak loading from the FSRU and is equivalent to 6,111l/s (6.111 cumec). It was decided to model the peak flow so that a 'worst case scenario' could be observed in the receiving water. The modelling approach adopted in this study considers the background concentration of chlorine to be zero and that the differential change in temperature is 8^{o}C below ambient with ambient modelled at 12^{o}C so that the output represents solely the effect of discharging effluent in the receiving waters.

Table 1 Characteristics of the Cold Water Discharge from Outfall Pipe

Maximum Discharge rate (m^3/hr)	Maximum Residual Total Chlorine Concentration (mg/l)	Maximum Differential Temperature (^{0}C)
22,000	**0.50**	**-8.0**

3.2 Intake and Outfall Location of the Cooling Water

The seawater intake for the LNG regasification system will be on the side of the FSRU underwater. Screens will be installed to prevent debris in the sea water from entering the FSRU. The approach velocity at the screens will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm. However, some small debris, leaves, plankton, and juvenile fish will be drawn in through the screens. It is expected that any silt entering the seawater circulating water system will remain in suspension and carry right through the system.

The regasification water outlet is also on the side of the FSRU underwater. The maximum projected change in water temperature is 8 °C below ambient seawater temperature. Other seawater inlet and exit points are at multiple locations. The FSRU regasification seawater discharge point is the largest discharge point from the FSRU.

Following the intake of seawater into the vessel, an electric current is passed through the seawater (a process known as electrolysis). Electrolysis breaks up the naturally occurring salt molecules (sodium chloride) in seawater and produces chlorine and hypochlorite, which prevents the growth of marine organisms in the internal piping system and the seawater heat exchangers of the FSRU. When the seawater is discharged from the vessel back into the marine environment, some short-lived residual chlorine would be present before mixing and decay. The concentration of residual chlorine at the discharge shall be monitored and shall not exceed the permissible limit of 0.5 mg/l.

In order to simulate the discharge from the outfall it was allocated a single finite element node location within the model domain at Irish Grid E102833, N149341 and the seawater intake was modelled at the node located at E102778, N149285.

3.3 Sanitary Effluent Discharge

Sanitary effluent will be generated by the LNG Terminal and by the Power Plant. All sanitary effluent will be pumped or fall by gravity to a common wastewater treatment plant (WWTP) on site. The effluent waste stream will be monitored for compliance with the licence limits and then discharged, via the storm water outfall pipe, to the Estuary.

A biological Wastewater Treatment System is proposed. It will be sized for a headcount of 67. Table 2 summarises the effluent stream generated from the WWTP and provides estimated quantities.

Effluent leaving the WWTP will be continuously monitored for pH before discharging to the estuary. The automatic control system associated with the WWTP will sound an alarm if pH falls outside of the expected range. This will alert the operator to take corrective action to remedy the problem. If the problem continues to go outside the pre-set range, this will automatically close the discharge valve and effluent will be diverted to a holding tank.

Table 2 Characteristic of WWTP Discharge

Parameter	Emission Limit Value
Volume	35 m^3/day
pH	6 – 10
BOD	25 mg/l
Suspended Solids	35 mg/l
Ammonia	5 mg/l as N
Total Phosphorous	2 mg/l as N

3.4 Power Plant Process Effluent

The Power Plant will generate several process water effluent streams. Some of the effluent streams will be collected and removed offsite and the remaining effluent streams will be pumped or fall by gravity to the effluent sump. Process water effluent leaving the effluent sump will be continuously monitored for pH before discharging to the estuary via the storm water outfall pipe.

The automatic control system associated with the effluent sump will sound an alarm if the pH goes outside a pre-set range – typically 6 to 9. This will alert the operator to take corrective action to remedy the problem. If the pH continues to go outside the pre-set range, this will automatically close the discharge valve and open the associated re-circulation valve and will then start the re-circulation process during which period the sump will be dosed with either acid or caustic soda to return the pH to between 7 and 8. At this stage, the automatic discharge valve will re-open and the re-circulation valve will close. A regular visual check on oils and greases will also be made in this sump to ensure that the discharge will be free of these contaminants before discharge. The process effluent in the sump will be monitored for compliance with the IE licence limits and then discharged, via the storm water outfall pipe, to the Shannon Estuary. Table 3 below summarises the Power Plant Process Effluent Sump Discharge.

All sanitary effluent from the FSRU will be retained onboard and discharged ashore via vacuum lorry.

Error! Reference source not found.**3 Power Plant Process Effluent Sump Discharge**

Parameter	Typical Range of Emissions (min to max)
Volume range	0 to 1,128m3/day
pH	6 – 9
Temperature range	25°C to 40°C
BOD	20 mg/l
Suspended Solids	30 mg/l
Total Dissolved Solids	5000 mg/l
Mineral Oil	20 mg/l
Total Ammonia (as N)	5 mg/l
Total Phosphorous (as P)	5 mg/l

3.5 Water Temperature Simulation Results

Using the maximum flow rate of 22,000m^3/hr, the Telemac-3D model was used to estimate the concentrations of the total residual Chloride and water temperature within the receiving waters of the Shannon Estuary from the regasification process. The process discharge was specified with a residual total chlorine concentration of 0.5mg/l and a maximum temperature decrease over the ambient temperature of 8^o C. The ambient temperature in the Shannon Estuary was set at 12^o C, and the discharging water temperature was set to 4^{o}C. The time step used in the model simulations was set to a time interval of 2 seconds because of the refined vertical spacing of 15 vertical layers. Full k – e vertical and horizontal turbulent modelling was performed. The model simulations were performed over a spring to neap tidal cycle for a simulation period of 360 hours. The duration of the simulation was sufficiently long enough to allow steady state conditions to be attained in the vicinity of the outfall and in the medium Field which includes Ballylongford Bay. This ensured that the minimum temperature and maximum concentration values, which would be reached throughout the water body, would be observed.

In order to analyse the model results similar to the hydrodynamics, snapshots of the predicted temperature plume within the study area were output at four principal stages of the tidal cycle over both a typical spring and neap tides and at four different layer depths vertically (layer 15 (surface), layer 10, layer 5, and layer 1 (bottom)) so as to demonstrate the extent and nature of the temperature plume, refer to figures 11.1 to 11.16. The minimum temperature envelope (representing maximum change in temperature) for the four selected vertical depths are shown in figures 11.17 to 11.20. To demonstrate the vertical mixing of the temperature plume time series of over two successive spring tides are presented in figure 11.21 and 11.22 at the proposed discharge site and also at 140m west of site for the four vertical layers. This shows the near field mixing of the temperature plume sinking towards the seabed due to its higher density with minimum temperatures of the discharge water towards the bottom layers at 130m from the site. At the site itself due to the elevation of the discharge port from the vessel minimum temperature is encountered at mid-depth. At the medium and far fields, the temperature change is small and is well mixed vertically and horizontally due to the high ebb and flood velocities. At the outfall site, the predicted minimum temperature is 10.38^{o}C representing a maximum temperature change over the ambient of 1.62^{o}C and occurs at layer 10. The maximum temperature change (decrease) in the bottom layer along the seabed is 0.76^{o} C. At 140m from the discharge site the minimum temperature which occurs on spring tides is 11.54^{o} C occurring in the bottom layer and representing a maximum decrease in ambient temperature of 0.46^{o} C.

The EPA proposal for estuarine waters states that the temperature measured downstream of a point of thermal discharge (at the edge of the mixing zone) must not exceed the unaffected temperature by more than 1.5^{o}C. The EPA have in previous discharge licenses allowed a regulatory mixing zone length of no greater than 10% of the channel width. In the case of the Shannon Estuary at Ardmore Point, the minimum estuary width is 2.3km indicating an allowable mixing zone of 230m. Figure 11.23 presents the maximum reduction in ambient temperature within the receiving water body. This plot shows that within 200m of the discharge the maximum reduction in ambient temperature is less than 0.5^{o} C and that within 3km it is less than 0.1^{o}C. The maximum reduction in temperature within the Ballylongford bay area is > 0.05^{o} C and < 0.1^{o}C which is insignificant.

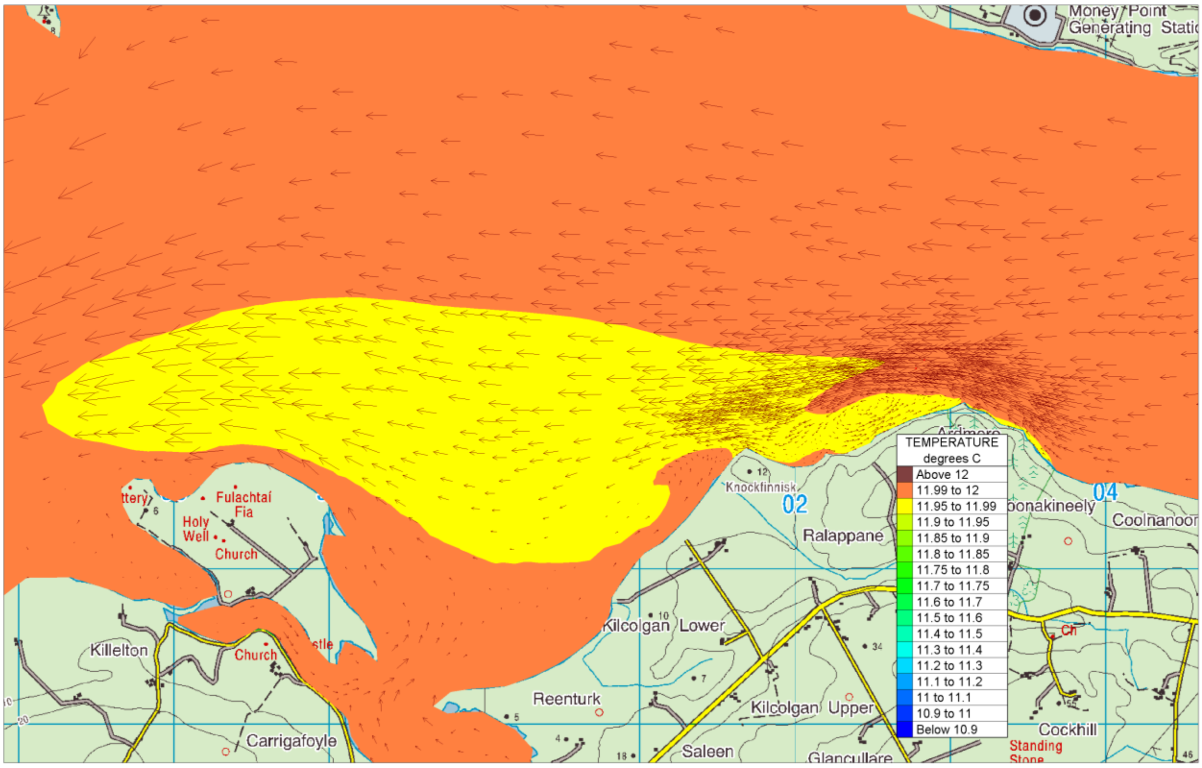

Figure 11.1 Predicted Temperature in Surface Layer (15) at Mid-Ebb Spring Tide

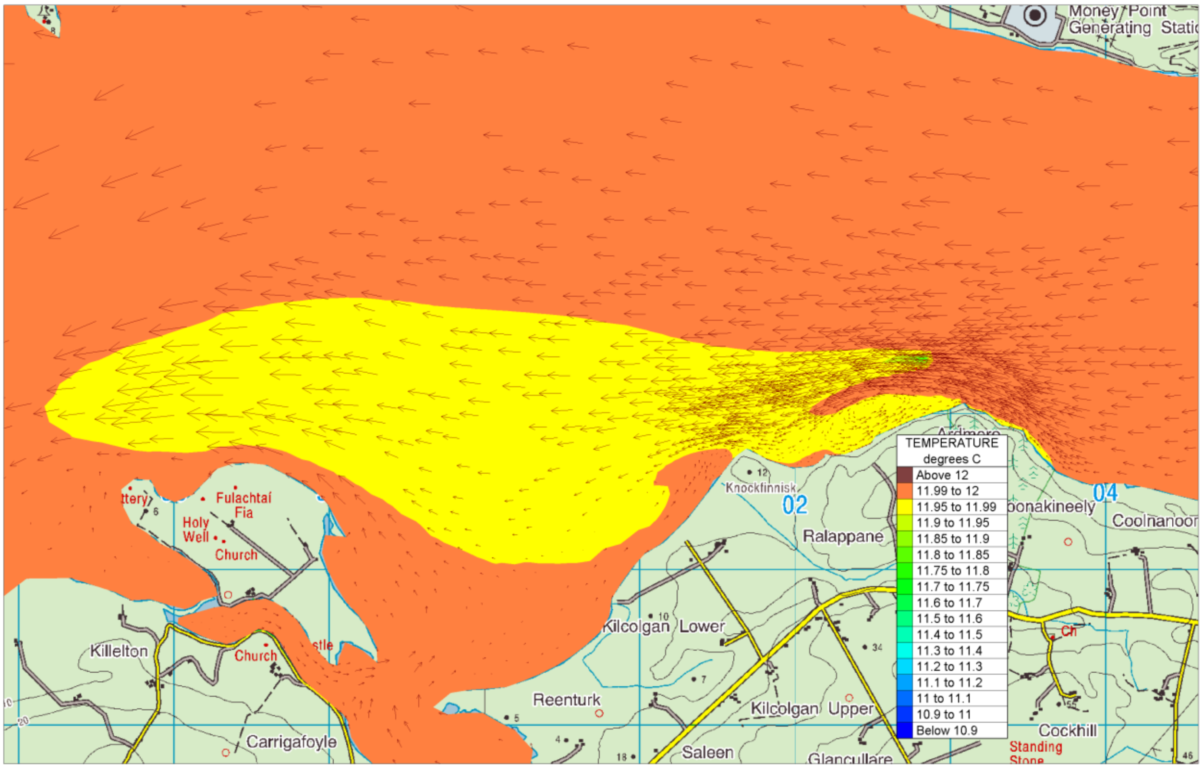

Figure 11.2 Predicted Temperature in Vertical Layer (10) at Mid-Ebb Spring Tide

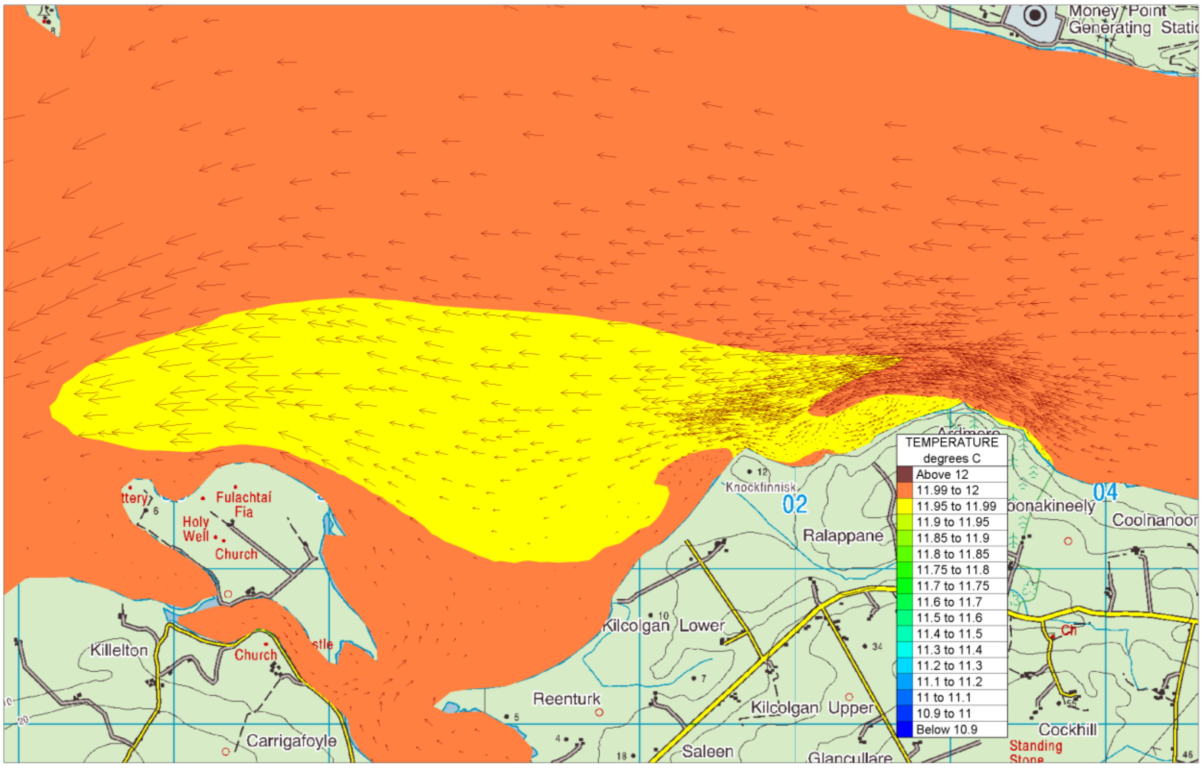

Figure 11.3 Predicted Temperature in Vertical Layer (5) at Mid-Ebb Spring Tide

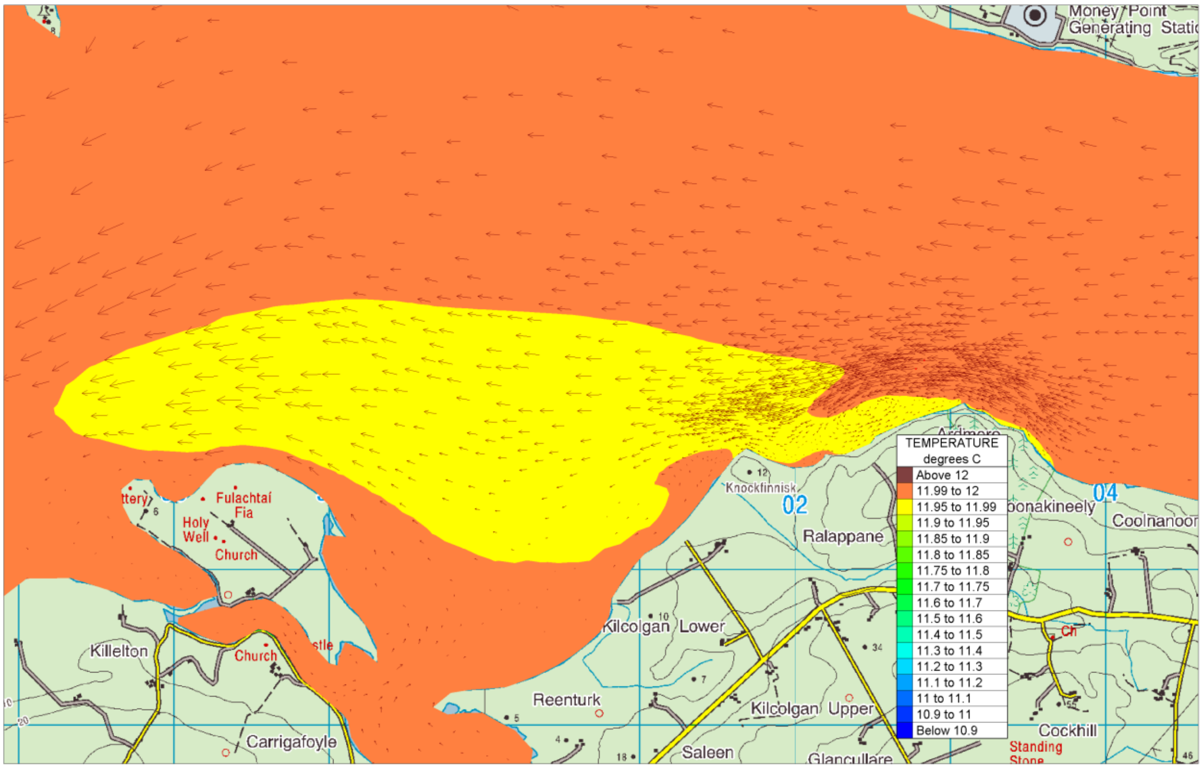

Figure 11.4 Predicted Temperature in Bottom Layer (Layer 1) at Mid-Ebb Spring Tide

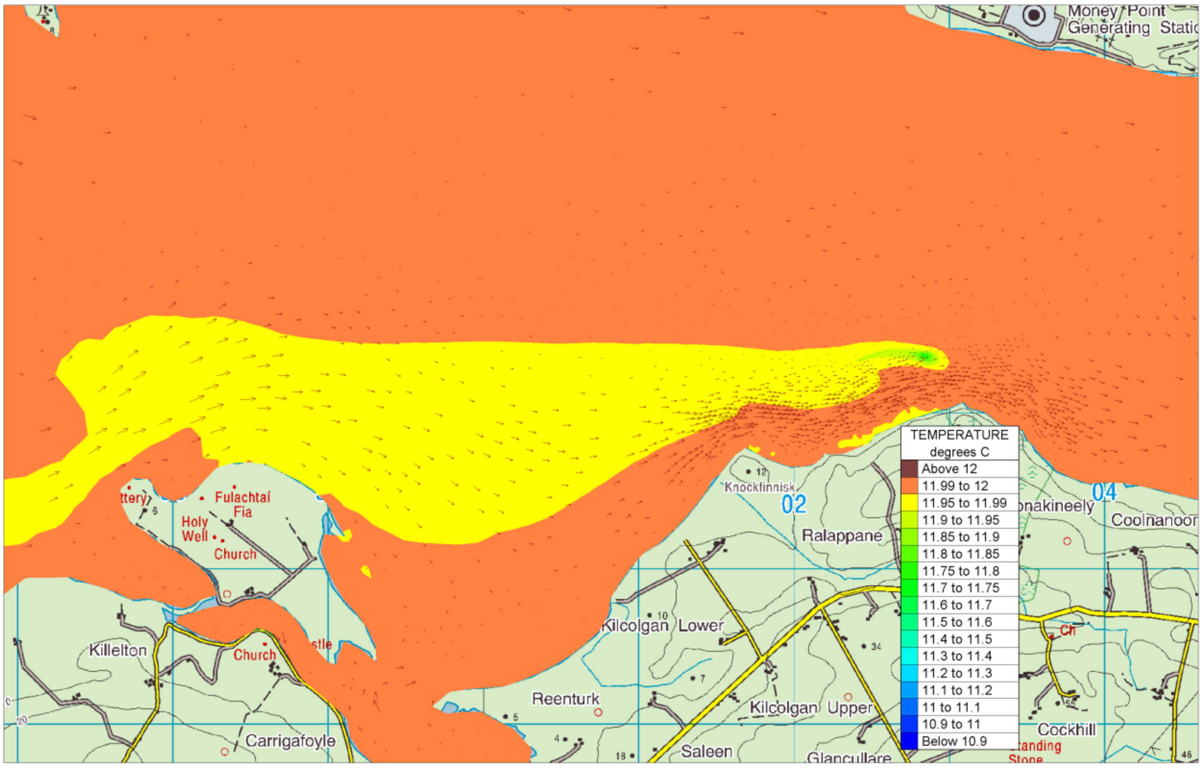

Figure 11.5 Predicted Temperature in Surface Layer (Layer 15) at Low Water Spring Tide

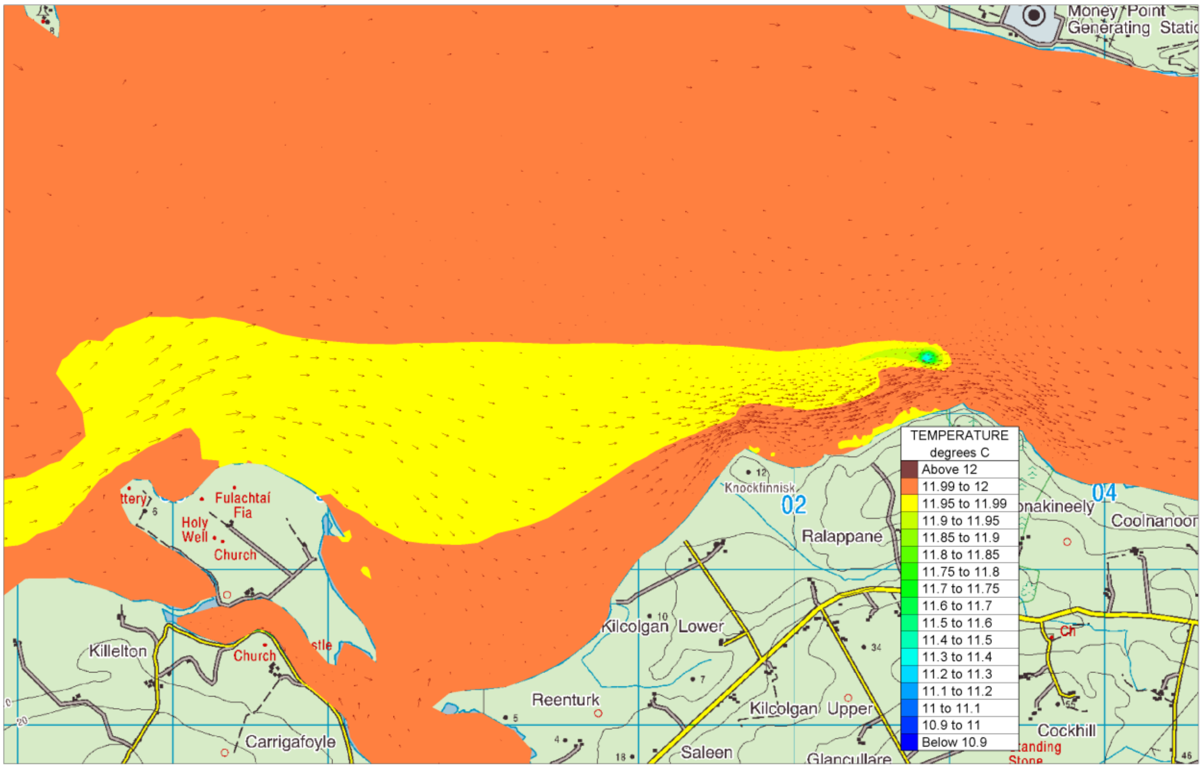

Figure 11.6 Predicted Temperature in Vertical Layer 10 at Low Water Spring Tide

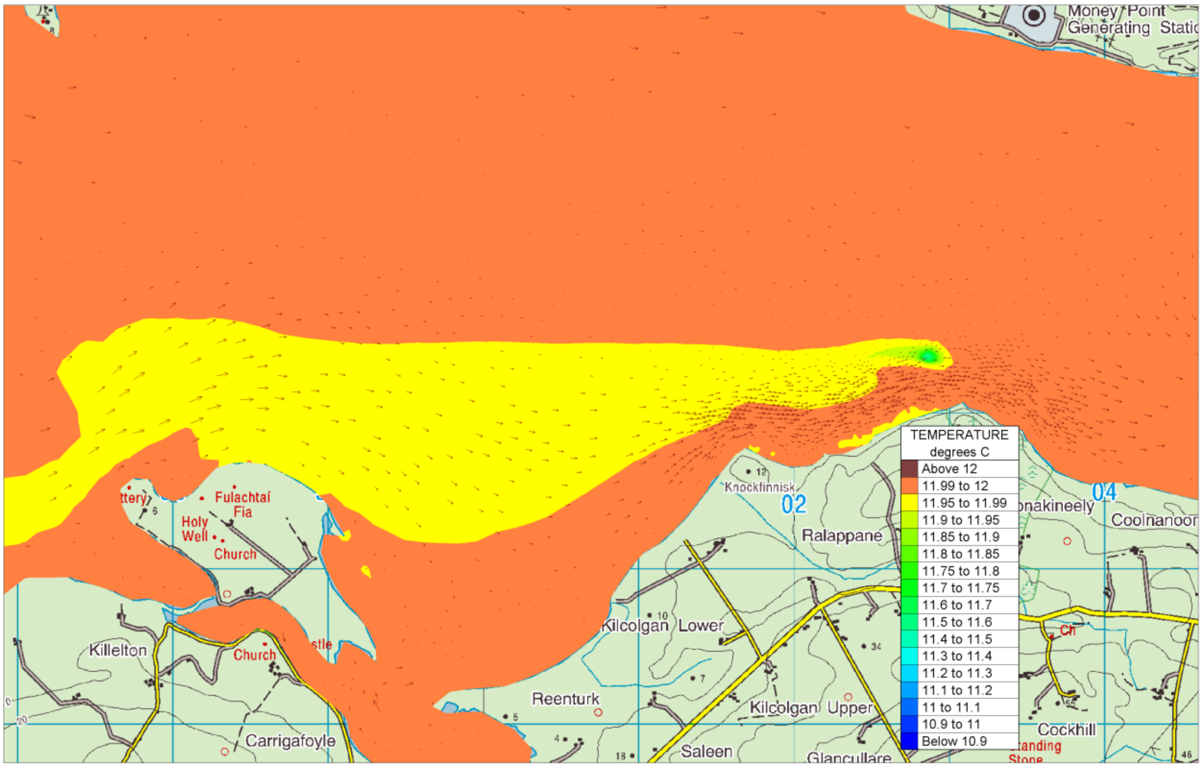

Figure 11.7 Predicted Temperature in Vertical Layer 5 at Low Water Spring Tide

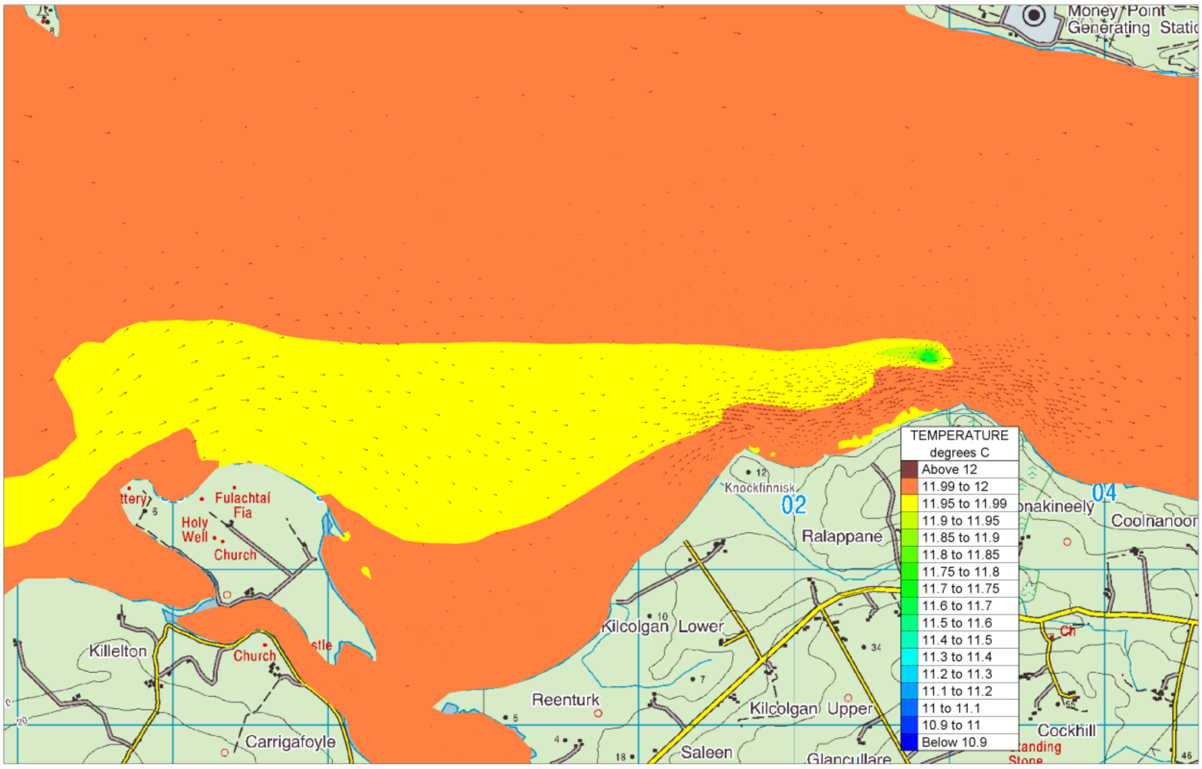

Figure 11.8 Predicted Temperature in Bottom Layer (Layer 1) at Low Water Spring Tide

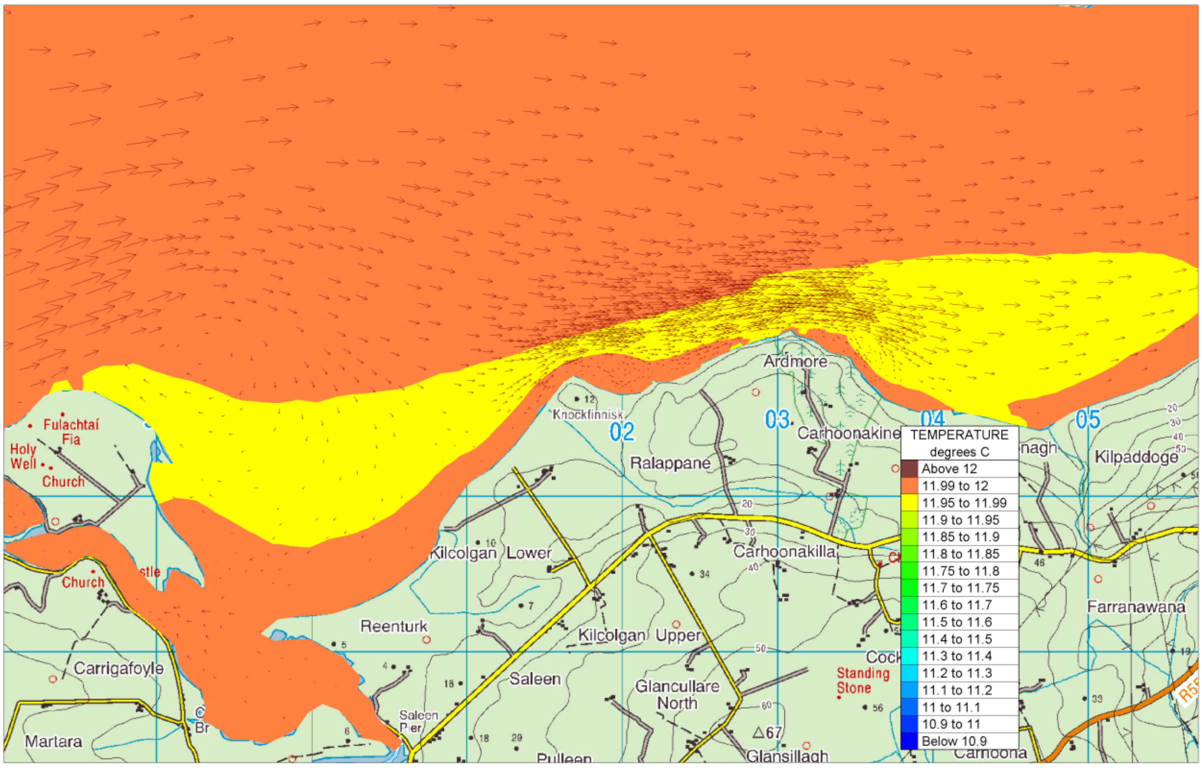

Figure 11.9 Predicted Temperature in Surface Layer (Layer 15) at Mid-flood Spring Tide

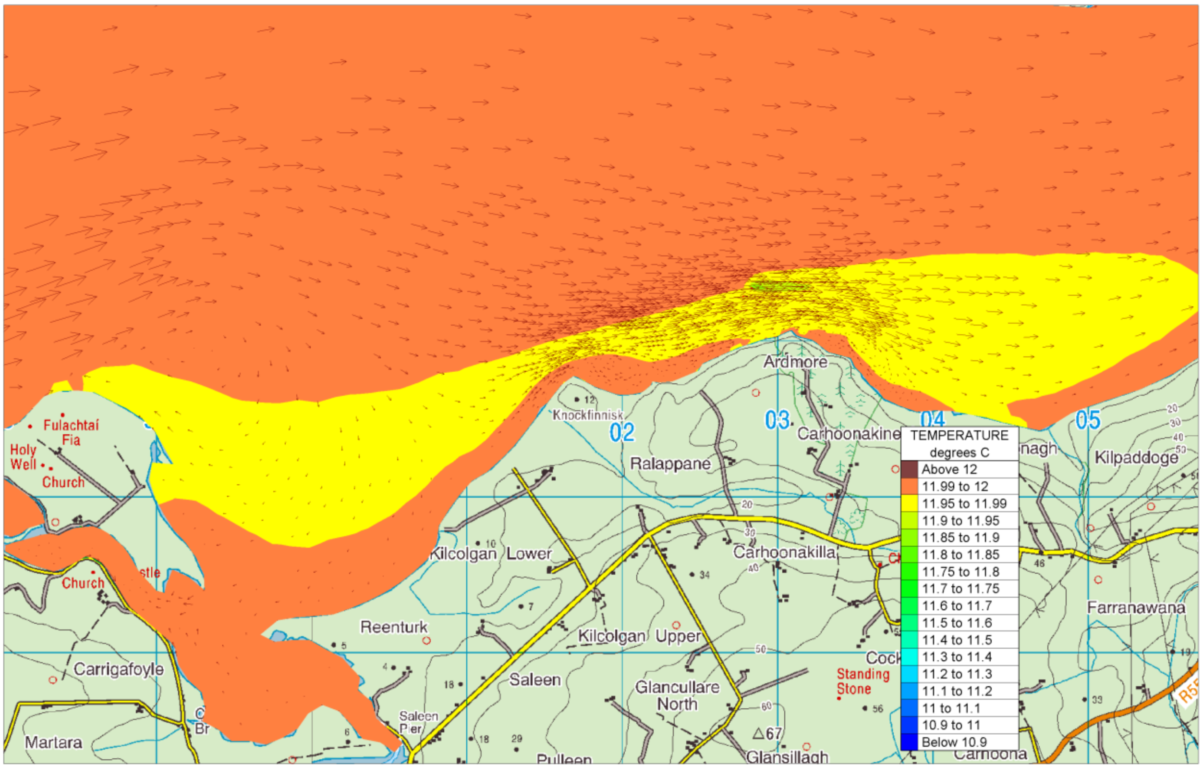

Figure 11.10 Predicted Temperature in Vertical Layer 10 at Mid-Flood Spring Tide

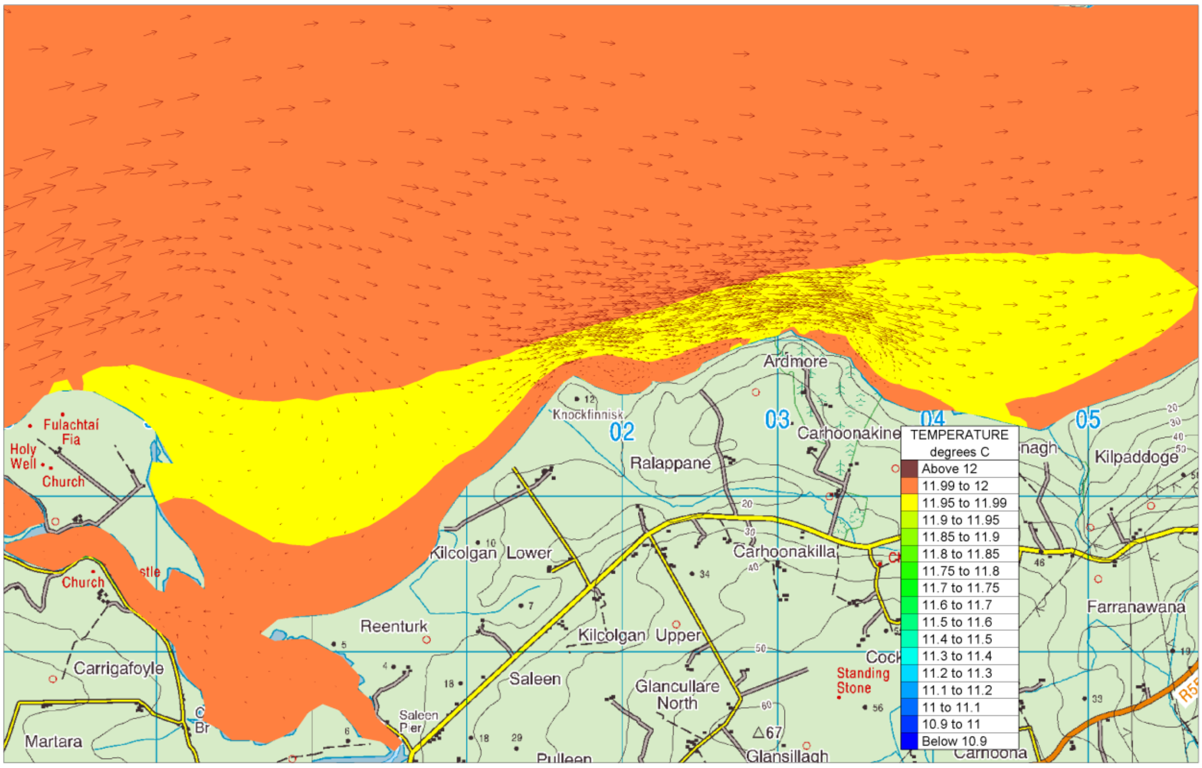

Figure 11.11 Predicted Temperature in Vertical Layer 5 at Mid-flood Spring Tide

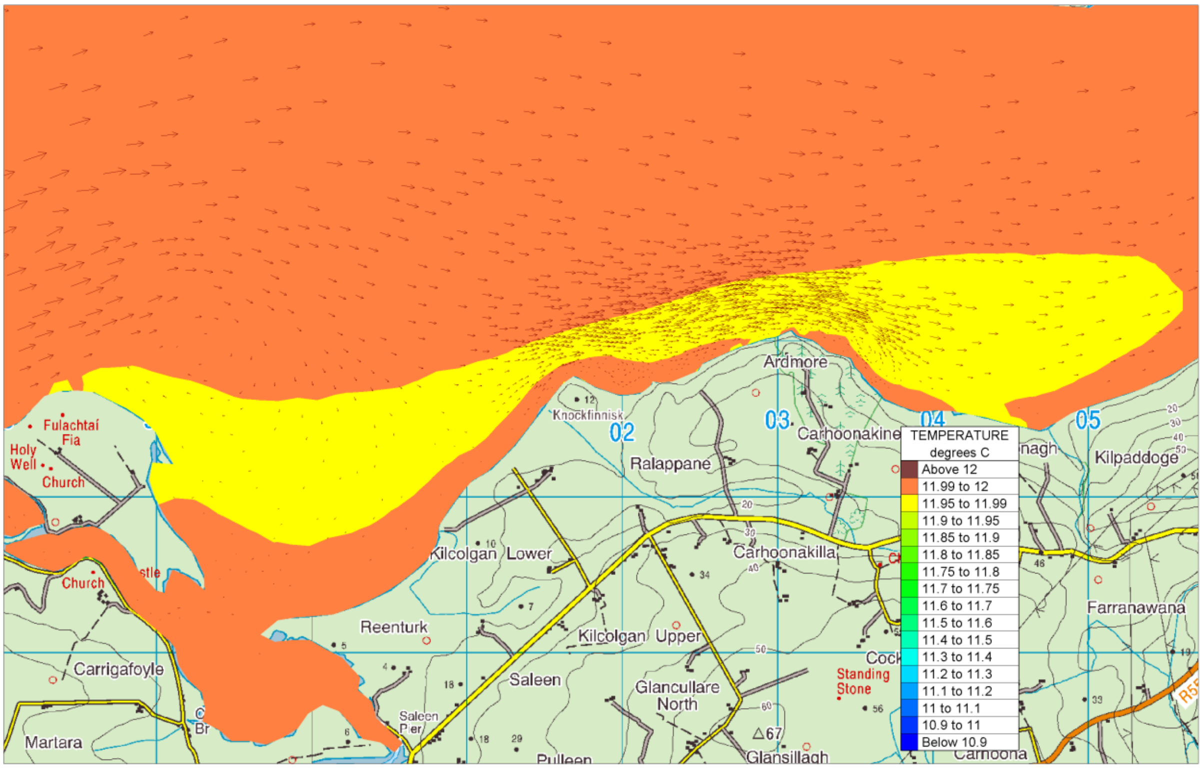

Figure 11.12 Predicted Temperature in Bottom Layer (Layer 1) at Mid-Flood Spring Tide

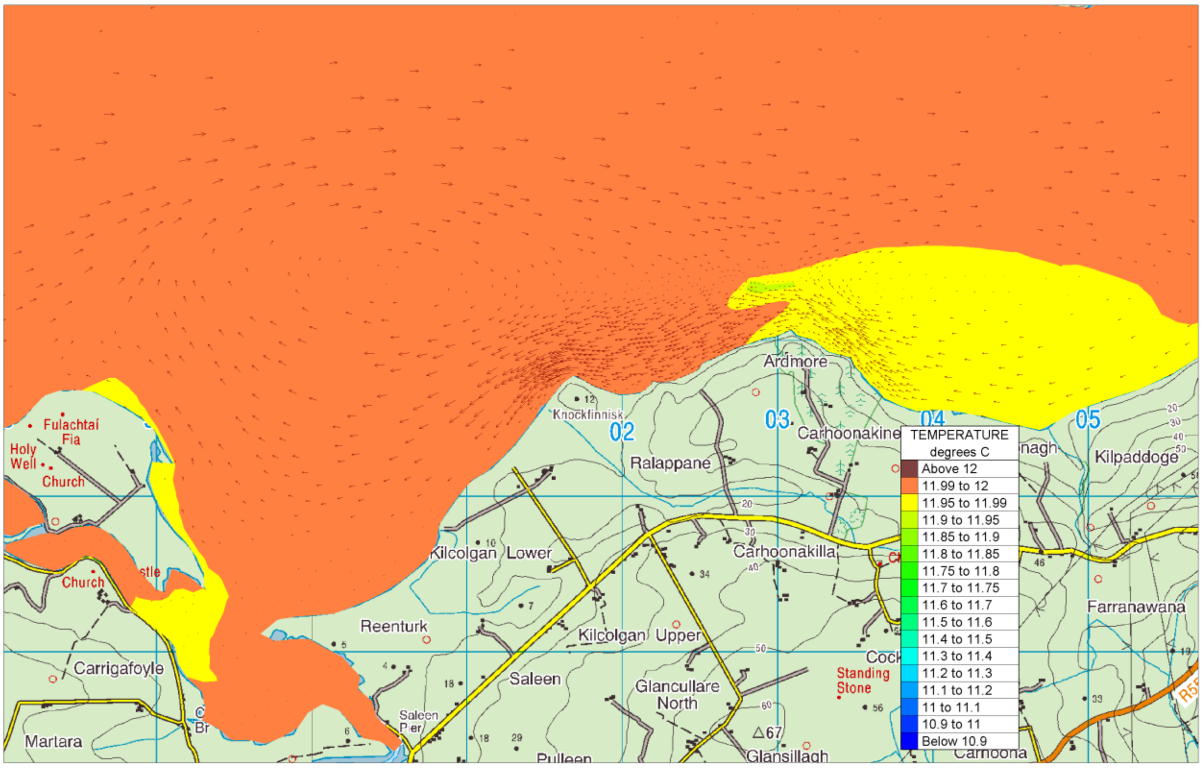

Figure 11.13 Predicted Temperature in Surface Layer (Layer 15) at High Water Spring Tide

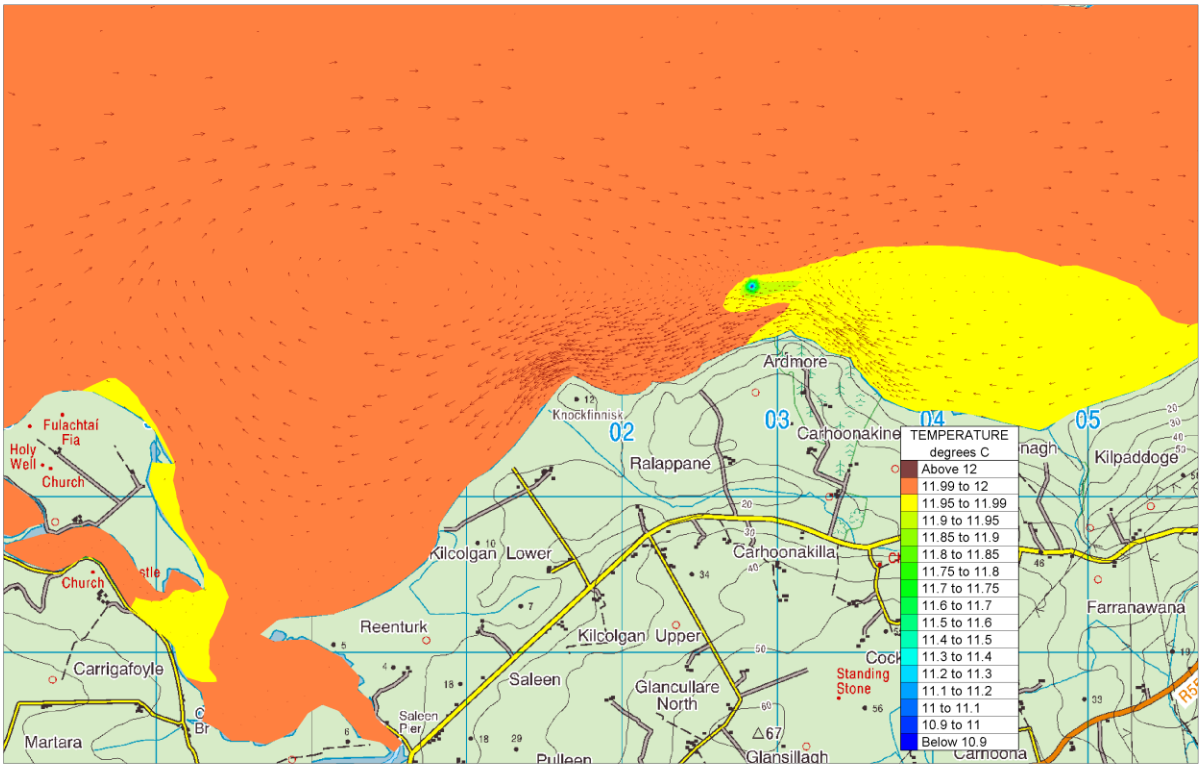

Figure 11.14 Predicted Temperature in Vertical Layer 10 at High Water Spring Tide

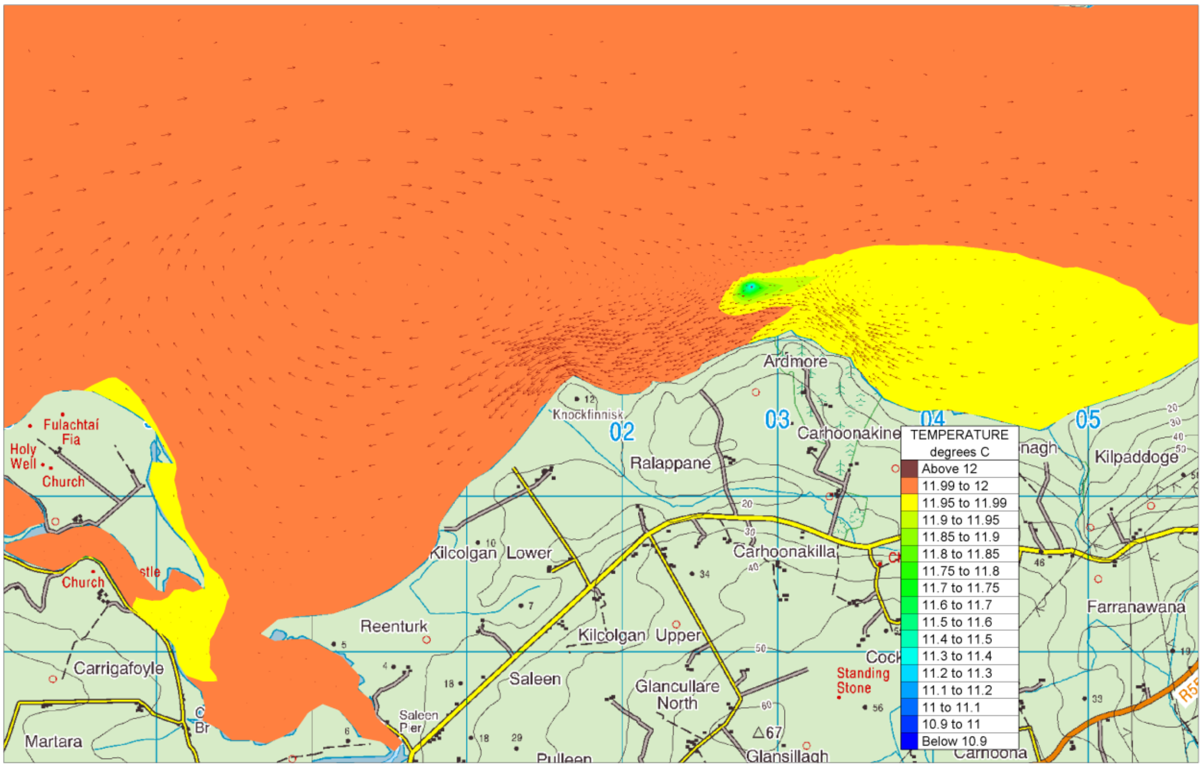

Figure 11.15 Predicted Temperature in Vertical Layer 5 at High Water Spring Tide

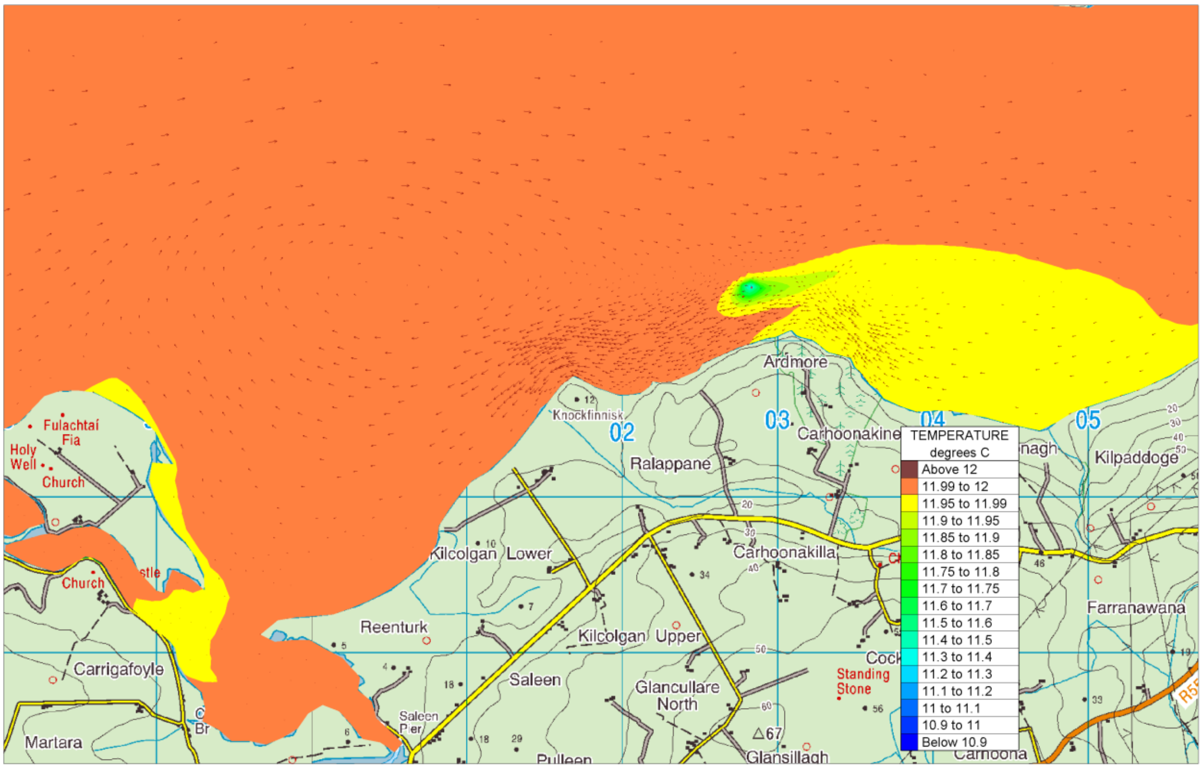

Figure 11.16 Predicted Temperature in Bottom Layer (Layer 1) at High Water Spring Tide

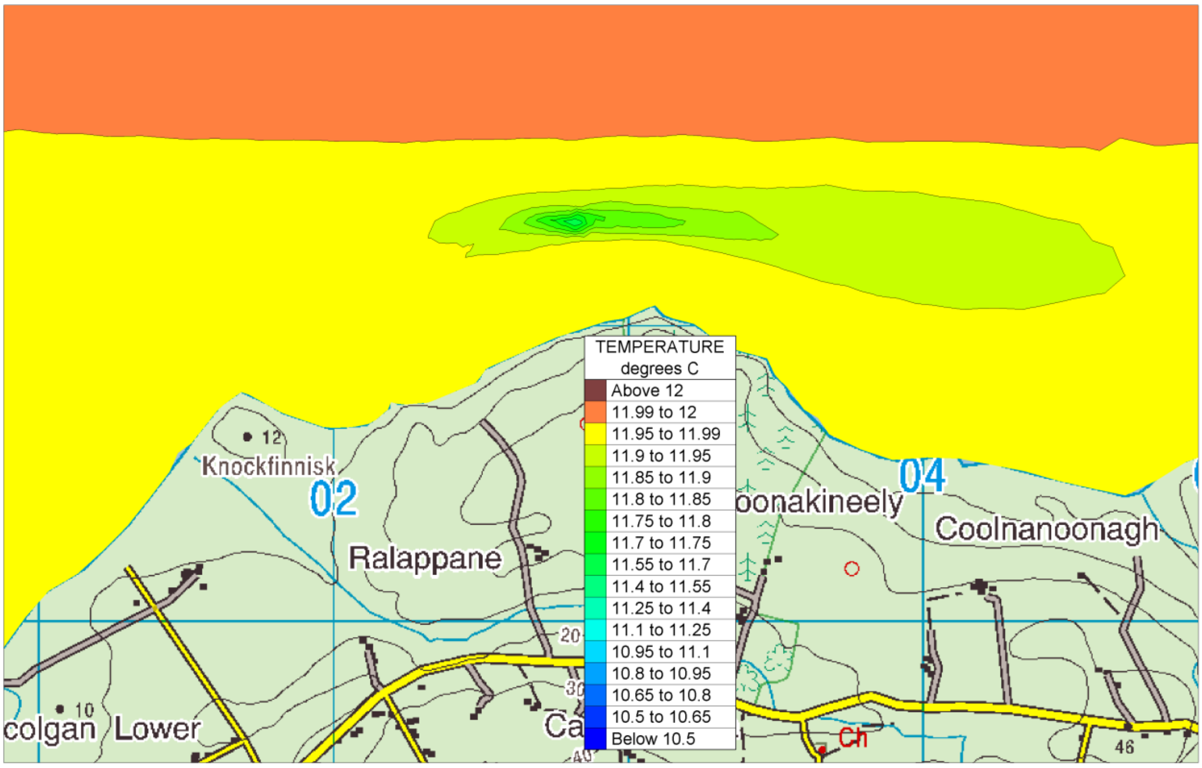

Figure 11.17 Predicted Minimum Temperature Envelope – Surface Layer (15) for spring-neap-spring 15day simulation

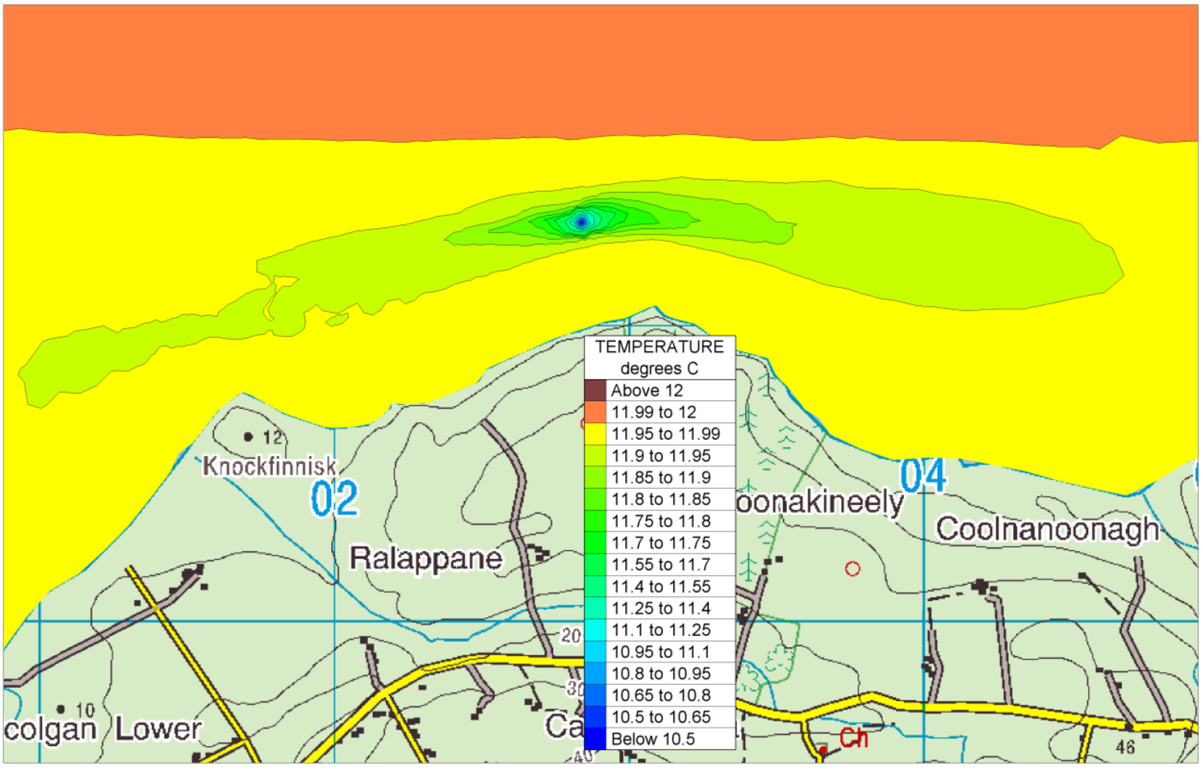

Figure 11.18 Predicted Minimum Temperature Envelope – Vertical Layer (10) for spring-neap-spring 15day simulation

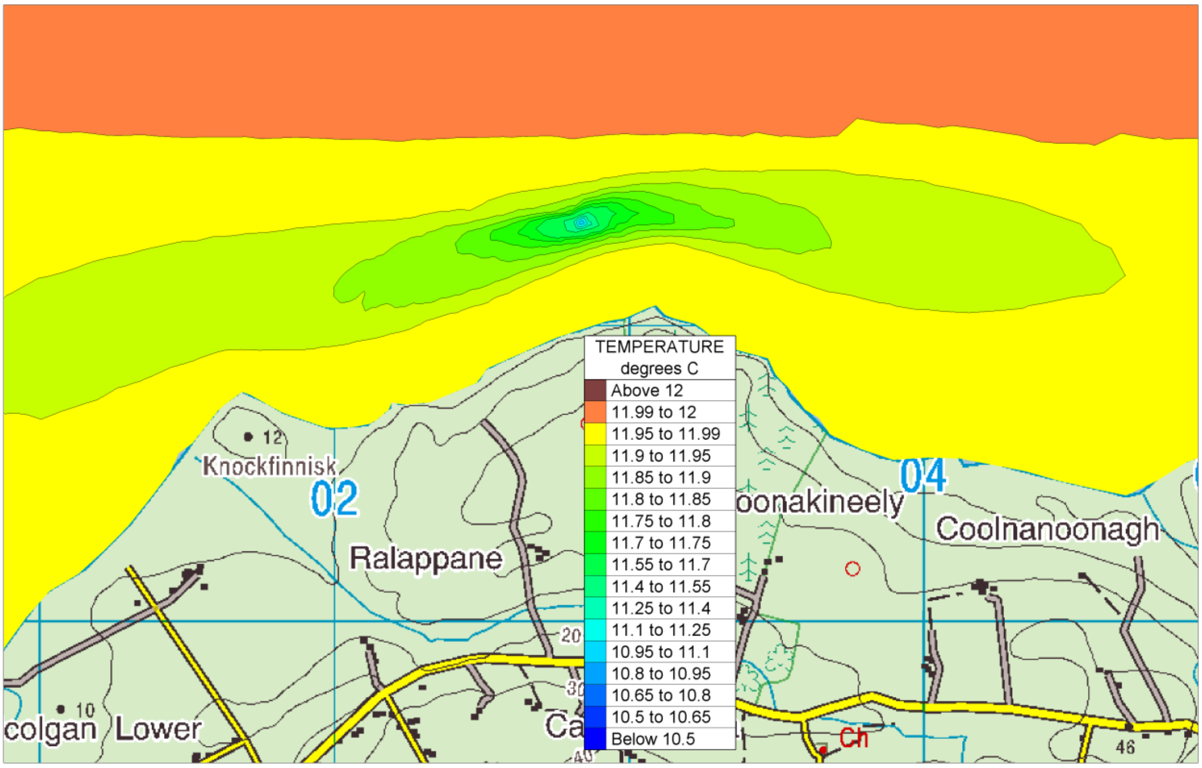

Figure 11.19 Predicted Minimum Temperature Envelope – Vertical Layer (5) for spring-neap-spring 15day simulation

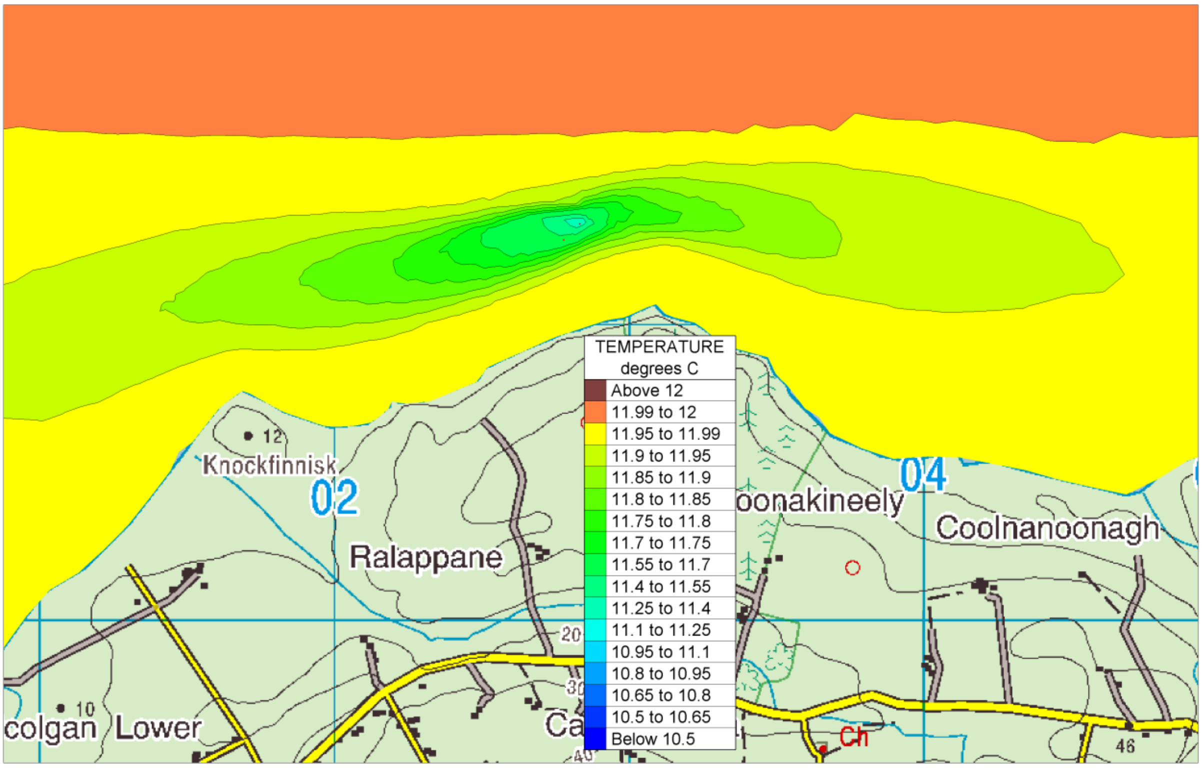

Figure 11.20 Predicted Minimum Temperature Envelope – Bottom Layer (1) for spring-neap-spring 15day simulation

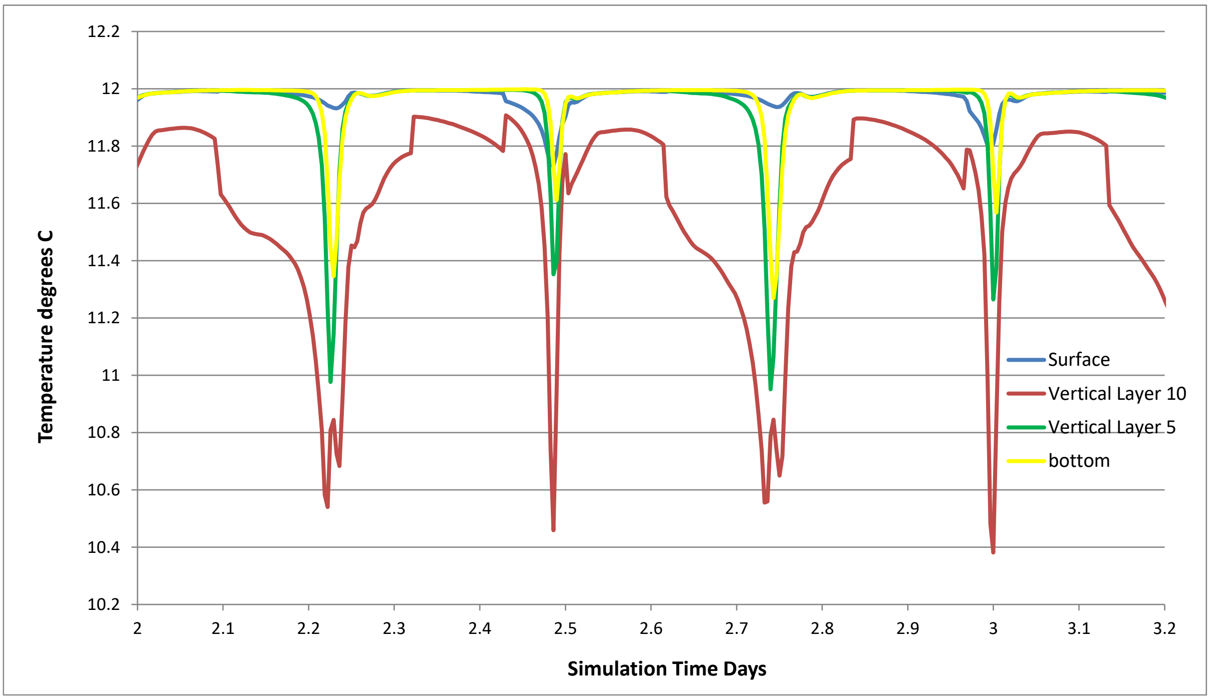

Figure 11.21 Temperature Time Series within receiving waters at FSRU outfall Node Point over sample spring tide

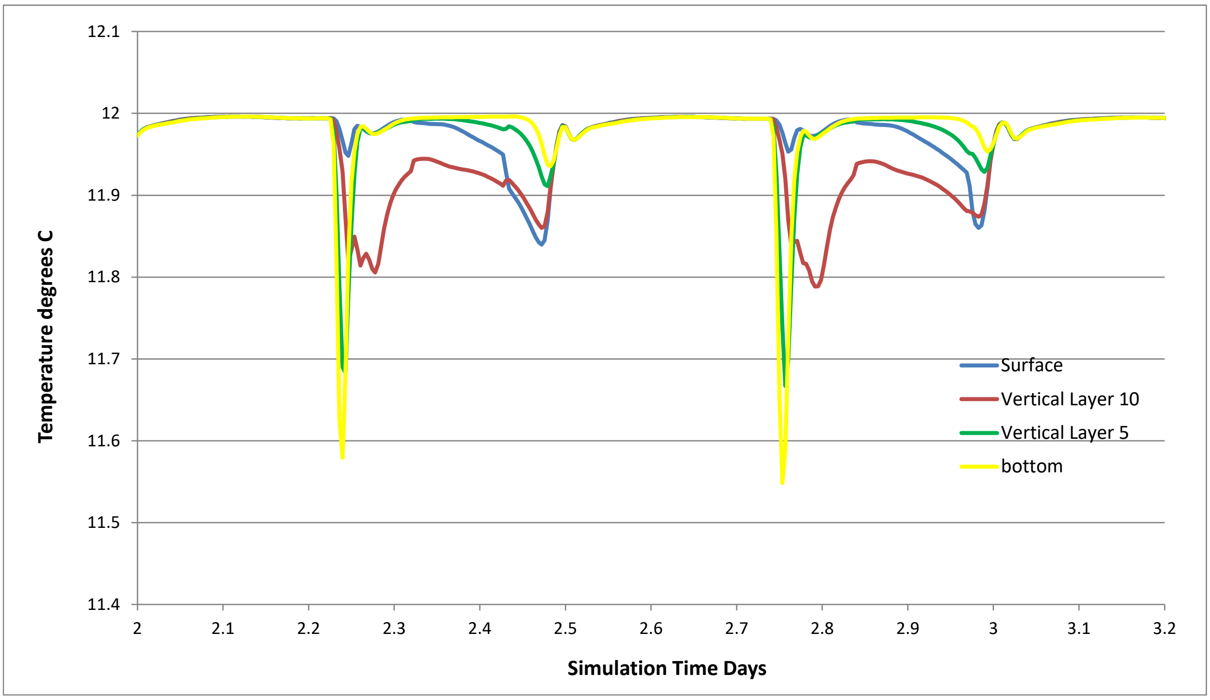

Figure 11.22 Temperature Time Series within receiving waters at 130m west of the FSRU Discharge Point over sample spring tide

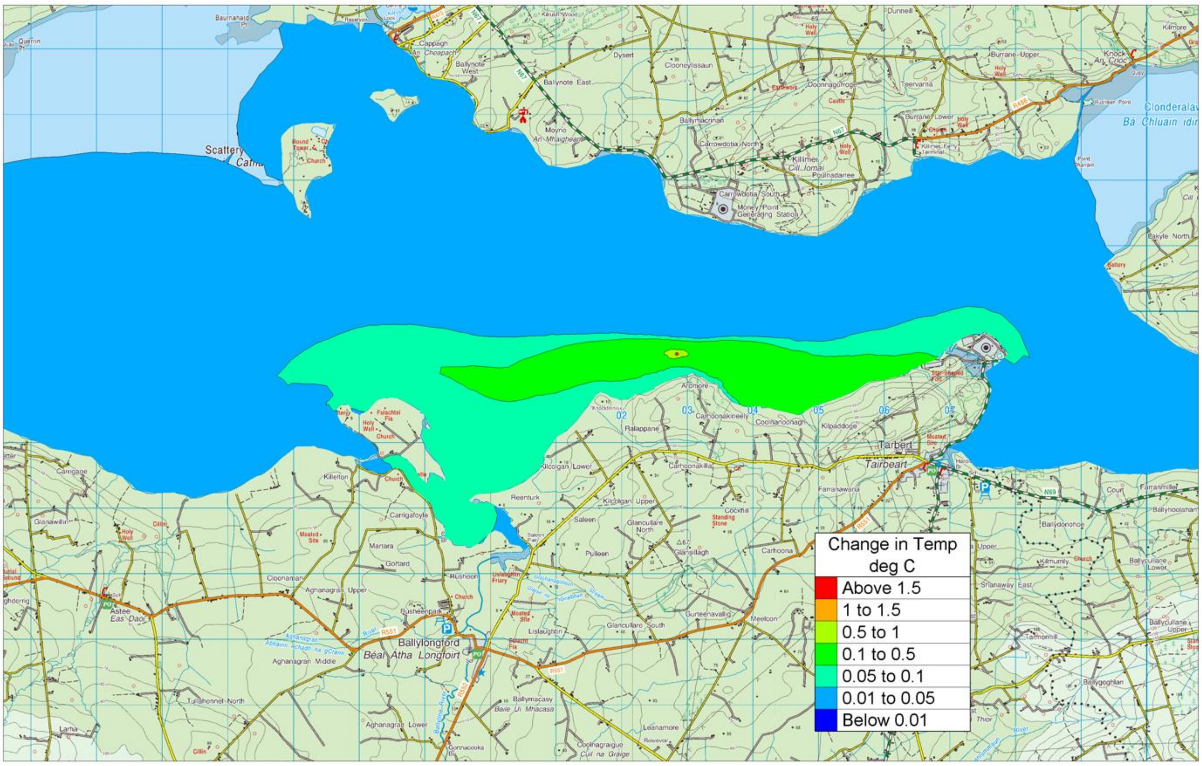

Figure 11.23 Maximum Temperature reduction envelope within receiving Shannon Estuary Water body over full 15-day simulation

3.6 Residual Chlorine Simulation Results

The residual Chlorine at 0.5mg/l and discharge rate of 6.111cumec was modelled in combination with the active tracer of temperature (i.e. includes the baroclinic hydrodynamic effects of density difference as a result of temperature).

The residual chlorine plume as maximum concentration envelopes for the selected four vertical layers (layers 15, 10, 5 and 1) are presented in Figures 12.1 to 12.4 for the spring-neap-spring simulation. The Residual Chlorine similar to the temperature mixing description sinks vertically at the discharge point and generally has maximum concentrations within a relatively short distance of the discharge point in the bottom (bed) layer due to the higher density of the colder discharge water over the ambient receiving waters. Within a reasonably short distance, the plume due to the high ebb and flood velocities and associated turbulence becomes well mixed vertically and horizontally.

Within 1.5km both East and West of the discharge point the predicted maximum Residual Chlorine concentration is less than 0.01mg/l, refer to Figure 12.5. Maximum concentrations above 0.1mg/l are shown to occur only within 20m of the discharge point and for a short period of time.

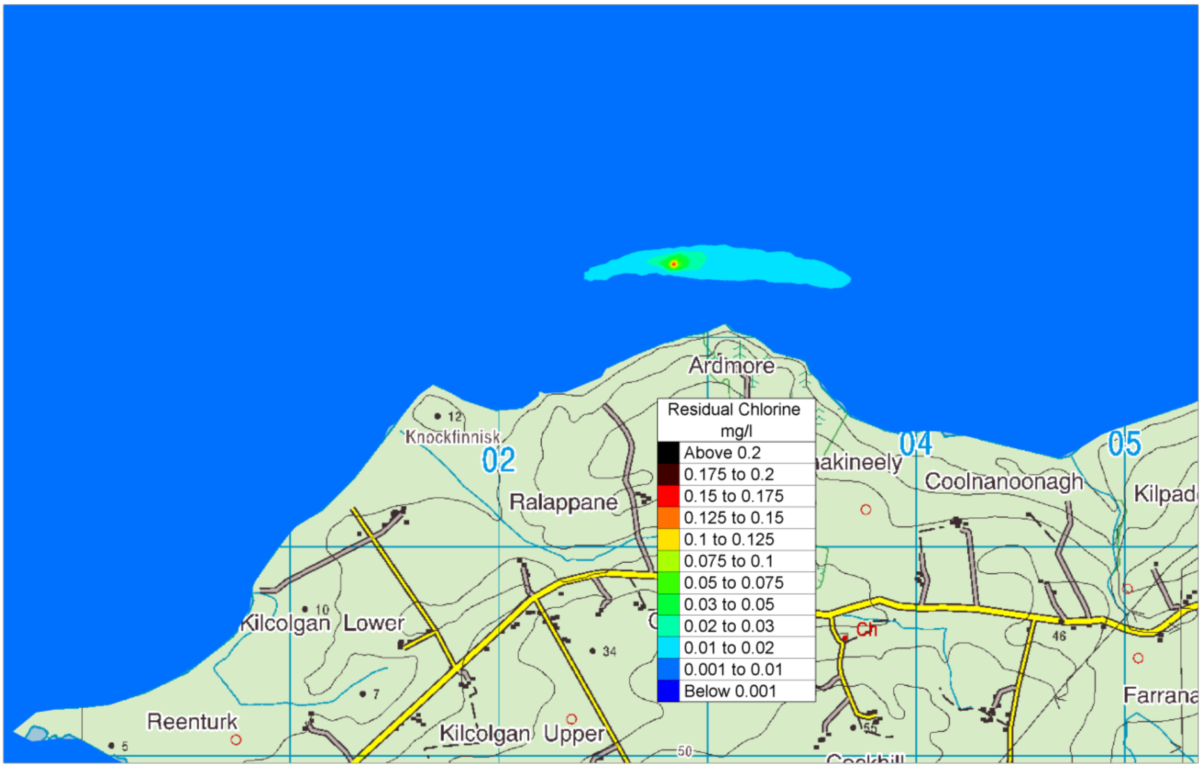

Figure 12.1 Maximum Concentration envelope in Surface Layer (layer 15) of Total Residual Chlorine

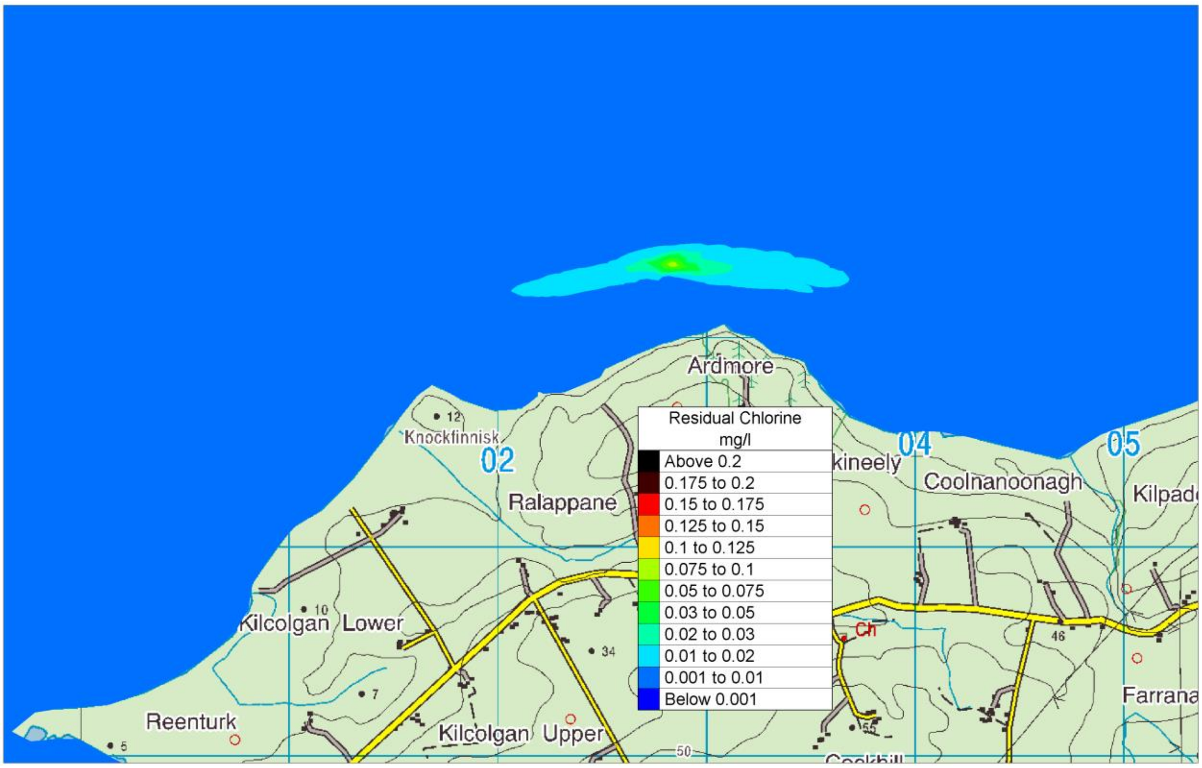

Figure 12.2 Maximum Concentration envelope in Layer 10 of Total Residual Chlorine

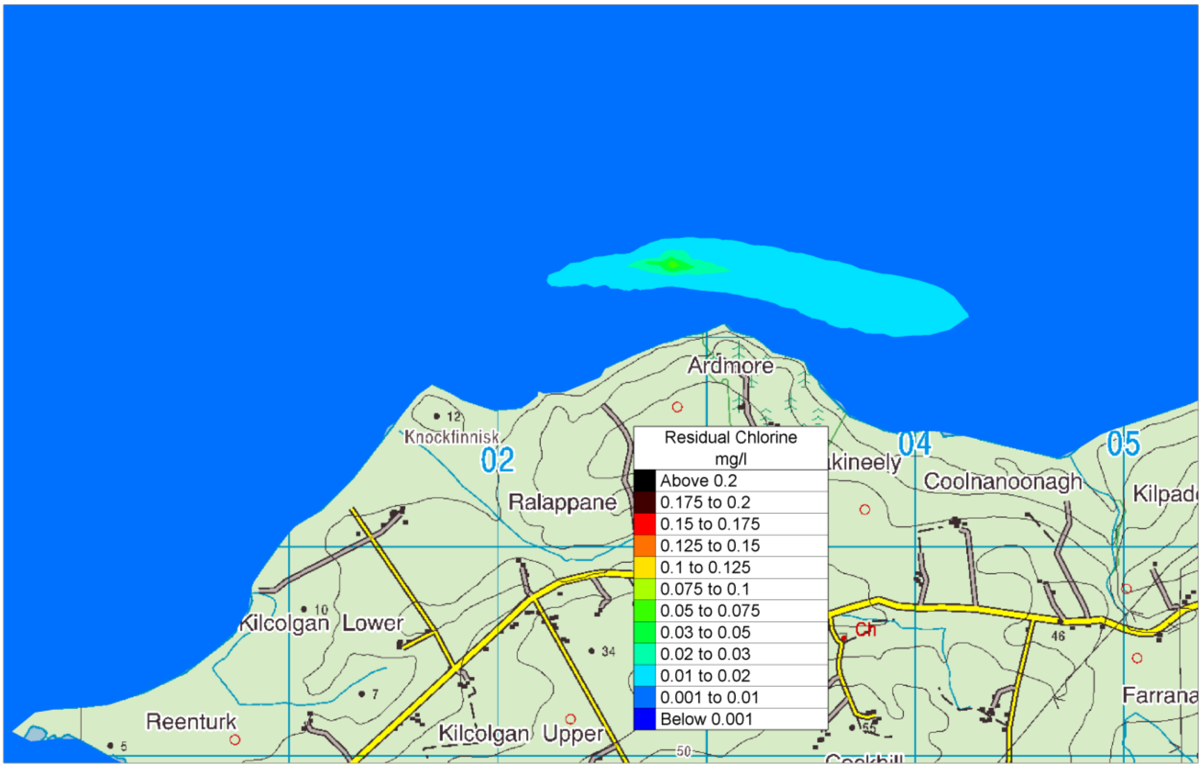

Figure 12.3 Maximum Concentration envelope in Layer 5 of Total Residual Chlorine

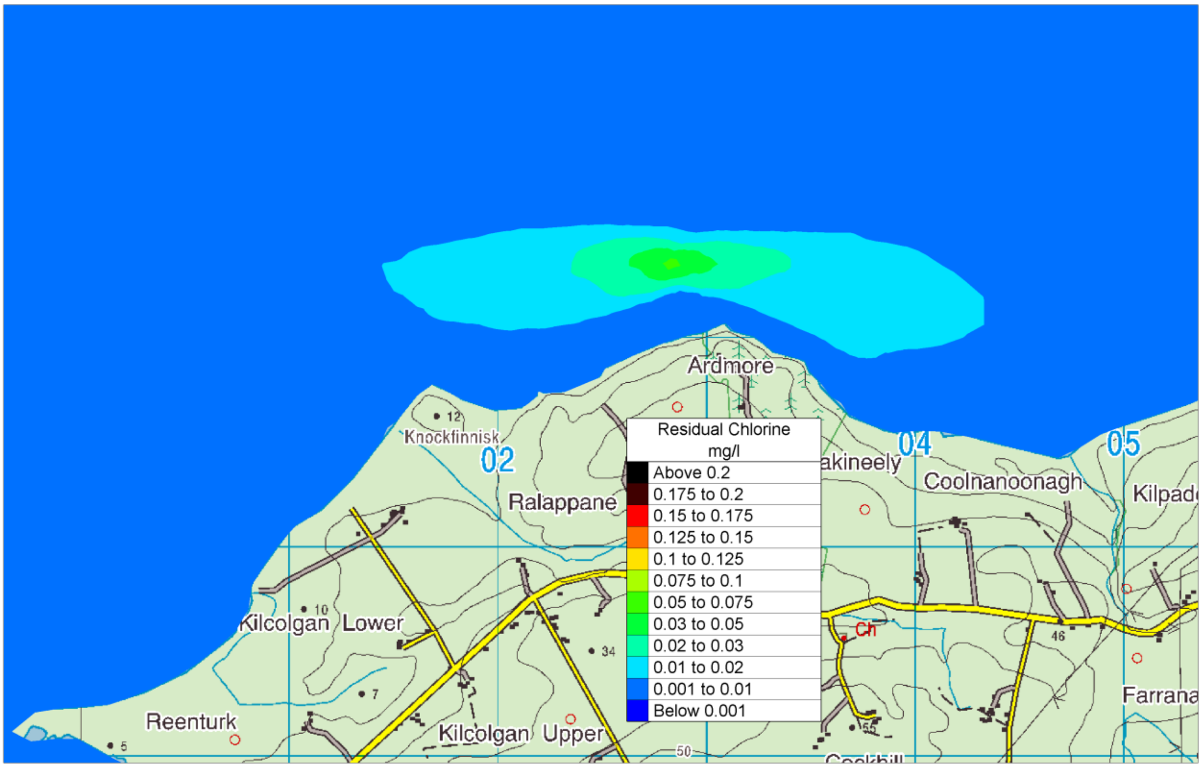

Figure 12.4 Maximum Concentration envelope in bottom Layer (Layer 1) of Total Residual Chlorine

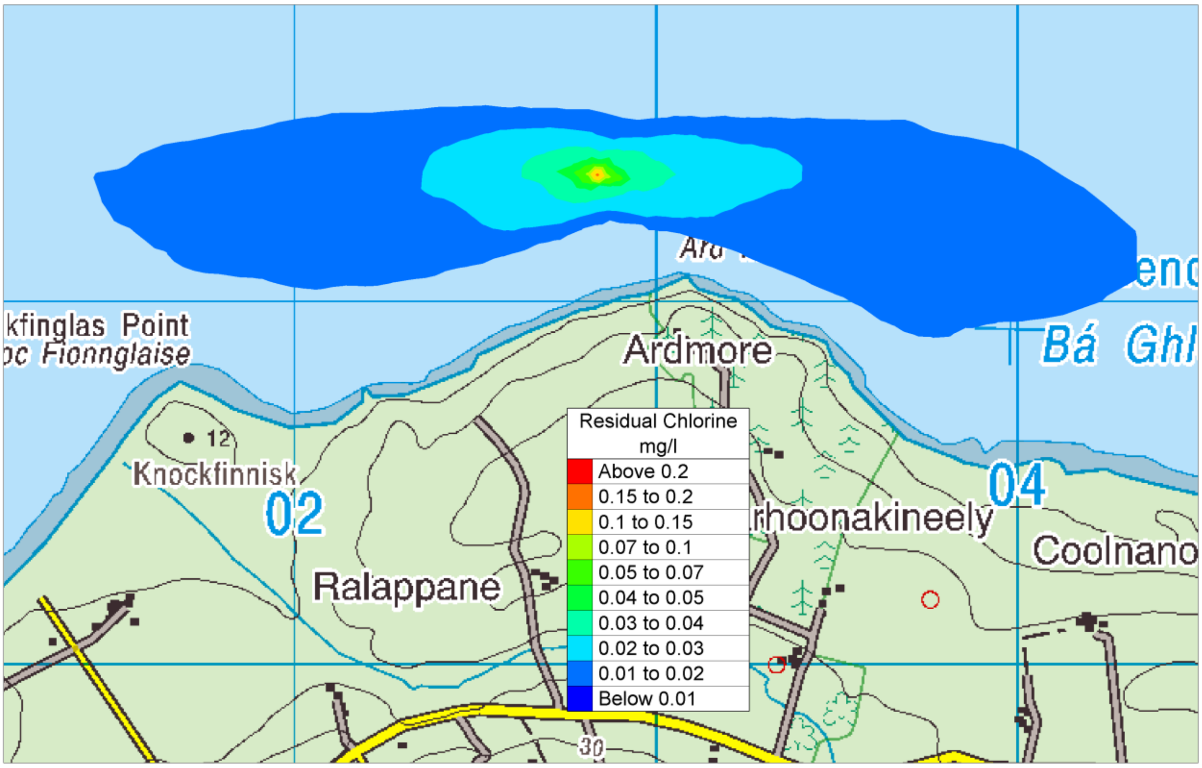

Figure 12.5 Maximum Residual Chlorine envelope within receiving Shannon Estuary Water body over full 15day simulation (all vertical layers)

3.7 Treated Sanitary Effluent Discharge

The proposed treated sanitary effluent discharge from development was modelled discharging from the proposed nearshore outfall pipe located on the sea bed at grid location E102554, N148936. The parameters of interest modelled are temperature, BOD, Ammonia, Total Phosphorous and *E.coli*.

The modelled effluent was a combination of the treated sanitary effluent of 35m^3/day and the process effluent at a mean daily discharge of 778m^3/day and an instantaneous maximum hydraulic load of 1,128 m^3/day. This was modelled as a thermal discharge at 40^{o}C with the receiving waterbody ambient temperature of 12^{o}C (effluent at 20^{o}C above ambient). The various treated effluent concentrations were specified based on tables 2 and 3 presented earlier.

The Heated discharge from the processed waters was modelled at 28^{o}C above ambient with the ambient at 12^{o}C. The maximum and mean temperature envelopes are presented in figures 13 and 14 over a full 15 day spring-neap-spring tidal period. These plots show a very local rise in temperature at the outfall site having a maximum increase of 0.9135^{o}C and a mean increase at the outfall site of 0.069^{o}C. The maximum temperature increase reduces within 100m of the discharge point to 0.171^{o}C which is an insignificant impact. The heated plume rises and mixes in the water column due to a lower density than the receiving waters. At the outfall site, the maximum temperature occurs at the sea bed but within a short distance, the plume is well mixed vertically.

E.coli was modelled from the sanitary discharge only using a conservative die-off rate of T_{90} = 36hours (winter conditions) at a secondary treated effluent concentration of 10^6 No./100ml and a discharge rate of 0.41l/s. The maximum and mean concentration envelopes for E.coli are presented in figures 15 and 16 over a complete spring-neap-spring tidal period. The predicted concentration plume shows no impact on Ballylongford and Glenclossagh Bays where shellfish activities areas are located. The highest concentration occurs in the receiving waters at the outfall site which is predicted to reach 1,458 No/100ml E.coli and within 100m (mixing zone) this has reduced to 279 No. / 100ml. The tidal mean concentration over 15 days of tides is 102 No./100ml at the outfall site and significantly lower elsewhere.

BOD concentration was modelled at 9l/s at a concentration of 20mg/l from the process effluent and at 0.41l/s at 25mg/l from the sanitary effluent discharge. The maximum and mean concentration envelopes for BOD are presented in figures 17 and 18 over a complete spring-neap-spring tidal period. The highest concentration occurs in the receiving waters at the outfall site at a concentration of 0.692mg/l BOD. The maximum BOD concentration within 100m of the outfall site is 0.132mg/l. The average BOD concentration in the receiving water at the outfall site is 0.048mg/l.

The total ammonia discharge from the treated process water and treated sanitary water produces a maximum ammoniacal nitrogen concentration within the receiving waterbody of 0.1513mg/l N and a mean concentration at the outfall site of 0.012mg/l N, refer to figures 19 and 20. The maximum ammoniacal nitrogen concentration within 100m of the outfall site is predicted to be 0.033mg/l N.

The dispersion simulations show that the total phosphorous concentration from the treated process water and treated sanitary water produce a maximum concentration within the receiving waterbody of 0.167mg/l P occurring at the outfall site and a mean concentration at the outfall site of 0.0117mg/l P, refer to figures 21 and 22. The maximum total phosphorous concentration at 100m from the outfall site is predicted to be 0.032mg/l P.

All of the above modelled water quality parameters are shown to easily satisfy the permissible limits set out in the surface water regulations and will not impact the water quality status of the receiving Shannon Estuary waters and will not impact the nearby shellfish waters in Ballylongford and Glenclossagh Bays.

Table 4 Predicted Maximum Concentrations within the receiving waters (note this occurred for all parameters at the proposed outfall site)

Parameter	Maximum	Average
Temperature difference	0.914°C	0.069°C
BOD	0.692 mg/l O2	0.049 m/l O2
Total Ammonia	0.1713 mg/l N	0.0120mg/l N
Total Phosphorous	0.1670mg/l P	0.0117mg/l P
E.coli	1458 No/100ml	102 No. / 100ml

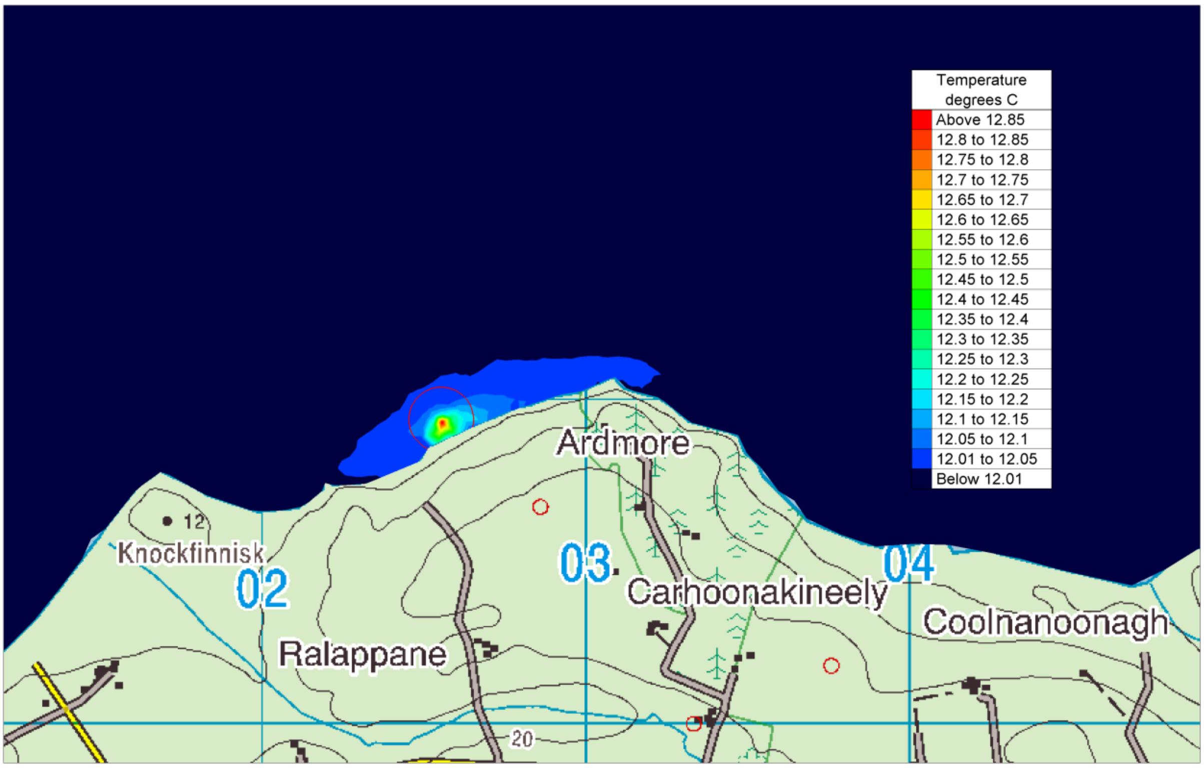

Figure 13 ***Predicted Maximum Temperature Envelope over 15-day for spring-neap-spring tide simulation modelling effluent at 40°C and ambient temperature at 12°C.***

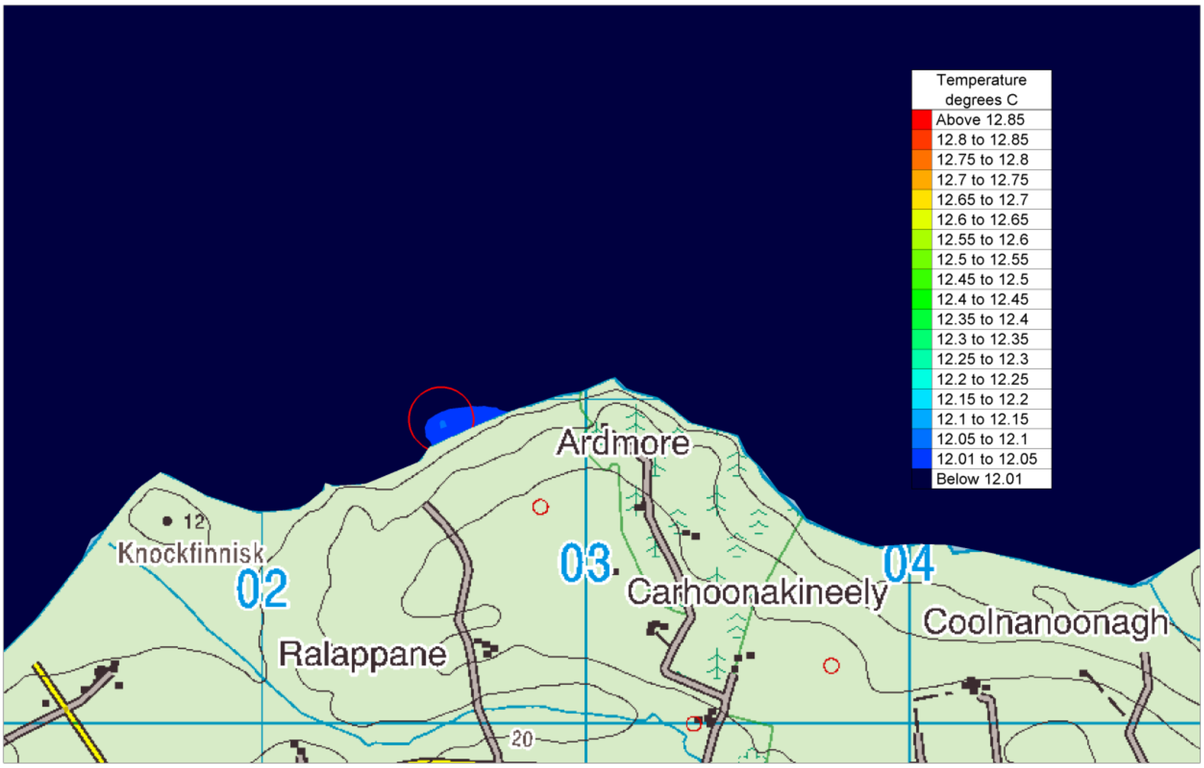

Figure 14 ***Predicted Mean Temperature Envelope over 15-day for spring-neap-spring tide simulation modelling effluent at 40°C and ambient temperature at 12°C.***

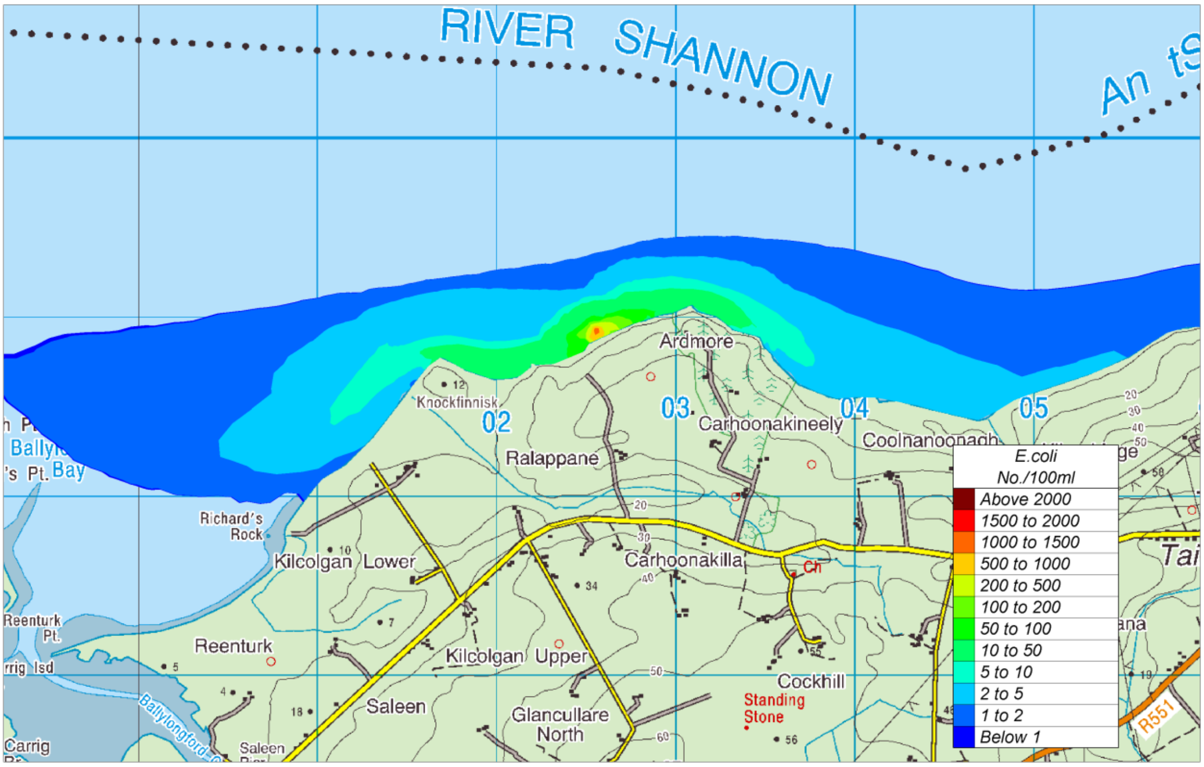

Figure 15 Predicted Maximum ***E.coli*** **Concentration (No./100ml) Envelope over 15-day for spring-neap-spring tide simulation**

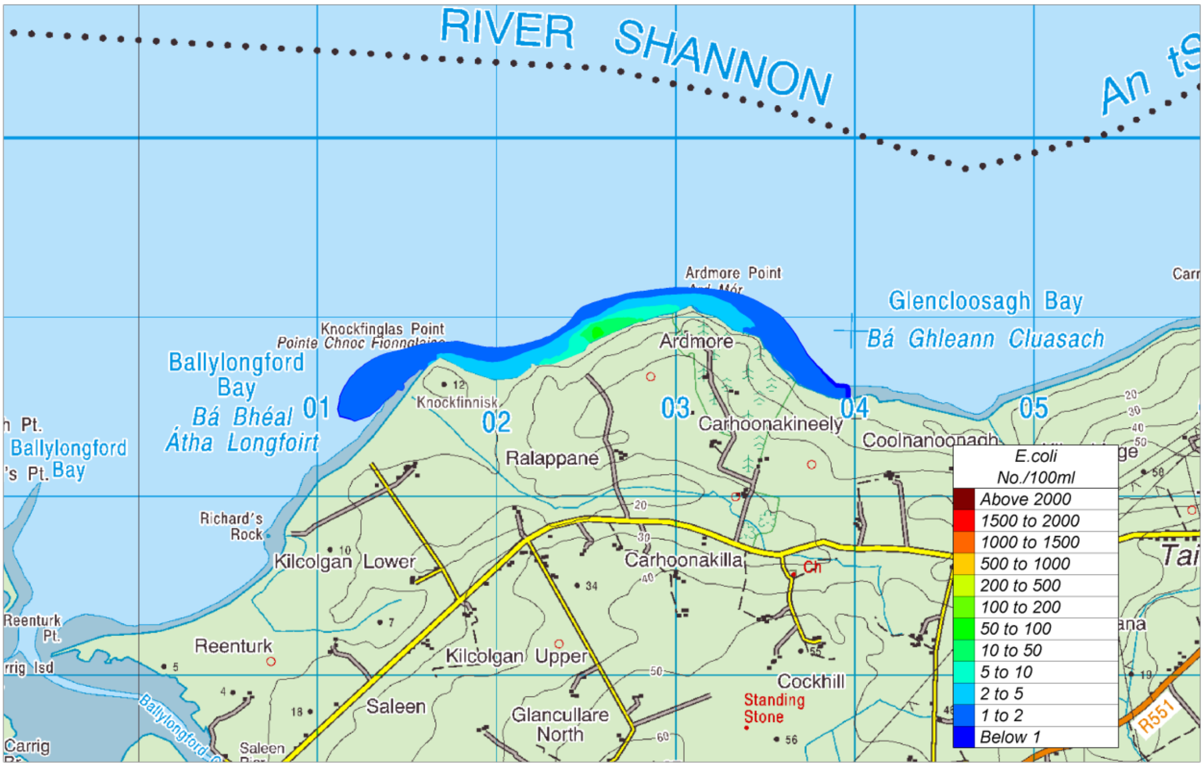

Figure 16 **Predicted average** ***E.coli*** **Concentration (No./100ml) Envelope over 15-day for spring-neap-spring tide simulation**

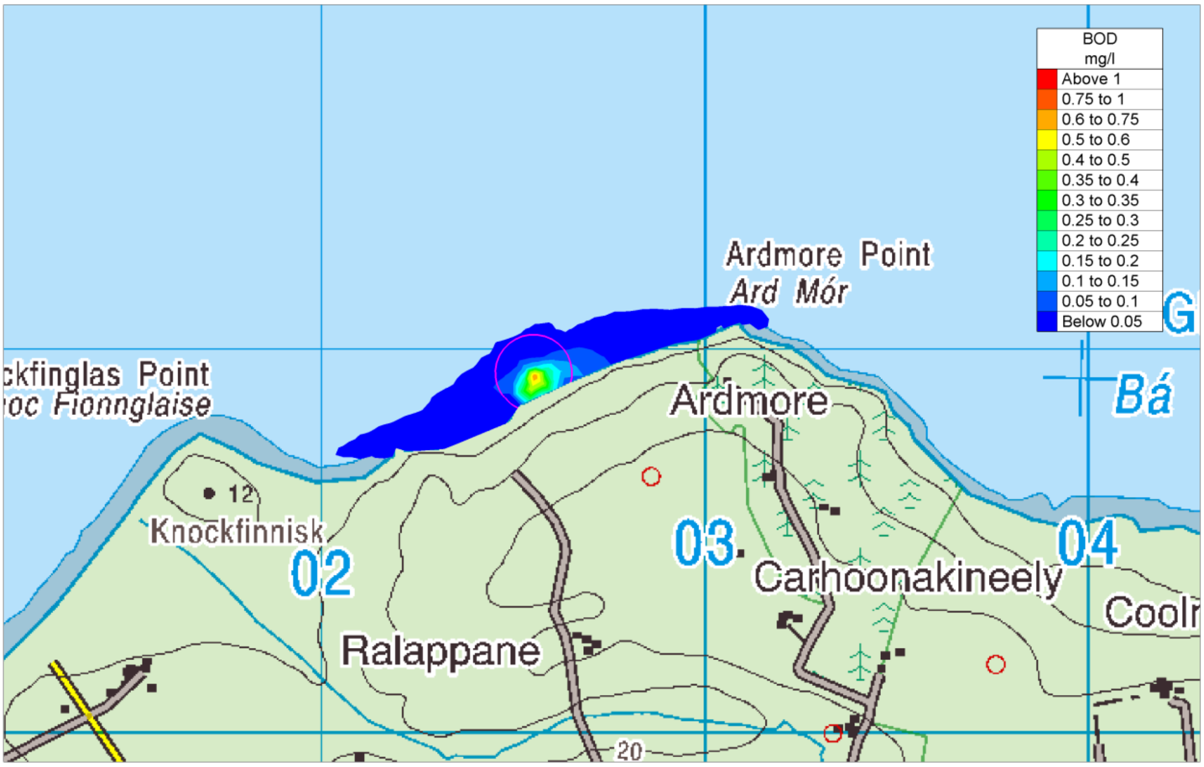

Figure 17 Predicted Maximum BOD Concentration (mg/l) Envelope over 15-day for spring-neap-spring tide simulation

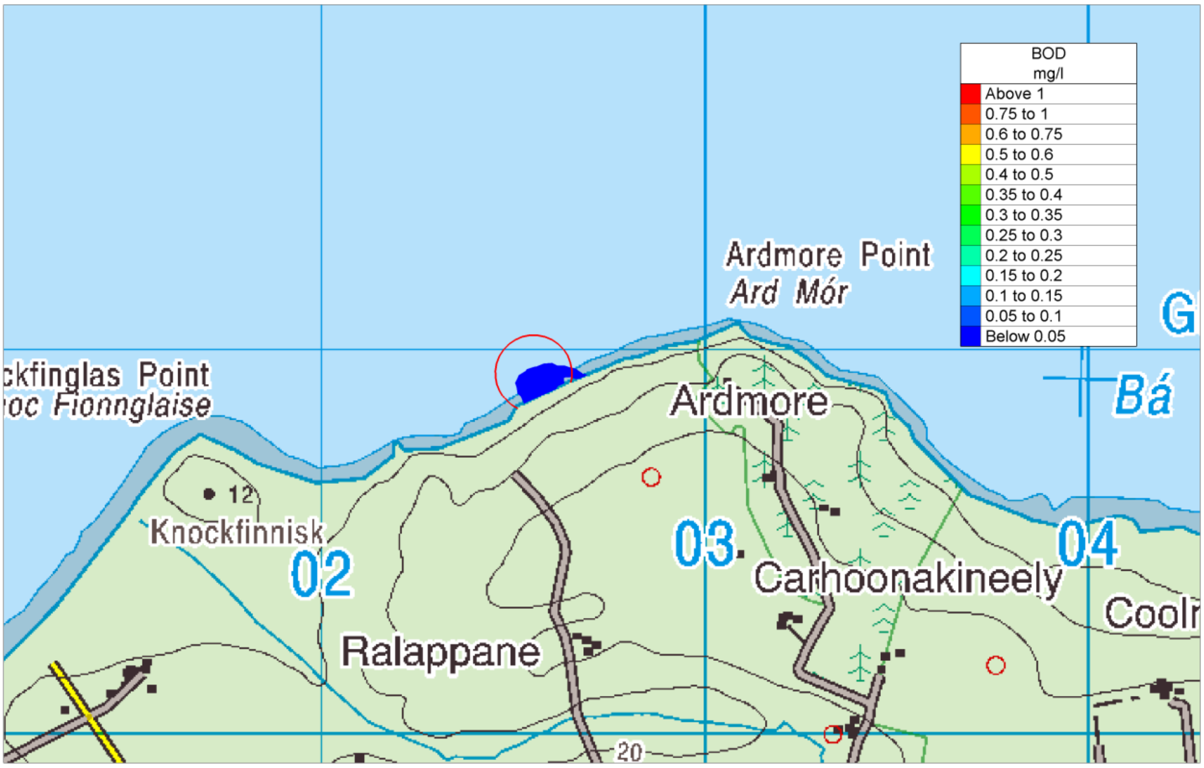

Figure 18 Predicted Mean BOD Concentration (mg/l) Envelope over 15-day for spring-neap-spring tide simulation

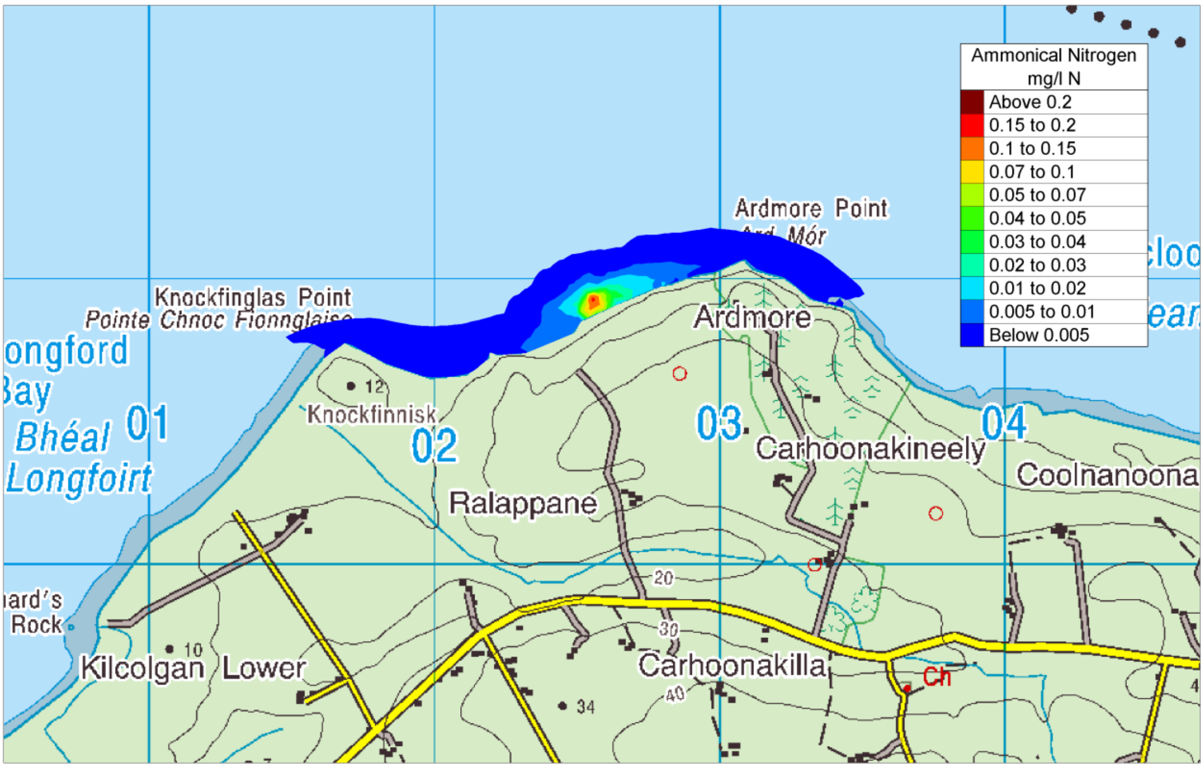

Figure 19 Predicted Maximum Ammoniacal Nitrogen Concentration (mg/l N) Envelope over 15-day for spring-neap-spring tide simulation

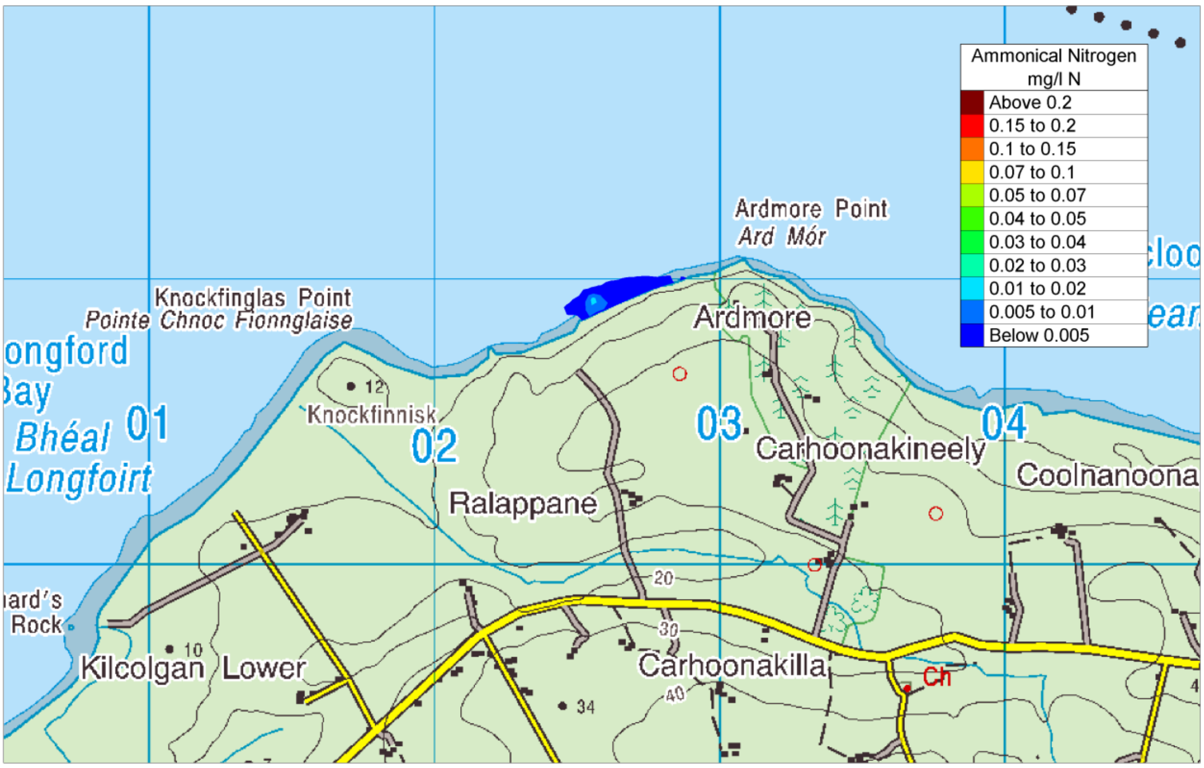

Figure 20 Predicted Mean Ammoniacal Nitrogen Concentration (mg/l N) Envelope over 15-day for spring-neap-spring tide simulation

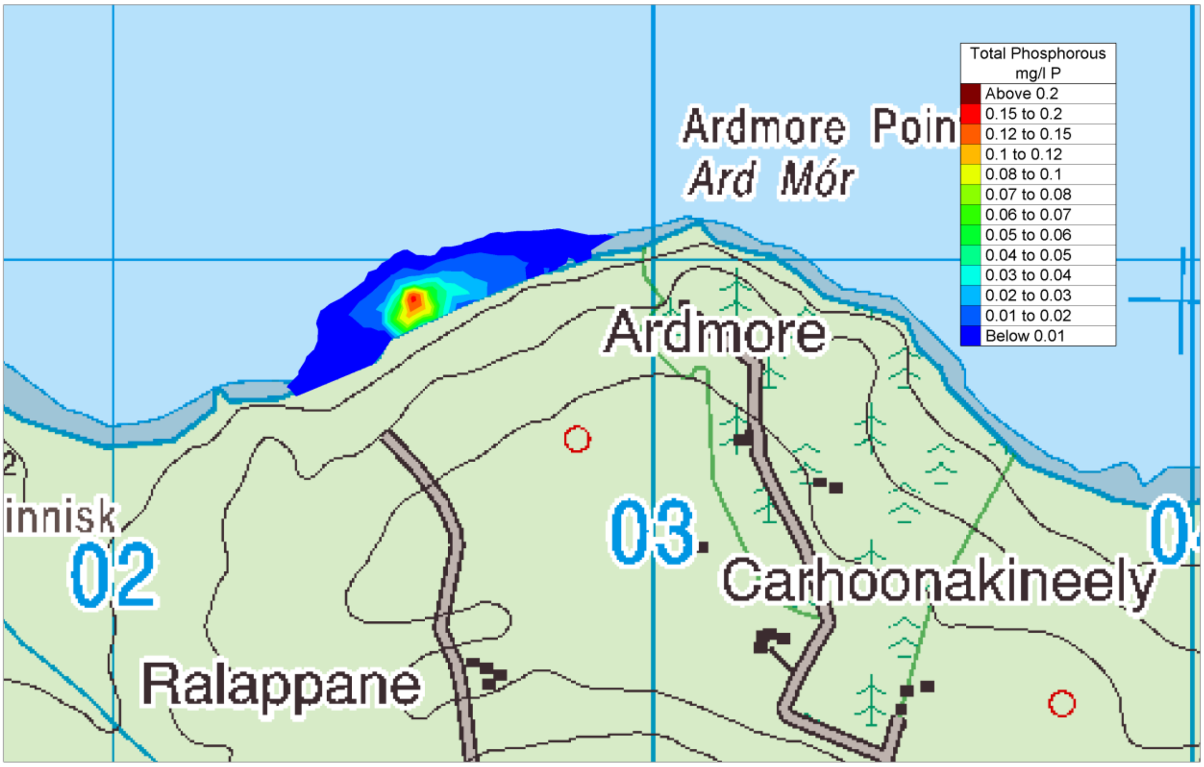

Figure 21 Predicted Maximum Total Phosphorous Concentration (mg/l P) Envelope over 15-day for spring-neap-spring tide simulation

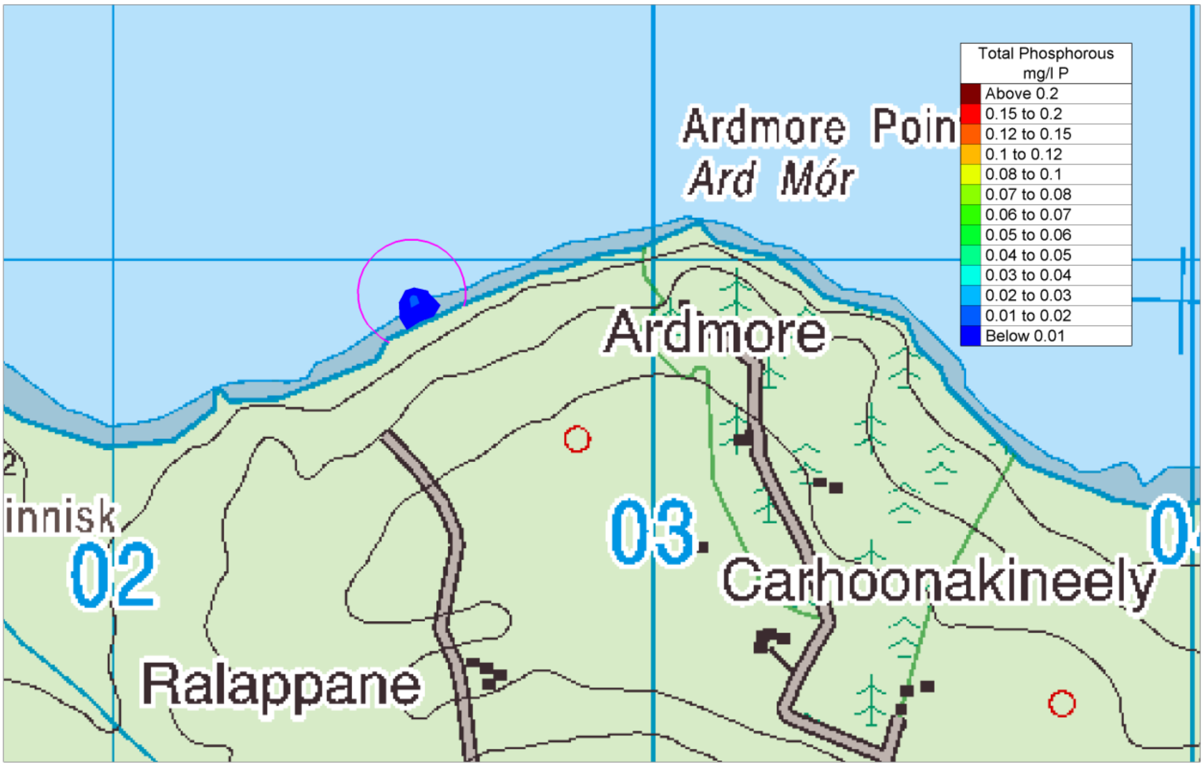

Figure 22 Predicted Mean Total Phosphorous Concentration (mg/l P) Envelope over 15-day for spring-neap-spring tide simulation

4 SEDIMENT DEPOSITION FROM PROPOSED PILING ACTIVITIES

The proposed pilling activities associated with the construction of the proposed jetty, the piled access Trestle, Unloading Platform, Mooring Dolphin 1, Mooring Dolphin 2, Bresting Dolphin, Bent and Tugboat Berths and Moorings has the potential to disturb sediments.

The proposed piles are 76 No. 914mm diameter piles and 127 No. 1067mm Piles, of 92 will be concrete filled, at an average pile length of 20m representing a piling volume of 1,980m^3. At a porosity of 20%, the total mass of sediment removed by the pile drilling operation is estimated conservatively to be 5.5 million kg (5,500 tonnes).

It is proposed that piles will be prefabricated as much as possible to minimize in-water construction.

The majority of the piles supporting the jetty would be driven, with some piles drilled and socketed into the underlying rock to ensure stability of the jetty. This operation would require a jack-up platform supporting a large crane-mounted drill and a large barge-mounted support crane. Spoils from the drilling operation will be conveyed to the surface via reverse-circulation through the drill stem and contained within designated scows or other vessels.

Spoils from the drilling operation will be conveyed to the surface via reverse-circulation through the drill stem and contained within designated scows or other vessels. Approximately 1000m^3 pile arisings are anticipated from the socketed piles (approximately 80 no.), none of which will be from onshore piling operations. The spoils would be placed on a barge, dried, then transferred to shore for drying and reused in general earthworks or in landscaped bunds.

To allow for disturbance of sediments by the piling process and potential spillage of sediment via reverse circulation a conservative factor of 25% of the sediment removed is used as a spillage rate of sediment. Sediment transport simulations are carried out based on a fine to very fine sand as identified in the geotechnical investigations. An 18-day simulation was performed with 0.9kg/s of sediment releases continuously from the pilling site. On the final tidal cycle of the 18-day simulation, the sediment deposition rates in sediment depth (mm) at hourly intervals from Highwater are presented in figures 23.1 to 23.12. The maximum predicted sediment deposition rate envelope in mm per m^2 is presented in figure 23.14 and shows in the Ballylongford Bay area maximum rates from the piling operation are less than 0.2mm which is insignificant.

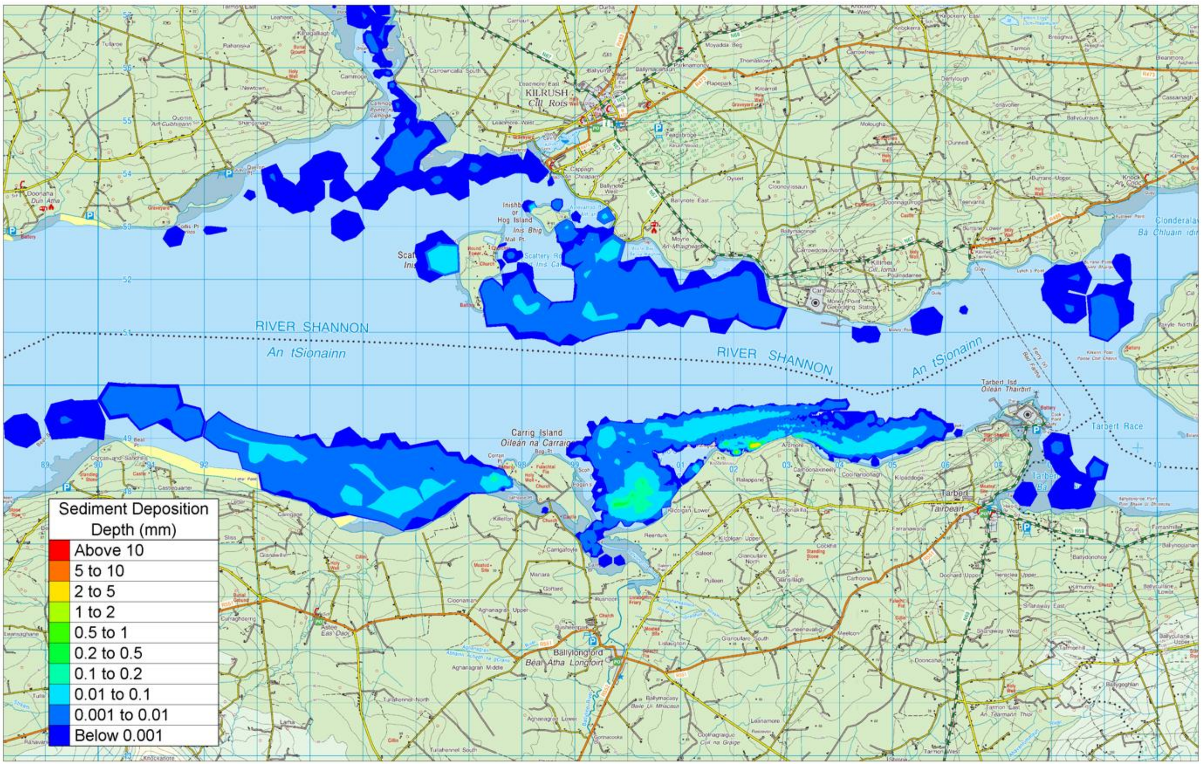

Figure 23.1 Sediment deposition at HW + 0.5hrs

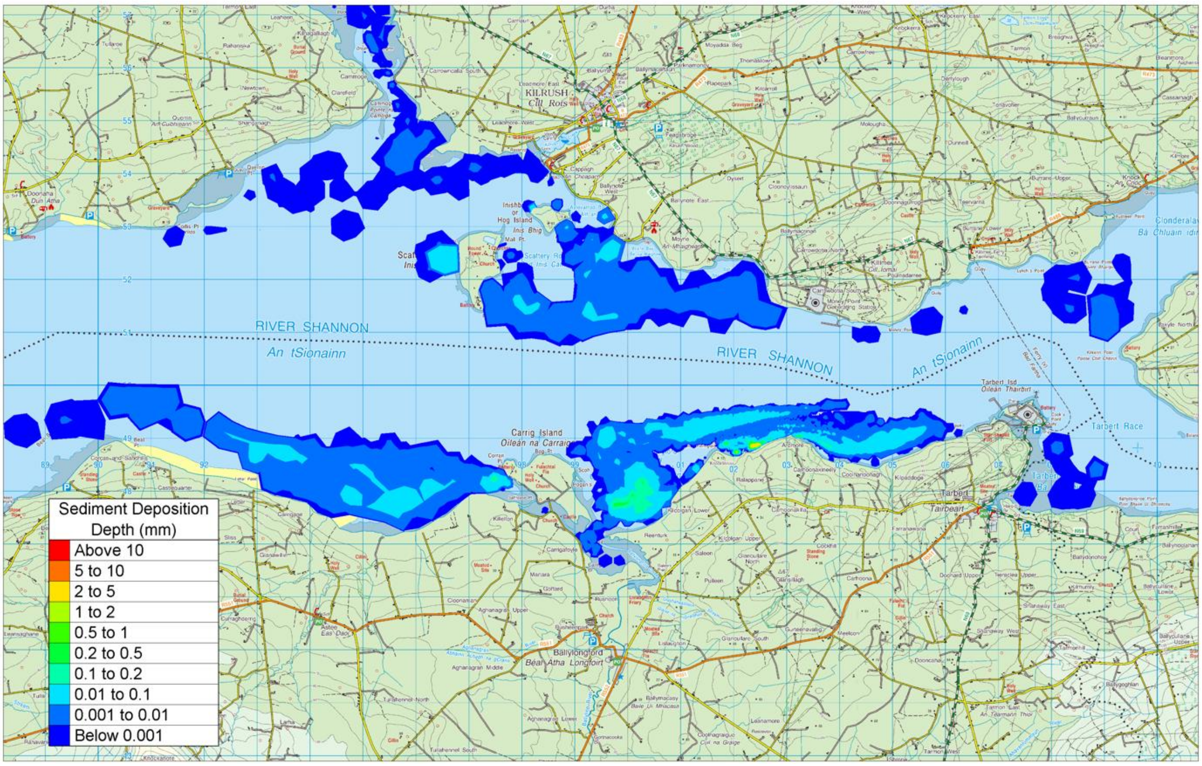

Figure 23.2 Sediment deposition at HW +1.5hrs

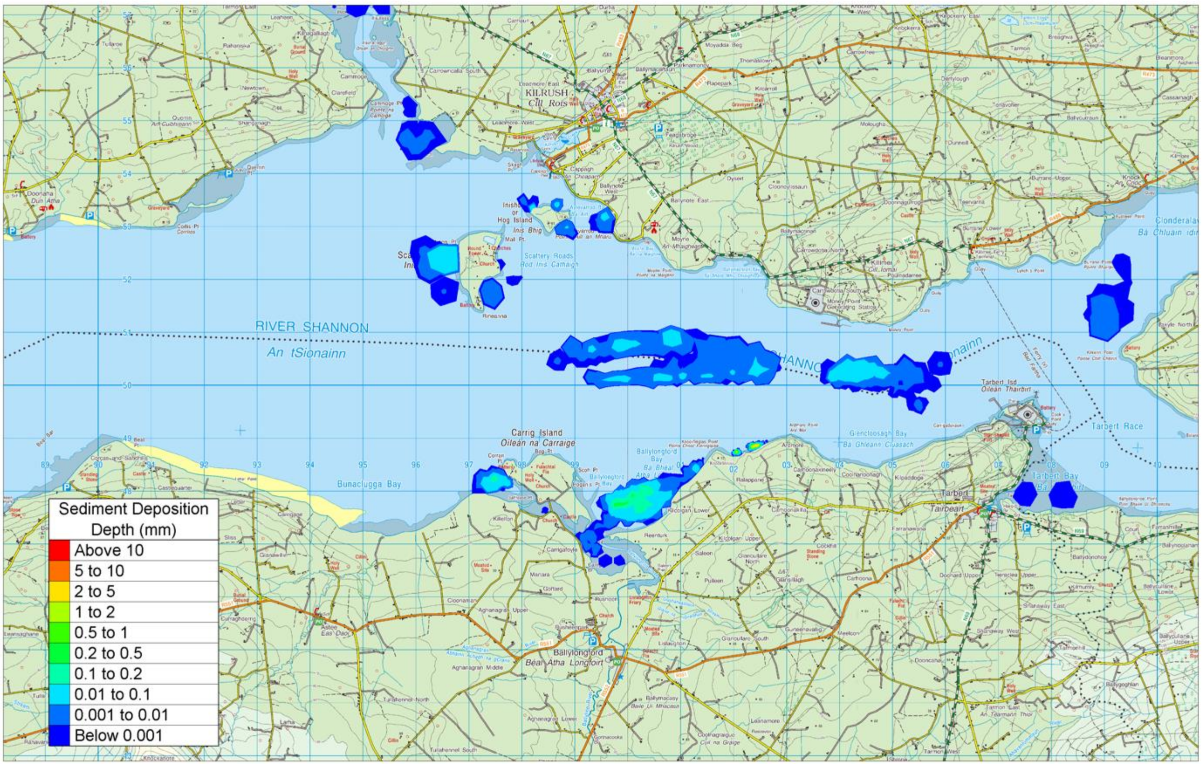

Figure 23.3 Sediment deposition at HW +2.5hrs

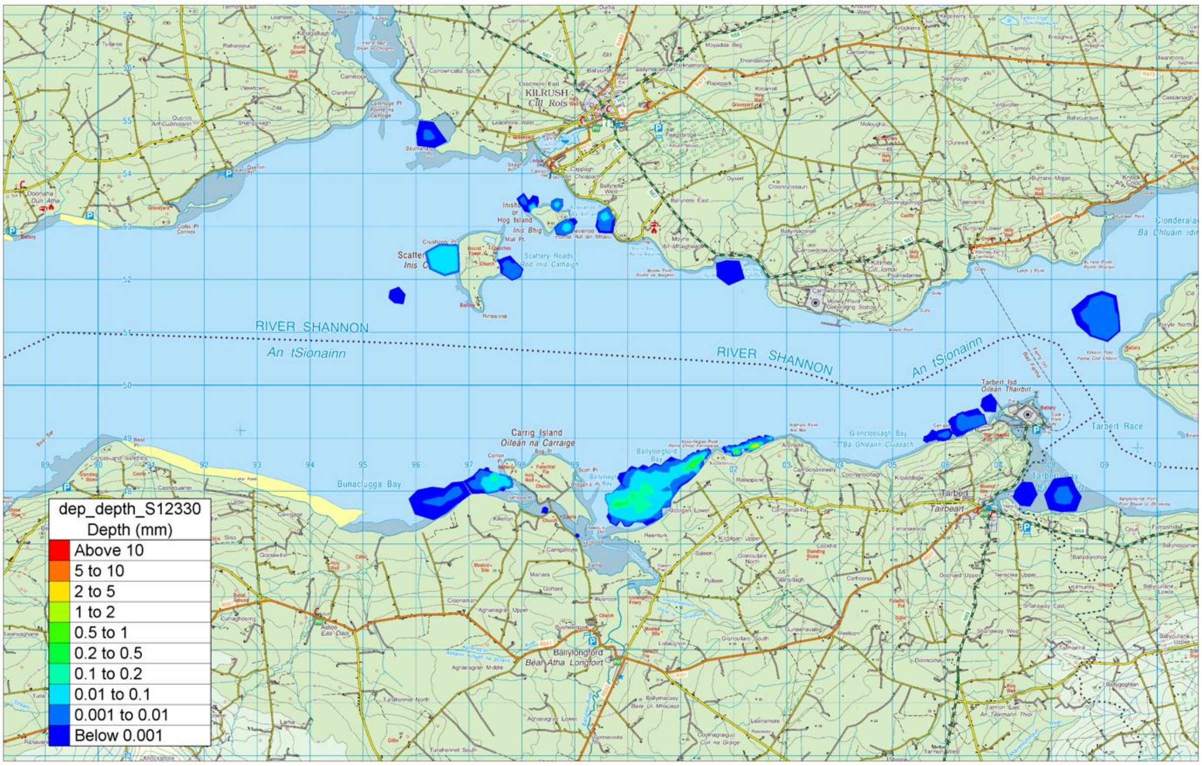

Figure 23.4 Sediment deposition at HW + Mid - ebb

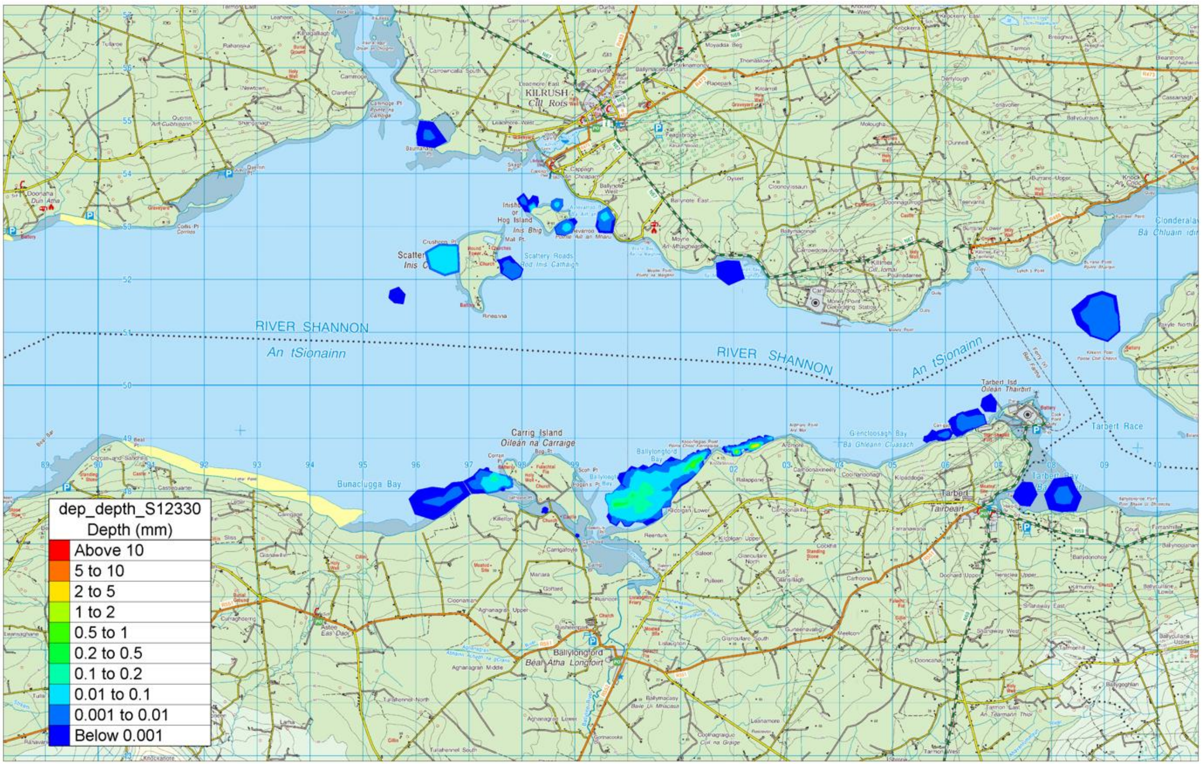

Figure 23.5 Sediment deposition at LW - 2hrs

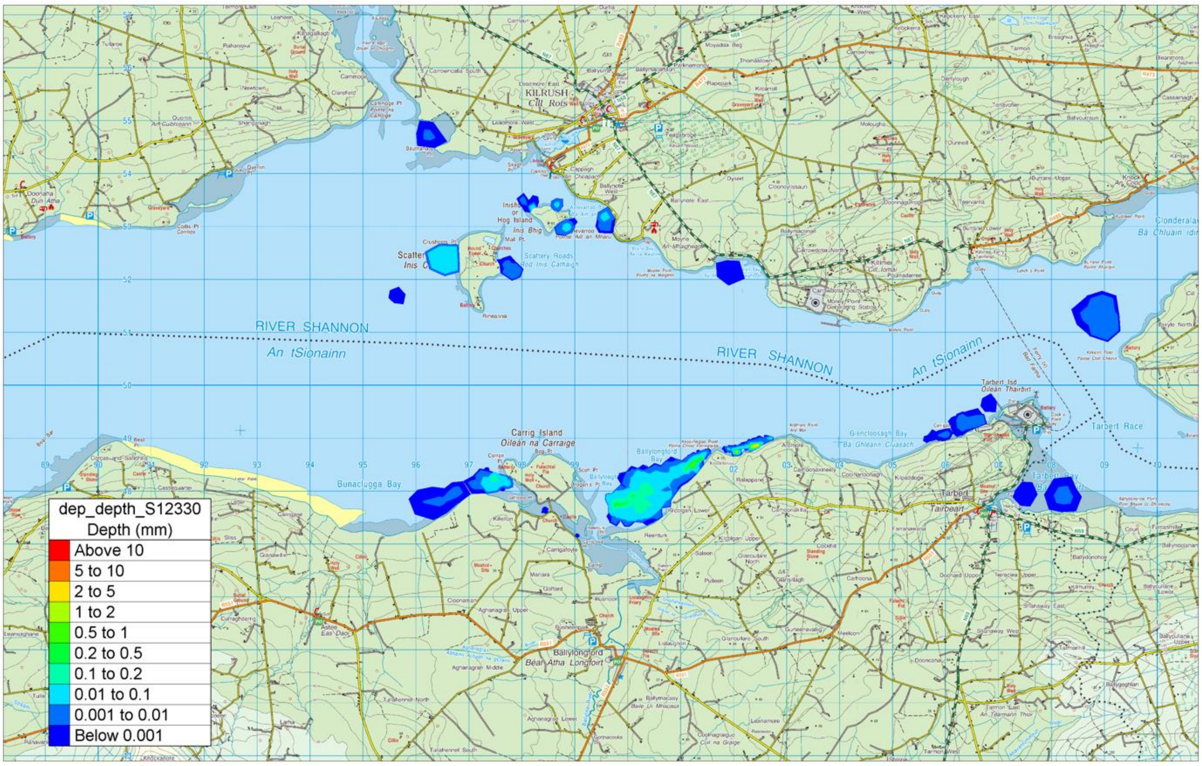

Figure 23.6 Sediment deposition at LW – 1hr

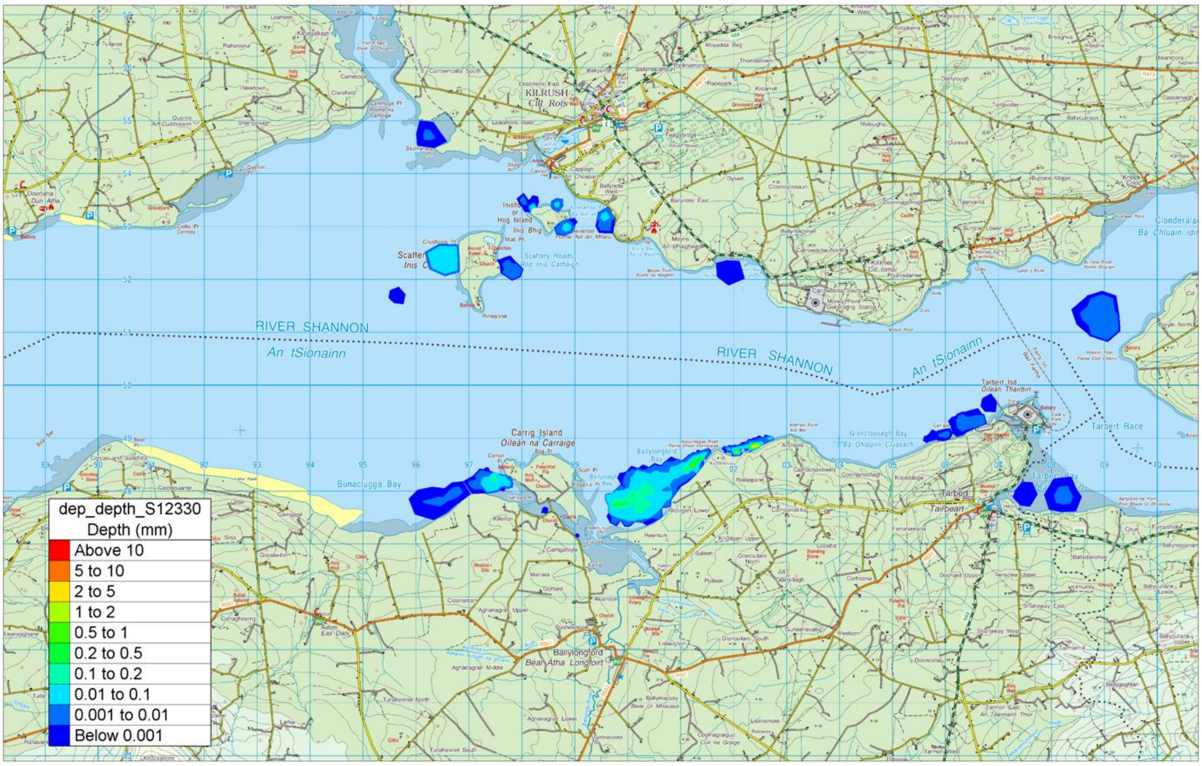

Figure 23.7 Sediment deposition at Low Water

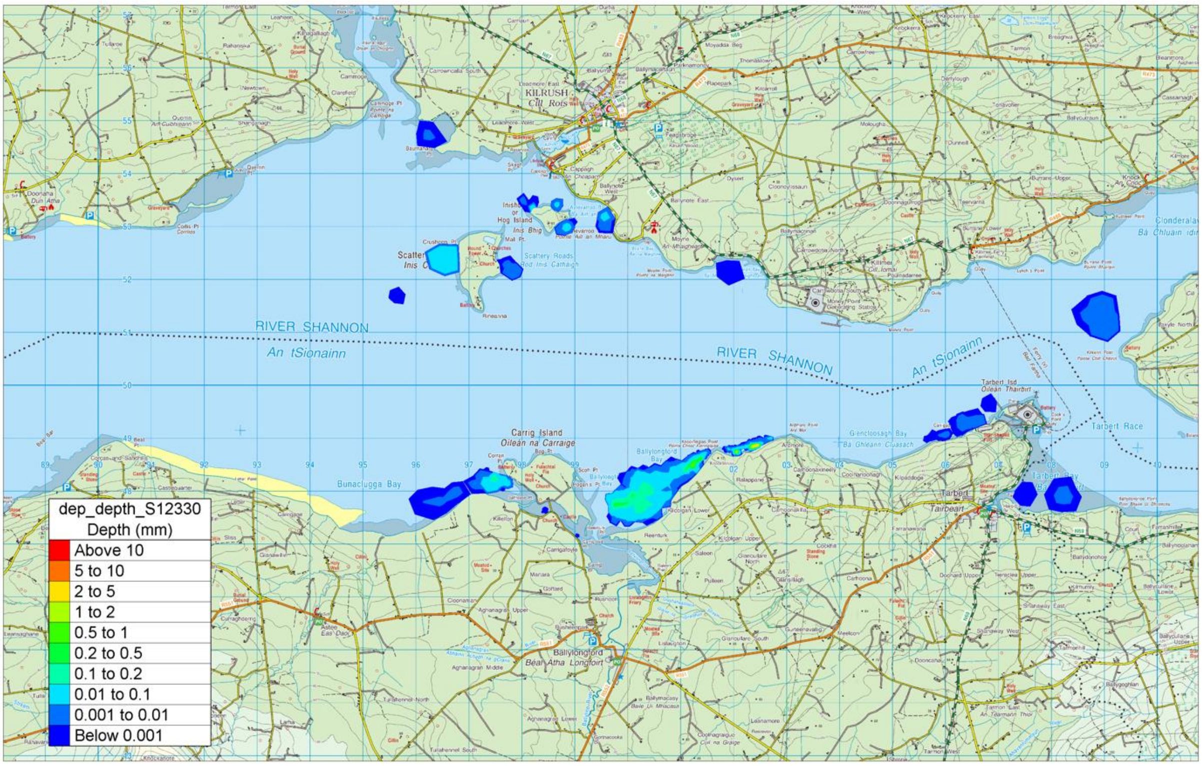

Figure 23.8 Sediment deposition at LW + 1

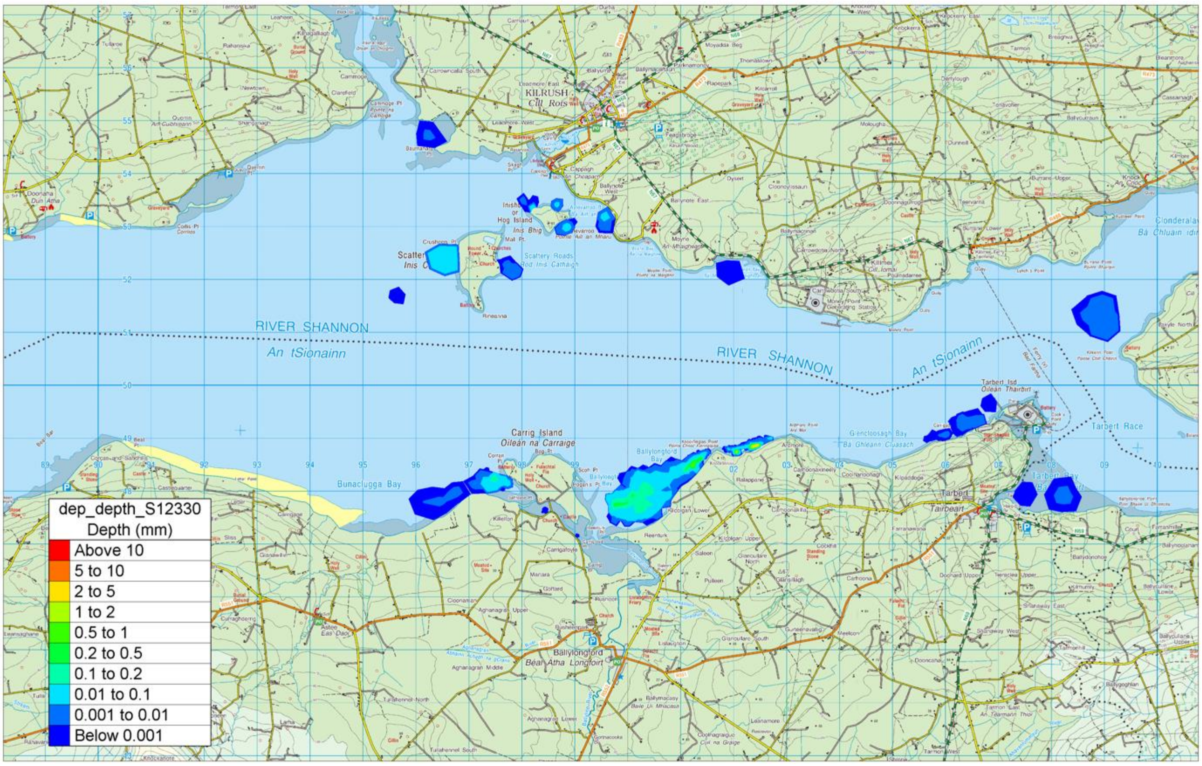

Figure 23.9 Sediment deposition at HW + 2hrs

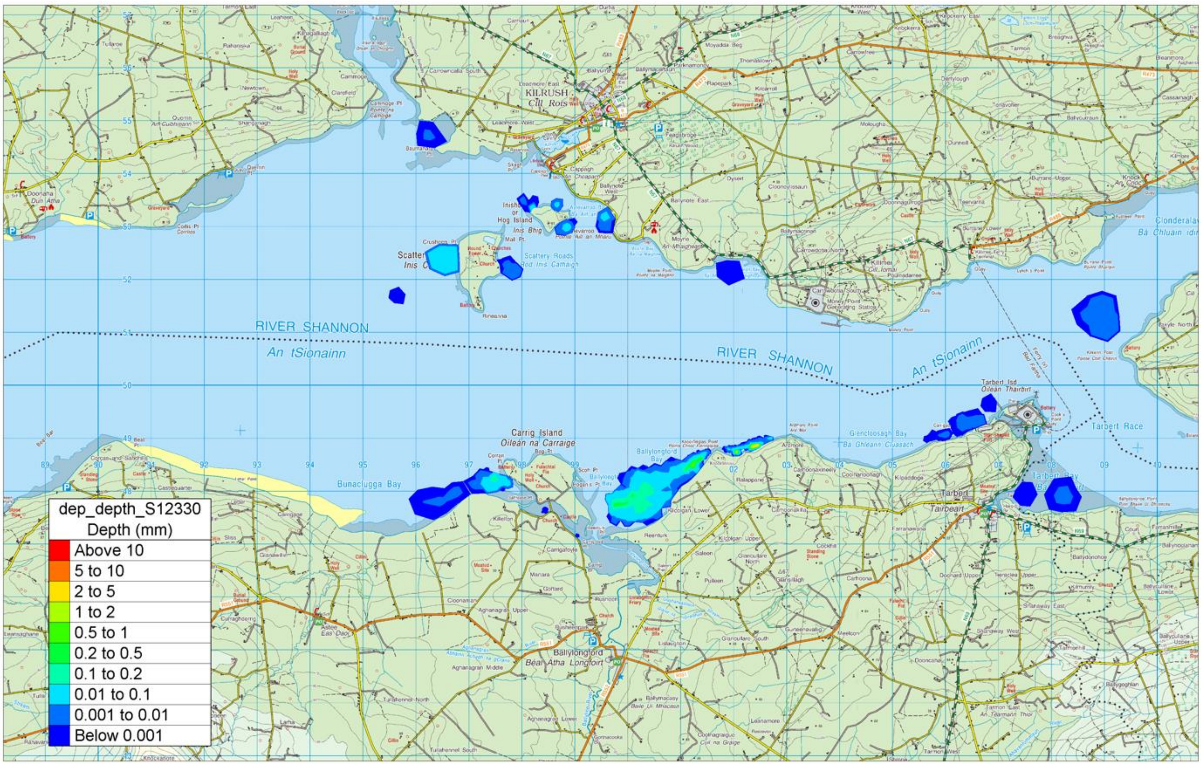

Figure 23.10 Sediment deposition at Mid-Flood

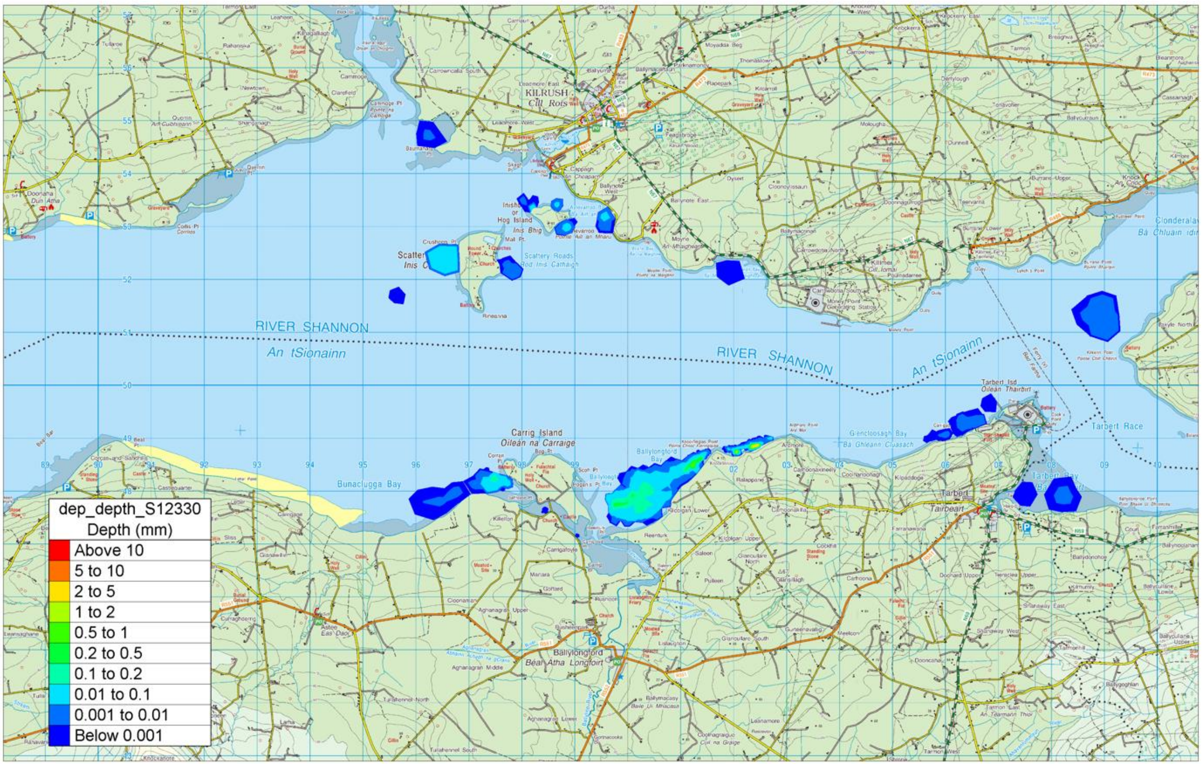

Figure 23.11 Sediment deposition at HW-2

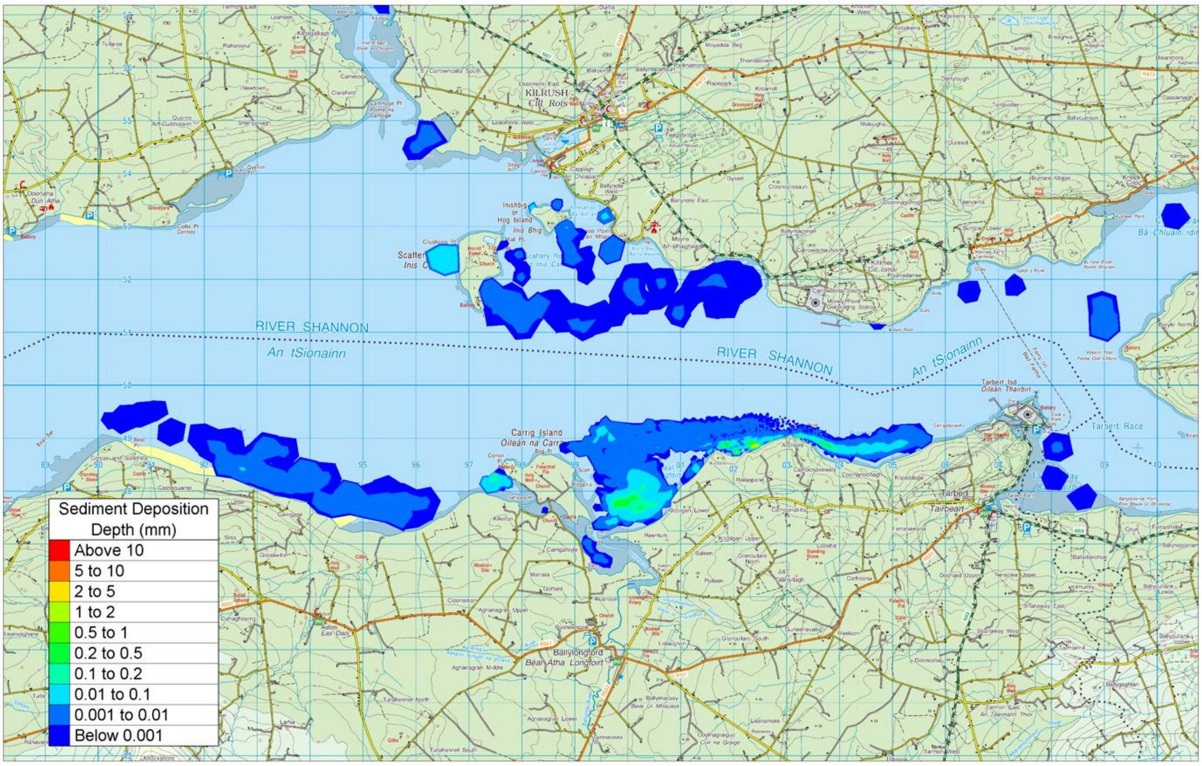

Figure 23.12 Sediment deposition at HW -1 hr

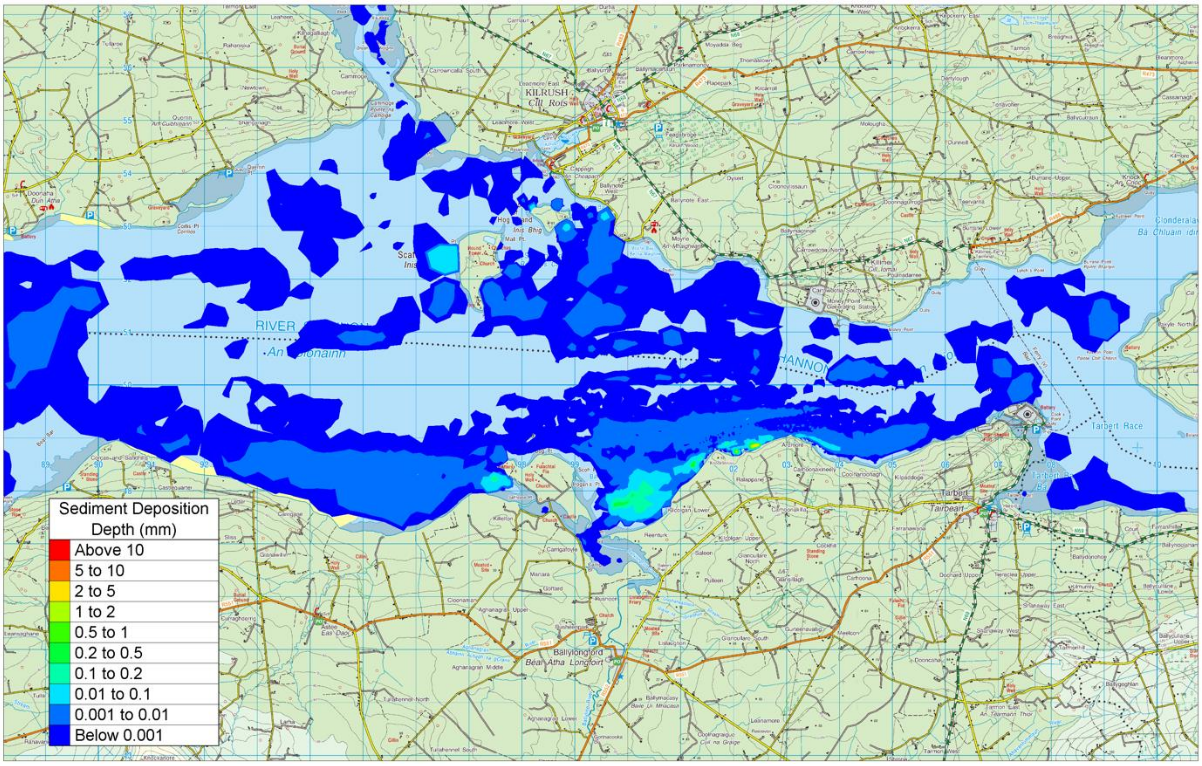

Figure 23.13 Mean tidal sediment deposition envelope

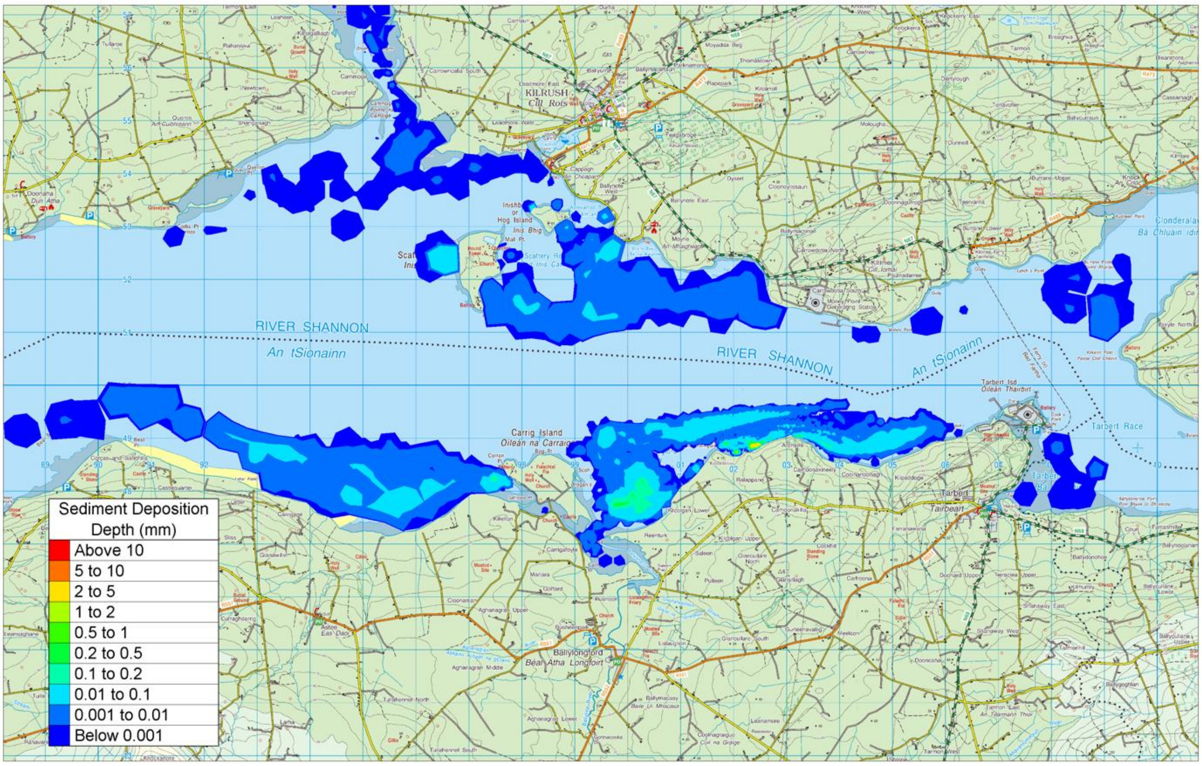

Figure 23.14 Maximum sediment deposition rate envelope

Appendix 4

Underwater Noise Modelling

Report for:	Shannon LNG Limited
Report reference:	20.4720
Date:	10 August 2021
Release:	Rev. 6

Vysus Group

Underwater Noise from Shannon Technology and Energy Park

Prediction of underwater noise

Report Information

Underwater Noise from Shannon Technology and Energy Park: Prediction of underwater noise

Report reference:	**Date:**	**Release:**
20.4720	10 August 2021	Rev. 6
Prepared by:	**Reviewed by:**	**Approved by:**
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Document control (Vysus Group internal use):

Release	Prepared by	Date	Comments
0	RSL	22 Oct 2020	First issue for client
1	RSL	6 Nov 2020	Included sea water pumps as noise sources
2	PTA, ASZ	23 Dec 2020	Update with FSRU data and a 5th scenario
3	RSL, PTA	21 May 2021	Included measurements and SEA modelling for FSRU source level
4	PTA, RSL	16 Jul 2021	Inclusion of AECOM comments, addition of extra construction scenarios, inclusion of more species
5	RSL	27 July 2021	Slight correction of intro and minor typos.
6	RSL	10 Aug 2021	Client's comments to descriptions of scenarios B and E, and App. B

Table of Contents

Executive Summary

In relation to a planned Liquified Natural Gas (LNG) import terminal and power plant at Shannon Estuary in Ireland, the Shannon Technology and Energy Park (STEP), the underwater noise was predicted by Vysus Group for the following scenarios in the construction and operation phases:

Construction phase:

- C1 Impact pile driving
- C2 Vibratory pile driving, including support vessels
- C3 Drilling for socket piles, including support vessels
- C4 Blasting – on land

Operation Phase:

- A FSRU (Floating Storage and Regasification Unit) as the only noise source
- B FSRU together with an offloading LNG carrier, including 1 tug in idling mode close to the carrier
- D FSRU together with approaching LNG carrier, including 4 sailing tugs
- E FSRU together with berthing LNG carrier, including 4 engaged tugs, a general cargo ship sailing in the middle of the Estuary, and ship moored at Moneypoint.

The noise was modelling along multiple transects in an “n x 2D” approach, using a Parabolic Equation (PE) model for low to medium frequencies as well as a Beam Tracing model for high frequencies. This approach accounts for range dependent bathymetry, multi-layered seabed, and frequency dependence. The predicted noise was compared to sets of acoustic criteria, relating to bottlenose dolphins, harbour & grey seals, harbour porpoises, salmon, twaite shads, marine and river lamp-rays, as recommended for the study by LGL Ecological Research Associates Inc. Evaluation of these criteria led to tables of distances (and corresponding areas) to threshold. These tables are presented in the report and have been passed on to LGL for detailed assessment of the potential acoustic impact on the listed species. This biological assessment follows in a separate report.

For the best possible estimate of the FSRU’s source level, underwater noise measurements were taken on the Golar Freeze FSRU on a site in Jamaica, and the corresponding source level was determined. Further, the underwater noise source level of an FSRU (Golar Igloo) was modelled using state-of-the-art Statistical Energy Analysis (SEA) software VAOne. Based on these, a conservative source level spectrum was derived and applied for the Shannon LNG terminal study

Furthermore, measurements of ambient noise were taken on-site on two days in May 2020 as spot-checks. Statistical analyses of the ambient noise are presented in the report and are used for coarse comparison with the predicted underwater noise. In particular, a measured event of a passing ferry was considered, and it was found that the predicted noise contribution from the FSRU on its own (scenario A) or with the offloading carrier (scenario B) was less than that of the ferry except for ranges within 1200 m.

Vysus Group and Lloyd’s Register

Following a strategic carve-out from the Lloyd’s Register (LR) Group, LR’s Energy business is now Vysus Group, a standalone engineering and technical consultancy, offering specialist asset performance, risk management and project management expertise across complex industrial assets, energy assets (oil and gas, nuclear, renewables), the energy transition, rail infrastructure, and marine.

The current study was initially awarded to Lloyd’s Register Consulting – Energy A/S, and subsequently transferred to Vysus Denmark A/S, which is a subsidiary of Vysus Group.

Introduction

1 Introduction

In the context of the future construction of an LNG terminal and power plant in the Lower River Shannon Special Area of Conservation (SAC) and River Fergus Special Area of Protection, Shannon LNG Limited has requested Vysus Denmark A/S (hereafter VG) to perform prediction of underwater noise for a variety of noise source scenarios. The site considered is a Floating Storage and Regasification Unit (FSRU) nearshore terminal for Liquified Natural Gas (LNG), the Shannon Technology and Energy Park (STEP), located near Tarbert and Ardmore Point in the Shannon Estuary, County Kerry, Western Ireland.

This study concerns establishment of an FSRU, including construction of the associated jetty, as well as an approaching LNG carrier, and ships sailing and berthed in the Estuary.

This report presents methodology and findings of the underwater acoustic modelling, as well as on-site measurements of ambient underwater noise performed in May 2020 and source level measurements in Jamaica in March 2021. The modelling results have been transferred to VG's sub-contractor LGL Ecological Research Associates, Inc. (www.lgl.com, hereafter LGL) for subsequent, biological sound exposure assessment. LGL's assessment will follow in a separate report. Furthermore, the acoustic criteria applied in this report were prepared by LGL.

2 Site description

2.1 Location overview and bathymetry

Figure 1 and Figure 2 show location overviews of the section of the Shannon Estuary near the LNG terminal. The indicated positions A, B, C and M are those assumed as noise source positions in this study.

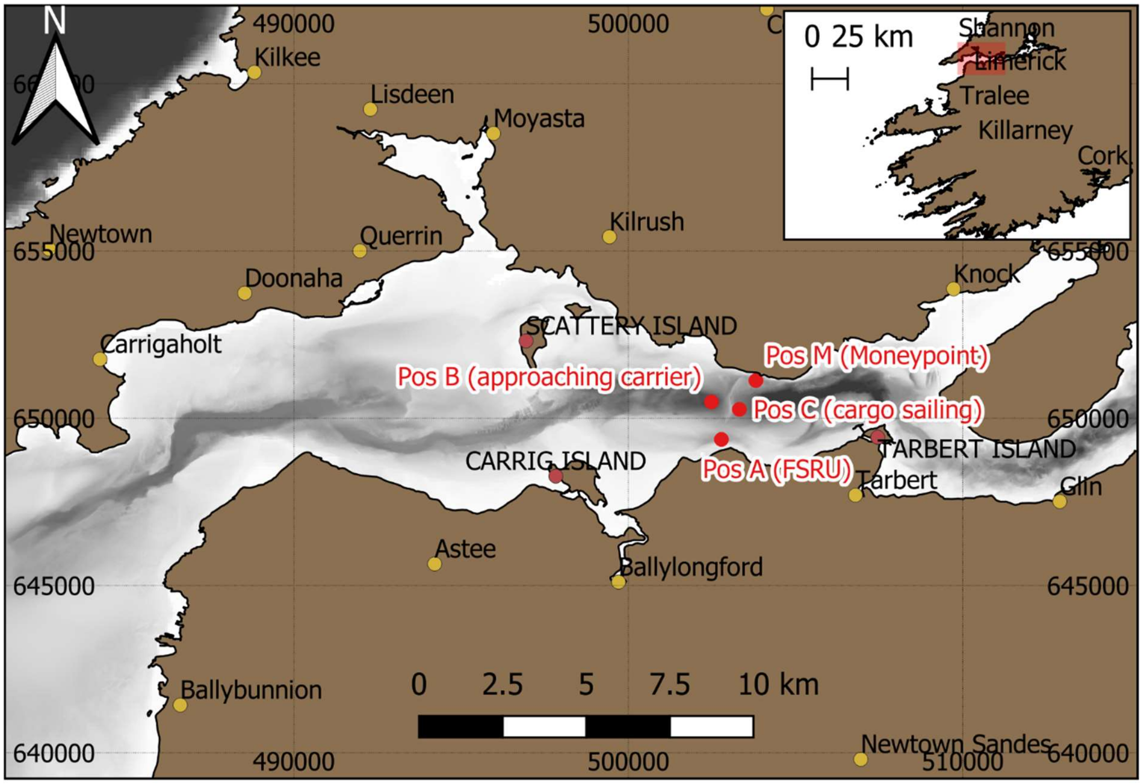

Figure 1. Situation map and location of main noise sources. Projection is IRENET95/Irish Transverse Mercator. Land polygons ©OpenStreetMap contributors [1]. Placename data from OSi [2] under standard CC license [3].

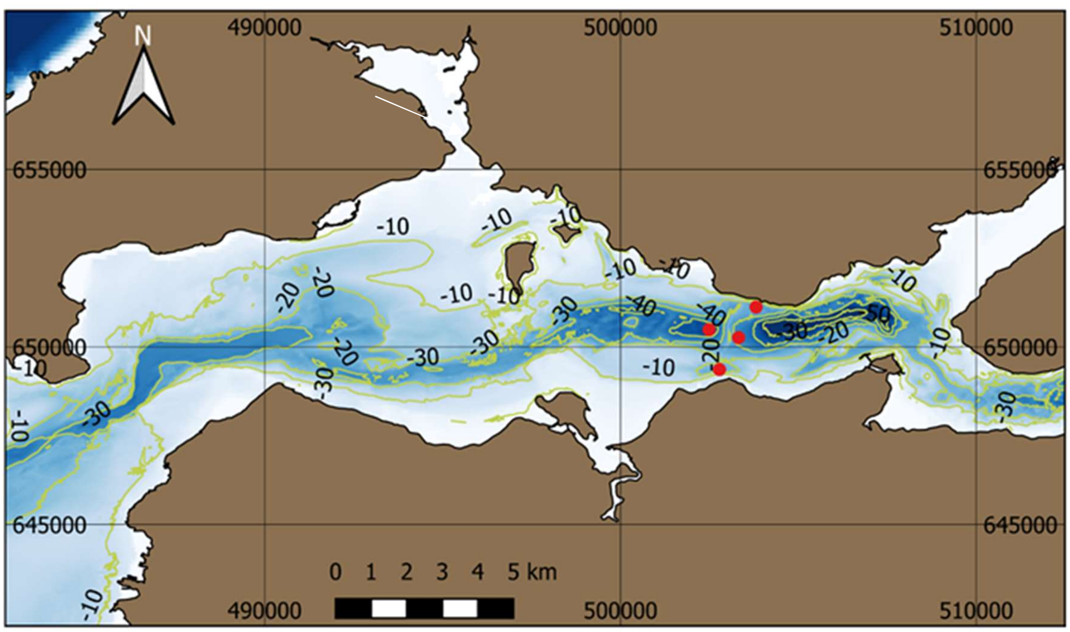

Figure 2. Location water depths overview, red spots indicate source locations. Projection is IRENET95/Irish Transverse Mercator, and water depth is referred to LAT. Land polygons ©OpenStreetMap contributors [1]. For bathymetry sources, see main text.

Position A is at the FSRU location of the jetty, while Position B is in deeper water and used for the source location of the approaching LNG carrier. Position C is the position used for the general cargo ship sailing in the middle of the estuary and position M is the location of the berthed ship at Moneypoint Power station. It is seen from Figure 2 that the water depth is generally within approximately 50 m, with the deepest region in the middle of the estuary.

The digital bathymetry data was obtained from:

- EMODnet: As NetCDF file with horizontal resolution of one sixteenth arc minute, which is approximately 115 m [1]
- INFOMAR/Geological Survey, Ireland (GSI): Merged GeoTiff files[1)] with horizontal resolution 5 and 10 m, respectively [5]

Bathymetry data was obtained as referenced to LAT, but converted to MHWS for use in the project, see Section 2.3.

A drawing of the LNG import jetty is shown in Figure 3. The jetty extends approximately 320 m out from the shore, to reach local deep water in the order of 20 m depth. As seen, the FSRU is moored at dolphins at a platform located at the end of the jetty, with an orientation nearly parallel to the shore.

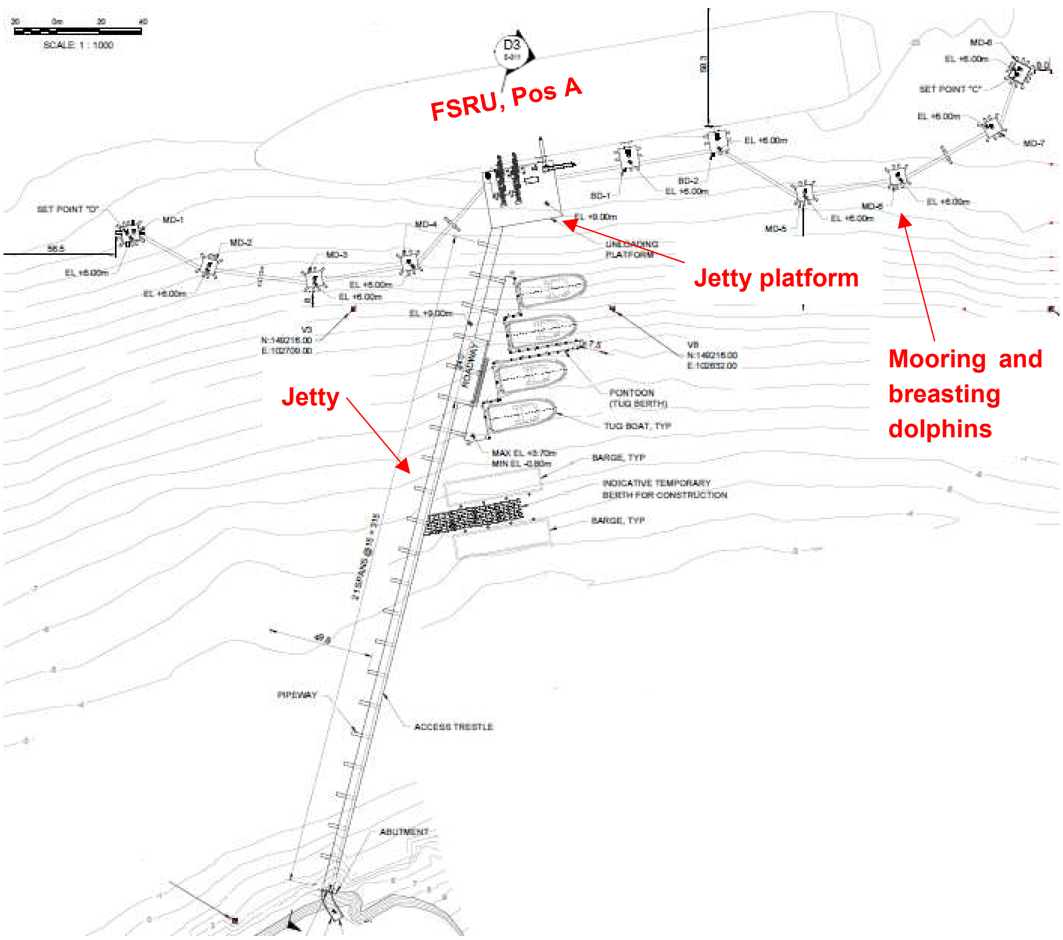

Figure 3. LNG import jetty and Floating Storage and Regasification Unit (FSRU). Pos A, corresponding to the FSRU location, is the source location used for the acoustic modelling, see Figure 1.

1) Contains Irish Publish Sector Data (Geological Survey) licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0) license [3].

2.2 Bathymetry

Range-dependent bathymetry can strongly influence the sound transmission loss over range. Bathymetry slope (either downward or upward) affects the horizontal sound propagation in shallow water mainly by two features:

- Change in water column height
- Change in the grazing angles of sound rays with the sea bottom and sea surface

These features combine with the shallow water low-frequency cut-off phenomenon (Section 2.3) and the bottom loss dependency on grazing angle. The consequence is a general tendency that downward slopes lead to increased noise levels ("downslope enhancement") and vice versa for upward slopes.

A recent parameter sensitivity study involving bathymetry is given in [6] for offshore wind on the US Atlantic Coast. It was found ([6] Sect. 7.3 Sensitivity Study) that the combination of local water depth and bathymetry was the environmental parameter with the highest impact on the acoustic propagation. The second most influential environmental parameter was found to be the seabed geoacoustic properties. These findings are in line with those of [7] for a more general study of underwater noise modelling.

2.3 Tide levels

An important feature of shallow water sound propagation is the shallow water low-frequency cutoff phenomenon [8]. It implies that the shallow-water channel supports propagation of frequency components above a certain cutoff frequency. At the same time, frequency components below this cutoff "leak" to the seabed, causing quick attenuation over horizontal propagation range. In a practical sense, the shallow water cutoff phenomenon may be seen as a high-pass filter, attenuating frequencies below cutoff.

According to the Metocean Analysis and Coastal Modelling report [9], there is a significant tidal variation at the site. As a larger vertical water volume generally leads to higher noise levels, it was decided to base this study on a high-water scenario: MHWS (Mean High Water Springs).

Since digital bathymetry data was obtained as LAT (Lowest Astronomical Tide), a correction was made. With reference to Table 1 it was decided to add 5 m to the LAT-based water depths for use in the acoustic modelling.

Description	Datum	Jetty South	Tarbert
Mean High Water Springs	MHWS	4.9 m	5.0 m
Mean High Water Neaps	MHWN	3.8 m	3.8 m
Mean Low Water Neaps	MLWN	1.7 m	1.7 m
Mean Low Water Springs	MLWS	0.6 m	0.5 m

Table 1. Tide levels (referred to Chart Datum, i.e. LAT) from [8]. Tarbert town is located approximately 4 km east of the Shannon LNG site.

2.4 Seabed properties

As mentioned in Section 2.2, the geoacoustic properties of the seabed have a strong influence on underwater acoustic propagation in shallow water [6],[7]. Given the shallowness of the considered part of the Shannon Estuary, significant efforts were assigned to deriving a geoacoustic model.

The basis for the derivation was a comprehensive site ground investigation report [10]. This borehole survey report included location map extracts, borehole co-ordinates, borehole logs, field test results, laboratory test results. The report was examined by VG's geophysicists to estimate compressional wave sound speed c_p [m/s], shear wave sound speed c_s [m/s], and density values [kg/m^3] for individual lithological units identified within boreholes and hence derive likely compressional and shear wave attenuation [dB/wavelength] figures for layer models representative of the area.

Outline of the analysis approach:

- Lab test data noted for:
    - Bulk and Dry Density
    - Moisture content
    - Compressional and shear wave speeds c_p and c_s
    - SPT (N) count
- Shear wave speed c_s estimated from Dry Density values [11]
- Bulk Density estimated from c_p values - Gardner's Equation [12]
- Bulk density estimated from SPT 'N' count [11]
- Compressional wave speed c_p estimated from assorted c_p observations and estimations – Catagna's Equation [13]
- Gross estimate of sand content from BH logs
    - Compared with moisture content values
    - Gross estimate of Bulk Density using Gassman's fluid substitution calculator [14]
- Bulk Density values compared, collated and edited from all sources
- C_p values compared, collated and edited from all sources
- C_s values taken from lab-test data direct measurements or estimated from [8]
- Compressional wave attenuation values α_p estimated from c_p and density [8],[15]
- Shear wave attenuation values estimated from c_s and density [8]

The investigation undertaken by VG's geophysicists lead to the following observations:

- Boreholes split into two main groups: East and West
- The Western group displayed a reasonable correlation between individual boreholes
- Boreholes of the Eastern group are apparently highly heterogeneous within the unconsolidated sections overlying bedrock

On this basis, for the acoustic modelling it was decided to apply the geoacoustic model corresponding to the Western boreholes across all of the estuary. The properties are given in Table 2.

Layer, depth below seafloor	Description	Density	Compressional wave speed	Compressional wave attenuation	Shear wave speed	Shear wave attenuation
		ρ [kg/m^3]	c_p [m/s]	α_p [dB/λ]	c_s [m/s]	α_s [dB/λ]
0-4 m	Sandy, clayey gravel	1900	1500	0.9	230	2
4-12 m	Gravelly clay	2100	2019	0.4	275	1.3
12-14 m	Sandy, clayey gravel	2000	1627	0.8	240	2.5
14-30 m	Bedrock	2700	4600	0.1	2340	0.2

Table 2. Geoacoustic model for Shannon Estuary seabed.

It is noted that the seabed down to 14 m depth has rather low shear wave speed (less than 300 m/s), while the bedrock layer below 14 m has high shear wave speed (above 2300 m/s). For seabeds with low shear wave speeds, the shear properties can usually be ignored in the acoustic model. However, in the opposite case, some conversion from the sound wave, i.e. compressional wave to shear wave will take place. This can be regarded as a loss, since the converted energy is no longer contributing to the sound wave (i.e. compressional wave) in the water.

2.5 Sound speed profile in water

The speed of sound c [m/s] in water depends primarily on temperature, salinity, and depth (i.e. hydrostatic pressure) [17]:

$c = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3 + (1.34 - 0.010T)(S - 35) + 0.016D$

Here, T [ºC] is temperature, S [parts per thousand] is salinity, and D [m] is water depth. The temperature generally has greater influence than salinity.

For shallow water regions, the speed of sound may either be nearly constant over depth for a well-mixed water column or show some dependence on depth. Typically, in a warm period, the upper part of the water column is heated up, causing increased sound speed here. Similarly, wind tends to mix the water column, leading to near-constant temperature and sound speed over depth.

For the present study, several profile measurements of temperature and salinity were downloaded from the NODC database [18], [19] for locations near the Shannon LNG site. Data were available for 2003-2011, and representative examples of sound speed profiles are plotted in Figure 4. Here, red profiles correspond to late summer, golden to summer, blue to winter, lilac to autumn. The dashed green profile is the one assumed for the present study based on the considerations below:

The water sound speed profile impacts the sound propagation in mainly two ways:

- Refraction

  The sound tends to bend towards the water depth having lowest sound speed, due to acoustic refraction. As a consequence, profiles with decreasing sound speed for increasing depth are downward refracting. This will generally lead to more sound interaction with the seabed materials, and increased losses over propagation range. On the contrary, upward refracting or (near-)vertical profiles lead to a smaller amount of bottom interaction.

- Coupling to seabed

  When the (compressional) sound speeds of the water and the upper seabed layers are close in range, a relatively large amount of acoustic energy is absorbed into the seabed. Seen from receiver positions in the water, this scenario has relatively strong attenuation over range. On the contrary, when water sound speed and seabed sound speed are very different, more energy is reflected at the seafloor, leading to higher noise levels in the water.

Based on the above discussion and the database sound speed profiles, it was decided to assume a near-constant sound speed profile of approximately 1485 m/s, shown as the dashed green line in Figure 4. This represents a conservative choice, as profiles corresponding to stratified conditions or significantly higher temperatures would lead to lower noise levels

In shallow water, the bathymetry and seabed acoustic properties generally constitute the more influential propagation parameters [6],[20].

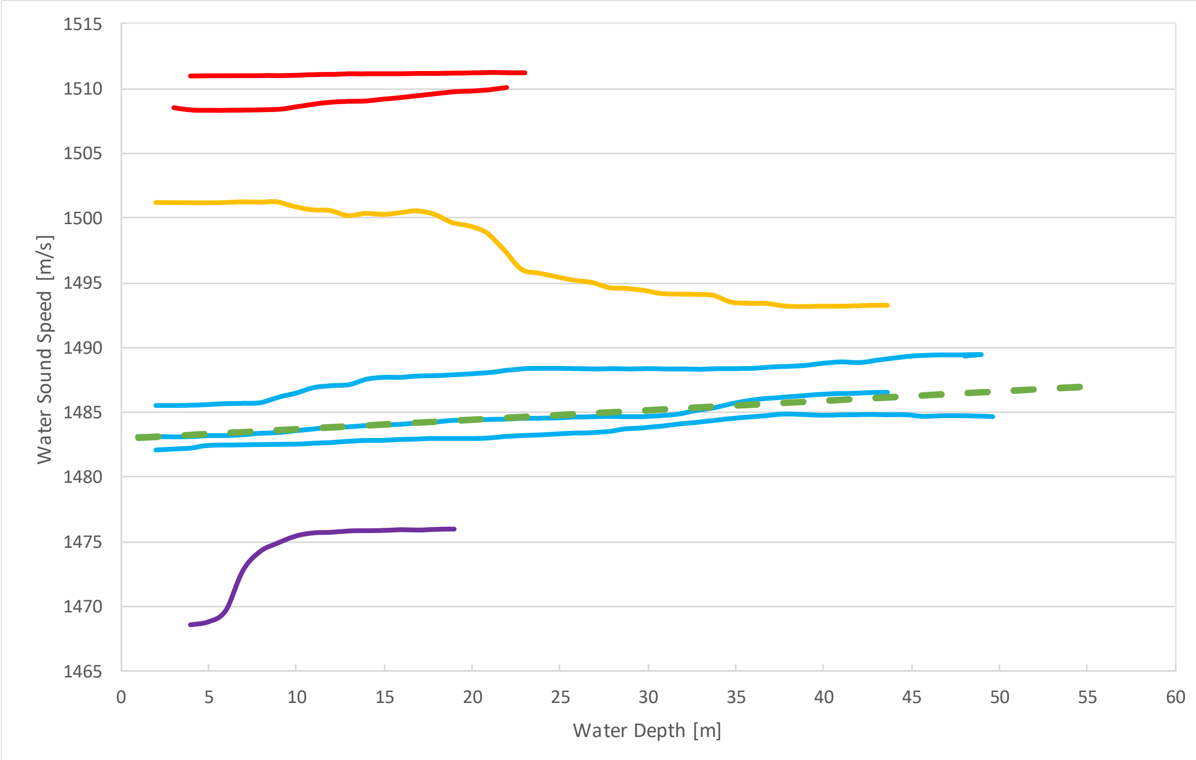

Figure 4. Sound speed profiles in water. Dashed green line is the profile applied for the underwater acoustic modelling. See the text for other colours.

2.6 Sound absorption of sea water

As sound propagates through sea water, it experiences attenuation due to volume absorption of the water. The related losses are proportional to frequency and travelled distance of the sound wave, see the following simplified formula for absorption α_{water} [dB/km] where FkHz is frequency in kHz [8]:

$$\alpha_{water} = 3.3 \cdot 10^{-3} + \frac{0.11FkHz^2}{1 + FkHz^2} + \frac{44FkHz^2}{4100 + FkHz^2} + 3.0 \cdot 10^{-4} \cdot FkHz^2$$

In engineering terms this loss feature only becomes significant above some kHz, and for long ranges.

3 Underwater acoustic metrics and weighting functions

3.1 Level metrics

Multiple level metrics are defined to quantify underwater sound. Generally, dB levels of field quantities F (e.g. pressure, particle displacement...) are defined as [21]:

$$L_F = 20 \log \frac{F}{F_0} \text{ dB}$$

Here, F_0 is the reference value, and “log” is the logarithm to base 10. Similarly, level metrics of power quantities W (e.g. sound exposure) are defined as:

$$L_W = 10 \log \frac{W}{W_0} \text{ dB}$$

Sound pressure level

From this, sound pressure level L_p becomes:

$$L_p = 20 \log \frac{p}{p_0} \text{ dB}$$

For underwater sound pressure, the reference is p_0= 1 μPa.

0-to-peak level

The "0-to-peak" level $L_{p,0\text{-}pk}$ is the single largest deviation of the sound pressure from zero, i.e. max(|p(t)|). Note that this may occur with either a negative or positive value of the sound pressure.

RMS or Leq sound pressure level

Particularly for continuous noise, an energy-based time averaged level is often used. It is the Root Mean Square (RMS) taken over a time interval T=t_2-t_1 [s], and the related level in dB is often referred to as equivalent continuous sound pressure level", or L_{eqT} over time interval T.

Starting from the Mean Square average pressure p_{ms}, [Pa^2] the RMS pressure p_{rms} [Pa] follows as:

$$p_{ms} = \overline{p^2} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} p^2(t) dt$$

$$p_{rms} = \sqrt{p_{MS}}$$

The RMS sound pressure level in dB is then:

$$L_{p,rms} = 20 \log \frac{p_{rms}}{p_0} \text{ dB}$$

As before, the reference value for underwater sound pressure is p_0=1 μPa.

Sound exposure level

For assessment of piling underwater noise, the sound exposure level (SEL) L_E [1μPa²s] is a common metric. For a single hammer strike event, one starts from the sound exposure E [Pa²s], also called the time-integrated squared sound pressure, which is based on the sound pressure p [Pa] as:

$E = \int_{t_1}^{t_2} p^2(t)\, dt$ in units of Pa²s, based on pulse time duration T=t_2-t_1 [s]. Usually, t_1 and t_2 are taken as the times at which 5% and 95% of the event's sound exposure has been reached.

The dB level for SEL is then:

$$L_E = 10 \log \frac{E}{E_0} \text{ dB}$$

The reference value for underwater sound exposure is $E_0=(p_0)^2T_0$ = 1 μPa²s as T_0=1 s.

SEL considering a single hammer strike event is called a single-strike SEL, or SEL_{ss}.

Cumulative sound exposure level

Sound exposure level based on multiple events is called cumulative sound exposure level, or SEL_{cum}. Cumulative sound exposure level is calculated by summing the sound exposure (linear units) of each event and converting to 1 μPa²s (see e.g.[22]):

$$L_{E,cum} = 10 \log \sum_{i=1}^{n} 10^{\frac{L_{E,i}}{10}} \text{ dB}$$

For a number of n equal events, SEL_{cum} is SEL_{ss}+10Log(n).

It is common to assess the cumulative sound exposure level for a period of 24 hours, $L_{E,24h}$ [23].

Sound intensity and Transmission loss

Sound intensity is the average rate of flow of energy through a unit area normal to the direction of propagation. Considering the magnitude of a propagating plane wave, sound intensity I [W/m²] is:

$$I = \frac{p_{rms}^2}{\rho_0 c}$$

Here, p_{RMS} is the RMS sound pressure [Pa], ρ_0 is the density [kg/m³], and c is the sound speed.

The sound transmission loss describes the change in signal strength with range, defined as the ratio in dB between the acoustic intensity I at a field point and the intensity I_{1m} at 1 m:

$$TL = 10\log_{10}\frac{I}{I_{1m}} = 20\log_{10}\frac{p}{p_{1m}}$$

Here, in the last part p [Pa] is the sound pressure at a field point, and p_{1m} is the sound pressure at 1 metre distance from the source.

3.2 Frequency spectra and auditory weighting functions

In addition to single-value metrics as described in Section 3.1, sound is often described in terms of frequency spectra. These describe the sound energy distribution as a function of frequency, the latter having units of "cycle per s", which is [Hz]. Frequency spectra are either constant bandwidth, or constant percentage bandwidth. The most common constant percentage bandwidth spectrum is a 1/3-octave spectrum. Alternatively, analysis may be done in narrowband frequency bands (typically "FFT" type), having constant bandwidth.

For the purpose of assessing impact on differentiated sea mammals, auditory weighting functions were defined by the National Marine Fisheries Service (USA) [23]. These reflect the different hearing properties categorized for 5 specific groups of animals, see weighting curves in Figure 5.

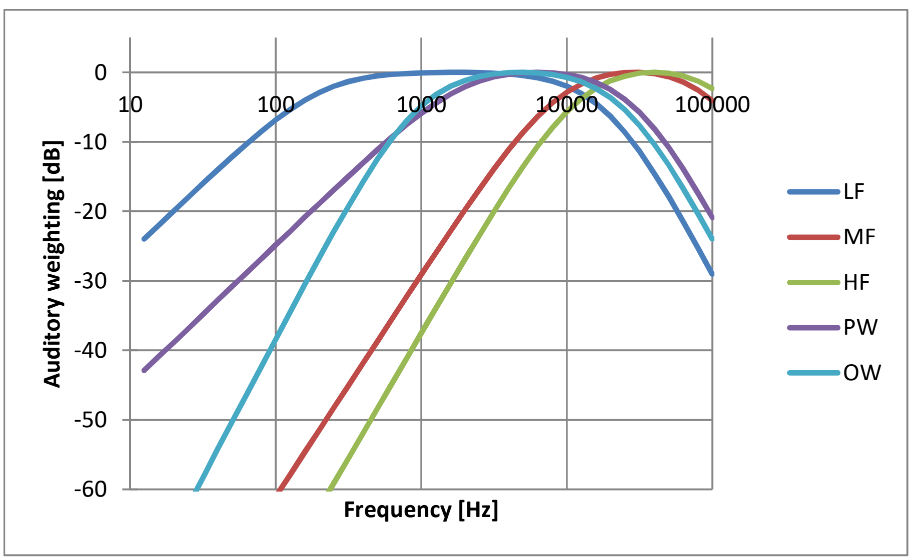

Figure 5. Frequency weighting functions for hearing groups as defined in [23]. See Table 3 for abbreviations.

The hearing groups are listed in Table 3. Of these, the Mid-frequency (MF) cetaceans, High-frequency (HF) cetaceans, and the Phocid pinnipeds (PW) are considered in this study.

Abbreviation	Hearing group	Weighted metric for sound exposure
LF	Low-frequency cetaceans	$L_{E,p,LF}$
MF	Mid-frequency cetaceans	$L_{E,p,MF}$
HF	High-frequency cetaceans	$L_{E,p,HF}$
PW	Phocid pinnipeds (underwater)	$L_{E,p,PW}$

Table 3. Overview of marine mammal hearing groups [23].

The weighting functions presented here are mostly used for relating sound exposure levels to the various hearing groups. Hence, sound exposure levels without applied frequency weighting are referred to as $L_{E,flat}$. Applying the frequency weighting functions to the underlying spectra of $L_{E,flat}$ produce a new set of weighted sound exposure levels as listed in the rightmost column of Table 3. Similarly, unweighted levels of RMS sound pressure $L_{p,rsm,flat}$ can be combined with the weighting functions to account for the hearing abilities of the corresponding hearing group.

4 Measurements of ambient underwater noise

The ambient underwater noise level in the area was investigated by spot check measurements. Due to the imposed travel restrictions of the COVID-19 pandemic, VG was prohibited from carrying out the measurements. The ambient underwater noise measurements were therefore performed by external company Aquafact Environmental Consultants (www.aquafact.ie) using VG's hydrophone logger equipment (Table 4) deployed from a small boat. Measurements were taken on 21st and 26th of May 2020, and the GPS track plotted in Figure 7 indicates the location. Subsequently, the recorded time series were extracted from the logger equipment and analysed by VG.

The ambient noise mainly originates from natural sounds, such as waves noise and noise from animals and from ship traffic in the area. Both grey seals and dolphins were spotted during the measurements. The ship traffic mainly includes the ferry crossing from Killimer to Tarbert, but also noise from distant cargo ships was present during the measurements. Several small speed boats and jet skis also passed at some distance during the measurements. On the 26th four ships were on anchor at Scattery Island. Engine noise was audible in the recordings during night-time with low noise levels, possibly originating from nearby generators.

The measurements on 21st May 2020 were conducted in the period from 07:00AM – 13:00PM. In the beginning of this period the weather was sunny with wind F2 SW, and the sea state calm with very small wavelets. The predicted tide was HW – 5:45 4.6m, LW – 11:43 0.8m. The wind increased to F3-4 SE with start of caps on waves, and the hydrophone was retrieved at 13:00PM due to weather and sea state.

The measurements on 26st May 2020 were conducted in the period from 19:00PM – 00:45AM. In the beginning of this period the weather was overcast with wind F2 W, and the sea state calm with very small wavelets. The predicted tide was HW – 20:48 4.4m, LW – 02:52 0.8m. The wind decreased during the measurements to <F1 with calm sea state.

Instrument	Make	Type	Serial no.
Logger	RTSys	SYLence	SYL205
Hydrophone	HTI	96-min	785052
Hydrophone calibrator	Brüel & Kjær	4223	817757

Table 4. Equipment used for ambient underwater noise measurements

Figure 6. Picture of buoy with submerged hydrophone from the ambient noise measurements. (photo taken by Aquafact).

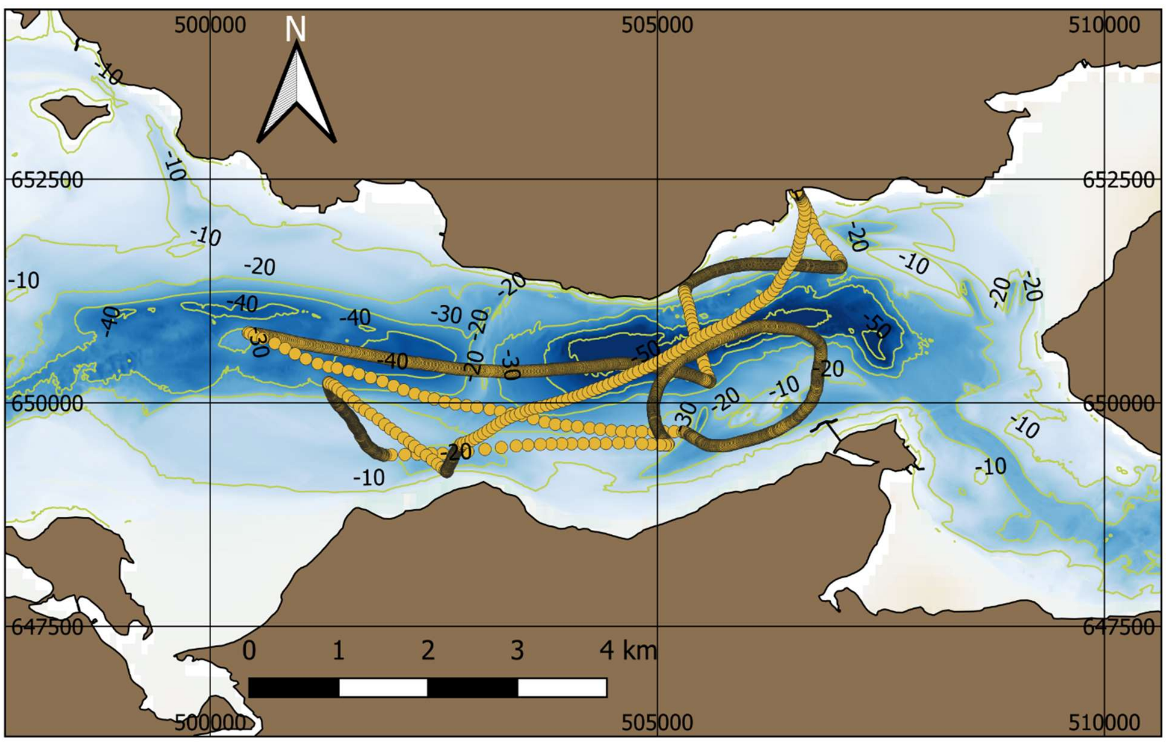

Figure 7. GPS track of ambient noise measurements. For source of bathymetry data, see Section 2.1. Land polygons ©OpenStreetMap contributors [1].

The measurements were performed as "drifting measurements" with the logger and the hydrophone submerged from a floating buoy. The hydrophone was deployed at a depth of 10-15 m corresponding to approx. half the water depth in the area. The signals were recorded with a sampling rate of 96000 Hz.

The recordings were analysed in terms of various statistical exceedance levels Lx (i.e. L90 means the level that is exceeded in 90% of the measurement time). The analysis was carried out for both the unweighted signal and the MF weighted signals (MF refers to the Mid-frequency (MF) cetaceans, as defined in [23]).

Further, frequency analysis was performed for a set of selected periods in both 1/3-octave bands and in narrow band frequency resolution (FFT). The results are shown in the below tables and figures.

Parameter	DAY 21 May 2020 07:00-13:10	EVENING-NIGHT 26 May 2020 19:00-00:45	NIGHT 27 May 2020 00:12-00:45	ALL 21+26 May 2020 (-)
L99	95.5	91.4	91.4	92.3
L95	101.8	93.9	92.0	95.5
L90	104.8	95.7	92.4	99.9
L50	117.3	112.5	95.2	116.4
L10	121.1	125.4	102.3	124.5
L5	124.0	126.9	104.3	126.1
L1	129.4	131.0	109.1	130.3

Table 5. Statistical data of underwater noise levels (Exceedance Levels, in dB re 1 µPa, 10 Hz high-pass filter, based on 5 sec. $L_{p,rms}$ levels, unweighted levels)

Parameter	DAY 21 May 2020 07:00-13:10	EVENING-NIGHT 26 May 2020 19:00-00:45	NIGHT 27 May 2020 00:12-00:45	ALL 21+26 May 2020 (-)
L99	86.2	86.1	86.6	86.1
L95	86.5	86.2	86.7	86.3
L90	86.7	86.3	86.9	86.5
L50	88.2	88.9	88.8	88.4
L10	98.2	105.4	95.5	104.4
L5	102.8	105.9	97.3	105.6
L1	109.0	106.9	98.5	108.0

Table 6. Statistical data of underwater noise levels (Exceedance Levels, in dB re 1 µPa, 10 Hz high-pass filter, based on 5 sec. $L_{p,rms}$ levels, MF-weighted levels)

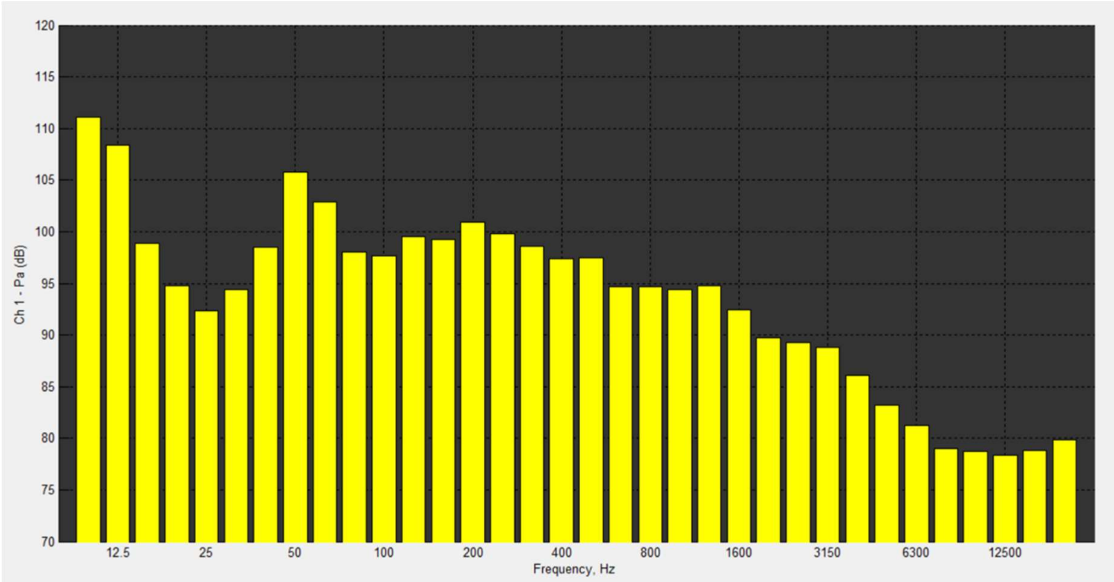

Figure 8. Typical 1/3 octave frequency band spectrum, DAY- Ferry 200 m away crossing from Killimer to Tarbert ($L_{p,rms}$, unweighted dB re 1 µPa).

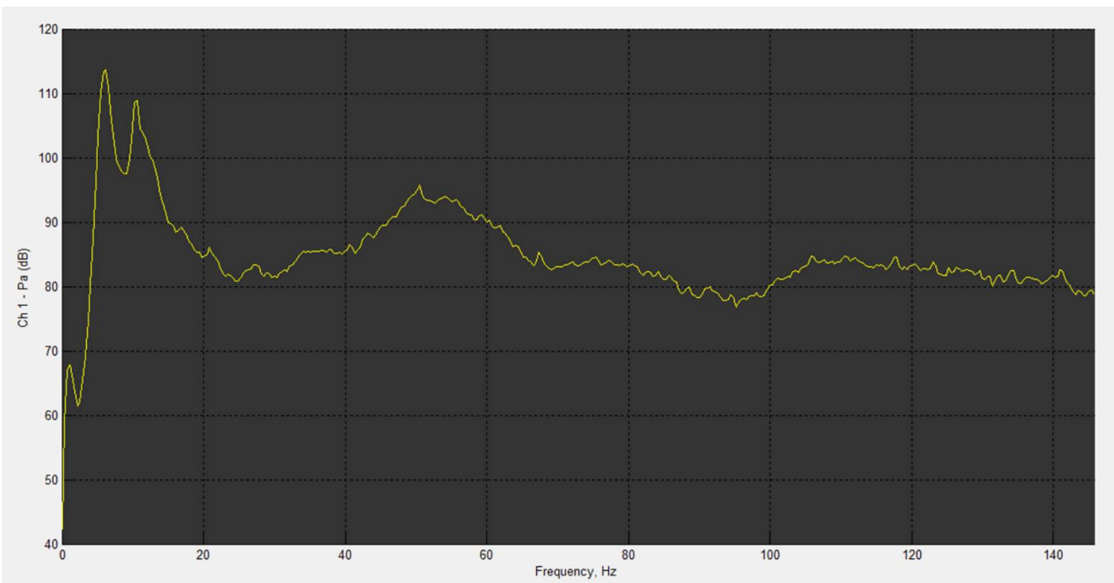

Figure 9. Typical narrowband frequency band spectrum, DAY - Ferry 200 m away crossing from Killimer to Tarbert ($L_{p,rms}$, un-weighted dB re 1 µPa, Hanning window, 10 Hz HP filter)

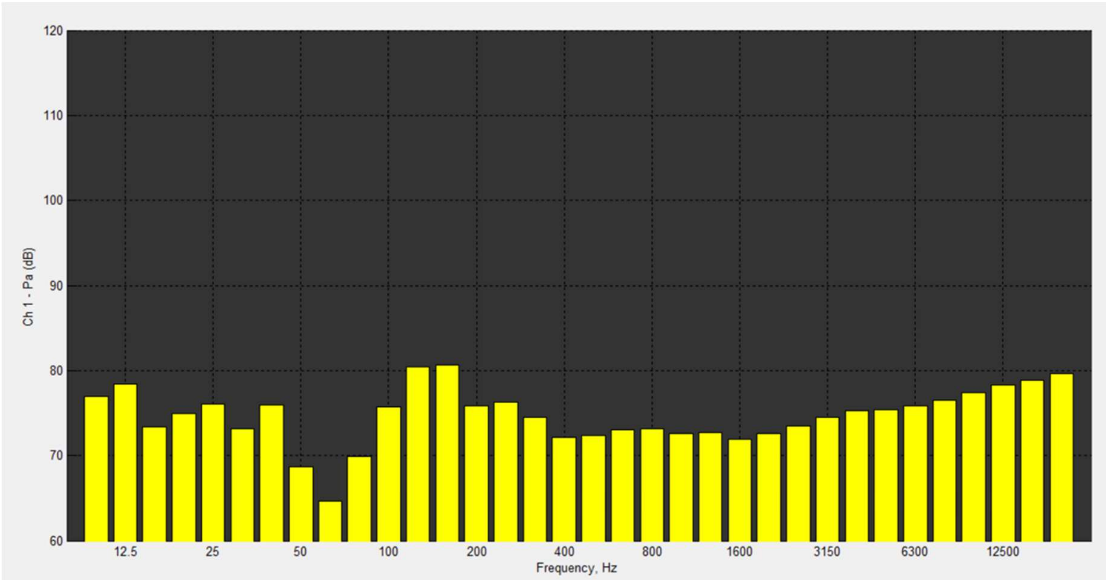

Figure 10. Typical 1/3 octave frequency band spectrum, NIGHT – No audible ships ($L_{p,rms}$, unweighted dB re 1 μPa)

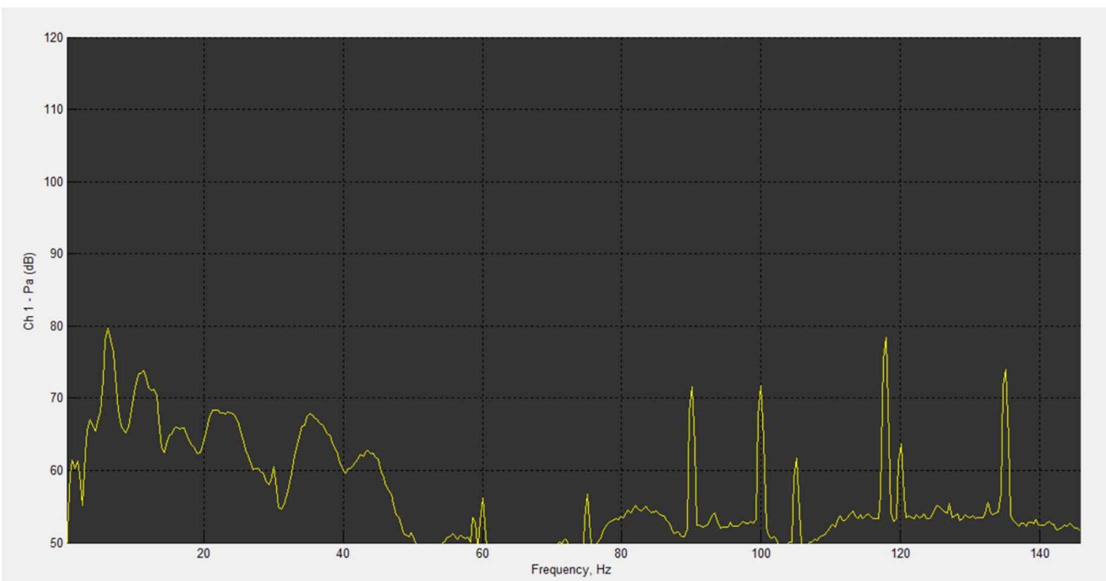

Figure 11. Typical narrowband frequency band spectrum, NIGHT - Distant engine audible in recording - possibly generator – peaks seen in spectrum ($L_{p,rms}$, un-weighted dB re 1 μPa, Hanning window, 10 Hz HP filter)

4.1 Underwater noise from nearby vessel

An event of the Killimer-Tarbert ferry crossing the estuary at approximately 200 m from the measurement location was registered. The estimated sailing speed of the ferry was 5 knots. The corresponding noise spectra are shown in Figure 8 and Figure 9. The broadband $L_{p,rms}$ level was 120 dB re 1 μPa (unweighted), and 88 dB re 1 μPa with MF weighting.

5 Acoustic modelling approach

5.1 Survey mapping approach

The modelling study was carried out following VG's Survey mapping methodology. This involves an "n x 2D" approach, i.e. calculating sound propagation in a number of two-dimensional (depth vs. range) transects by means of a point source (i.e. monopole) based long-range models out to a maximum range away from the source. As illustrated in Figure 12 and Figure 13, 15 such azimuthal transects were modelled for each of the two source positions A and B. Due to the irregular geometry of the estuary, these transects have lengths varying from a few hundreds of meters to 19 km. Similarly, the bathymetry profile varies greatly between the transects.

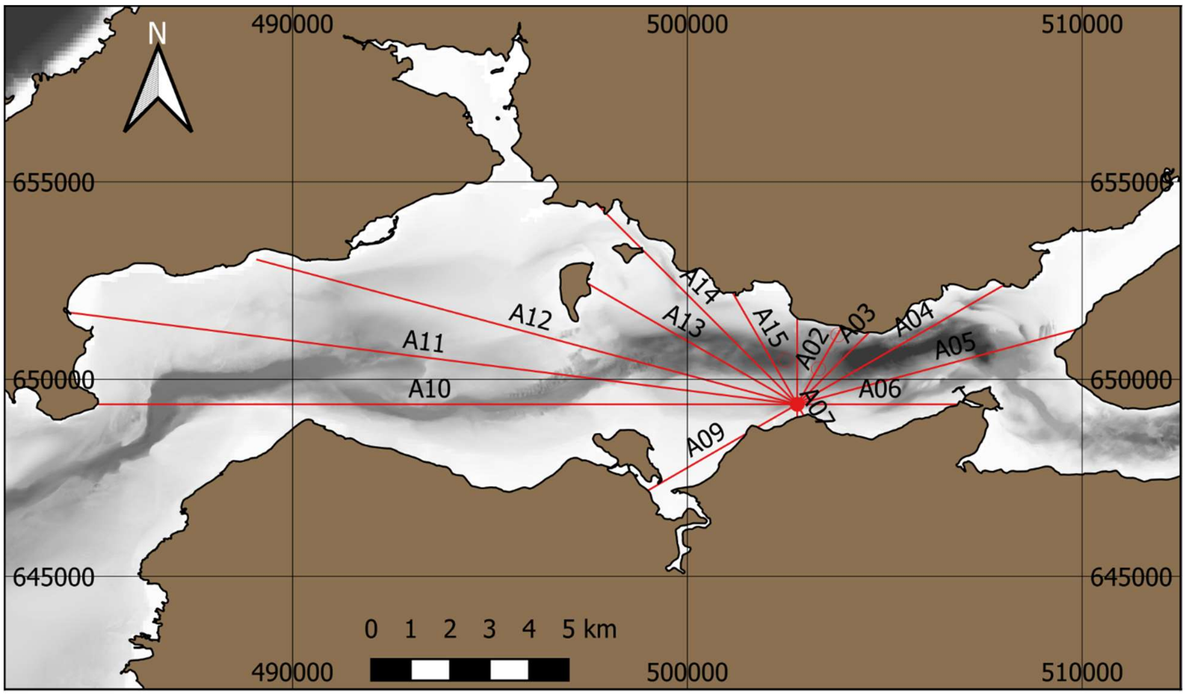

Figure 12. Transects A01-15 emanating from source position A.

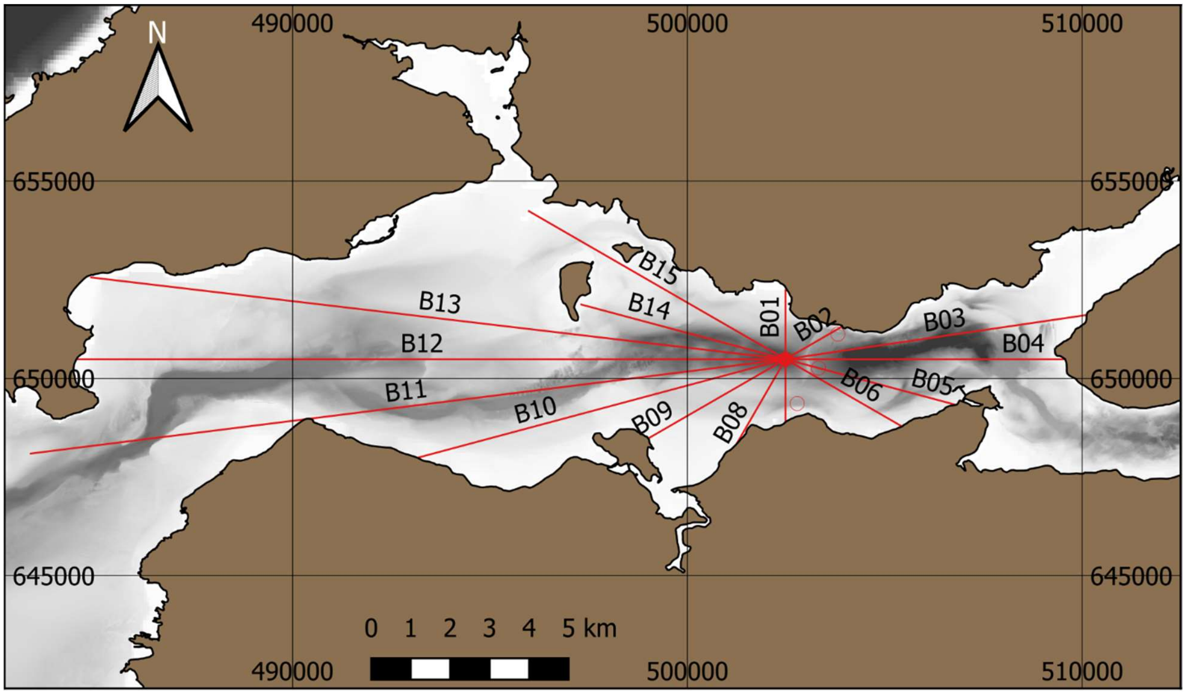

Figure 13. Transects B01-15 emanating from source position B.

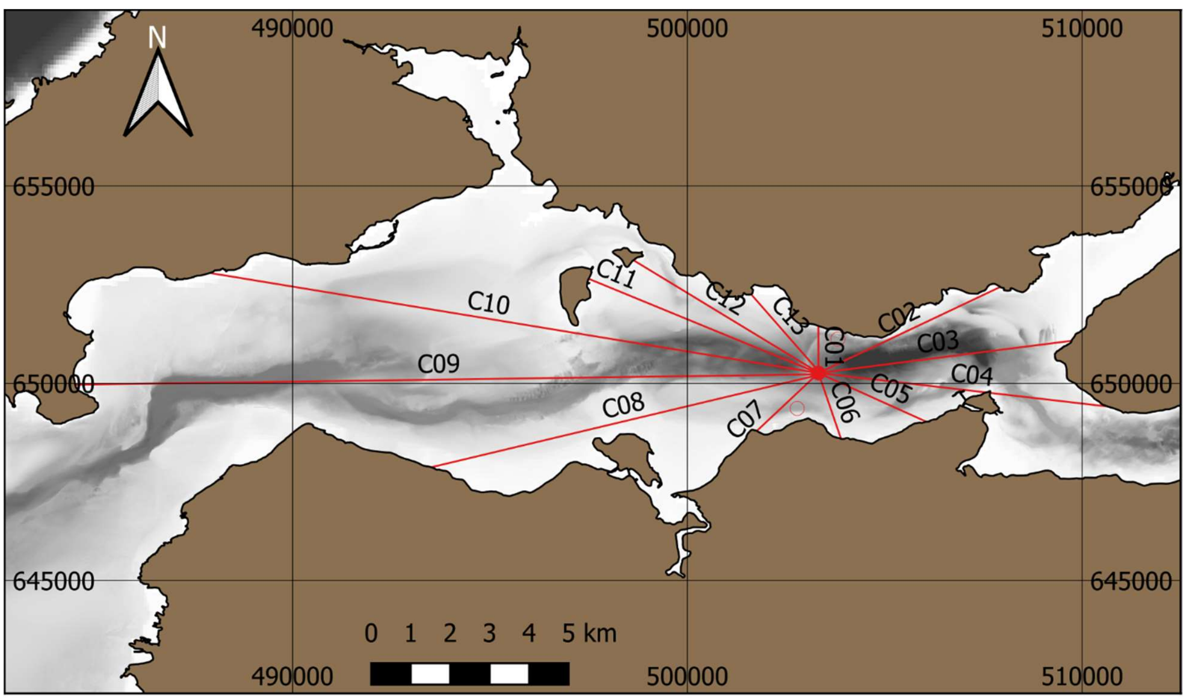

Figure 14 Transects C01-13 emanating from source position C.

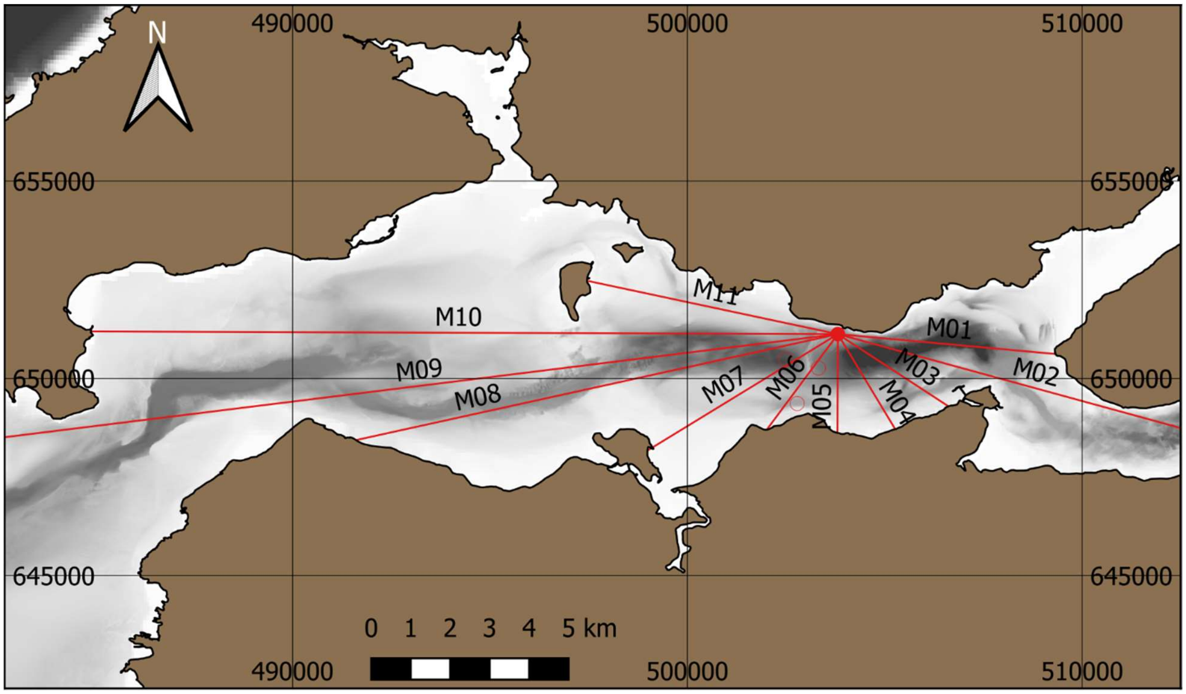

Figure 15 Transects M01-M11 emanating from source position M.

5.2 Model components

5.2.1 Background for sound propagation model

Any numerical model is an approximated representation of the actual physics. Following [24] any physical or mathematical model has inherent limitation in applicability, leading to a “domain of applicability” of that model.

Fundamentally, acoustic models are based on the Wave Equation for pressure:

$$\nabla^2 p - \frac{1}{c^2}\frac{\delta^2 p}{\delta t^2} = 0$$

Here, ∇^2 is the Laplacian operator, p is the acoustic pressure, c is the sound speed, and t is the time. The wave equation can only be solved analytically for simple cases. It is therefore often simplified according to various assumptions, leading to the Helmholtz equation, which is the basis for many underwater acoustic models [8], [20]. For the present study, the **Parabolic Equation** (PE) type of model is used for the frequency range up to 1600 Hz. This assumes a single point source and acts on the Helmholtz formulation of the Wave Equation. The Helmholtz Equation derives from the Wave Equation by assuming that properties are constant over time, leading to a frequency domain representation. For even higher frequencies, a **Beam Tracing** (BT) type of model is used. A brief introduction to these and other common underwater noise model types is found in [20].

Parabolic Equation (PE) parts from the Helmholtz equation by assuming that only out-going wave propagation is considered [20]. Then, the solution is found from range-wise step-by-step marching away from the sound source. The PE variant applied in the present study is a split-step Padé expansion type for approved numerical accuracy, developed by Collins, which allows for range-dependent properties such as bathymetry. The model was extensively benchmarked [26].The actual code is **RAMGeo**, as implemented by CMST in the Matlab based AcTUP suite [16]. In VG implementation, the calculation core is unchanged from RAMGeo while memory use and file logistics have been optimised for speed.

In 2017 the US regulatory entity Bureau of Ocean energy Management (BOEM) held a workshop on best practices for offshore wind and marine protected species [27]. One topic was the suitability of various types of underwater noise modelling. Specifically, the PE model type was found to perform well in the verification study.

The frequency range 2kHz to 160 kHz is addressed using a Beam Tracing model, which uses a high-frequency approximation to solve the Wave Equation. In a simpler form, bundles of geometric rays are emitted from the point source and traced as they propagate through the acoustic environment. Rather than such infinitely narrow rays, the more sophisticated BT approach assigns a Gaussian profile to the these, forming “beams”. This BT used in this study is **Bellhop**, as implemented by CMST’s AcTUP suite [16].

Volume absorption is included in the calculations according to section 2.6.

5.2.2 Additional, derived metrics

The main output of the Survey mapping method is either the unweighted (“flat”), single-strike sound exposure level $L_{E,p,ss}$ for impulsive sources such as pile driving or blasting, or the RMS sound pressure level $L_{p,rms}$ for continuous noise such as ship noise. From these, several additional metrics were derived:

- 24h cumulative sound exposure level, with frequency weightings
- Zero-to-peak sound pressure level
- Root-Mean-Square (RMS) sound pressure level (for piling and blasting)

The approach behind each of these derived metrics is discussed in the sections below.

5.2.2.1 Cumulative sound exposure level, with frequency weightings

Piling noise

For a N hammer strike events of equal acoustic energy (e.g. same single-strike Sound Exposure Level), the cumulative Sound Exposure Level is calculated as $L_{E,p,24h} = L_{E,p,single-strike} + 10\log_{10} N$, with N being the number of strikes within the 24 hours period [22].

Continuous noise

For vessel noise, the cumulative Sound Exposure Level is calculated from the RMS (which is the same as the Leq) sound pressure level with a correction for the time duration of the activity:

$$L_{E,p,24h} = L_{p,RMS} + 10\log_{10}\frac{T}{T_0}$$

Here, T_0 is 1 s.

5.2.2.2 Hearing group specific, cumulative sound exposure level

In accordance with [23], the 24-hour cumulative sound exposure level was calculated for the MF hearing group. This was done by applying the corresponding frequency weighting to the centre frequency of each 1/3-octave band of the flat-weighted, cumulative sound exposure level, and calculating the overall value.

5.2.2.3 Zero-to-peak sound pressure level

For pile driving, the zero-to-peak sound pressure level was derived from the single-strike Sound Exposure Level based on the following semi-empirical formula [28]:

$$L_{p,0pk} \approx 1.12 \cdot L_{p,E} + 7.3 \text{ dB}$$

Here, the original peak-to-peak expression from [28] was subtracted 5 dB for conversion to zero-to-peak.

5.2.2.4 RMS sound pressure level

For continuous noise sources, such as ships, the RMS (Root Mean Square) sound pressure $L_{p,rms}$ is directly calculated by the model.

For impact pile driving, the RMS sound pressure may be estimated from the single-strike, sound exposure level by accounting for the pulse duration, T_p [s]:

$$L_{p,rms} \approx L_{p,E} - \Delta_{Tp}$$

$$\Delta_{Tp} = 10\log_{10}\frac{T_p}{T_0}$$

Here, T_0 =1 s. For this study, the following semi-empirical expression was used [28]

$$L_{p,rms} \approx 1.23 L_{p,E} - 23.9\ \mathrm{dB}$$

5.2.3 Extension of frequency range

The hearing ability of marine mammals generally spans an enormous frequency range. As an example, the -frequency (MF) cetacean weighting correspond to effective hearing up to 160 kHz [23], with the highest sensitivity approximately between 25 kHz and 70 kHz (see MF curve in Figure 5). However, the frequency range of noise source of this study typically peaks already at 80-300 Hz, with main energy within the first kHz. For higher frequencies, the generally spectrum falls off steadily.

Source data are typically not available for the for the full frequency spectrum up to 160 kHz. Real-world measured noise spectra tend to reduce steadily in level for frequencies above 1-2 kHz. On that background, it seems fair and conservative to assign a steady high-frequency slope to the noise spectra.

Where data were missing at higher frequencies it was decided to extrapolate the noise spectra by a constant slope according to Table 7:

Noise source	High-frequency slope, dB per 1/3-octave band
Impact piling	-2.8
Socket drilling	-1.9
Vibratory driving	-4.0
Rock blasting	-3.0
Carier offloading and sailing, tugboats,crew boat, cargo ships	-1.4
FSRU and crane barge	-2.0
Jack-up rig	-1.0

Table 7. Overview of assumed slope constants for high-frequency extrapolation of source spectra.

It is noted that several additional phenomena with frequency dependent losses become significant in the kHz range, with losses increasing with frequency, e.g. sea surface absorption (interaction with air bubbles from waves and vessels). Such losses add to the bottom loss, causing even higher losses than for say 0-1 kHz range.

5.3 Application of underwater acoustic propagation models

The point source based models RAMGeo and Bellhop introduced in Section 5.2.1 were run for all transects. Each transect was implemented as a 2D axisymmetric slice, including variations in bathymetry along the transect (see Figure 16 as an example), and with the seabed layer properties (density and compression wave properties) of Table 2. As discussed in Section 2.4 this is a fluid-type representation of the seabed, which is assumed to be slightly conservative.

The RAMGeo model was run for centre frequencies of the 1/3-octave bands from 50 Hz to 1600 Hz for pile driving with a frequency range extending down to 20 Hz for the ship sources. The Bellhop model was run for centre frequencies of the 1/1-octave bands from 2 kHz to 160 kHz. Examples of the calculated transmission loss slices are given in Figure 16 and Figure 17. It is seen how the sound field for lower frequencies is characterised by modal interference patterns, and a significant amount of acoustic penetration of the seabed. The spatial resolution was approximately 0.5 m. It is seen how the sound field for lower frequencies is characterised by modal interference patterns, and a significant amount of acoustic penetration of the seabed.

Separate sets of TL transects were calculated for source positions A, B, C, and M (see Figure 2), as well as for sources corresponding to different depth locations.

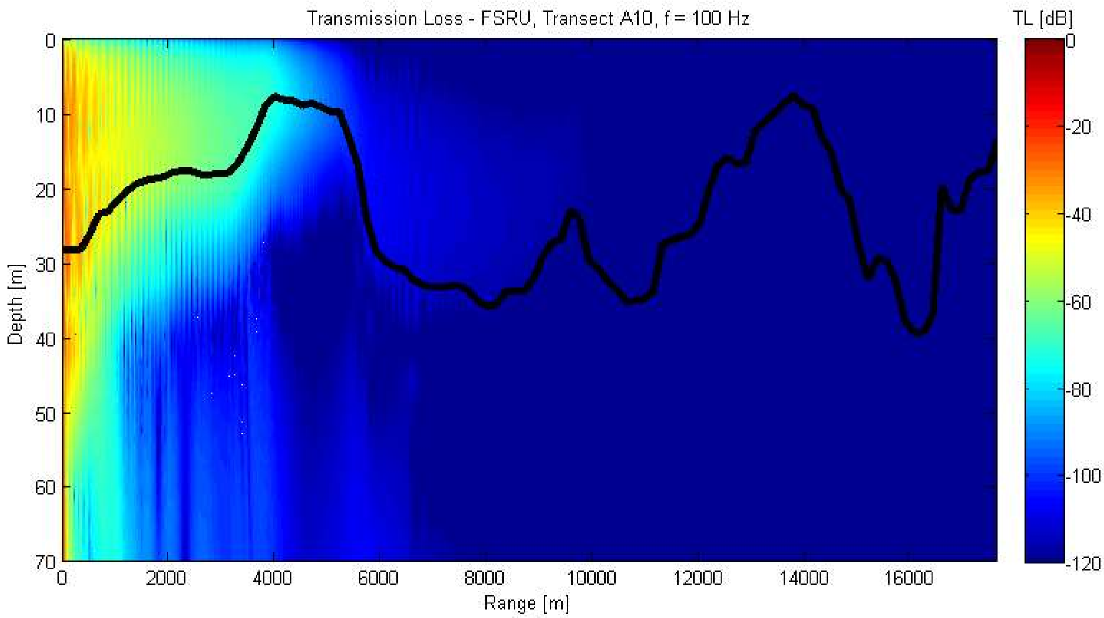

Figure 16. Transmission loss along transect A10 at 100 Hz. Black line indicates seafloor.

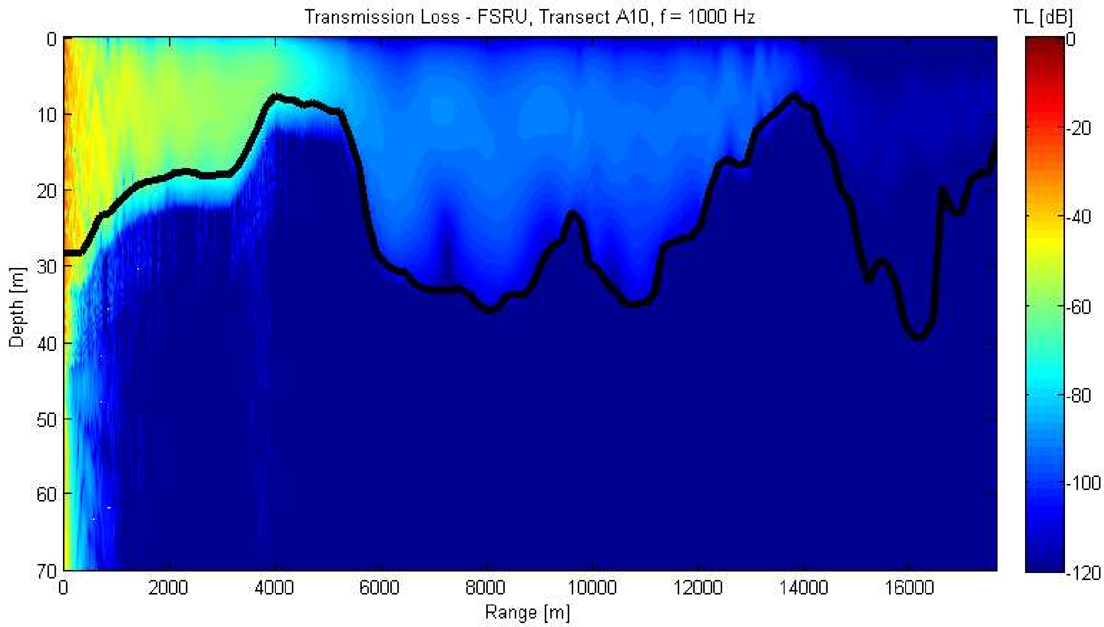

Figure 17. Transmission loss along transect A10 at 1 kHz. Black line indicates seafloor.

5.3.1 Method for evaluating acoustic criteria

The source spectra of Section 6.2 were combined with the transmission loss calculated by RAMGeo and Bellhop. Subsequently, the detailed grids of results were condensed to curves showing Max-over-Depth as illustrated in Figure 18. In this figure each curve represents the Max-over-Depth RMS sound pressure across the water column for a given transect, A1-A15. For the simplest scenarios with only a single source position, it is possible to compare this type of predicted range-dependent metric to the relevant acoustic criteria of Section 5.4 to find the corresponding Distance-to-Threshold. This is the distance from the source to the point after which the source falls below the assessment criteria level. In Figure 18, the red horizontal line represents a criteria threshold of $L_{p,rms}$=120 dB. It follows graphically that the plotted transects exceed this level for ranges within approximately 2000 m, which is then taken as the Distance-to-Threshold.

Due to the often-significant variation between directions caused by differences in bathymetry, the Distance-to-Threshold values of multiple directions are furthermore combined into an Area-to-Threshold for the same criteria.

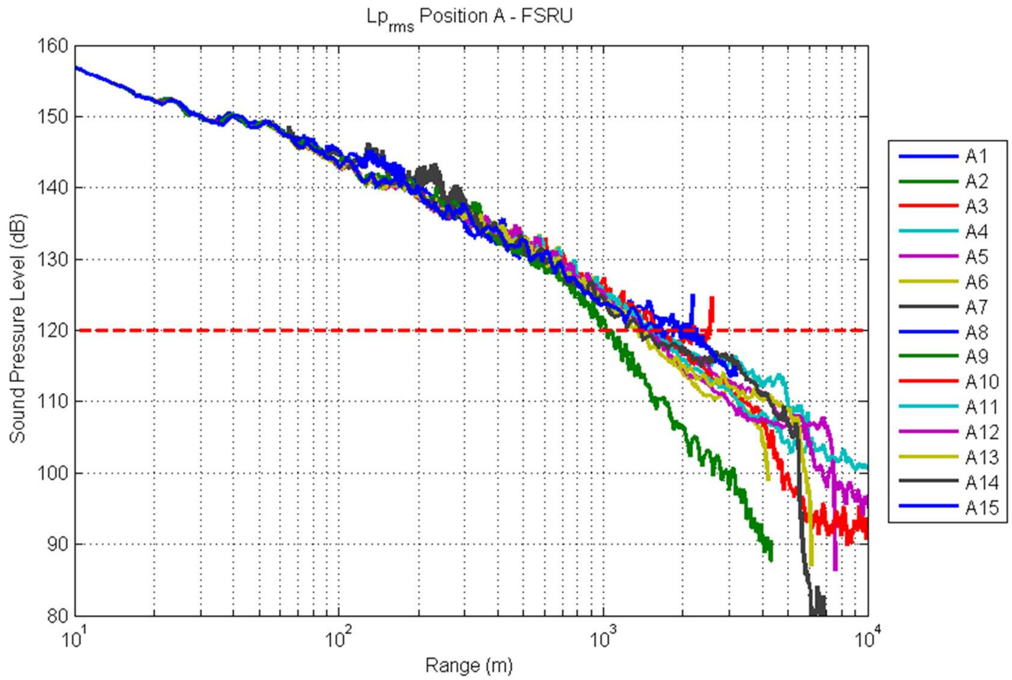

Figure 18. Max-over-depth of flat-weighted RMS sound pressure level $L_{p,rms}$ for FSRU.

Since the present study involves scenarios with multiple simultaneous source positions, an alternative method was applied for assessing Distance- and Area-to-Threshold. In the case of multiple source positions, the concept of transects becomes problematic, since it is not evident where their common origin should be located. The following approach was implemented:

- From the noise map of the whole area covered, contours are calculated, showing the areas where the evaluated acoustic metric exceeds a given threshold, as shown by the two green areas in the figure. These could represent local threshold contours of two sources, or they could be local "hot-spots" of the sound field.
- The Area-to-Threshold is calculated by directly summing the areas covered by these contours, i.e. the two green regions in the figure.
- Distance-to-Threshold is evaluated along 8 principal directions (North, North East, East, South East, South, South West, West, North West) as follows:
    - The geometric centroid is found of the convex hull enclosing all the contours. This convex hull is the blue line in Figure 19.
    - The Distance-to-Threshold is found in each direction by casting a ray from the centroid and finding the furthest distance at which the tangent to this ray intersects with the blue envelope line. This is illustrated by the red lines in the figure for selected directions. As examples, for directions N, E, and SW the corresponding distance end-points are indicated with blue ovals. The resulting Distance-to-Threshold for N, E, and SW are shown with black arrows.

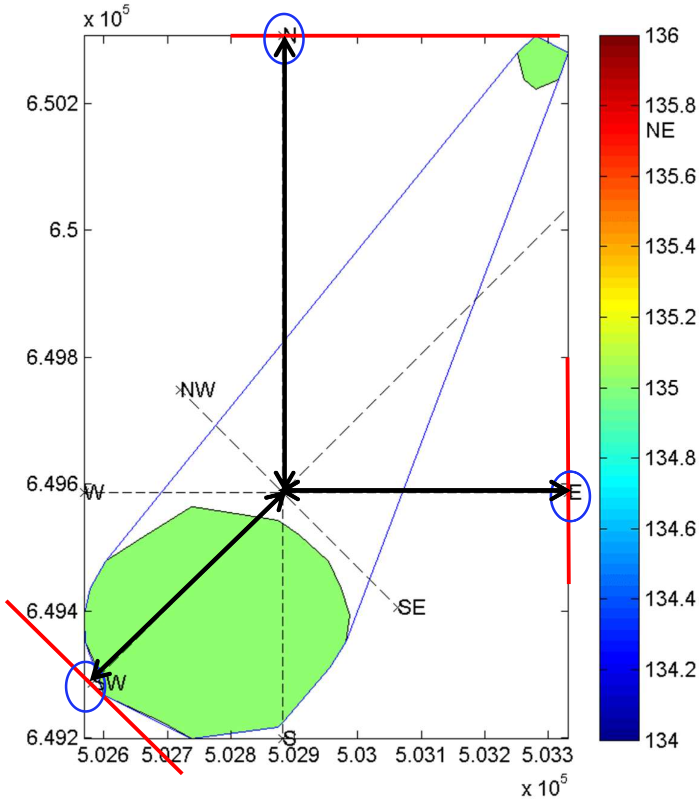

Figure 19. Example for calculation of Distance-to-Threshold for complex multiple source scenarios, shown with an example threshold of 135 dB.

5.4 Acoustic criteria for impact assessment

The Shannon Estuary is home to a colony of bottlenose dolphins, which are characterised as Mid-frequency cetaceans in [23]. For detailed evaluation of the project's acoustic impact on these specific animals, VG's sub-contractor LGL prepared a set of acoustic criteria. These are described in the following. This report presents the findings in terms of Distance-to-Threshold, and Area to Threshold. The results are subsequently undergoing detailed assessment by LGL, as will be presented in LGL's separate assessment report.

5.4.1 PTS/"Level A" criteria

Hearing group	Metric	Threshold value, non-impulsive noise	Threshold value, impulsive noise
Mid-frequency cetaceans (MF)	$L_{p,0\text{-}pk}$	-	230 dB
	$L_{E,p,MF,24h}$	198 dB	185 dB
High-frequency cetaceans (HF)	$L_{p,0\text{-}pk}$	-	202 dB
	$L_{E,p,HF,24h}$	173 dB	155 dB
Phocid Pinnipeds (PW)	$L_{p,0\text{-}pk}$	-	218 dB
	$L_{E,p,PW,24h}$	201 dB	185 dB

Table 8. Level A harassment thresholds for marine mammals according to the National Marine Fisheries Service 2018 guideline [23], for the relevant hearing groups. Units of $L_{p,0\text{-}pk}$ are dB re 1µPa. Units of $L_{E,p,xx,24h}$ are dB re 1µPa^{2}s.

5.4.2 TTS criteria for marine mammals

Hearing group	Metric	Threshold value, non-impulsive noise	Threshold value, impulsive noise
Mid-frequency cetaceans (MF)	$L_{p,0\text{-}pk}$	-	224 dB
	$L_{E,p,MF,24h}$	178 dB	170 dB
High-frequency cetaceans (HF)	$L_{p,0\text{-}pk}$	-	196 dB
	$L_{E,p,HF,24h}$	153 dB	140 dB
Phocid Pinnipeds (PW)	$L_{p,0\text{-}pk}$	-	212 dB
	$L_{E,p,PW,24h}$	181 dB	170 dB

Table 9. TTS thresholds for marine mammals as provided by LGL (based on the National Marine Fisheries Service 2018 guideline [23]), for the relevant hearing groups. Units of $L_{p,0\text{-}pk}$ are dB re 1μPa. Units of $L_{E,p,xx,24h}$ are dB re 1μPa^{2}s.

5.4.3 Behavioural criteria for marine mammals

For impulsive noise, a multiple tiered step function of threshold is investigated, for $L_{p,rms}$ with auditory frequency weighting. Hence, thresholds in steps of 10 dB from 120 to 180 dB are investigated for **impulsive** noise.

Similarly, for **non-impulsive** noise, thresholds of $L_{p,rms}$ in steps of 5 dB from 120 to 180 dB are investigated.

Besides the multi-tier steps, the following specific criteria apply:

Hearing group	Metric	Threshold value, non-impulsive noise
Mid-frequency cetaceans (MF)	$L_{p,rms,MF}$	160 dB
High-frequency cetaceans (HF)	$L_{p,rms,HF}$	160 dB
Phocid Pinnipeds (PW)	$L_{p,rms,PW}$	160 dB

Table 10. Behavioural thresholds for marine mammals ("Level B") [29]. Units of $L_{p,rms}$ are dB re 1 μPa.

5.4.4 Acoustic criteria for fish species

Type of animal	Metric	Threshold value		
		Mortality and potential mortality	Recoverable injury	Temporary Threshold Shift (TTS)
Fish: no swim bladder	$L_{p,0\text{-}pk}$	213 dB	213 dB	-
	$L_{E,p,flat,24h}$	219 dB	216 dB	186 dB
Fish: swim bladder not involved in hearing	$L_{p,0\text{-}pk}$	207 dB	207 dB	-
	$L_{E,p,flat,24h}$	210 dB	203 dB	186 dB
Fish: swim bladder involved in hearing	$L_{p,0\text{-}pk}$	207 dB	207 dB	-
	$L_{E,p,flat,24h}$	207 dB	203 dB	186 dB

Table 11. Thresholds corresponding to mortality, injury, or temporary threshold shift for fish [30]. Units of $L_{p,0\text{-}pk}$ are dB re 1 μPa. Units of $L_{E,p,flat,24h}$ are dB re 1 μPa^{2}s. The cumulative SEL criteria refers to the duration of the piling operation, which has the same value as the $L_{E,p,flat,24h}$ stated in the table.

Type of animal	Metric	Threshold value,
Fish	$L_{p,rms,flat}$	150 dB

Table 12. Thresholds corresponding to behavioural response for fish [31]. Units of $L_{p,rms}$ are dB re 1 μPa.

6 Construction Phase

6.1 Scenario overview

The following scenarios were modelled:

C1 Impact pile driving

C2 Vibratory pile driving, including support vessels

C3 Drilling for socket piles, including support vessels

C4 Rock blasting on land

For all scenarios C1-C4 it is assumed that only one of the respective installation events takes place within a 24-hour window. For the modelling, in all scenarios C1-C4 the noise sources are assumed to be located at position A of Figure 2.

The included support vessels in C2 and C3 are:

- One jack-up rig (100% operation time)
- One crane barge (100% operation time)
- One tugboat (20% sailing, 80% idling)
- One crew boat (10% operation time).

Support vessels are not included in the C1 scenario for impact pile driving, as the criteria values are stated differently for impulsive sources (impact pile driving) and continuous sources (support vessels). Mixing the acoustic metrics across the two types of sources will therefore not allow any meaningful comparison with criteria thresholds. The results for scenarios C1 are therefore intended for comparison with the criteria specifically for impulsive sources.

6.2 Noise source assumptions

6.2.1 Impact pile driving

Installation by impact pile driving involves a large hydraulic hammer impacting the pile head, causing impulsive (i.e. transient) noise.

The driven pile was assumed to be of steel material with outer diameter 1.067 m. The coarse hammer protocol in Table 13 and the subsequent details were provided by SISK for purpose of the acoustic modelling. An example of a representative hammer for the impact driving is an IHC Hydrohammer S-150 hydraulic hammer of nominal energy 150 kJ.

Energy level	Metric	No. of strikes
30%	45 kJ	30
70%	105 kJ	2376
100%	150 kJ	234
		Total 2640 strikes

Table 13. Coarse hammer protocol

Driving of one pile was assumed to take approximately 1 hour at an average blow rate of 44 strikes per minute. It was assumed that only one pile was installed per 24 hours.

Based on VG's in-house measurement experience as well as literature, the source spectrum of Figure 20 was applied, corresponding to a broadband level of 208 dB (single-strike SEL). The spectral shape is mainly based on measurements relating to a 0.7 m diameter pile installed at water depth 13 m in coarse sand overlaying a hard calcarenite bottom [28]. Frequencies above 8 kHz were extrapolated assuming a constant slope.

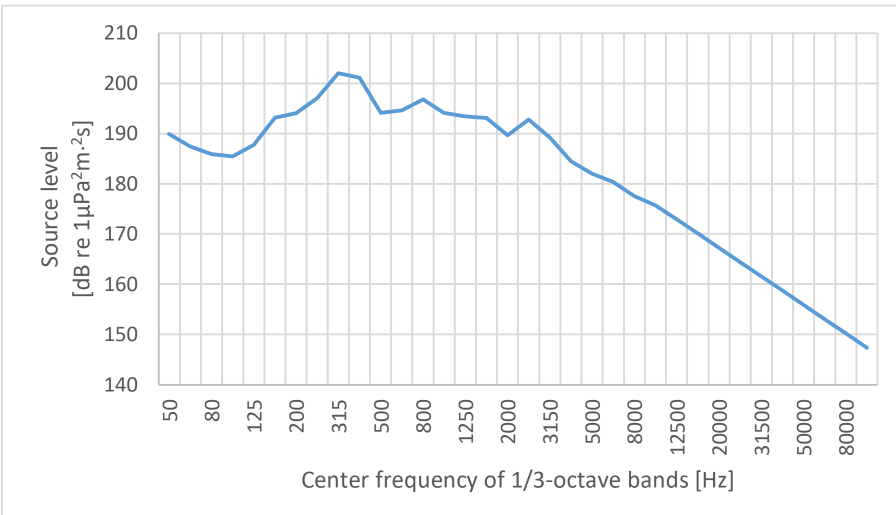

Figure 20. Source level 1/3-octave spectrum for pile driving, stated as $L_{S,E}$.

The piling noise source was assumed to be located at Position A (see Figure 2). The assumed monopole source level $L_{S,E}$ for impact pile driving was 208 dB re 1 μPa^{2}m^{2}s, and the assigned source depth was 20 m below the sea surface.

6.2.2 Vibratory pile driving

In a vibratory hammer, or vibro-hammer, the driving unit consists of contra-rotating eccentric masses in a housing attached to the pile head. As opposed to the impact technique of Section 6.2.1, vibratory (or vibro-) driving causes continuous noise.

The driven pile was assumed to be of steel material with outer diameter 1.067 m. According to information by SISK, a representative vibratory hammer is the ICE 815C Vibro Hammer, which has an eccentric moment of 46 kgm and max. centrifugal force 1250 kN. The vibro hammer's maximum rotational speed 1570 RPM, which corresponds to a fundamental frequency component of 26 Hz.

For the installation of one pile, approximate 20 minutes of vibro-driving is required according to SISK. It is assumed that only one vibro-driving event takes place per 24 hours.

For the acoustic modelling, VG's in-house measurement experience combined with literature cases led to an estimated monopole source level L_S of 182 dB re 1 μPa·m when accounting for the current pile size and hammer force. The source was assigned a source depth of 20 m at Position A. The shape of the assumed spectrum shown in Figure 21 was based mainly on [32] in combination with various other sources. Frequencies above 2500 Hz were extrapolated assuming a constant slope.

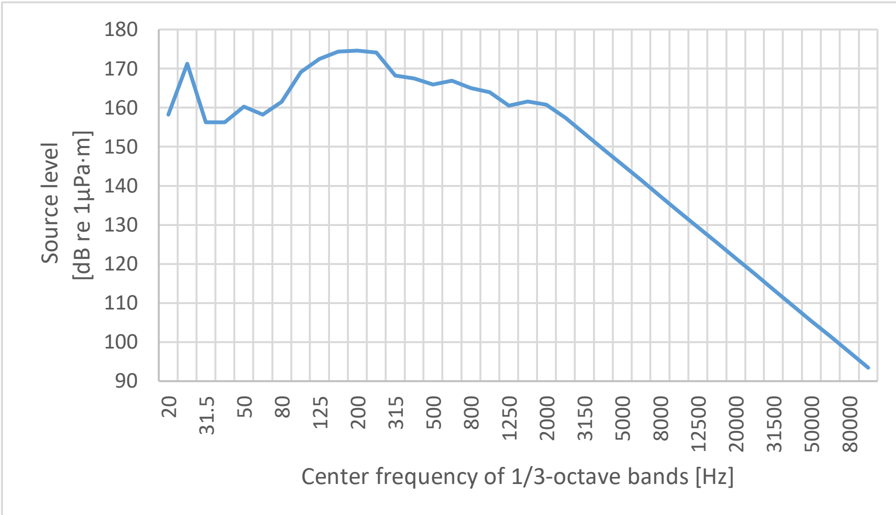

Figure 21. Source level 1/3-octave spectrum for vibro-driving, L_s dB re 1 µPa·m.

6.2.3 Socket pile drilling

This pile installation technique emits continuous type noise during operation. According to information provided by SISK, a representative drill machinery is the LD408 pile top drill rig. This has drilling diameter range 1.3 to 2.0 m, maximum power swivel torque 81 kNm, and variable drill speed 0-38 RPM.

For the installation of one pile, approximately 25 hours of drilling is required according to SISK. For the modelling it is assumed that the drilling event takes full 24 hours.

Measurements from a small-diameter socket drill were reported in [33]. These were converted to 1/3-oct spectra and scaled to a larger drill in [34]. For the present study, the noise source data of the latter is used after slight re-scaling to the Shannon pile diameter of 1.067 m.

For socket drilling, the assumed monopole source level L_S was 168 dB re 1 µPa·m, and the assigned source depth was 20 m at Position A. The corresponding 1/3-octave band spectrum is shown in Figure 22.

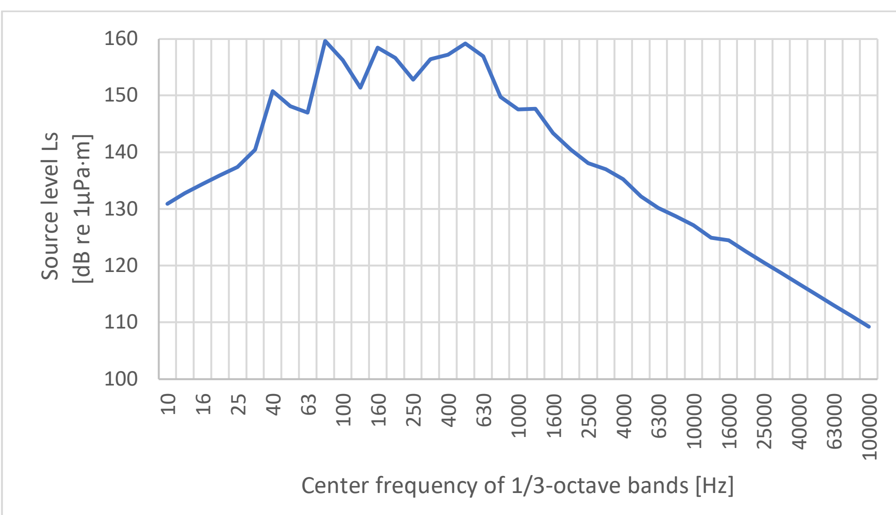

Figure 22. Source level 1/3-octave spectrum for socket drilling, L_s dB re 1 µPa·m.

6.2.4 Blasting

For the on-shore LNG terminal, a certain amount of rock blasting is envisioned. The blast holes will be distributed inside the sandstone area indicated by dark brown in Figure 23. It is noted that this area is approximately 70 m or further in-land from the coastline.

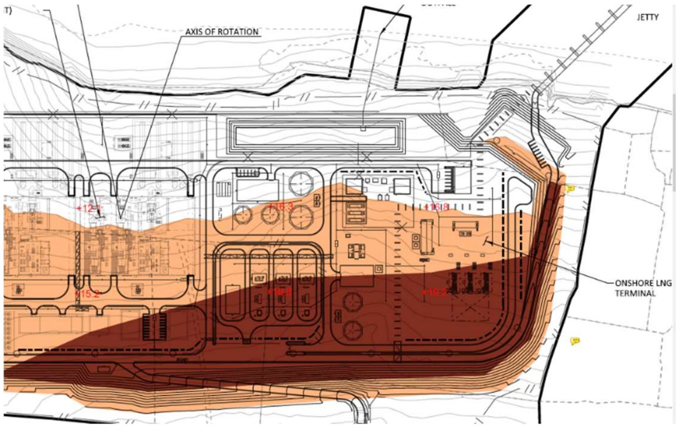

Figure 23. Overview of on-land blasting area (dark brown polygon).

The rock material is sandstone, and the following information was provided by SISK:

Blasting charge is assumed to be Sureblend 100. It is informed that this emulsion has a density of 1.2 g/cm^2, and that 1.35 kg of the Sureblend is equivalent to 1 kg of TNT.

Taking a maximum hole depth of 10 m, a conservative estimate of maximum of 90 kg (TNT equivalent) is required per hole.

For the acoustic modelling, one blasting event per 24 hours is assumed.

As a practical and conservative assessment of a blasting event source level, the following approach was applied:

1. Based on the TNT equivalent weight, a semi-empirical expression from [35] was used to estimate the Peak sound pressure level for an in-water blasting charge.

2. The report [36] makes reference to measurement work by the same organization indicating that the peak sound pressure is reduced to approximately 5% when the same blasting charge is embedded e.g. in a borehole. On that background, the in-water $L_{p,pk}$ from step 1 was reduced by 26 dB, i.e. 20Log(5%) and the corresponding Sound Exposure Level was estimated from $L_{p,pk}$ using a semi-empirical expression from [35]. This provides a source level for an embedded charge, in terms of broadband SEL $L_{S,E}$.

3. To account for the propagation distance between the nearest blasting location and the water, a spectral attenuation was used to shape the measured far-field spectrum reported in [37] (extrapolated at a constant slope above 2 kHz). The attenuation assumed propagation through a sandstone layer with generic geoacoustic properties. For this simplified assessment only compressional wave properties were considered, having attenuation α_p=0.10 dB/λ [15]. Assuming 70 m of propagation, the resulting source level spectrum is shown in Figure 24. The monopole source level is 206 dB re 1 μPa^{2}m^{2}s.

For the acoustic modelling, the blasting source is assumed to be located at Position A at source depth 20 m. As an approximation, the semi-empirical relations between L_E, $L_{p,pk}$ and $L_{p,rms}$ for piling (Sect. 5.2.2.3 and 5.2.2.4) were applied for blasting.

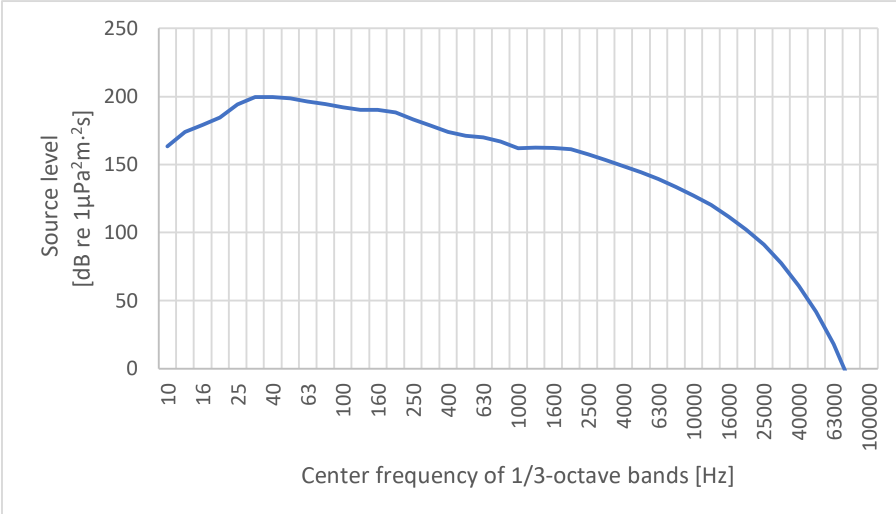

Figure 24. Source level 1/3-octave spectrum for blasting event, stated as $L_{S,E}$.

6.2.5 Support vessels

The source levels for the vessels used in the prediction were assessed based on literature data and VG's in-house data from measurements on similar vessels. The corresponding spectra assumed for this study are stated in Figure 25. The values are given as monopole source levels L_s in dB re 1 µPa·m.

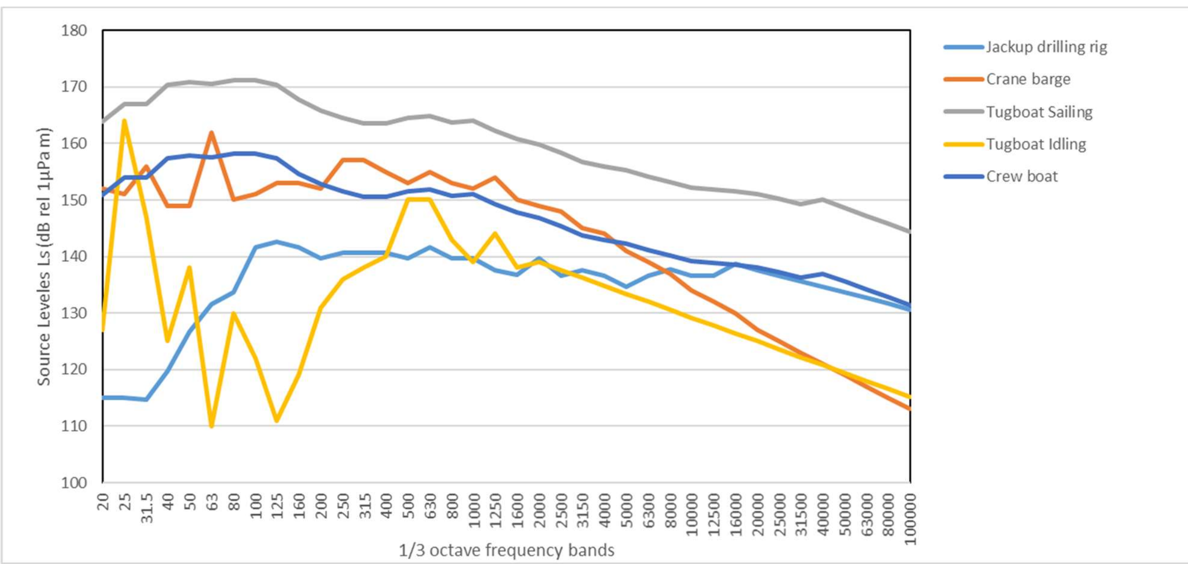

Figure 25. Underwater source levels for support vessels used in the predictions (L_s dB re 1 µPa·m).

For the drilling rig, the source level is based on measurements by Vysus on a large jack-up drilling rig. The source level has been corrected by subtracting the drilling contribution, leading to a source level only including the jack-up rig. The rig has been assumed in operation 100% of the time. The crane barge source level has been taken from JIP report [44]. This gives a source level of 168 dB and the spectral shape has been assumed to be similar to a pipe layer vessel. The barge has been assumed in operation 100% of the time. The source level of the sailing tugboat has been taken from the Port of Vancouver ECHO1 database [40]. The tug is stated to be sailing 20% of the effective time, and the remaining time (80%) is on idle. The crew boat source level is also taken from the JIP report [44]. This gives a source level of 168 dB and the spectral shape has been assumed to be similar to the sailing tugboat. The crew boat has been assumed to be in operation in 10% of the effective time. The sources have been collected into one combined source strength with correction for the respective operation times. The source depth for the support vessels is assigned as 3.5 m.

6.3 Results – Construction Phase

In the following, all noise results represent the maximum observation across all depth positions at the same range, or “Max-over-depth”.

Selected contour maps of the sound fields are shown in Figure 26 to Figure 29. Note that these represent interpolated results based on the detailed transects and are included for visual overview mainly. Tables of distance-to-threshold and area-to-threshold are provided in Appendices C to F. These were derived directly from the detailed transect results.

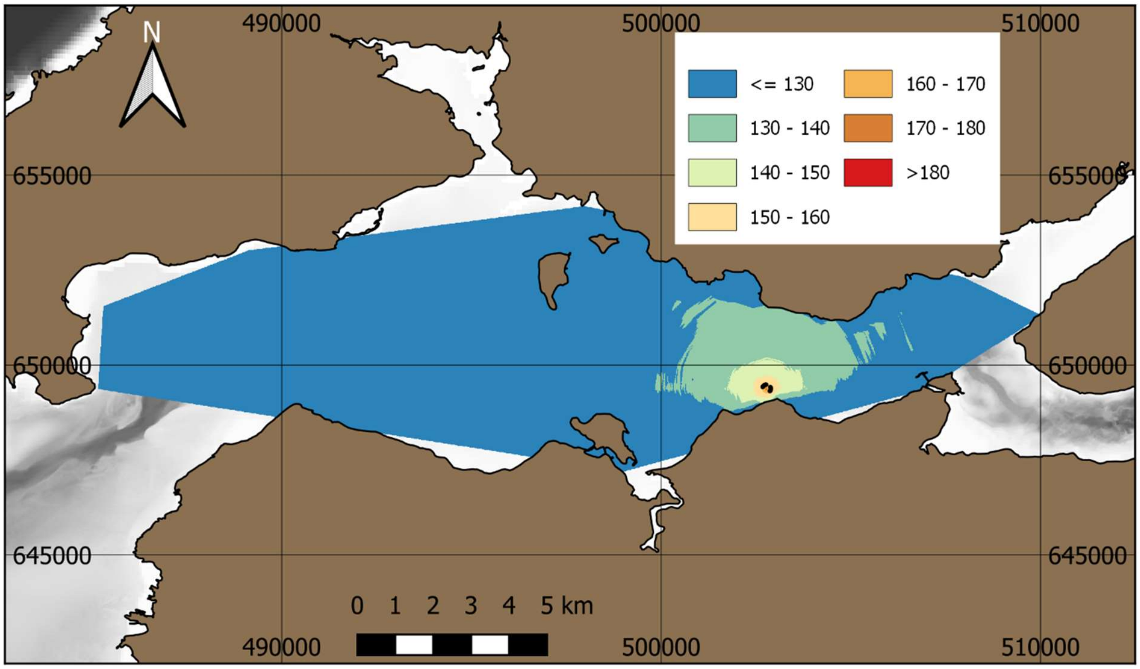

Figure 26. Scenario C1) Construction Impact Pile driving. Contour map of $L_{p,rms}$ (MF-weighted, “Max-over-depth”). Values in dB re 1 µPa. Behavioural criteria of 160 dB is indicated by dashed line.

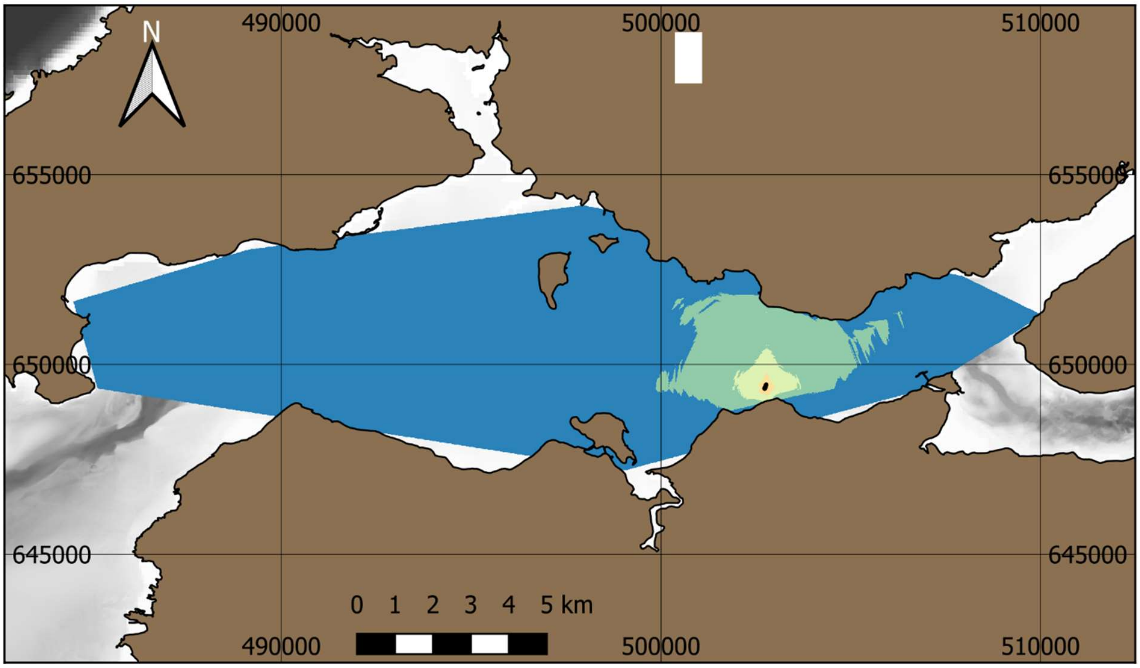

Figure 27. Scenario C2) Construction Vibratory driving incl. supporting vessels. Contour map of $L_{p,rms}$ (MF-weighted, "Max-over-depth"). Values in dB re 1 µPa. Behavioural criteria of 120 dB is indicated by dashed line.

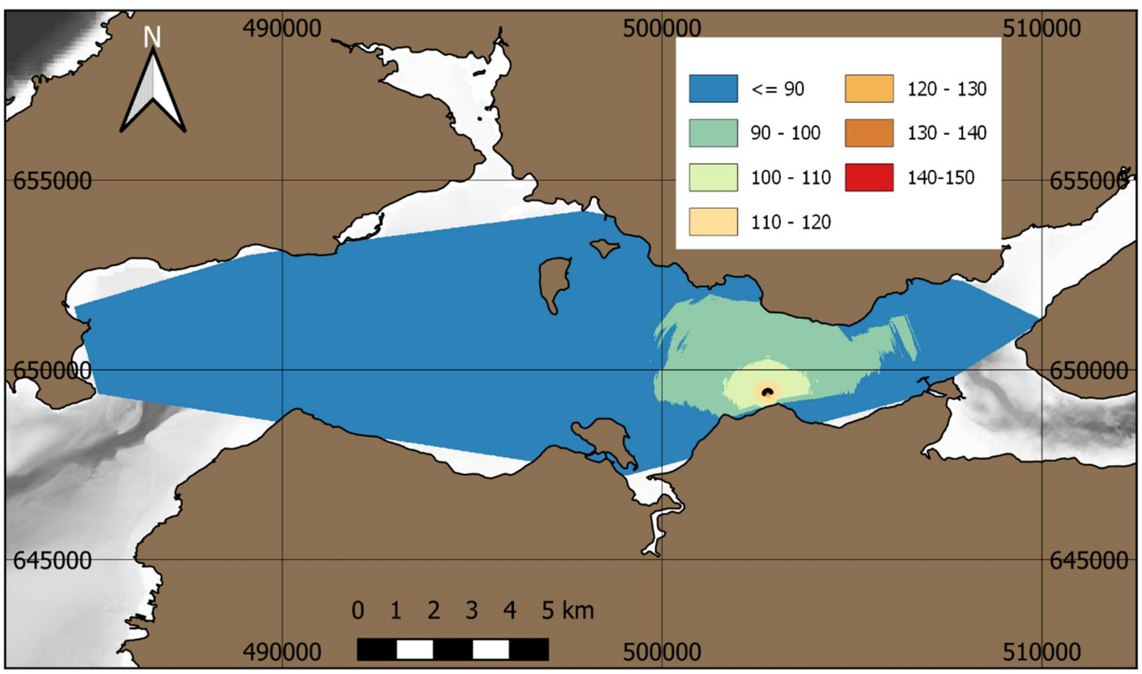

Figure 28. Scenario C3) Construction Socket pile drilling. Contour map of $L_{p,rms}$ (MF-weighted, "Max-over-depth"). Values in dB re 1 µPa. Behavioural criteria of 120 dB is indicated by dashed line.

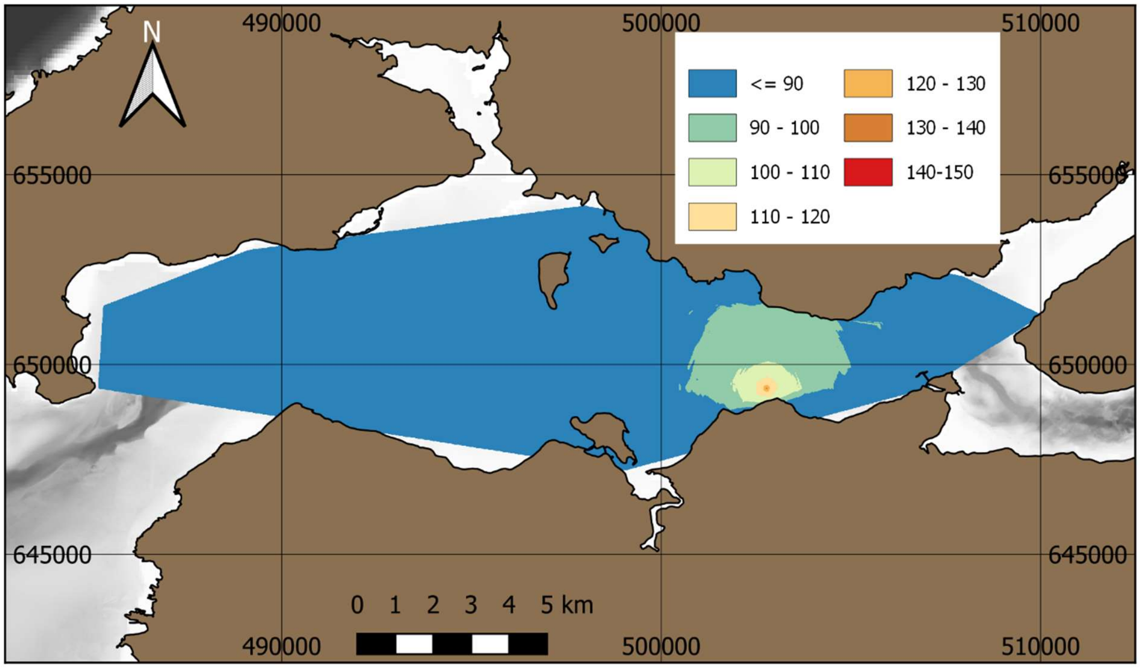

Figure 29. Scenario C4) Blasting. Contour map of $L_{p,rms}$ (MF-weighted, "Max-over-depth"). Values in dB re 1 μPa. Entire sound field is below the behavioural criteria of 160 dB.

7 Operational Phase

7.1 Scenario overview

The following scenarios were modelled in the operational scenario, with reference to the locations of Figure 2:

A **FSRU alone**. This is assumed to be a single, continuous noise source, located at position A.

B **FSRU together with an offloading LNG carrier**, including 1 tug in idling mode close to the carrier. This scenario covers 24 hours. All sources are located at position A. The scenario includes the following activities with corresponding time durations:

- FSRU operating continuously
- LNG carrier and tug involved in offloading for 23 hours and 45 minutes
- Carrier and 4 sailing/engaged tugs transiting for 15 minutes

D **FSRU together with approaching LNG carrier**, including 4 sailing/engaged tugs close to the carrier. All sources are assumed to be continuous during the transit time from Position B to A (see Figure 2). FSRU source located at position A, carrier and tugs located at position B. This scenario only addresses the 15 minutes during which the approach activity takes place.

E **FSRU together with berthing LNG carrier, including 4 engaged tugs, a general cargo ship sailing in the middle of the Estuary, and ship moored at Moneypoint**. FSRU, LNG Carrier and Tugs are located at Position A, the general cargo ship at Position C, and the moored ship at position M. This scenario is an expansion of the Offloading scenario and covers 24 hours. It includes the following activities with corresponding time durations:

- FSRU operating continuously
- LNG carrier and tug berthed for 23 hours and 45 minutes
- Carrier and 4 sailing/engaged tugs transiting for 15 minutes

- Cargo ship sailing in estuary for 15 minutes
- Moored ship at Moneypoint, operating continuously

Further as described in Appendix B, Scenario A with the FSRU was modelled for two additional conditions that include onboard noise abatement measures.

7.2 Noise source assumptions

7.2.1 FSRU, LNG carrier, tugs, and cargo ships

The source levels for the vessels used in the prediction are assessed based on literature data and VG's in-house data for measurements on similar vessels. The spectra assumed for this study are stated in Figure 30. The values are given as monopole source levels L_s in dB re 1 µPa·m. The source depth for the vessels is assigned as 0.7 times the draught of that vessel.

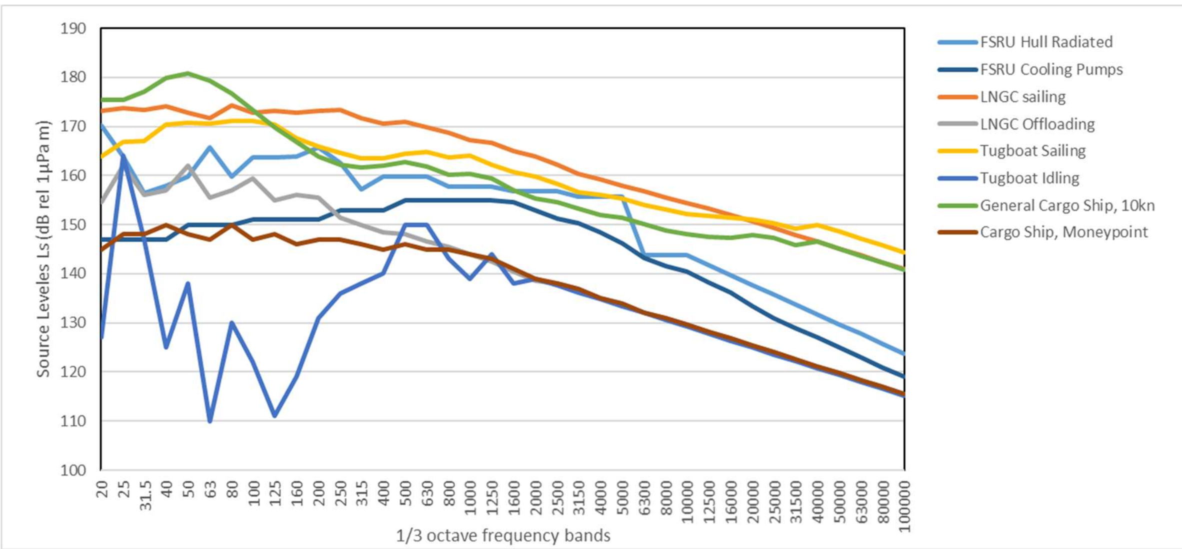

Figure 30. Underwater source levels for ships used in the predictions (L_s dB re. 1 µPa·m).

The basis of the evaluations is the use of an FSRU size 180.000 m^3 with an estimated length of ~300 m, draught of 12.9 m, operating diesel generators located low in the hull, and various pumps and compressors running for the regassification process. Sea water cooling intake/outlets are located approx. 3.5 m below the surface at a flow rate of 22.000 m^3/hr plus additional 3500 m^3/hr for engine and aux. equipment cooling. The diesel generators are assumed to be fitted with standard vibration isolators on both engines and generators. Operation of potential propulsion or thrusters is excluded from the evaluation / assumed not in operation.

The underwater noise from the FSRU will consist of hull radiated noise, and noise from sea chest outlets and inlets for the onboard cooling water systems - no propulsion system is in operation. As no literature information on underwater source data for FSRUs could be located, several initiatives were made to provide as accurate data as possible for the underwater noise from the FSRU. These included the following:

- An underwater noise measurement campaign was conducted on the Golar Freeze FSRU, located in the Old Harbour in Jamaica. This was found to be a practical opportunity for obtaining actual measured data from an FSRU, considering potential interfering noise from other ships etc. The measurements are documented in Appendix A of this report.
- To further investigate the underwater noise emission from the FSRU, a detailed model and prediction was carried out using Statistical Energy Analysis methodology of the Golar Igloo FSRU. The study and results are shown in the Appendix B of this report.

The two initiatives gave results within the range of expectations for the source data. However, the frequency content of the two investigations gave different results, as the equipment and operation conditions were not fully comparable. The predicted noise levels on the Golar Igloo was higher at higher frequencies than the measured levels on the Golar Freeze. As a conservative approach, it was decided to use the highest level in each 1/3 octave band from the two studies and combine these into a source level, which was used for the hull radiated noise from the FSRU.

The noise emission from the onboard sea water cooling pumps has been estimated based on information in the paper Robinson et al. 2012 Measurement of underwater noise from arising from marine aggregate operations [39], including an estimated 3 dB reduction for sea chest attenuation.

The approaching LNG carrier sailing condition is assumed to be at low speed (~5 knots) with main propulsion engaged and with assistance of 4 tugs. During the docked conditions for offloading the LNG carrier is assumed to have auxiliary generators in low to mid-load condition and no propulsion system engaged. The main source in this condition is expected to be the cargo pumps and the onboard generators. The draught of the LNG carrier is assumed to be 11.6 m.

The tugs are assumed to be operating in two conditions: Sailing while assisting the LNG carrier, and idling close to the jetty. The draught of each tug is assumed to be 6.1 m. The data for the tugs are taken form the Port of Vancouver ECHO1 data base, using the 50% average level for tugs [40].

The size of the general cargo ship sailing in the estuary is based on Shannon Foynes Port Authority Risk assessment [41]. The ship is assumed to be 40.000 DWT sailing at approx. 10 knots, and with a draught of 10.9 m. The source data are also taken from the Port of Vancouver ECHO1 data base [40]. The ship moored at Moneypoint is assumed to be 150.000 DWT, berthed (0 knots) with only one auxiliary generator running (low load), draught assumed to be 16.9 m, and source data taken from [42] .

In Figure 31 the broadband source levels are shown for a comparison of the relative importance of the individual sources, revealing that sailing vessels (general cargo vessels, LNG carrier, and tugs) are expected to have the highest overall levels.

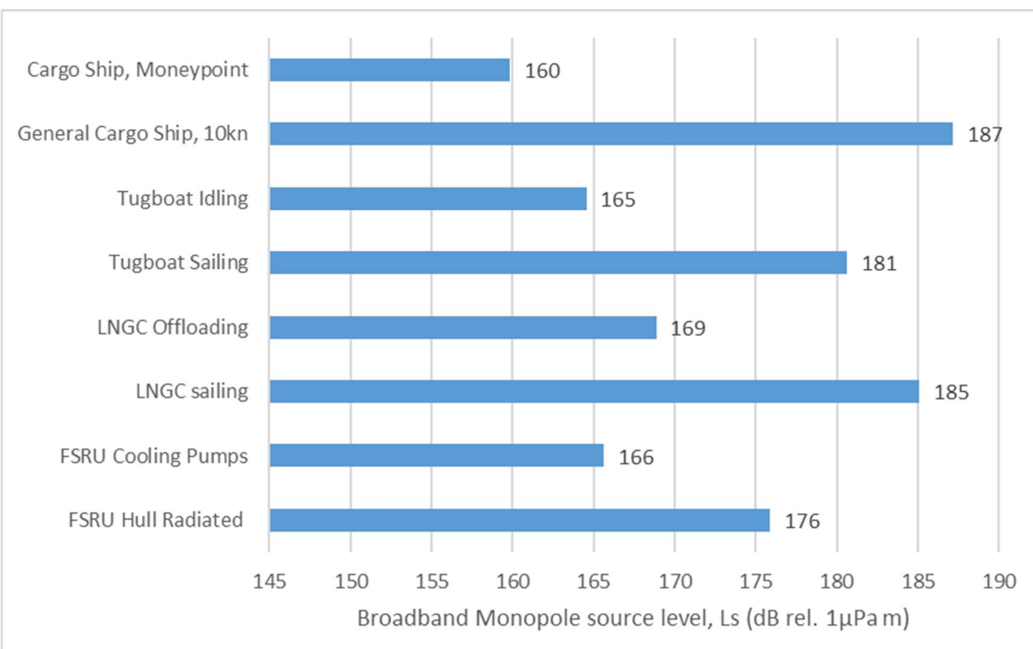

Figure 31. Broadband underwater source levels for ships used in the predictions (L_s dB re 1 µPa·m)

7.3 Results – Operation Phase

In the following, all noise results represent the maximum observation across all depth positions at the same range, or “Max-over-depth”.

Tables of distance-to-threshold and area-to-threshold are provided in Appendices A to E.

Selected contour maps of the sound fields are shown in Figure 32 to Figure 35. Note that these represent interpolated results based on the detailed transects and are mainly included for visual overview. The distances and areas of Appendices G to J were derived directly from the detailed transect results.

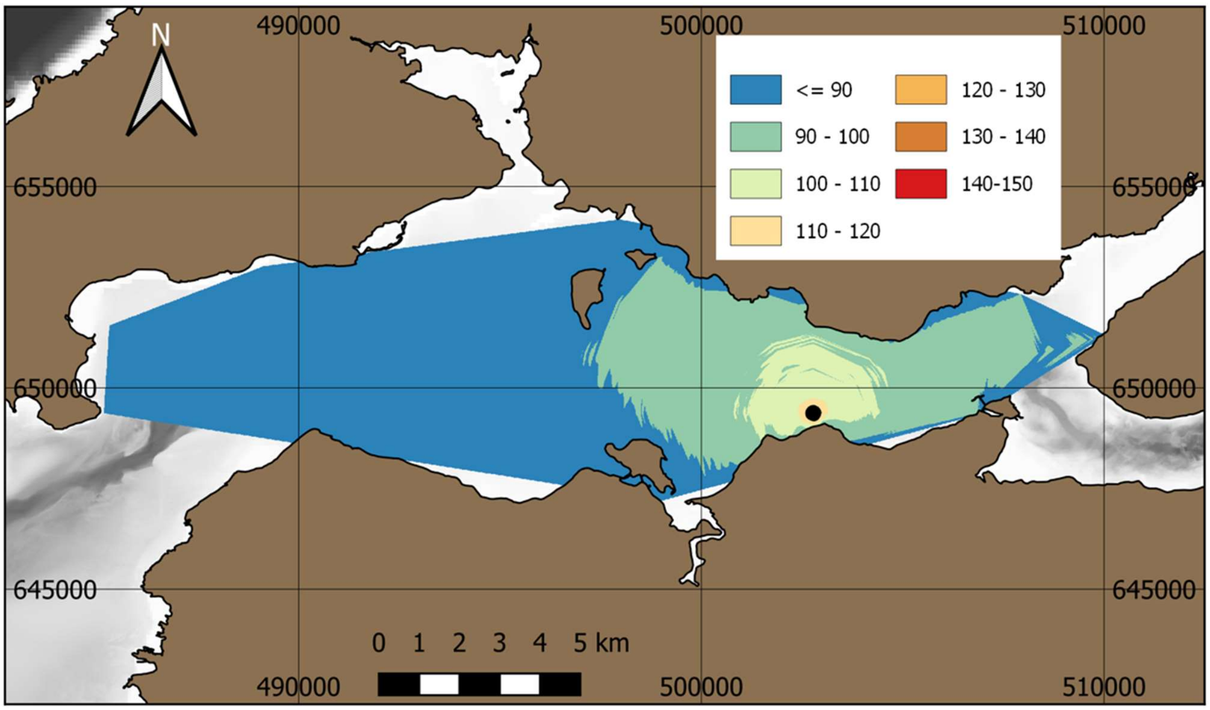

Figure 32. Scenario A) FSRU with onboard seawater pumps. Contour map of $L_{p,rms}$ (MF-weighted, “Max-over-depth”). Values in dB re 1µPa. Behavioural criteria of 120 dB is indicated by dashed line.

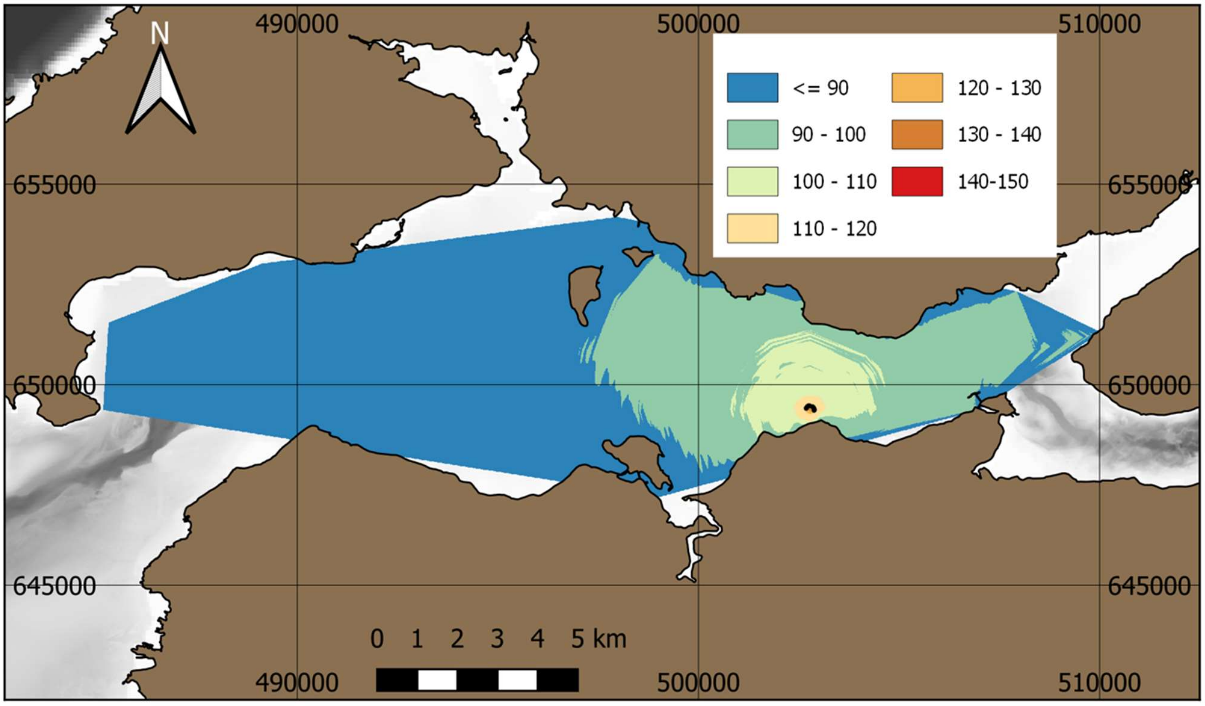

Figure 33. Scenario B) FSRU together with an offloading LNG carrier, including 1 tug in idling mode. Contour map of $L_{p,rms}$ (MF-weighted, "Max-over-depth"). Values in dB re 1 µPa. Behavioural criteria of 120 dB is indicated by dashed line.

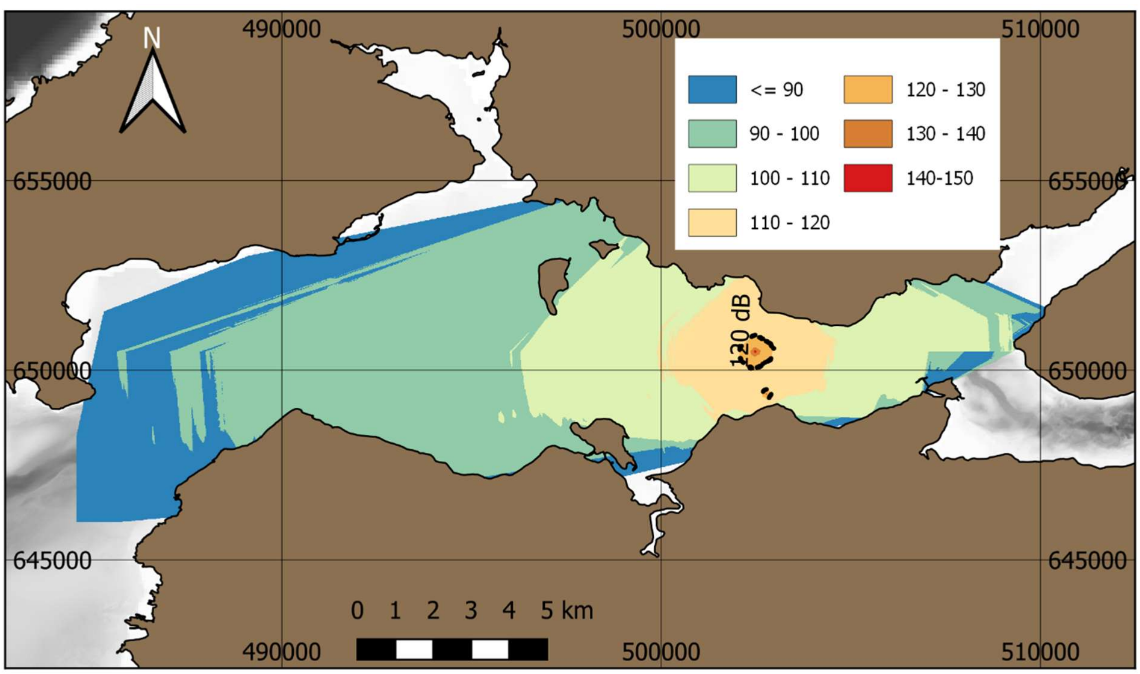

Figure 34. Scenario D) FSRU together with approaching LNG carrier, including 4 sailing tugs. Contour map of $L_{p,rms}$ (MF-weighted, "Max-over-depth"). Values in dB re 1 µPa. Behavioural criteria of 120 dB is indicated by dashed line.

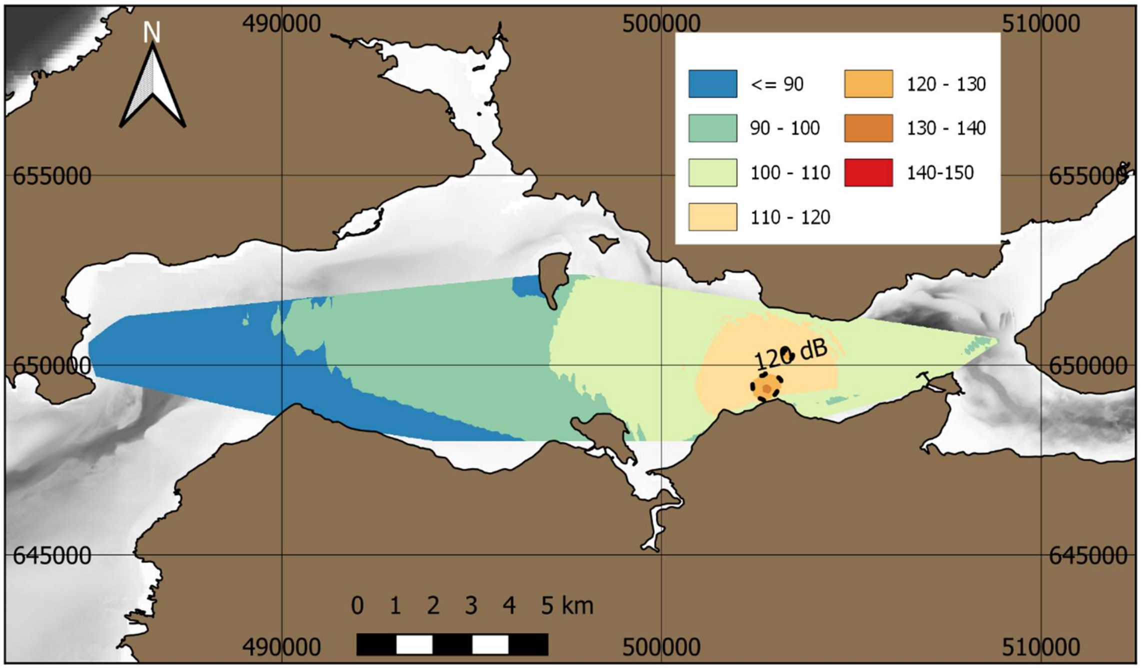

Figure 35. Scenario E) FSRU together with berthing LNG carrier, including 4 idling /engaged tugs, a general cargo ship sailing in the middle of the Estuary, and ship moored at Moneypoint. Contour map of $L_{p,rms}$ (MF-weighted, "Max-over-depth"). Values in dB re 1 µPa. Behavioural criteria of 120 dB is indicated by dashed line.

8 Final Comments

Section 4 describes the existing ambient noise at the site as 88 dB using MF-weighting, based on the statistical Median (L50) of all measurements. Assuming MF-weighting, Table 14 shows a rough comparison with the predicted $L_{p,rms}$ for the modelled scenarios. It follows that the various scenarios produce noise levels exceeding the ambient noise at all multiple km ranges.

Similarly, 4.1 describes the noise from a passing ferry. Applying a coarse conversion, this corresponds to approximately $L_{p,rms}$ = 108 dB (using MF-weighting) at a distance of 10 m from the ferry. The right-most column in Table 14 shows the distance within which the predicted noise exceeds that of 10 m from the ferry.

Scenario	Range within which the prediction exceeds...	
	Ambient noise	Noise from ferry
C1 – Impact pile driving	All ranges, i.e multiple km	15 km
C2 – Vibratory driving	9.8 km	1.0 km
C3 – Socket pile drilling	9.8 km	1.1 km
C4 - Blasting	7.4 km	0.8 km
A - FSRU as the only noise source	15 km	1.2 km
B - FSRU together with an offloading LNG carrier	15 km	1.2 km

D - FSRU together with approaching LNG carrier	All ranges, i.e multiple km	6.2 km
E - FSRU together with berthing LNG carrier, 4 tugs engaged, cargo ship sailing in estuary, berthed ship at Moneypoint	All ranges, i.e multiple km	6.5 km

Table 14. Predicted noise compared to ambient noise (Median, L50), and noise from ferry. Based on MF-weighted $L_{p,rms}$.

For scenarios corresponding to C1 impact pile driving, D approaching LNG carrier, and E multiple vessels, the noise exceeds that of the ferry for more than 6 km away from the source. However, for the scenarios A and B with the FSRU as only noise source or FSRU with offloading carrier, respectively, the noise only exceeds that of the ferry for approximately 1.2 km distance from the source. Similarly, for C2 vibro-driving, C3 drilling, and C4 blasting, the same distance is at 0.8-1.2 km.

It is noted that the above comparisons are based on physical, acoustic metrics. In cases of excessive noise, the degree of audibility or potential animal response strongly depend on the respective hearing abilities.

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Appendix A. Measurement of Underwater noise source level for Golar Freeze FSRU

Vysus Group (VG) has undertaken measurements of the underwater noise emission from the Floating Storage and Regasification Unit (FSRU) Golar Freeze located at Old Harbour (Jamaica). The measurements were carried out on 19th March 2021 in the period 07:00AM – 08:15AM local time. Due to Covid19 restrictions, it was not possible for Vysus technicians to perform the measurements. The measurements were therefore caried out by New Fortress Energy crew on site following a detailed description from VG. The measurements were performed using equipment from VG's lab.

Description of FSRU

The FSRU was located at Old Harbour in Jamaica at the offshore mooring point, see Figure 36. Local water depth at the offshore mooring point is approx. 15 m.

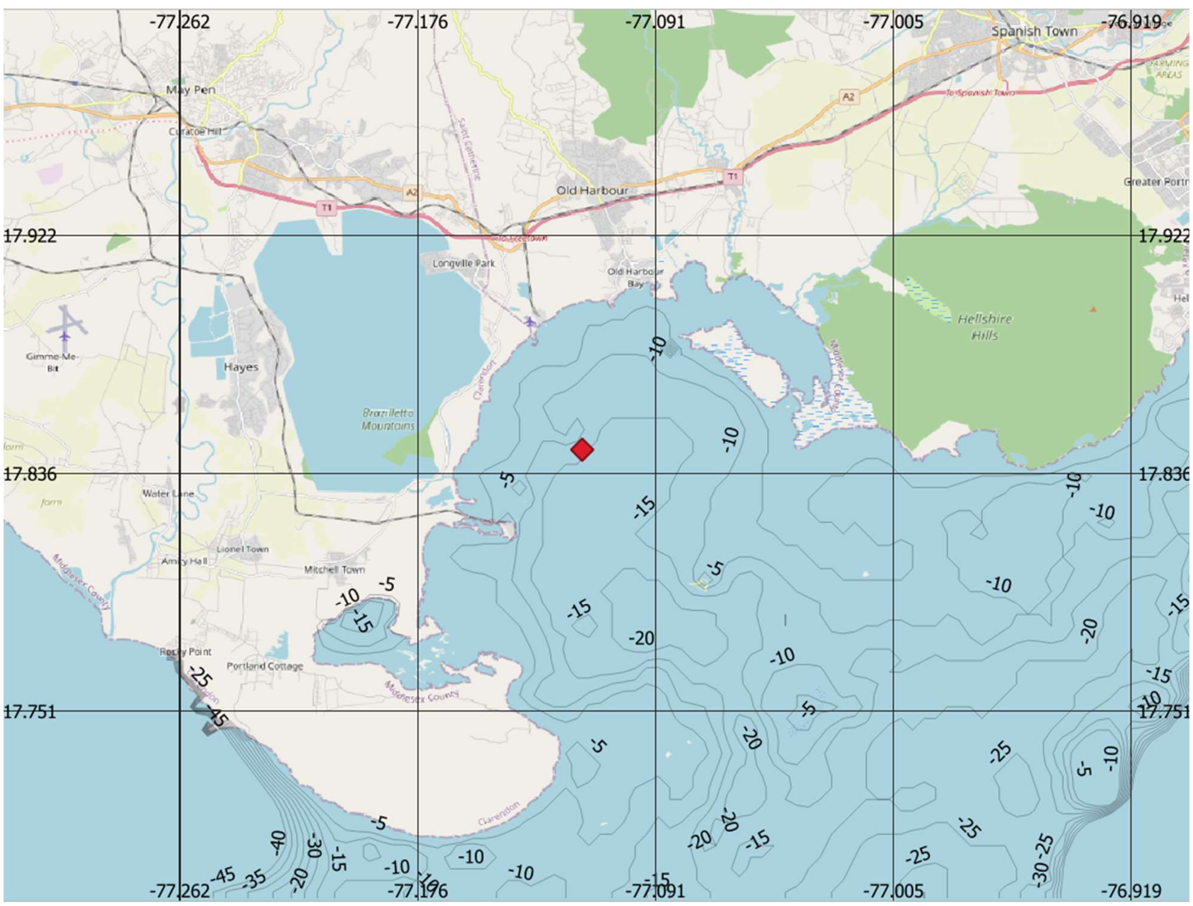

Figure 36. Location of Golar Freeze FSRU (red diamond).

© OpenStreetMap contributors, **https://www.openstreetmap.org/copyright***, Depth data from GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234d-e053-6c86abc040b9).*

The FSRU main particulars and operating conditions given in the following tables:

Feature	Value
Length over all	287.55 m
Breath moulded	43.4 m
Draught	11.9 m
Cargo Capacity	125,862 m3 (100% -160°C)

Table 15. Main particulars of FSRU.

Feature	Property
Gas export	48.624 MMSCFD
Cargo volume	62,212 m^3
Cargo volume send out at time of testing	2,558.2 m^3
Turbo generator #1	2040KW/1798 RPM
Turbo generator #2	2078KW/1800 RPM
Booster pumps	Two running
MSO compressor	One running
Diesel generators	None running

Table 16. Operating conditions during the measurements.

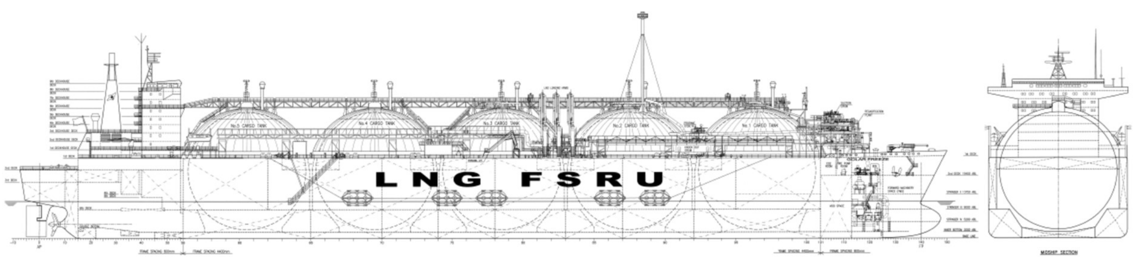

Figure 37. Side view and section of the Golar Freeze FSRU.

<u>Measurements</u>

The measurements were carried out using a 4-channel SoundTrap 4300 underwater logger unit connected with two HTI 96-min hydrophones. The hydrophones were deployed at 6 and 10 m depth. The hydrophones were located on a drifting submerged line with a floating buoy and an elastic release to supress wave motions. Time signals were recorded with a sampling rate of 96 kHz and later analysed by Vysus Group's noise specialists in Denmark.

The underwater noise was measured in 6 points (P1 – P6) around the FSRU in distances varying from 712 m to 211 m to the geometrical centre of the FSRU. The distance to the vessel was determined by registering the GPS position at the start and end of each measurement together with the fixed position of the FSRU, corrected to the geometrical centre of the vessel.

The ambient noise was measured in a position in the centre of the bay at approximately 1.5 km from the FSRU.

During the measurements the air temperature was 25 °C, wind ≈3 m/s (N), air pressure 1017 mBar, and current in NE direction. The wave height was assessed as < 0.5 m - Sea state 2.

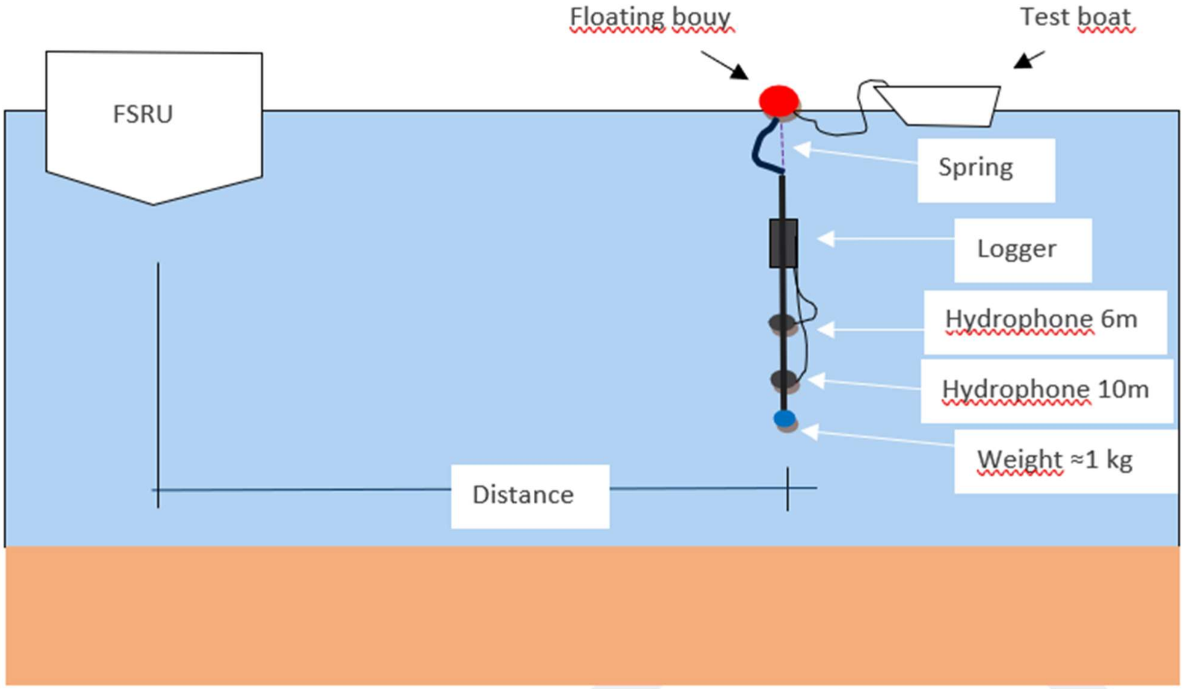

Figure 38. Sketch of measurement setup.

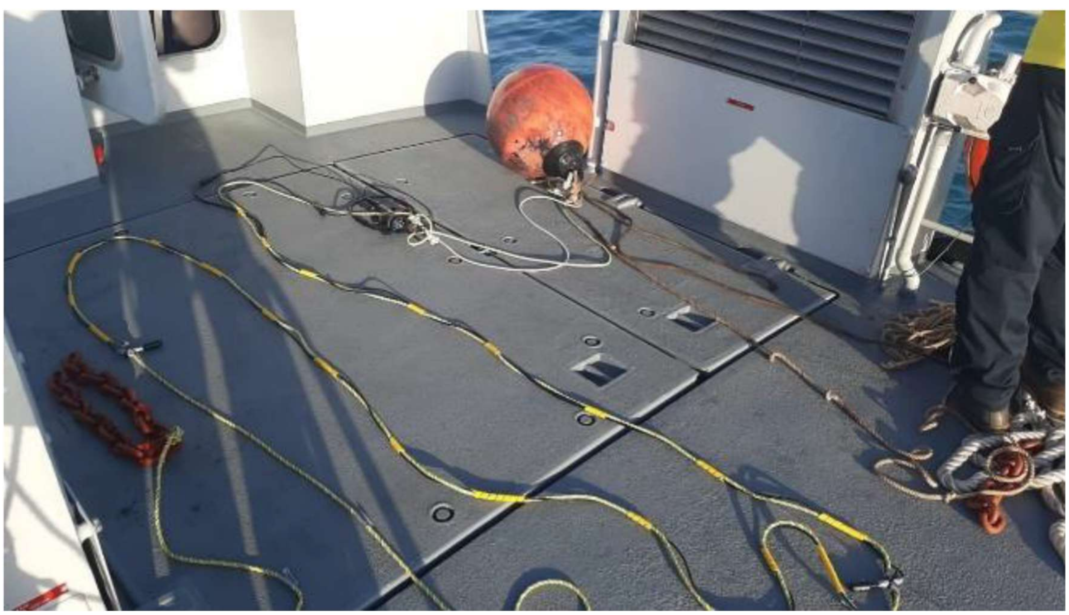

Figure 39. Measurement equipment on deck of test boat.

Figure 40. Golar Freeze FSRU seen from position P3.

Figure 41. Golar Freeze FSRU seen from position P6.

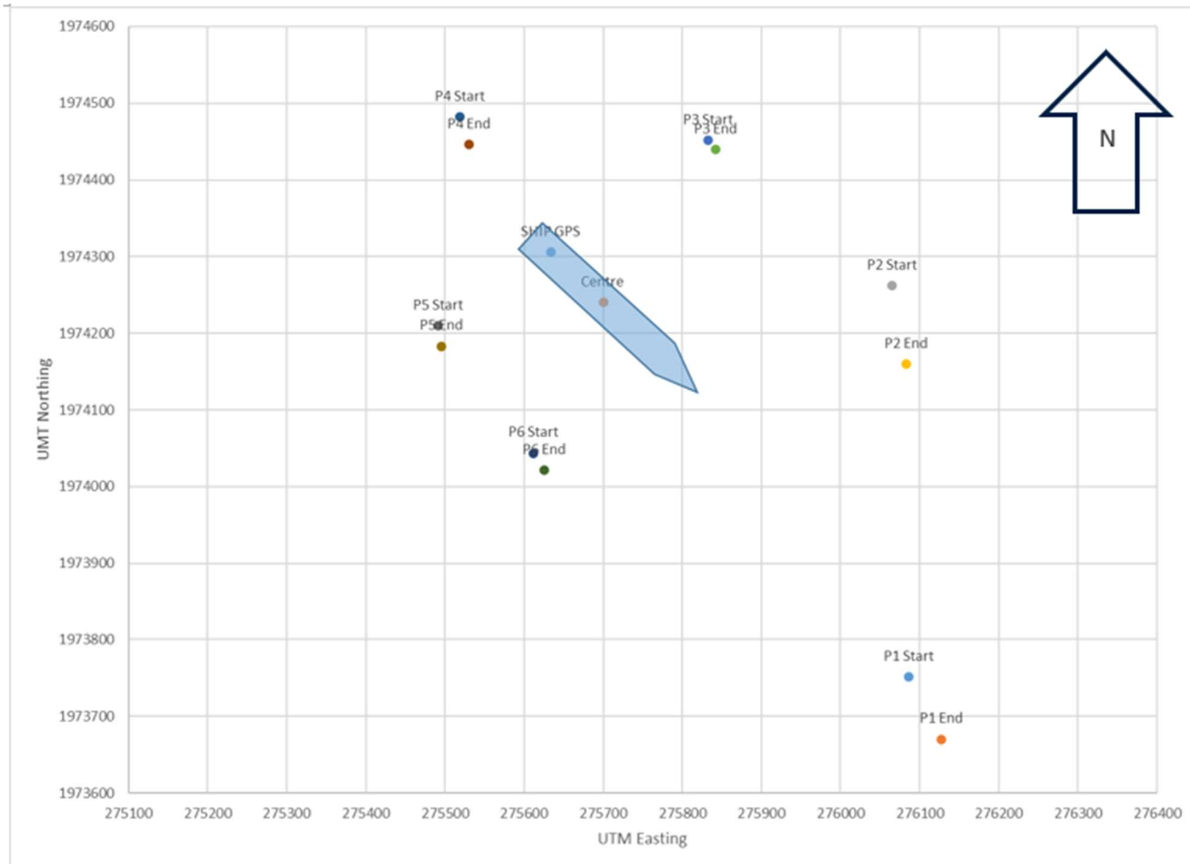

Figure 42. Location of measurement points relative to Golar Freeze FSRU.

Conversion to source level

The shallow water of only 15 m on the test site is affecting the measured underwater noise levels significantly. It is therefore necessary to perform a calculation of the expected transmission loss in the water to correct to an equivalent source level level for the vessel. The calculation of the transmission loss (TL) between the ship's geometrical centre and the individual positions has been made using the RAMGeo Parabolic Equation propagation code of the ActUP suite. The calculations were performed at each 1/3-octave band centre frequency from 20-10.000 Hz in vertical steps of 0.25 m and horizontal steps of 0.5 m. The source level (SL, equivalent monopole source level) was subsequently determined for each measurement position as the measured underwater noise levels (Lp,rms in dB re. 1µPa) plus the calculated transmission loss: SL= Lp+TL.

The sound pressure level was analysed over a period of approximately 2 minutes deemed to represent the most stable period in the measurements, excluding periods evaluated to be affected by the deployment, currents and surface waves. To compensate for the drifting hydrophones the calculated transmission losses were horizontally averaged over a distance corresponding to the start and end positions in each position, and a vertical average of ±0.5 m of the nominal depths of 6 m and 10 m. The source levels computed in each position were averaged on energy basis to get the final source level for the FSRU.

The input data assumed in the calculation of the transmission loss are given below in Table 17 and Table 18:

Depth below surface [m]	Temperature [°C]	Salinity [ppt]	Sound Speed [m/s]
0	27	36	1540.1
15	25	33.2	1532.7

Table 17. End points of linear sound speed profile.

Layer Description	Layer, position below seafloor		Compressional wave speed	Density	Compressional wave Attenuation	Shear wave speed	Shear wave Attenuation
	z-top [m]	z-bottom [m]	c_p [m/s]	ρ [kg/m3]	α_p [dB/λ]	c_s [m/s]	α_s [dB/λ]
Silty sand	0	3	1600	1800	0.70	-	-
Clayey silt	3	7	1500	1940	0.20	-	-
Silty clay	7	60	1550	1800	0.20	-	-
Limestone	60	200	5350	2700	0.10	2400	0.2

Table 18. Geoacoustic model for Old Harbour seabed.

Results

The determined source levels are given in the below Figure. The measured levels were assessed as being affected by ambient noise for frequencies above 3150 Hz. Further, the shallow water cut-off frequency was determined as approximately 70 Hz, caused by the shallow water depth of only 15 m.

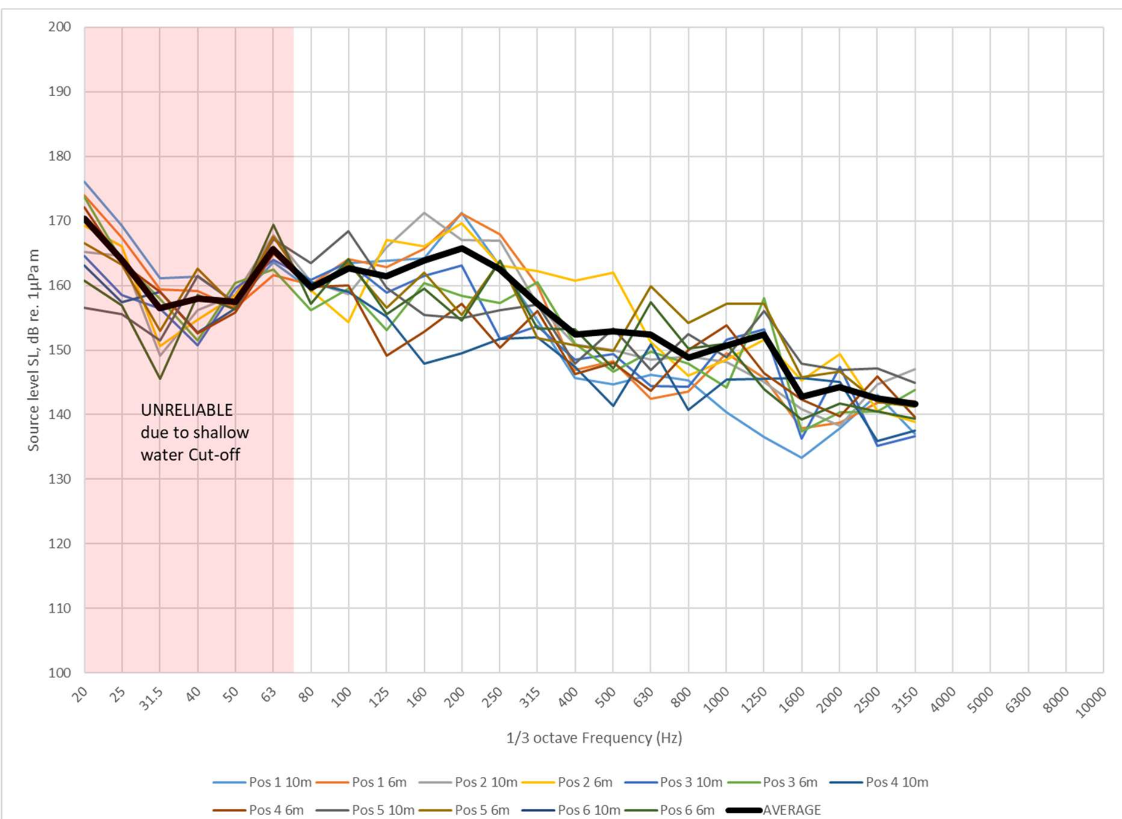

Figure 43. Measured underwater source level spectra - Golar Freeze FSRU.

The results show quite some variance in the different directions measured. This could be due to directivity of the vessel, but it could also be due to uncertainties in the measurements and the calculation of the transmission loss in. It should also be noticed that the measurements were carried out by non-specialist crew due to Covid-19 restrictions. However, the results are deemed to be a reasonable indication of the true source level of the FSRU.

Appendix B. SEA modelling of underwater noise source level for FSRU Golar Igloo

The following describes the results of detailed predictions of the underwater noise from the FSRU Golar Igloo. The calculations are done by Statistical Energy Analysis (SEA) using the commercial software VAOne. The objective of the calculations is to evaluate the underwater noise source strength of the FSRU. It should be noted that the Golar Igloo is only an example of a potential FSRU which could be located at the Shannon Technology and Energy Park – other FSRUs could be used too.

A 3D calculation model of the Golar Igloo FSRU has been constructed, including the main geometries of shell plates, bulkheads, stiffeners etc. The model incudes material data for the steel structure including, density, loss factors and young's modulus. The various located sources are then added to the model with both a structure-borne and airborne source strength. The source strengths are vendor data were available – other source data are taken from previous measurements on similar equipment.

Description

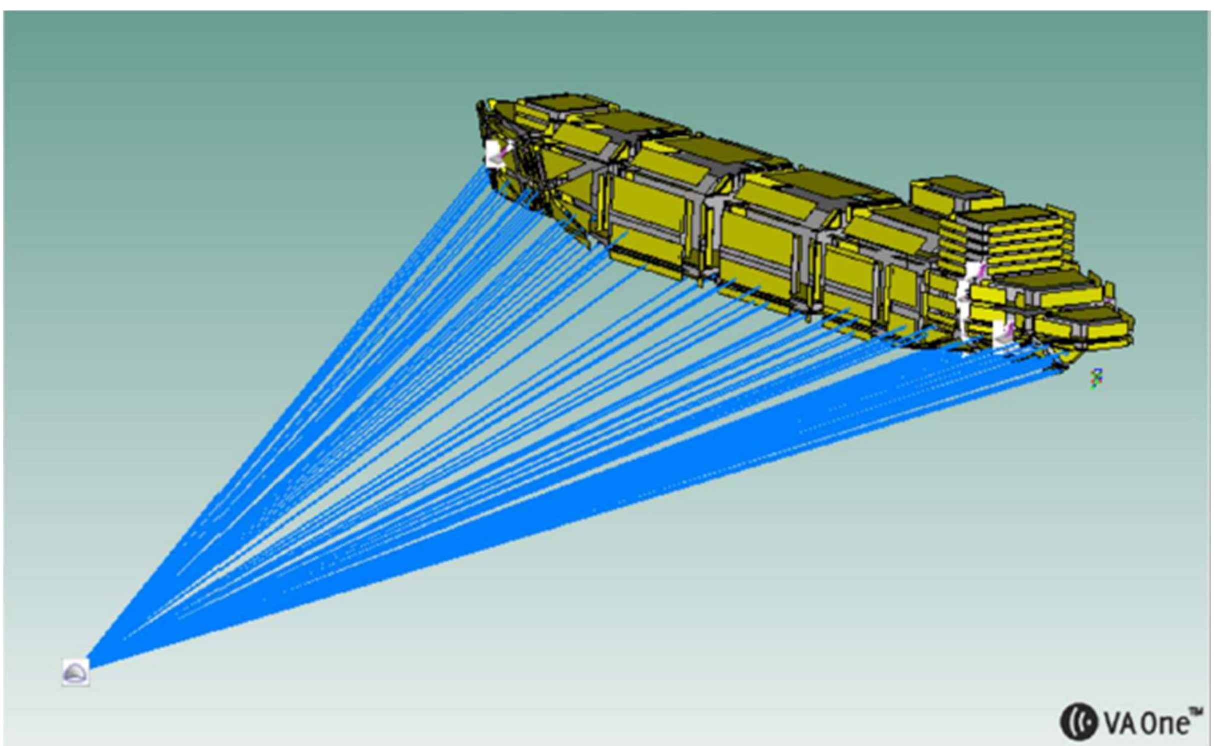

Figure 44. Picture of VAOne model of the Golar Igloo (exploded view).

The model has been created using the information from the steel drawings for the vessel on steel thicknesses of deck plates and other steel structures. The steel thickness in the outer shell above the propeller is around 40 mm. The shell below water is 18-19.5 mm and the main part of the hull above water is 14.5 mm. The main decks in the aft part of the hull, incl. engine rooms are 15 mm. Bulkheads have a general steel thickness of 11 mm.

The steel structure has been calculated with a frequency independent loss factor of 1%, which is found to be representative based on measurements in ship structures. Each enclosed room is modelled as an acoustic cavity with and airborne absorption coefficient as stated in the below Table 19.

Parameter	31.5	63	125	250	500	1000	2000	4000	8000
Mech. Loss factor (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%
Absorption coeff. (-)	0.005	0.008	0.01	0.05	0.10	0.10	0.10	0.10	0.10

Table 19. Structural mechanical loss factor in steel and air absorption coefficients used in model.

The calculations are carried out using the statistical energy analysis methodology with the software VAOne ver. 2014. This method considers each steel plate, beam of acoustic cavity as a subsystem and an energy storage, and the method tracks the energy flow between the different subsystems. The energy flow between the subsystems are determined by coupling loss factors calculated according to the SEA theory. Steel plates are coupled together as well as acoustic cavities are coupled to the steel plates in the model. For the steel plates both bending, shear and longitudinal waves fields are considered as each wave type is calculated as a separate subsystem. The calculations can therefore also handle the coupling between different wave types in different connected plates, e.g. coupling between longitudinal ways in one plate to bending was in a coupled plate. The sound radiation efficiencies are theoretically calculated in the software, based on the steel properties, stiffening elements, and acoustic medium (air/seawater).

The calculations are carried out in 1/1-ocatve bands from 31.5 to 8000 Hz. The Statistical Energy Analysis method has a fundamental assumption of a sufficient modal density in each subsystem. The modal density will decrease with frequency, which means there is a lower frequency where the results gets unreliable. The lower frequency limit is determined to be around 100 Hz, and results below this frequency should be considered as a guideline only.

The outer shell part below the waterline is loaded with water on one side. The underwater noise level is calculated using an energy sink at a distance of 300 m from the FSRU centre line and 80m below the surface, corresponding to approx. 15° angle to the water surface. Previous calculations have shown that the calculation results in other depts gives the same results and therefore only one point is used in the calculations. Reflections from the sea surface are not included in the calculation model and the calculated sound pressure level in the energy sink point is therefore the unaffected underwater sound pressure level. Hence, the monopole underwater source level (SL) can be determined by only correcting for the distance from the energy sink point to the determined acoustical centre of the vessel, which is the vessel centreline at a depth of 0.7 times the draught of 11.9 m.

Table 20 shows an overview of the sources included in the model. The table show the number of sources assumed to be running in each of the two calculated scenarios; With gensets running, and with gensets stopped and using shore power. It is in general assumed that one piece of each type equipment will be on standby, e.g. only 3 out of the 4 generator sets are assumed in operation.

The calculations include both airborne and structure-borne source contributions from the identified sources. The used airborne source levels are given in Table 21. The airborne levels are introduced in the model directly as sound power sources. The structure-borne sources are introduced into the model by equivalent power sources giving the levels indicated in Table 22. The sources are based on a combination of vendor data and Vysus measurements on similar equipment on previous projects. The generators are assumed to be equipped with standard vibration isolators.

Location on Deck	Room	Equipment - Source level	Generators running	Generators Stopped
Floor	Aux. room	Ballast Pumps – A	2	2
		Main CSW Pumps – A	2	2
		Aux boiler Sea water pumps – B	2	2
		MDO Transfer Pump – B	1	1
		CSW pumps for Cargo Mach. – A	1	1
		Sewage grey water Dist. Pump – B	1	1
		Clean water discharge pump – B	1	1
4th Deck	Engine rooms	Main Generator Engine -C	3	
		Main GE Chiller units – D	2	
	Purifyrer room PS	Main GE HFO Circ. Pumps – B	2	
		Main GE HFO supply Pumps - B	2	
		Main GE purifier pumps – B	2	
	Purifyrer room SB	Main GE HFO Circ. Pumps – B	2	
		Main GE HFO Supply Pumps – B	2	
		Main GE purifier pumps – B	2	
3rd Deck		Sewage treatment unit – B	1	1
		Aux. boiler water Circ. Pumps – B	4	4
		Fresh Water Unit – B	1	1
2nd Deck		Hydraulic Power Unit – E	1	1
Tank Top	FWD Pump Room	Large Pumps – A	2	2

Table 20. Number of equipment assumed to be running in the two calculations scenarios (with Gensets running, and with Gensets stopped, with equipment running on shore power).

Equipment	31.5	63	125	250	500	1000	2000	4000	8000	Tot
A Large Pump	50	65	82	91	94	94	92	86	75	99
B Small Pump	50	65	85	89	88	90	88	83	69	96
C Main Generator	66	81	99	109	118	119	118	114	105	124
D Chiller	50	65	85	89	88	90	88	83	69	96
E HPU	54	68	82	93	89	86	89	79	65	96

Table 21. Airborne source levels used, per source (LwA, A-weighted sound power level in 1/1-octave bands, in dB rel. 1pW).

Equipment	31.5	63	125	250	500	1000	2000	4000	8000
A Large Pump	112	113	111	95	93	89	83	83	76
B Small Pump	101	106	103	90	91	88	86	73	65
C Main Generator	120	114	116	104	104	90	81	70	69
D Chiller	91	102	96	96	90	90	91	90	79
E HPU	105	113	112	111	107	90	90	87	75

Table 22. Structure-borne source levels used, per source (Lv, velocity levels in 1/1-octave bands in dB rel. 10^{-9} m/s).

Results

The results of the calculations are shown in the below Figure.

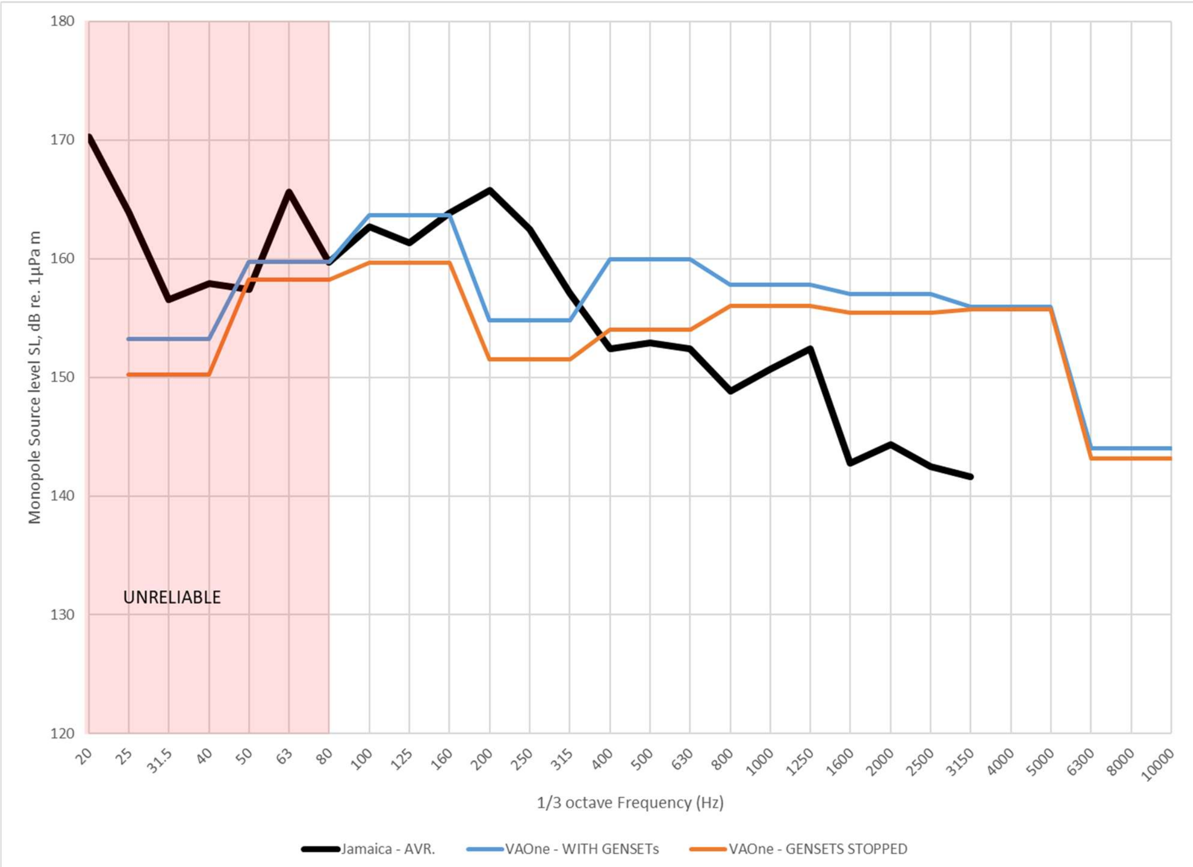

Figure 45. Predicted underwater source level for the hull-radiated noise from FSRU Golar Igloo, compared to the measurements on the Golar Freeze FSRU measured in Jamaica.

Figure 45 shows the predicted underwater source level for the FSRU for the scenarios with and without the gensets in operation. The estimated source level used in the previous predictions together with the source level measured on the Golar Freeze in Jamaica are shown for comparison. For reference the sound pressure level inside the engine room with two diesel generators running is predicted by the model as 111 dB(A), which is very realistic compared to measurements in other generator rooms.

Looking at the results it appears the calculated source levels for the Golar Igloo are above the measured source strength at high frequencies and a below at lower frequencies. It should be noted that the Golar Freeze did not have diesel generators operating during the measurements, as the power on Golar Freeze was provided by two steam turbines, so the calculated and measured source levels are not directly comparable.

From the detailed results it appears the underwater noise is dominated by the structure-borne sources compared to the airborne sources. Especially the diesel generators and the large pumps, such as ballast pumps and seawater cooling pumps have a significant contribution to the source levels.

Appendix C. CONSTRUCTION SCENARIO C1 – Impact Pile driving Results

Distance-to-Threshold, impulsive, SELcum

Transect	PW weighted		MF weighted		HF-Weighted	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	170	185	170	185	140	155
N	1464	393	430	90	2013	1337
NE	3692	505	585	82	5713	2731
E	4010	590	786	91	7640	3163
SE	2443	465	634	71	5103	2153
S	1775	427	444	83	2439	1506
SW	3096	500	539	73	4288	2539
W	3267	516	636	94	5398	2602
NW	2852	452	541	84	3909	1987
Area, m2	15527129	644681	808257	19962	31919440	8565018

Distance-to-Threshold, impulsive, 0-peak, flat

Transect	Mid-frequency cetaceans (MF)		High-frequency cetaceans (HF)		High-frequency cetaceans	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	224	230	196	202	212	218
N	-	-	227	128	32	-
NE	-	-	246	138	33	-
E	-	-	261	140	38	-
SE	-	-	231	125	43	-
S	-	-	246	147	48	-
SW	-	-	257	114	43	-
W	-	-	288	119	39	-
NW	-	-	252	131	34	-
Area, m2	-	-	183563	48881	4238	-

Distance-to-Threshold (m), RMS Flat-Weighted

Criteria / Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	2702	2629	2486	2370	2128	2023	1593	1522	1321	1240	663	476	308
NE	8097	7575	6025	5388	5092	4948	4134	3596	2791	1716	806	549	367
E	11085	10304	8125	7240	6836	6635	4614	3853	2949	1680	1021	669	384
SE	7654	7030	5471	4868	4596	4437	2984	2304	1861	1487	831	502	332
S	2927	2733	2616	2519	2415	2227	2098	1853	1702	1526	657	485	335
SW	8077	7744	6154	5083	4336	3686	3463	2967	2373	1910	868	595	345
W	11789	11228	8363	6528	5794	4826	4447	3151	2287	1725	1039	627	374
NW	8594	8135	5679	4311	4354	4057	3850	3029	2273	1290	786	538	348
Area (m2)	65594356	55722103	47898145	42961055	38134838	32001422	23375830	16676217	10400842	4461838	1823398	844884	357795

Distance-to-Threshold (m), RMS MF-Weighted

Criteria / Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1900	1679	1377	943	572	412	289	183	103	60	31	-	-
NE	4960	4295	2979	1417	849	581	336	188	99	61	31	-	-
E	6618	5901	3853	1924	1073	780	366	200	131	75	36	-	-
SE	4409	4079	2685	1837	904	635	293	181	126	69	41	-	-
S	2214	2087	1662	1584	656	446	310	215	138	77	43	-	-
SW	3731	3407	2797	2076	889	518	346	231	119	70	42	-	-
W	4922	3940	2828	1754	1002	598	374	221	108	77	37	-	-
NW	3932	3476	2521	1173	778	511	329	186	83	63	32	-	-
Area (m2)	26053612	16816979	10553816	4081897	1637963	765300	294879	115344	37865	12981	3730	-	-

Distance-to-Threshold (m), RMS HF-Weighted

Criteria / Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1752	1381	1047	555	421	285	203	110	60	31	-	-	-
NE	4091	2857	1453	773	522	296	203	110	60	30	-	-	-
E	4756	3303	1785	976	683	349	201	133	74	36	-	-	-
SE	3406	2320	1746	843	546	278	172	119	69	41	-	-	-
S	1966	1589	1471	670	418	303	186	125	76	43	-	-	-
SW	3154	2599	1977	926	537	357	207	111	69	42	-	-	-
W	3663	2613	1745	1056	650	357	209	107	77	37	-	-	-
NW	3298	2372	1239	811	527	321	183	89	63	32	-	-	-
Area (m2)	15353121	9670425	3453322	1530618	711774	285436	110438	37320	12792	3656	-	-	-

Distance-to-Threshold (m), RMS PW-Weighted

Criteria / Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	2458	2465	2245	1992	1700	1435	1264	701	490	367	240	157	85
NE	8172	6595	5432	5130	4560	3682	1836	982	634	387	255	139	76
E	11126	8867	7262	6852	5932	4004	1952	1186	937	434	273	144	96
SE	7571	5947	4847	4560	4029	2399	1677	1016	750	362	240	129	86
S	2702	2564	2449	2312	2108	1759	1478	728	544	375	238	161	99
SW	7322	6365	4988	4115	3378	3069	2148	1093	664	430	240	149	92
W	10706	8869	6434	5681	4256	3170	2072	1274	722	447	227	157	97
NW	7819	6216	4295	4294	3801	2820	1718	909	686	387	217	151	81
Area (m2)	51851436	43411276	38083225	32594664	23686276	14965221	7872275	2453186	1102119	452879	172071	64873	23327

Distance-to-Threshold, Impulsive, 0-peak flat weighting, fish species

Transect	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	213		207		207	
N	28		66		66	
NE	28		62		62	
E	30		81		81	
SE	36		74		74	
S	42		85		85	
SW	36		75		75	
W	30		81		81	
NW	29		65		65	
Area, m2	2946		15756		15756	

Distance-to-Threshold, Impulsive, SELcum flat weighting, fish species

Transect	TTS	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
		Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	186	216	219	203	210	203	207
N	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-
SE	-	-	-	-	-	-	-
S	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-
NW	-	-	-	-	-	-	-
Area, m2	-	-	-	-	-	-	-

Appendix D. CONSTRUCTION SCENARIO C2 – Vibratory driving Results

Distance-to-Threshold, Non-impulsive, SELcum

Transect	PW weighted		MF weighted		HF-Weighted	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	181	201	178	198	153	173
N	-	-	-	-	-	-
NE	-	-	-	-	-	-
E	-	-	-	-	-	-
SE	-	-	-	-	-	-
S	-	-	-	-	-	-
SW	-	-	-	-	-	-
W	-	-	-	-	-	-
NW	-	-	-	-	-	-
Area, m2	-	-	-	-	-	-

Distance-to-Threshold, Non-impulsive, SELcum flat weighting, fish species

Transect	TTS	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
		Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	186	216	219	203	210	203	207
N	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-
SE	-	-	-	-	-	-	-
S	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-
NW	-	-	-	-	-	-	-
Area, m2	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS Flat-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1732	1563	1295	620	398	199	96	-	-	-	-	-	-
NE	3445	2721	1768	716	462	228	102	-	-	-	-	-	-
E	3624	2755	1640	875	449	215	99	-	-	-	-	-	-
SE	2272	1883	1500	707	388	230	117	-	-	-	-	-	-
S	1966	1732	1605	607	395	213	98	-	-	-	-	-	-
SW	2983	2317	1818	738	392	195	112	-	-	-	-	-	-
W	3151	2294	1588	800	437	204	118	-	-	-	-	-	-
NW	3142	2080	1284	663	417	220	113	-	-	-	-	-	-
Area (m2)	18095932	11058753	4114585	1423649	512365	129372	32670	-	-	-	-	-	-

Distance-to-Threshold (m), RMS PW-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	529	322	174	75	-	-	-	-	-	-	-	-	-
NE	608	346	178	86	-	-	-	-	-	-	-	-	-
E	737	359	189	94	-	-	-	-	-	-	-	-	-
SE	606	297	180	81	-	-	-	-	-	-	-	-	-
S	523	313	170	79	-	-	-	-	-	-	-	-	-
SW	623	350	176	98	-	-	-	-	-	-	-	-	-
W	662	366	187	117	-	-	-	-	-	-	-	-	-
NW	534	344	170	95	-	-	-	-	-	-	-	-	-
Area (m2)	1014792	333785	97471	23043	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS MF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1	-	-	-	-	-	-	-	-	-	-	-	-
NE	1	-	-	-	-	-	-	-	-	-	-	-	-
E	1	-	-	-	-	-	-	-	-	-	-	-	-
SE	2	-	-	-	-	-	-	-	-	-	-	-	-
S	2	-	-	-	-	-	-	-	-	-	-	-	-
SW	2	-	-	-	-	-	-	-	-	-	-	-	-
W	1	-	-	-	-	-	-	-	-	-	-	-	-
NW	1	-	-	-	-	-	-	-	-	-	-	-	-
Area (m2)	2	-	-	-	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS HF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	-	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-	-
SE	-	-	-	-	-	-	-	-	-	-	-	-	-
S	-	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-	-	-	-	-	-	-
NW	-	-	-	-	-	-	-	-	-	-	-	-	-
Area (m2)	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix E. CONSTRUCTION SCENARIO C3 – Socket Pile Drilling Results

Distance-to-Threshold, Non-impulsive, SELcum

Transect	PW weighted		MF weighted		HF-Weighted	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	181	201	178	198	153	173
N	33	-	-	-	248	-
NE	24	-	-	-	176	-
E	24	-	-	-	77	-
SE	33	-	-	-	213	-
S	43	-	-	-	280	-
SW	33	-	-	-	214	-
W	25	-	-	-	80	-
NW	24	-	-	-	175	-
Area, m2	2058	-	-	-	43784	-

Distance-to-Threshold, Non-impulsive, SELcum flat weighting, fish species

Transect	TTS	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
		Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	186	216	219	203	210	203	207
N	180	-	-	-	-	-	-
NE	129	-	-	-	-	-	-
E	104	-	-	-	-	-	-
SE	149	-	-	-	-	-	-
S	202	-	-	-	-	-	-
SW	154	-	-	-	-	-	-
W	110	-	-	-	-	-	-
NW	125	-	-	-	-	-	-
Area, m2	42791	-	-	-	-	-	-

Distance-to-Threshold (m), RMS Flat-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1471	1615	480	242	85	39	-	-	-	-	-	-	-
NE	1207	1185	348	179	62	28	-	-	-	-	-	-	-
E	951	517	245	126	73	28	-	-	-	-	-	-	-
SE	1334	843	389	191	98	27	-	-	-	-	-	-	-
S	1467	1073	432	246	109	34	-	-	-	-	-	-	-
SW	1449	978	363	185	101	27	-	-	-	-	-	-	-
W	962	496	260	123	78	30	-	-	-	-	-	-	-
NW	1258	1175	331	163	59	27	-	-	-	-	-	-	-
Area (m2)	2932827	838789	238322	65671	16627	2379	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS PW-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	228	109	51	-	-	-	-	-	-	-	-	-	-
NE	169	78	37	-	-	-	-	-	-	-	-	-	-
E	129	79	38	-	-	-	-	-	-	-	-	-	-
SE	194	103	46	-	-	-	-	-	-	-	-	-	-
S	236	126	57	-	-	-	-	-	-	-	-	-	-
SW	195	103	46	-	-	-	-	-	-	-	-	-	-
W	117	81	39	-	-	-	-	-	-	-	-	-	-
NW	154	76	36	-	-	-	-	-	-	-	-	-	-
Area (m2)	67643	21773	4863	-	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS MF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	-	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-	-
SE	-	-	-	-	-	-	-	-	-	-	-	-	-
S	-	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-	-	-	-	-	-	-
NW	-	-	-	-	-	-	-	-	-	-	-	-	-
Area (m2)	-	-	-	-	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS HF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	-	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-	-
SE	-	-	-	-	-	-	-	-	-	-	-	-	-
S	-	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-	-	-	-	-	-	-
NW	-	-	-	-	-	-	-	-	-	-	-	-	-
Area (m2)	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix F. CONSTRUCTION SCENARIO C4 – Blasting Results

Distance-to-Threshold, Non-impulsive, SELcum

Transect	PW weighted		MF weighted		HF-Weighted	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	170	185	170	185	140	155
N	-	-	-	-	-	-
NE	-	-	-	-	-	-
E	-	-	-	-	-	-
SE	-	-	-	-	-	-
S	-	-	-	-	-	-
SW	-	-	-	-	-	-
W	-	-	-	-	-	-
NW	-	-	-	-	-	-
Area, m2	-	-	-	-	-	-

Distance-to-Threshold, impulsive, 0-peak, flat

Transect	Mid-frequency cetaceans (MF)		High-frequency cetaceans (HF)		High-frequency cetaceans	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	224	230	196	202	212	218
N	-	-	272	86	8	-
NE	-	-	217	79	6	-
E	-	-	221	92	7	-
SE	-	-	280	78	8	-
S	-	-	276	104	8	-
SW	-	-	233	78	9	-
W	-	-	262	97	8	-
NW	-	-	292	86	6	-
Area, m2	-	-	175058	20811	124	-

Distance-to-Threshold (m), RMS Flat-Weighted

Criteria / Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	3005	2889	2634	2539	2386	2103	1659	1697	1515	1304	1835	533	412
NE	6072	5809	5598	5370	5096	4204	4378	3729	3151	2226	1245	621	406
E	8325	7813	7582	7266	6828	5491	4869	4120	3420	2296	1213	790	466
SE	5775	5315	5199	4922	4668	3716	3470	2916	2107	1747	1081	616	386
S	3194	2953	2916	2770	2652	2470	2424	2039	1860	1735	898	554	388
SW	5348	5071	4884	4589	4144	4549	3865	3024	2635	2194	1107	714	386
W	6870	6506	6088	5843	5632	5981	4597	3643	2552	1981	1188	735	408
NW	4730	4806	4595	4494	4444	4779	3959	3201	2529	1659	1369	649	444
Area (m2)	570111 54	533273 12	495764 97	457956 12	419542 11	357881 96	271494 93	197362 85	131030 47	69962 18	23295 81	11093 53	43445 0

Distance-to-Threshold (m), RMS MF-Weighted

Criteria / Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	87	43	23	-	-	-	-	-	-	-	-	-	-
NE	80	49	21	-	-	-	-	-	-	-	-	-	-
E	102	58	16	-	-	-	-	-	-	-	-	-	-
SE	86	56	26	-	-	-	-	-	-	-	-	-	-
S	99	58	31	-	-	-	-	-	-	-	-	-	-
SW	90	59	27	-	-	-	-	-	-	-	-	-	-
W	101	59	17	-	-	-	-	-	-	-	-	-	-
NW	84	49	21	-	-	-	-	-	-	-	-	-	-
Area (m2)	24361	7846	1401	-	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS HF-Weighted

Criteria / Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	29	-	-	-	-	-	-	-	-	-	-	-	-
NE	29	-	-	-	-	-	-	-	-	-	-	-	-
E	29	-	-	-	-	-	-	-	-	-	-	-	-
SE	36	-	-	-	-	-	-	-	-	-	-	-	-
S	39	-	-	-	-	-	-	-	-	-	-	-	-
SW	37	-	-	-	-	-	-	-	-	-	-	-	-
W	30	-	-	-	-	-	-	-	-	-	-	-	-
NW	29	-	-	-	-	-	-	-	-	-	-	-	-
Area (m2)	2976	-	-	-	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS PW-Weighted

Criteria / Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1742	1565	1367	818	543	411	224	118	56	27	-	-	-
NE	3783	3210	2288	950	607	422	212	112	58	26	-	-	-
E	4116	3450	2299	1284	829	439	222	130	75	34	-	-	-
SE	2775	2101	1719	1077	705	431	272	130	69	39	-	-	-
S	1954	1803	1644	813	650	433	269	152	74	39	-	-	-
SW	3012	2609	2166	1074	811	454	251	113	72	40	-	-	-
W	3589	2568	2035	1263	785	448	249	117	79	36	-	-	-
NW	3155	2630	1763	913	638	426	234	103	62	27	-	-	-
Area (m2)	19884774	13521517	7773359	2670459	1321794	551528	170608	42993	12165	2986	-	-	-

Distance-to-Threshold, Impulsive, 0-peak flat weighting, fish species

Transect	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	213		207		207	
N	-		32		32	
NE	-		-		34	
E	-		-		50	
SE	-		-		51	
S	-		-		47	
SW	-		-		52	
W	-		-		52	
NW	-		-		36	
Area, m2	-		-		5017	

Appendix G. OPERATION SCENARIO A – FSRU

Distance-to-Threshold, Non-impulsive, SELcum

Transect	PW weigthed		MF weighted		HF-Weighted	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	181	201	178	198	153	173
N	-	-	-	-	36	-
NE	-	-	-	-	39	-
E	-	-	-	-	47	-
SE	-	-	-	-	49	-
S	-	-	-	-	49	-
SW	-	-	-	-	50	-
W	-	-	-	-	48	-
NW	-	-	-	-	39	-
Area, m2	-	-	-	-	5430	-

Distance-to-Threshold, Non-impulsive, SELcum flat weighting, fish species

Transect	TTS	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
		Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	186	216	219	203	210	203	207
N	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-
SE	-	-	-	-	-	-	-
S	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-
NW	-	-	-	-	-	-	-
Area, m2	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS Flat-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1160	751	515	314	189	91	33	-	-	-	-	-	-
NE	1939	840	584	334	185	80	31	-	-	-	-	-	-
E	2033	1021	675	356	159	87	31	-	-	-	-	-	-
SE	1724	832	545	340	208	76	37	-	-	-	-	-	-
S	1836	733	547	309	184	97	48	-	-	-	-	-	-
SW	2081	913	568	338	179	75	37	-	-	-	-	-	-
W	1747	1084	646	377	173	88	31	-	-	-	-	-	-
NW	1403	848	571	349	200	81	31	-	-	-	-	-	-
Area (m2)	6127265	2070326	967474	332684	96311	20927	3578	-	-	-	-	-	-

Distance-to-Threshold (m), RMS PW-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	387	223	121	62	30	-	-	-	-	-	-	-	-
NE	504	243	137	64	30	-	-	-	-	-	-	-	-
E	521	270	142	82	40	-	-	-	-	-	-	-	-
SE	401	226	125	74	43	-	-	-	-	-	-	-	-
S	409	240	130	79	43	-	-	-	-	-	-	-	-
SW	471	250	123	74	44	-	-	-	-	-	-	-	-
W	549	240	130	82	40	-	-	-	-	-	-	-	-
NW	471	238	117	66	31	-	-	-	-	-	-	-	-
Area (m2)	584691	169989	48520	14801	3844	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS MF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	98	57	22	-	-	-	-	-	-	-	-	-	-
NE	91	61	20	-	-	-	-	-	-	-	-	-	-
E	112	64	22	-	-	-	-	-	-	-	-	-	-
SE	95	53	30	-	-	-	-	-	-	-	-	-	-
S	111	49	33	-	-	-	-	-	-	-	-	-	-
SW	104	54	31	-	-	-	-	-	-	-	-	-	-
W	110	66	23	-	-	-	-	-	-	-	-	-	-
NW	94	62	20	-	-	-	-	-	-	-	-	-	-
Area (m2)	30790	8994	1664	-	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS HF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	58	29	-	-	-	-	-	-	-	-	-	-	-
NE	61	30	-	-	-	-	-	-	-	-	-	-	-
E	76	34	-	-	-	-	-	-	-	-	-	-	-
SE	70	40	-	-	-	-	-	-	-	-	-	-	-
S	72	41	-	-	-	-	-	-	-	-	-	-	-
SW	70	40	-	-	-	-	-	-	-	-	-	-	-
W	76	35	-	-	-	-	-	-	-	-	-	-	-
NW	61	30	-	-	-	-	-	-	-	-	-	-	-
Area (m2)	12609	3344	-	-	-	-	-	-	-	-	-	-	-

Appendix H. OPERATION SCENARIO B - FSRU with offloading LNG carrier

Distance-to-Threshold, Non-impulsive, SELcum

Transect	PW weigthed		MF weighted		HF-Weighted	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	181	201	178	198	153	173
N	100	-	29	-	392	35
NE	100	-	29	-	495	39
E	115	-	35	-	564	46
SE	100	-	40	-	399	49
S	115	-	41	-	417	49
SW	111	-	40	-	434	50
W	116	-	35	-	509	47
NW	100	-	30	-	440	39
Area, m2	34069	-	3334	-	570321	5361

Distance-to-Threshold, Non-impulsive, SELcum flat weighting, fish species

Transect	TTS	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
		Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	186	216	219	203	210	203	207
N	290	2	-	-	-	-	-
NE	295	1	-	-	-	-	-
E	314	0	-	-	-	-	-
SE	334	1	-	-	-	-	-
S	311	1	-	-	-	-	-
SW	357	1	-	-	-	-	-
W	338	0	-	-	-	-	-
NW	316	1	-	-	-	-	-
Area, m2	293155	1	-	-	-	-	-

Distance-to-Threshold (m), RMS Flat-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1366	1608	544	395	192	103	39	-	-	-	-	-	-
NE	2227	1709	639	410	203	92	36	-	-	-	-	-	-
E	2247	1055	762	379	187	96	40	-	-	-	-	-	-
SE	1625	1111	655	343	232	108	44	-	-	-	-	-	-
S	1734	1161	646	393	224	132	57	-	-	-	-	-	-
SW	2136	1312	684	377	217	102	44	-	-	-	-	-	-
W	1949	1231	684	472	194	97	39	-	-	-	-	-	-
NW	1691	1209	577	426	215	96	36	-	-	-	-	-	-
Area (m2)	7614427	2447536	1153412	441100	124522	29307	5153	-	-	-	-	-	-

Distance-to-Threshold (m), RMS PW-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	378	238	126	63	31	-	-	-	-	-	-	-	-
NE	498	237	130	65	31	-	-	-	-	-	-	-	-
E	530	257	127	83	41	-	-	-	-	-	-	-	-
SE	419	214	112	75	44	-	-	-	-	-	-	-	-
S	431	239	130	80	44	-	-	-	-	-	-	-	-
SW	489	263	135	75	45	-	-	-	-	-	-	-	-
W	554	267	151	83	41	-	-	-	-	-	-	-	-
NW	464	257	135	67	33	-	-	-	-	-	-	-	-
Area (m2)	601081	176067	50230	15314	4043	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS MF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	99	58	23	-	-	-	-	-	-	-	-	-	-
NE	92	61	21	-	-	-	-	-	-	-	-	-	-
E	113	65	23	-	-	-	-	-	-	-	-	-	-
SE	96	54	31	-	-	-	-	-	-	-	-	-	-
S	112	50	34	-	-	-	-	-	-	-	-	-	-
SW	105	55	31	-	-	-	-	-	-	-	-	-	-
W	111	67	24	-	-	-	-	-	-	-	-	-	-
NW	95	63	21	-	-	-	-	-	-	-	-	-	-
Area (m2)	31466	9219	1778	-	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS HF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	59	30	-	-	-	-	-	-	-	-	-	-	-
NE	62	31	-	-	-	-	-	-	-	-	-	-	-
E	77	35	-	-	-	-	-	-	-	-	-	-	-
SE	71	40	-	-	-	-	-	-	-	-	-	-	-
S	74	42	-	-	-	-	-	-	-	-	-	-	-
SW	71	41	-	-	-	-	-	-	-	-	-	-	-
W	77	36	-	-	-	-	-	-	-	-	-	-	-
NW	62	31	-	-	-	-	-	-	-	-	-	-	-
Area (m2)	13000	3513	-	-	-	-	-	-	-	-	-	-	-

Appendix I. OPERATION SCENARIO D – FSRU with approaching LNG carrier

Distance-to-Threshold, Non-impulsive, SELcum

Transect	PW weigthed		MF weighted		HF-Weighted	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	181	201	178	198	153	173
N	-	-	-	-	217	-
NE	-	-	-	-	216	-
E	-	-	-	-	223	-
SE	-	-	-	-	208	-
S	-	-	-	-	213	-
SW	-	-	-	-	208	-
W	-	-	-	-	220	-
NW	-	-	-	-	187	-
Area, m2	-	-	-	-	135022	-

Distance-to-Threshold, Non-impulsive, SELcum flat weighting, fish species

Transect	TTS	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
		Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	186	216	219	203	210	203	207
N	104	-	-	-	-	-	-
NE	94	-	-	-	-	-	-
E	115	-	-	-	-	-	-
SE	85	-	-	-	-	-	-
S	103	-	-	-	-	-	-
SW	106	-	-	-	-	-	-
W	120	-	-	-	-	-	-
NW	123	-	-	-	-	-	-
Area, m2	30713	-	-	-	-	-	-

Distance-to-Threshold (m), RMS Flat-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	2897	1940	1461	1355	1056	755	271	115	55	-	-	-	-
NE	4038	2510	1852	1163	925	587	241	117	36	-	-	-	-
E	5384	3653	2175	1131	755	468	256	143	55	-	-	-	-
SE	3841	3049	1808	1307	1097	897	248	106	45	-	-	-	-
S	2382	2137	1825	1343	1139	986	273	123	57	-	-	-	-
SW	5186	2894	2212	1205	722	554	310	130	43	-	-	-	-
W	5955	3142	2362	1390	900	553	282	144	35	-	-	-	-
NW	4027	2515	1817	1255	898	682	252	145	42	-	-	-	-
Area (m2)	34052129	18146714	8965558	4274785	1949453	767905	207605	44434	5147	-	-	-	-

Distance-to-Threshold (m), RMS PW-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	2004	1258	715	462	127	41	8	-	-	-	-	-	-
NE	2172	1114	569	343	110	42	6	-	-	-	-	-	-
E	2797	1230	423	232	116	75	12	-	-	-	-	-	-
SE	2631	1613	908	818	107	71	10	-	-	-	-	-	-
S	1903	1417	990	939	118	70	10	-	-	-	-	-	-
SW	2686	1245	605	539	128	65	9	-	-	-	-	-	-
W	2387	1308	555	309	154	66	10	-	-	-	-	-	-
NW	1822	885	648	405	131	38	6	-	-	-	-	-	-
Area (m2)	12646663	3402926	690433	175543	44588	8797	193	-	-	-	-	-	-

Distance-to-Threshold (m), RMS MF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	669	258	120	65	17	-	-	-	-	-	-	-	-
NE	569	212	106	65	11	-	-	-	-	-	-	-	-
E	401	215	124	82	21	-	-	-	-	-	-	-	-
SE	906	203	128	66	20	-	-	-	-	-	-	-	-
S	983	232	136	64	20	-	-	-	-	-	-	-	-
SW	578	263	143	58	17	-	-	-	-	-	-	-	-
W	496	268	151	71	18	-	-	-	-	-	-	-	-
NW	582	228	118	59	12	-	-	-	-	-	-	-	-
Area (m2)	601362	162767	48419	11825	710	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS HF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	490	169	85	36	2	-	-	-	-	-	-	-	-
NE	397	166	88	34	1	-	-	-	-	-	-	-	-
E	294	194	118	63	3	-	-	-	-	-	-	-	-
SE	860	189	117	62	2	-	-	-	-	-	-	-	-
S	988	195	116	64	2	-	-	-	-	-	-	-	-
SW	560	181	108	55	2	-	-	-	-	-	-	-	-
W	355	182	107	53	2	-	-	-	-	-	-	-	-
NW	413	151	79	33	2	-	-	-	-	-	-	-	-
Area (m2)	300460	95795	29681	6499	11	-	-	-	-	-	-	-	-

Appendix J. OPERATION SCENARIO E – FSRU with offloading LNG carrier, 4 tugs engaged, general cargo ship in the estuary, berthed ship at Moneypoint

Distance-to-Threshold, Non-impulsive, SELcum

Transect	PW weigthed		MF weighted		HF-Weighted	
	TTS	PTS	TTS	PTS	TTS	PTS
Criteria (dB)	181	210	178	198	153	173
N	100	-	29	-	392	35
NE	100	-	29	-	495	39
E	115	-	35	-	564	46
SE	100	-	40	-	399	49
S	115	-	41	-	417	49
SW	111	-	40	-	434	50
W	116	-	35	-	509	47
NW	100	-	30	-	440	39
Area, m2	34069	-	3334	-	570321	5361

Distance-to-Threshold, Non-impulsive, SELcum flat weighting, fish species

Transect	TTS	No swim bladder		Swim bladder not involved in hearing		Swim bladder involved in hearing	
		Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality	Recoverable injury	Mortality and potential mortality
Criteria (dB)	186	216	219	203	210	203	207
N	290	-	-	2	-	-	-
NE	295	-	-	1	-	-	-
E	314	-	-	0	-	-	-
SE	334	-	-	1	-	-	-
S	311	-	-	1	-	-	-
SW	357	-	-	1	-	-	-
W	338	-	-	0	-	-	-
NW	316	-	-	1	-	-	-
Area, m2	293155	-	-	1	-	-	-

Distance-to-Threshold (m), RMS Flat-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1708	1628	1340	1341	1061	1136	631	506	439	-	-	-	-
NE	4719	3356	2570	1970	992	1280	652	570	484	-	-	-	-
E	6260	4443	3277	2082	1134	682	450	360	291	-	-	-	-
SE	4175	3016	2395	1588	1261	488	345	233	173	-	-	-	-
S	2153	1985	1651	1405	1539	925	716	588	544	-	-	-	-
SW	3863	3046	2278	1759	1751	1055	798	647	603	-	-	-	-
W	5840	4715	3116	2027	1256	757	547	404	318	-	-	-	-
NW	4551	3809	2912	1765	1015	569	405	236	148	-	-	-	-
Area (m2)	27473607	18768378	12197431	7244537	3481064	1244175	301462	60156	8917	-	-	-	-

Distance-to-Threshold (m), RMS PW-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	1302	1388	1375	719	87	26	-	-	-	-	-	-	-
NE	1507	1653	1576	808	92	24	-	-	-	-	-	-	-
E	1869	965	855	449	103	29	-	-	-	-	-	-	-
SE	1773	781	419	256	85	37	-	-	-	-	-	-	-
S	1328	800	652	387	99	41	-	-	-	-	-	-	-
SW	1922	1118	760	425	120	33	-	-	-	-	-	-	-
W	1869	1103	614	313	134	22	-	-	-	-	-	-	-
NW	1469	690	375	228	108	22	-	-	-	-	-	-	-
Area (m2)	5974153	1487891	435492	118418	30592	2211	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS MF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	762	727	113	38	-	-	-	-	-	-	-	-	-
NE	939	820	120	45	-	-	-	-	-	-	-	-	-
E	637	470	123	52	-	-	-	-	-	-	-	-	-
SE	414	264	95	55	-	-	-	-	-	-	-	-	-
S	542	405	105	59	-	-	-	-	-	-	-	-	-
SW	814	436	124	49	-	-	-	-	-	-	-	-	-
W	900	336	147	43	-	-	-	-	-	-	-	-	-
NW	491	240	127	36	-	-	-	-	-	-	-	-	-
Area (m2)	439904	141686	41173	6110	-	-	-	-	-	-	-	-	-

Distance-to-Threshold (m), RMS HF-Weighted

Criteria Transect	120	125	130	135	140	145	150	155	160	165	170	175	180
N	722	705	80	26	-	-	-	-	-	-	-	-	-
NE	802	778	82	24	-	-	-	-	-	-	-	-	-
E	483	422	95	27	-	-	-	-	-	-	-	-	-
SE	306	235	78	36	-	-	-	-	-	-	-	-	-
S	506	379	97	40	-	-	-	-	-	-	-	-	-
SW	575	426	111	31	-	-	-	-	-	-	-	-	-
W	465	305	123	20	-	-	-	-	-	-	-	-	-
NW	282	238	97	22	-	-	-	-	-	-	-	-	-
Area (m2)	260169	88342	25717	2049	-	-	-	-	-	-	-	-	-

Appendix 5

Effects of Shannon LNG Construction and Operation Activities on Marine Mammals and Fish

Impact Assessment of Potential Acoustic Effects of Shannon LNG Construction and Operation Activities on Marine Mammals and Fish in the Shannon Estuary, Ireland

Prepared by

LGL Ecological Research Associates — Celebrating 50 Years

for

Vysus Group

And

Shannon LNG Limited

DRAFT

Submitted August 2021

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Glossary

CI	Confidence Interval
CHP	Combined Heat and Power
C-POD	hydrophone that passively monitors acoustic signals in the water
CV	Coefficient of Variation
dB	decibel
dB re 1 µPa	decibels relative to 1 micropascal
DPM	detection positive minutes
ESB	Electricity Supply Board
EU	European Union
FSRU	Floating Storage Regasification Unit
h	hour
Hz	hertz
HF	High-frequency cetacean
HF-weighting	Frequency weighting for high-frequency cetaceans, allowing for their functional hearing bandwidths and appropriate in characterizing auditory effects of sounds
IUCN	International Union for Conservation of Nature
IWDG	Irish Whale and Dolphin Group
kHz	kilohertz
L_{E}	sound exposure level
$L_{\mathrm{E,24}}$	cumulative sound exposure level over a 24-h period
$L_{\mathrm{S,}}$	sound pressure level at the source
$L_{\mathrm{S,E}}$	sound exposure level at the source
L_{p}	sound pressure level, for underwater sound pressure, decibels are referenced to 1 µPa
$L_{\mathrm{p,0\text{-}pk}}$	zero-to-peak sound pressure level (the largest deviation of the sound pressure from zero)
$L_{\mathrm{p,pk\text{-}pk}}$	peak-to-peak sound pressure level
$L_{\mathrm{p,rms}}$	root-mean-square sound pressure level
$L_{\mathrm{p,rms,MF}}$	root-mean-square sound pressure level, weighted for mid-frequency cetaceans
MF	Mid-frequency cetacean
MF-weighting	Frequency weighting for mid-frequency cetaceans allowing for their functional hearing bandwidths to appropriately characterize potential auditory effects of sounds
MMscm/d	million metric standard cubic metres per day
MW	megawatt
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier
NBDC	National Biodiversity Data Centre
NMFS	(U.S.) National Marine Fisheries Service
NPWS	National Parks and Wildlife Service
TTS	Temporary Threshold Shift or hearing impairment
PTS	Permanent Threshold Shift or hearing impairment
PW	Phocid in water
PW-weighting	Frequency weighting for phocids in water allowing for their functional hearing bandwidths to appropriately characterize potential auditory effects of sounds
rms	root-mean-square, used to calculate an energy-based time averaged level
SAC	Special Area of Conservation
SCI	Sites of Community Importance
SD	Standard Deviation
SFPC	Shannon Foynes Port Company
VG	Vysus Group

Executive Summary

Shannon LNG is proposing a Liquefied Natural Gas (LNG) marine terminal and power plant in the Shannon Estuary, Ireland. The Lower River Shannon is a prime wildlife conservation area and has been designated as a Special Area of Conservation (SAC) for Annex I qualifying interests of large shallow inlets and bays, mudflats, sandflats, reefs, and the bottlenose dolphin (*Tursiops truncatus*), which is an Annex II species (NPWS 2012). Activities associated with the construction and operation of the LNG terminal (e.g., pile driving, vessel noise) have the potential to impact marine mammals and fish that occur within the SAC by introducing sound into the marine environment. The potential effects are assessed for several marine species occurring in the Shannon Estuary, with a particular focus on the resident population of bottlenose dolphin. The assessment of potential effects for the bottlenose dolphin was based on its occurrence in the estuary and the extent of the potentially affected area which was determined by underwater acoustic modeling and available sound threshold criteria.

Of the activities that were acoustically modeled, sound pressure levels (frequency-weighted for various marine mammal hearing groups) resulting from an approaching LNG carrier with four tugs were found to travel the farthest distance. Based on a behavioural disturbance threshold of $L_{p,rms}$ 120 dB re 1 µPa for continuous sounds, the distances were 983 m for mid-frequency (MF) cetaceans such as the bottlenose dolphin, 988 m for high-frequency (HF) cetaceans such as the harbour porpoise (*Phocoena phocoena*), and 2.8 km for seals. The next largest impact area was for a cumulative sound scenario involving multiple project operations and other nearby vessel traffic. Sound pressure levels at or above the behavioural threshold of $L_{p,rms}$ 160 dB for impulsive sound such as impact pile driving could occur up to 138 m away for MF cetaceans, 77 m for HF cetaceans, and 937 m for seals. The activities with the largest threshold distances would in turn be expected to have the greatest potential impact on marine mammals in the estuary. Based on the disturbance thresholds, 3 exposures annually were estimated for bottlenose dolphins during approaching or departing LNG carriers during the operational phase, and 12 annual exposures were estimated for the cumulative sound scenario during the operational phase. Only 4 exposures were estimated for all impact pile driving during construction.

For bottlenose dolphins, as well as seals, only sounds from impact pile driving have the potential to cause permanent threshold shift (PTS), with a total of two bottlenose dolphin exposures estimated for all impact pile driving activities combined. PTS would only be possible if a bottlenose dolphin were to approach within 94 m of the pile being driven and remain within that distance for the entire ~60 min of impact pile driving. Similarly, temporary threshold shift (TTS) would be possible if a dolphin remained within 786 m of impact pile driving for ~60 min. TTS was also determined to be a possibility for bottlenose dolphins within 41 m of some operational activities that emit continuous sounds. Although rarely observed in the estuary, harbour porpoise could theoretically be exposed above PTS/TTS threshold from impact pile driving activities. Activities that emit non-impulsive or continuous sounds have no potential for PTS in bottlenose dolphins, but they could elicit PTS in a harbour porpoise if the animal were to approach certain operational activities within 50 m and remain within that distance for the entire activity. However, PTS is considered highly unlikely to occur in marine mammals, as animals tend to move away from loud sound sources, and monitoring and mitigation measures would be implemented to minimize any impacts. The proposed activities likely would have no more than a minor impact, such as localized short-term avoidance of the area around the activities by individual marine mammals or potentially TTS, with no effect on the population.

Fish could also experience PTS/TTS or other injury from impact pile driving activities, with fish that use their swim bladder for hearing such as Twaite shad (*Allosa fallax fallax*) being slightly more susceptible to potential effects than other types of fish. Mortalities could occur within 142 m of impact pile driving, whereas TTS is possible within ~2 km of impact pile driving. The risk of injury within tens of metres from a continuous sound source is low for all fish types, and although TTS is unlikely, there could be a moderate risk within tens of metres from a continuous sound source.

Introduction

Shannon LNG Limited is proposing to construct a Liquefied Natural Gas (LNG) marine import terminal and power station in the Shannon Estuary, Ireland. Offshore facilities would consist of a jetty and a Floating Storage Regasification Unit (FSRU). Activities associated with the construction and operation of the LNG terminal will create noise that has the potential to impact marine mammals and fish. In this report we assess how those sounds (e.g., pile driving, vessel traffic) could affect bottlenose dolphins that regularly occur in the Shannon Estuary, as well as other species of marine mammals and fish. The bottlenose dolphin population in the estuary is considered to be resident and consists of ~145 individuals (Baker et al. 2018a; Berrow et al. 2020). To assess potential effects of project activities on bottlenose dolphins, the number of acoustic exposures that may occur during the planned activities was calculated based on the occurrence of dolphins in the area and the extent of the potentially affected area which was determined by underwater acoustic modeling and available sound threshold criteria. In addition, the potential impact on other marine mammals and fish were also assessed, based on modeled distances to available sound threshold criteria. The results are discussed within the context of the project and in light of the monitoring and mitigation measures that are anticipated to be implemented.

Project Area

The Shannon LNG terminal is proposed to be located at Ardmore Point on the southern shore of Shannon Estuary, on the west coast of Ireland (Figure 1) (Brown and Worbey 2020). The Lower River Shannon is a prime wildlife conservation area and has been designated as a Special Area of Conservation (SAC) for Annex I qualifying interests of large shallow inlets and bays, mudflats, sandflats, reefs, and the bottlenose dolphin (*Tursiops truncatus*), which is an Annex II species (NPWS 2012). The Shannon Estuary is the longest waterway in Ireland, with a distance of 100 km and 500 km^2 of navigable water (O'Brien et al. 2016; Blázquez et al. 2020; Brown and Worbey 2020). It is a busy industrialized waterway with a large variety of anthropogenic activities in and around it.

Major industrial developments in the region include a coal power station, oil-fired power station, aluminum refinery, and shipping facilities (Blázquez et al. 2020). Due to the bathymetry of the estuary, it is categorized as a deepwater berth allowing for some of the largest shipping vessels to use the area (Blázquez et al. 2020). The coal import facility is located along the outer estuary at the Electricity Supply Board (ESB) Moneypoint power generation station, across the estuary from the planned LNG terminal. The aluminum refinery (Rusal Aughinish) is situated ~26 km farther up river, and the oil-fired electricity generating power plant is located in Tarbert, ~5 km east of the proposed project site. Ireland has committed to end the burning of coal in ESB's Moneypoint generation plant by 2025 (Ireland's National Energy & Climate Plan 2021–2030). Furthermore, the oil-fired electricity generating power plant in Tarbert is expected to close by 2023 (Eirgrid: All-Island Generation Capacity Statement 2020–2029). The proposed activities are assessed in light of the current shipping activities associated with the Moneypoint and Tarbert power stations.

In 2020, there were six main shipping terminals handling 830 ships per year carrying a total dead weight tonnage of 10,000,000 in Shannon Estuary (Brown and Worbey 2020). With easy access to roads and railways, Shannon Foynes port is home to 37% of Ireland's bulk traffic (Brown and Worbey 2020). Shannon Foynes Port Company (SFPC) is responsible for all commercial marine activities on the Shannon Estuary between Shannon Bridge in Limerick City and the mouth of the estuary joining Loop Head in County Clare to Kerry Head in County Kerry. On a monthly basis, ~18 tankers and 103 dry cargo vessels operate along a well-defined passage along the main channel and past the proposed project area. Other vessel traffic includes 11 transits per month by small commercial and port services vessels; military vessels also transit through the area (Brown and Worbey 2020).

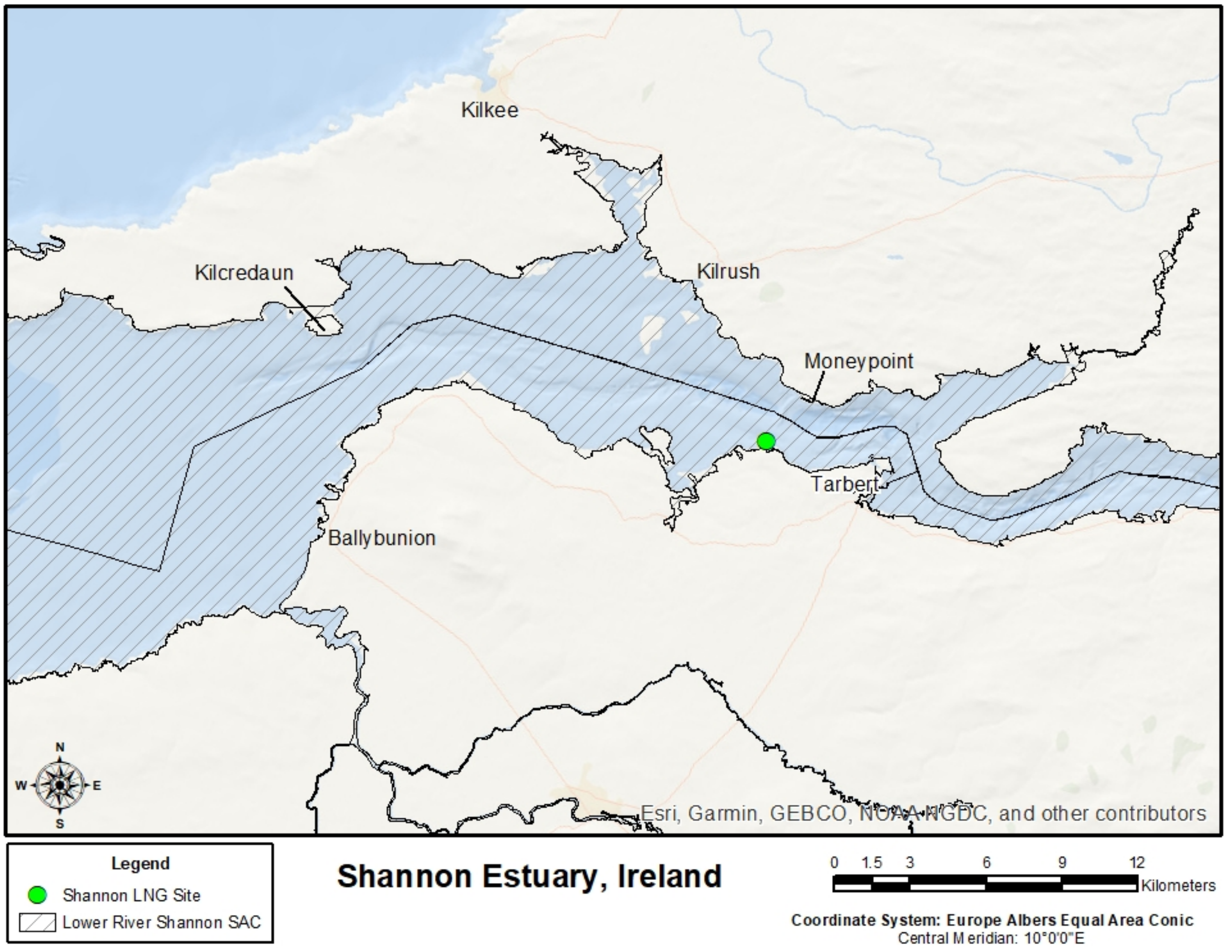


Figure 1. Location of the project site and Shannon Estuary region (Source: Halcrow 2007).

The estuary is also home to fishing activities, a car and passenger ferry which operates once every hour in each direction year-round, and dolphin watching vessels (O'Brien et al. 2016; Brown and Worbey 2020). According to Brown and Worbey (2020), as many as 500 dolphin watching boat trips occur annually within the estuary, including near the project area during July and August, and periodically during April–June and September–October. However, there may have been fewer trips (200–300) in recent years (S. Berrow, IWDG, pers. comm., 2 Nov. 2020).

Ambient noise in the estuary, consisting of natural sounds such as wave noise, as well as ship traffic, was measured in May 2020 (VG 2021). At night, unweighted root-mean-square sound pressure levels ($L_{p,rms}$) ranged from 91.4 decibels referenced to 1 micropascal (dB re 1 µPa) to 109.1 dB re 1 µPa with a median exceedance level of 95.2 dB re 1 µPa. During the day, unweighted $L_{p,rms}$ were noticeably higher and ranged from 95.5 dB re 1 µPa to 129.4 dB re 1 µPa with a median of 117.3 dB re 1 µPa. After applying MF-weighting to focus on frequencies that are audible to bottlenose dolphins, MF-weighted sound pressure levels ($L_{p,rms,MF}$) at night ranged from 86.6 dB re 1 µPa to 98.5 dB re 1 µPa with a median of 88.8 dB re 1 μPa. Unlike the unweighted levels, daytime MF-weighted ambient noise had similar low end (86.2 dB re 1 μPa) and median (88.2 dB re 1 μPa) $L_{p,rms,MF}$ as nighttime measurements, but the high end of the range did increase to $L_{p,rms,MF}$ 109.0 dB re 1 μPa.

Project Description

The Shannon LNG terminal would be located at Ardmore Point between Tarbert and Ballylongford on the southern shore of Shannon Estuary (Figure 1). The waters to the west of the location are considered the outer (or lower) estuary, whereas the inner (upper) estuary is located to the east of the site. One of the reasons this site was chosen is because it is a sheltered berthing area with water depths >15 m (Halcrow 2007; Brown and Worbey 2020). The LNG marine terminal would consist of an in-water jetty with tug docking berths and an FSRU, with an onshore nominal 500 MW high-efficiency Combined Heat and Power (CHP) plant (Shannon LNG 2020).

A 345-m jetty (or trestle) with a central loading platform, six mooring dolphins, and four breasting dolphins would be constructed to access the deeper waters of the estuary (Brown and Worbey 2020). Approximately 203 piles would be installed using a combination of techniques including a hydraulic impact hammer, vibratory hammer, and/or continuous flight auger (CFA) techniques. Piling for the construction of the jetty will commence initially from onshore (requiring approximately 4.5 months to complete) followed by approximately 11 months from the water. The jetty construction works will operate on a 24-h basis, 6 days a week with maintenance works on Sundays and over approximately 15.5 months. The exact number of piles is subject to the final design. The pile diameter would be ~1.067 m, and a 150 kJ impact hammer would be used. It will take approximately 1 day to install an individual pile with impact piling occurring for approximately 60 min per pile. Impact piling will not commence during night-time hours. Some onshore blasting related to site preparation may take place at locations 70 m or greater from the shoreline. Nonetheless, some sounds produced by onshore blasting could also enter the water.

The FSRU would not be permanently moored at the jetty and may depart the jetty on rare occasions in very poor weather conditions (wind speeds of approximately 60 knots or greater). Based on site-specific weather station data from 2007 to 2012, wind speeds greater than 60 knots were observed on only one occasion, for a duration of 60 h. This equates to an absence from the jetty of less than 0.001% over the total 5-year period. Loading of LNG onto the FSRU would be via ship-to-ship transfer from an LNG carrier berthed alongside. The FSRU would have an LNG storage capacity of up to 180,000 m^3. Up to one LNG carrier (LNGC) per week is expected to deliver its cargo to the FSRU. Upon arrival, mooring and berthing of the LNGC would require 12 h or less. A similar amount of time would be required to unmoor and unberth the LNGC upon departure. Once docked to the FSRU, offloading of the LNGC to the FSRU would require approximately 35 h. The LNGC is expected to have a capacity range of 130,000 to 180,000 m^3. At full operation, the LNG terminal would have a capacity of 22.6 MMscm/d (Shannon LNG 2020).

Project Sounds

Impulsive and non-impulsive sounds affect marine life differently, especially in terms of their potential to cause injury (Southall et al. 2007, 2019; Popper et al. 2014). Consequently, most available effects criteria for in-water sounds are divided into those two broad categories based on the temporal characteristics of the sound. During the project, impulsive sounds include blasting and impact pile driving; non-impulsive sounds include ship noise, vibratory pile driving, and socket drilling for piling. Project activities and their sound characteristics are shown in Table 1 and described below by project phase.

Construction Phase

Impulsive Sounds

Impact pile driving produces impulsive sounds that have higher source levels than vibratory pile driving. Madsen et al. (2006) reported that hydraulic impact pile driving produces broadband sounds, with much of the energy below 500 Hz, and that received $L_{p,rms}$ can exceed 200 dB re 1 µPa at 100 m. In the modeling of impact pile driving, VG (2021) assumed a single-strike broadband (50–1600 Hz) source level ($L_{S,E}$) of 208 dB re 1 $\mu Pa^2 m^2 \cdot s$ (Table 1).

Sounds from blasting are also categorized as impulsive and, depending on the size of the charge used, typically have higher source levels than impact pile driving. During this project blasting would only occur on land, although the sounds could emanate into the water. A source level of 232 dB re 1 $\mu Pa^2 m^2 \cdot s$ ($L_{S,E}$) was used for acoustic modeling of blasting (VG 2021), which was then corrected for the on-land location of an embedded blasting charge, resulting in a source level upon entering the water of 206 dB re 1 $\mu Pa^2 m^2 \cdot s$ ($L_{S,E}$) (Table 1).

Non-Impulsive Sounds

Non-impulsive sounds (sometimes also referred to as continuous sounds) would also be produced during project construction by socket drilling and vibratory pile driving activities. In the acoustic modeling, the drilling source level (L_S) was assumed to be 168 dB re 1 µPa·m. NPWS (2014) noted that pile driving generally produces low frequencies, but that some energy occurs at frequencies up to 20 kHz. The dominant frequency range of pile driving is most likely related to differences in the size, shape, and thickness of the piles. For modeling of vibratory pile driving, VG (2021) assumed a source level (L_S) of 182 dB re 1 µPa·m.

Table 1. Types of construction and operational activities and their associated source levels.

Project Phase	Activity	Type of Sound	Source Level[1]
Construction	Impact pile driving	Impulsive	$L_{S,E}$: 208 dB re 1 $\mu Pa^2 m^2 \cdot s$
Construction	Blasting[2]	Impulsive	$L_{S,E}$: 206 dB re 1 $\mu Pa^2 m^2 \cdot s$
Construction	Vibratory pile driving	Non-impulsive	L_S: 182 dB re 1 µPa · m
Construction	Socket drilling	Non-impulsive	L_S: 168 dB re 1 µPa · m
Construction	Support vessels[3]	Non-impulsive	L_S: 168 dB re 1 µPa · m
Operations	FSRU hull-radiated noise[4]	Non-impulsive	L_S: 176 dB re 1 µPa · m
Operations	FSRU cooling pumps	Non-impulsive	L_S: 166 dB re 1 µPa · m
Operations	LNGC offloading	Non-impulsive	L_S: 169 dB re 1 µPa · m
Operations	LNGC sailing	Non-impulsive	L_S: 185 dB re 1 µPa · m
Operations	Tugboat idling	Non-impulsive	L_S: 165 dB re 1 µPa · m
Operations	Tugboat sailing	Non-impulsive	L_S: 181 dB re 1 µPa · m
Operations	Cargo ship transiting at 10 knots	Non-impulsive	L_S: 187 dB re 1 µPa · m
Operations	Cargo ship docked at Moneypoint	Non-impulsive	L_S: 160 dB re 1 µPa · m

[1] See VG (2021)

[2] A source level (L_E) of 232 dB re 1 $\mu Pa^2 m^2 \cdot s$ was corrected for the on-land location of an embedded blasting charge, resulting in a source level (L_E) upon entering the water of 206 dB re 1 $\mu Pa^2 m^2 \cdot s$.

[3] Support vessels included 1 jack-up rig, 1 crane barge, 1 tug, and 1 crew boat.

[4] With engines on standard vibration mounts to reduce noise, but no cooling pumps.

Operations Phase

Non-Impulsive Sounds

Shipping is a known source of non-impulsive anthropogenic sound with most energy in the low frequencies between 10 and 100 Hz (Erbe 2019); however, especially smaller vessels can produce frequencies up to 50 kHz (O'Brien et al. 2016). Most vessel noise is created by propellers spinning in the water and forming bubbles which then grow, vibrate, and collapse to produce this range of sound (O'Brien et al. 2016; Erbe 2019). The size, speed, gross tonnage, draft, and operating equipment of a vessel all influence characteristics of shipping noise (O'Brien et al. 2016). Source levels for vessels typically range from L_S 130 to 160 dB µPa·m for small vessels (small fishing vessels and recreational boats) and up to L_S 200 dB re 1 µPa·m or greater for larger vessels such as cargo ships and large ferries (Richardson et al. 1995; Erbe 2019). Some small ships, such as tugs, can have L_S above 160 dB re 1 µPa·m (Richardson et al. 1995; VG 2021). However, estimated sound levels from a single tug are much lower relative to other sources of construction noise, such as impact pile driving.

In their modeling of FSRU and vessel sounds, VG (2021) assumed L_S of ~187 dB re 1 µPa·m for a cargo ship transiting at 10 knots, L_S 185 dB re 1 µPa·m for a sailing LNGC, and L_S 181 dB re 1 µPa·m for a transiting tug. Other source levels used were L_S 176 dB re 1 µPa·m for the FSRU hull-radiated noise (with engines on standard vibration mounts to reduce noise, but no cooling pumps), L_S 166 dB re 1 µPa·m for the FSRU cooling pumps, L_S 169 dB re 1 µPa·m for an offloading LNGC, L_S 165 dB re 1 µPa·m for an idling tug, and L_S 160 dB re 1 µPa·m for a cargo ship at Moneypoint (Table 1).

Marine Mammal Species Assessed

Occurrence in the Shannon Estuary

Bottlenose Dolphins

The bottlenose dolphin is considered least concern under the International Union for Conservation of Nature (IUCN) Red List and is listed in Annex II of the European Union's (EU) Habitats Directive. The Habitats Directive was adopted in 1992 and ensures the conservation of a wide range of rare, threatened, or endemic species in Europe. The core habitat areas for Annex II species, including the bottlenose dolphin, are designated as sites of community importance (SCIs), which can in turn be designated as SACs.

The Lower River Shannon, or outer part of the estuary, is one of two SACs designated for bottlenose dolphins in Irish waters (O'Brien et al. 2016; Rogan et al. 2018; Blázquez et al. 2020). Studies on the resident bottlenose dolphin population in Shannon Estuary have been occurring since 1993 by the Irish Whale and Dolphin Group (IWDG) and by the National Parks and Wildlife Service (NPWS) of Ireland as part of the EU's obligation to ensure conservation of this species (Blázquez et al. 2020). Data collected over 20 years show that the Shannon Estuary dolphin population is genetically and demographically isolated from other coastal dolphins (Mirimin et al. 2011; O'Brien et al. 2016; Rogan et al. 2018). Mark-recapture photo-identification studies indicate that bottlenose dolphins in the Shannon Estuary exhibit long-term site fidelity and seasonal residency (e.g., Ingram 2000; Ingram and Rogan 2002; Ingram and Rogan 2003; Englund et al. 2007, 2008; Berrow 2009; Rogan et al. 2018). The most recent photo-identification study occurred during June–October 2018, resulting in a mark-recapture abundance estimate of 139 individuals (CV=0.11, 95% CI=121–160) (Rogan et al. 2018). Baker et al. (2018a) provided an estimate of 145 individuals for 2015, based on direct counts. The median group size based on boat surveys throughout the estuary is 6 (e.g., Englund et al. 2007, 2008; Rogan et al. 2018), and the average group size has been reported as 9.71 (Barker and Berrow 2016). The mean group size (±SD) at the proposed LNG site at Ardmore Point was estimated at 6.2 ± 3.1 dolphins, based on watches from shore (Berrow et al. 2020).

Although the dolphins inhabit the Shannon Estuary year-round, the greatest number appear to occur there between June and August (Garagouni et al. 2019), with decreasing numbers during the winter (Ingram 2000; Englund et al. 2007; Rogan et al. 2018). The lower numbers during winter may be due to animals dispersing over a wider region in pursuit of prey affected by the seasonal changes (Garagouni et al. 2019), although data on the abundance and distribution of the population during winter is generally lacking. However, dolphin sightings were made off Ardmore Point each month during monitoring from October 2020 to March 2021 (Berrow 2020 a,b,c, 2021 a,b,c). One photo-identification study found that at least 62% of individuals from the Shannon bottlenose dolphin population also use waters outside of the Shannon Estuary during the summer (May–August), including Brandon Bay and Tralee Bay located adjacent to the estuary (Levesque et al. 2016).

Bottlenose dolphins in the Shannon Estuary prefer areas with the greatest slope and depth (Ingram and Rogan 2002). Two critical habitat areas occur within the Shannon Estuary that at least part of the population migrates between throughout the year; the larger of the two areas is located near the mouth of the estuary closest to Kilcredaun, and the smaller is located off Moneypoint (See Figure 1; Ingram and Rogan 2002; Rogan et al. 2018). In general, a smaller proportion of the population is found in the eastern part of the estuary compared to the western part (Baker et al. 2018b). The distribution of sightings in 2018 showed that dolphin presence throughout the estuary was similar to past studies, but noted greater activity within the inner estuary where it constricts near Tarbert/Killimer and farther upriver, near Glin (see Figure 1) (Ingram and Rogan 2002; Rogan et al. 2018). Baker et al. (2018b) found that only 25% of the population regularly uses the inner estuary; those dolphins were also seen in the outer estuary. Within the critical habitat areas, the dolphins appear to most commonly be found near northern-facing slopes (Garagouni et al. 2019). Dolphin distribution in the estuary is also correlated with tide level, with higher presence in bottleneck areas during ebb and slack low tides (Garagouni et al. 2019).

The location of the proposed in-water structures and immediate vicinity around them at the proposed LNG terminal at Ardmore Point has not been identified as a hot spot for bottlenose dolphin occurrence based on commercial dolphin-watching activities (see Berrow et al. 2020). However, sightings have been made in the area during several vessel-based surveys (e.g., Ingram and Rogan 2003; Englund et al. 2007, 2008; Berrow et al. 2012). Visual observations from shore at Ardmore Point show that the site is regularly used by the dolphins, which pass by the area but rarely stop and socialize or forage there; it is more likely used as a transition corridor to move between the outer and inner estuary (Berrow et al. 2020). During 23 days of observations from April through September 2020, 21 sightings of dolphins were made on 13 separate watch days. Most sightings were made off Moneypoint, near the ferry, near Scattery Island, and mid-channel; six sightings were made within 500 m of Ardmore Point, and a total of 22 individual dolphins were identified. During 23 observation days from October 2020 to March 2021, 20 dolphin sightings were made on 15 different watch days (Berrow 2020 a,b,c, 2021a,b,c). Thus, the encounter rates of bottlenose dolphin groups were similar during spring/ summer and autumn/winter, at 0.2 groups/hour of observation.

Passive acoustic monitoring with C-POD porpoise detectors was also conducted at two sites off Ardmore Point from August 2019 through May 2020; dolphin clicks were detected on 62% of monitoring days at each of the two sites (Berrow et al. 2020). The C-POD located closest to the LNG site (LNG1) had a mean detection positive minutes (DPM) per day of 4.4, whereas LNG2 had a DPM of 3.6; DPM was lower at LNG1 during the winter than during other seasons. The low DPM per day at these two sites supports evidence from visual monitoring that the area around Ardmore Point is primarily a transit corridor (Berrow et al. 2020). There were significantly more detections during the evening than during the day at LNG1, and significantly more detections in the evening and at night than during the day at LNG2 (Berrow et al. 2020).

The Shannon Estuary also acts as a calving area for the species, with neonates most frequently observed from July to September (Ingram 2000; Baker et al. 2018a), although Rogan et al. (2018) also reported neonates in October. An average of seven calves are born each year, with weaning taking place at a mean age of 2.9 years (Baker et al. 2018a). During watches from Ardmore Point, 10 calves were recorded, including four that were born in 2018 and 2019 (Berrow et al. 2020). However, it is not known whether this particular location is an important calving area within the estuary.

Other Marine Mammals

Harbour porpoise, harbour seals (*Phoca vitulina*), and grey seals (*Halichoerus grypus*) are listed in Annex II of the EU's Habitats Directive and are considered least concern under the IUCN Red List. Although harbour porpoise occur regularly along the coast of Ireland (O'Brien 2016), they are rarely seen in the Shannon Estuary (O'Callaghan et al. 2021). Only two sightings have been reported in the inner estuary (Berrow 2020a, Berrow et al. 2020; O'Callaghan et al. 2021). One sighting was made on 22 October 2020 of a single harbour porpoise that was foraging for ~1 h near Moneypoint (Berrow 2020a; O'Callaghan et al. 2021). Another sighting of an adult and juvenile was made near Scattery Island in 2018 (O'Callaghan et al. 2021). One sighting of two porpoise was made in the outer estuary during July 2005 (O'Callaghan et al. 2021). In addition, six strandings have been reported in the Shannon Estuary (O'Callaghan et al. 2021). Possible porpoise clicks have also been detected during monitoring in summer/autumn 2018 at two sites off Ardmore Point (Berrow et al. 2020) and off Moneypoint (O'Brien et al. 2013). However, O'Callaghan et al. (2021) note that these high-frequency clicks could have been generated by dolphins.

Grey seals are common in the Shannon Estuary. The National Biodiversity Data Centre (NBDC) database contains 231 records of the species in the Shannon Estuary, 46 of which are within close proximity to the proposed project. Rogan et al. (2018) reported four sightings of grey seals in Shannon Estuary during dolphin surveys in the summer/autumn of 2018, including two pups hauled out on a beach. During shore-based observations from Ardmore Point from April to August 2020, individual grey seals were seen on six occasions, five of which occurred within 500 m of the site (Berrow et al. 2020). Sightings of individual grey seals were also made during monitoring in October 2020, January 2021, February 2021 (Berrow 2020a, 2021a,b). Cronin et al. (2011) also reported movement of grey seals from the outer coast into the estuary, and Cadhla and Strong (2007) documented a breeding site in the outer estuary. Duck and Morris (2013) reported two sightings in the Inner Shannon Estuary during summer surveys in 2003, but no sightings during surveys in 2012.

Cronin et al. (2010) reported a gap in harbour seal distribution in the Shannon Estuary. Sightings reported through the NBDC include three records for the Fergus Estuary, and seven records near the proposed project location — three at Kilrush, three at Scattery Island, and one at Tarbert. Duck and Morris (2013) reported one harbour seal sighting in the inner Shannon Estuary during surveys in 2012, and eight sightings during surveys in 2003; no sightings were made in the outer Shannon Estuary during either survey.

Sound Production and Hearing

Bottlenose dolphins echolocate for navigating, foraging, coordinating group behaviour, and detecting and avoiding predators (Branstetter et al. 2018). Echolocation clicks typically have frequencies of 110–130 kHz while whistles are produced at frequencies of 1–24 kHz (Richardson et al. 1995). Bottlenose dolphins are classified as mid-frequency (MF) cetaceans meaning they can hear sounds in the frequency range of 150 Hz to 160 kHz (Southall et al. 2007; NMFS 2018) and their most sensitive hearing is between ~25 and 70 kHz (Ljungblad et al. 1982; Strahan et al. 2020). Frequencies lower than 30 kHz are important for social communication (Accomando et al. 2020). Because bottlenose dolphin hearing is most sensitive at mid-frequencies, noise disturbance from smaller vessels (e.g., recreational boats, fishing boats, and tour boats) are more likely to have an effect on their behaviour compared to larger vessels (O'Brien et al. 2016).

Similar to bottlenose dolphins, harbour porpoise also use echolocation to navigate and detect prey and predators. Their echolocation clicks are in the range of 110–150 kHz (Møhl and Andersen 1973; Teilmann et al. 2002). They also produce clicks at ~ 2 kHz (Richardson et al. 1995). Harbour porpoise are in the high-frequency (HF) hearing group, with a hearing range of 275 Hz to 160 kHz (NMFS 2018). Using auditory brainstem responses, Ruser et al. (2016) found that the harbour porpoise could hear best between 120 and 130 kHz. Kastelein et al. (2002) reported a broader "best" hearing range of 16–140 kHz, with maximum sensitivity between 100 and 140 kHz. Similarly, Kastelein et al. (2017) reported a maximum sensitivity for harbour porpoise at 125 kHz.

Harbour seals produce sounds such as clicks and growls at 0.1–150 kHz (Richardson et al. 1995). The functional hearing range for pinnipeds in water is generally considered to extend from 75 Hz to 75 kHz (Southall et al. 2007), although Cunningham and Reichmuth (2016) reported that a harbour seal was able to detect frequencies up to 180 kHz. In comparison with odontocetes, pinnipeds tend to hear best at lower frequencies, have lower high-frequency cutoffs, and poorer sensitivity at the best frequencies. Harbour seals hear well in water at frequencies from 1–60 kHz, with peak sensitivity at ~32 kHz (Kastak and Schusterman 1995). Below 30–50 kHz, the hearing thresholds of most pinniped species tested are essentially flat down to ~1 kHz and range between 60 and 85 dB re 1 µPa. Measurements for harbour seals indicate that below 1 kHz, their thresholds under quiet background conditions deteriorate gradually with decreasing frequency to ~75 dB re 1 µPa at 125 Hz (Kastelein et al. 2009).

Potential Impacts of Anthropogenic Sounds

Noise produced during project construction and operation, including from pile driving, LNGCs, and tugboats, may elicit some type of response from marine mammals inhabiting the Shannon Estuary. The potential effects of sound sources could consist of masking natural sounds, behavioural disturbance, and in theory temporary or permanent hearing impairment, or non-auditory physical or physiological effects (e.g., Richardson et al. 1995; Erbe 2019). The impact would depend on the behaviour of the animal at the time of reception of the sound, as well as the distance and received level of sound, the hearing ability of the animal within the frequency range of the sounds, the age and activity of the animal at the time of exposures, and the bathymetry and water depth of the area.

With some exceptions (Erbe et al. 2016), in order for anthropogenic sounds to be detected by an animal, they must be greater than or equal to both the ambient noise level at the corresponding frequencies and the hearing threshold of the animal. With that being said, industrial sounds can be up to ~20–30 dB stronger than the detection thresholds and/or ambient noise levels before they elicit notable changes in behaviour or distribution of animals sensitive to those sounds (Richardson et al. 1995). Individuals frequently exposed to the same sounds can develop tolerance and become habituated to sound levels ~40 to 60 dB above ambient or detection levels before showing behavioural or distributional changes.

Masking

Although masking of natural sounds, such as from conspecifics, can occur in noisy habitats (e.g., Pine et al. 2016; Morrison et al. 2020), cetaceans, including bottlenose dolphins and harbour porpoise, can change their vocal behaviour to avoid masking (e.g., Luís et al. 2014; Sairanen 2014; Gospić and Picciulin 2016; Gridley et al. 2016; Heiler et al. 2016; O'Brien et al. 2016; van Ginkel et al. 2018). Similarly, harbour seals have been shown to increase the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017). Noise in the marine environment also has the potential to lessen a marine mammals' ability to detect targets through decreasing the sensitivity of their hearing system and causing changes in behaviour (Branstetter et al. 2018). However, studies have shown that bottlenose dolphins can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2014, 2015; Nachtigall et al. 2018).

Madsen et al. (2006) argued that substantial masking effects would be unlikely during impact pile driving given the intermittent nature of these sounds and short signal duration. In contrast, there could be potential masking effects during vibratory pile driving as the sound emitted is continuous. David (2006) speculated that noise generated by pile driving with a 6 t diesel hammer has the potential to mask bottlenose dolphin vocalizations at 9 kHz within 10 to 15 km from the source if the vocalization is strong and up to 40 km if the call is weak; masking potential reduced with increasing frequency. Masking could reduce an animal's ability to communicate which could then lead to a decrease in socializing activities (Paiva et al. 2015).

Behavioural Effects

Marine mammal behavioural responses to vessels are presumably responses to the sounds produced by those vessels, but visual or other cues are also likely involved. Responses are variable and range from avoidance at long distances to little or no response or approach (Richardson et al. 1995). Responses depend on the speed, size, and direction of travel of the vessel relative to the marine mammal; slow vessel approaches tend to elicit fewer responses than fast, erratic approaches (Richardson et al. 1995).

Sini et al. (2005) found larger boats generally elicited positive reactions from bottlenose dolphins (e.g., approaching or following a boat, initiating bow riding, leaping or breaching), whereas smaller boats elicited more negative responses, including prolonged dives followed by increased respiration rate and longer inter-breath interval lengths, as well as active avoidance. Similarly, Nowacek (2001) found that when bottlenose dolphins were approached by boats in Sarasota, Florida, the dolphins decreased their group spacing, changed heading, and swam faster. Other behavioural responses of bottlenose dolphins to ships include interrupted feeding, resting, and social activities (Papale et al. 2011). A decrease in resting and socializing activities of bottlenose dolphins was also observed in the presence of vessel activity in Sicily, Italy, as well as an increase in time spent foraging and traveling, alterations in dive patterns, displays of breathing synchrony, changes in inter-animal distances, and increased travel speeds were also noted (Marley et al. 2017). Due to increased speeds during travel, high-energy demand paired with high metabolic rates could ultimately lead to induced stress and energetic consequences (Marley et al. 2017). A decrease in socializing activities is another concern due to the importance of socializing for young dolphins to develop their social behaviours, physical movements, problem solving skills, and foraging methods (Marley et al. 2017). The physical presence of vessels, not just ship noise, has been shown to disturb the foraging activity of bottlenose dolphins (Pirotta et al. 2015). Mullin et al. (1989) reported both attraction and avoidance of oil production platforms that operate drills by bottlenose dolphins in the Gulf of Mexico, depending on depth.

Vessel sounds have also been shown to elicit behavioural responses in harbour porpoise such as increased swimming speed and porpoising (e.g., Dyndo et al. 2015), and reduced foraging and echolocation (e.g., Teilmann et al. 2015; Wisniewska et al. 2018). Wisniewska et al. (2018) suggested that a decrease in foraging success could have long-term fitness consequences. However, Kastelein et al. (2019) surmised that if disturbance by noise would displace a harbour porpoise from a feeding area or otherwise impair foraging ability for a short period of time (e.g., 1 day), it would be able to compensate by increasing its food consumption following the disturbance. Harbour seals that are hauled out often enter the water when approached by vessels; responses of seals in the water are variable. Based on observations in the Arctic of ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) near drillships drilling, some seals tolerate drilling noise (Richardson et al. 1995).

Responses of marine mammals to pile driving can be similar to those described above for vessel presence. Avoidance is likely to be the primary behavioural response of marine mammals to pile driving. Currently, there is uncertainty regarding the extent to which marine mammals respond differently to impact pile driving versus vibratory pile driving (Graham et al. 2017). Based on sound levels measured during impact pile driving during wind turbine installation in northeastern Scotland and a disturbance threshold of 140 $dB_{p\text{-}p}$ re 1 µPa, Bailey et al. (2010) suggested that behavioural disturbance from pile driving may occur up to 50 km away for bottlenose dolphins. Graham et al. (2017) reported that bottlenose dolphins spent less time in a construction area when impact or vibratory piling was occurring. Similarly, Paiva et al. (2015) reported a significant decrease in the number of Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) detections during pile driving activities, which included vibratory and impact driving. In another study, Indo-Pacific humpback dolphins (*Sousa chinensis*) exposed to $L_{p,rms}$ of 170 dB remained within 300 to 500 m of the percussive pile driving area before, during, and after operations; although some dolphins temporarily abandoned the work area, their numbers returned close to those seen pre-construction during the follow-up survey seven months after construction activities ended (Würsig et al. 2000).

Harbour porpoises are known to be fairly responsive to anthropogenic sounds (reviewed in Richardson et al. 1995) and often avoid pile driving activities (e.g., Tougaard et al. 2009; Brandt et al. 2011; Haelters et al. 2015). Bailey et al. (2010) suggested that for harbour porpoise, behavioural disturbance from impact pile driving may occur up to 70 km away (based on a threshold of 90 $dB_{p\text{-}p}$ re 1 µPa), with major disturbance at distances up to 20 km (based on a threshold of 155 $dB_{p\text{-}p}$ re 1 µPa). During impact pile driving at Horns Rev I wind farm in the Danish North Sea, harbour porpoise acoustic activity decreased; however, it resumed to baseline levels 3 to 4.5 h after the cessation of pile driving activities (Tougaard et al. 2003, 2005). Tougaard et al. (2003) reported that effects of pile driving activity on harbour porpoises were documented at distances of 10–15 km from the activity and included a decrease in feeding behaviours and a decline in the number of porpoises in the Horns Rev area during the construction period as compared to periods before and after construction. There were fewer circling porpoises during pile driving and significantly more traveling within 15 km of the construction site (Tougaard et al. 2005). Based on Tougaard et al. (2005, 2009, 2011), behavioural effects extended as far as 20–25 km from the construction site. There was complete recovery of acoustic activity during the first year of regular operation of the wind farm; the acoustic activity was actually higher during operation than prior to construction (Tougaard et al. 2006b; Teilmann et al. 2008).

In contrast to the Before After Control Impact sampling design used during previous studies at Horn Rev wind farm, a gradient sampling design showed that the behavioural responses of harbour porpoises to pile driving were longer than previously reported. Brandt et al. (2011) recorded no porpoise clicks for at least 1 h at a distance of 2.6 km from the construction site at Horns Rev II, with reduced acoustic activity for 24–72 h. Out to a distance of 4.7 km, the recovery time was still longer than 16 h – the time between pile driving events; recovery time decreased with increasing distance from the construction site (Brandt et al. 2011). At a distance of ~22 km, negative effects were no longer detectable; rather, a temporary increase in click activity was apparent, possibly as a result of porpoises leaving the area near the construction site (Brandt et al. 2011).

During pile driving activities (using both vibratory and impact techniques) at the Nysted offshore wind farm off the coast of Denmark, a significant decrease in harbour porpoise echolocation activities and presumably abundance was reported within the construction area and in a reference area 10–15 km from the wind farm (Carstensen et al. 2006; Teilmann et al. 2008). Carstensen et al. (2006) reported a medium-term porpoise response to construction activities in general and a short-term response to ramming/vibration activities. Porpoises appeared to have left the area during piling but returned after several days (Tougaard et al. 2006a). Two years after construction, echolocation activity and presumably porpoise abundance were still significantly reduced in the wind farm but had returned to baseline levels at the reference sites (Tougaard et al. 2006a; Teilmann et al. 2008).

Teilmann et al. (2006) speculated as to the cause of the negative effect of construction persisting longer for porpoises at Nysted than at Horns Rev. Porpoises at Horns Rev may have been more tolerant to disturbance, since the area is thought to be important to porpoises as a feeding ground; the Horns Rev area has much higher densities of animals compared to Nysted (Teilmann et al. 2006). Another explanation proposed by Teilmann et al. (2006) took into account that the Nysted wind farm is located in a sheltered area whereas Horns Rev is exposed to wind and waves with higher background noise. Thus, noise from construction may be more audible to porpoises at Nysted compared to Horns Rev. Graham et al. (2017) reported that vibratory pile driving had a greater effect on reducing the probability of harbour porpoise occurrence in a construction area compared with impact pile driving.

Scheidat et al. (2011) suggested that harbour porpoise distribution was fairly quick to recover after construction of the Dutch offshore wind farm Egmond aan Zee, as acoustic activity of harbour porpoises was greater during the 3 years of operation than the 2 years prior to construction. In addition, Leopold and Camphuysen (2008) noted that construction of wind farm Egmond aan Zee did not lead to increased strandings in the area. Harbour porpoises near pile driving activities in Scotland may have exhibited a short-term response within 1–2 km of the installation site, but this was a short-term effect lasting no longer than 2–3 days (Thompson et al. 2010). During the construction of a harbour wall in Demark, which involved pile driving of 175 wooden piles, a 40 m-long air bubble curtain was constructed in hopes of reducing noise effects on three harbour porpoises in a facility on the opposite side of the harbour (Lucke et al. 2011). The bubble curtain was found to be helpful in reducing the piling noise, and the initial avoidance behaviour of the harbour porpoises to the piling sound was no longer apparent after installation of the bubble curtain (Lucke et al. 2011).

The effects of pile driving on the distribution and behaviour of pinnipeds may be small in comparison to the effects on cetaceans. Ringed seals exposed to pile driving pulses exhibited little or no reaction to impact pile driving sounds at a shallow water site in the Alaskan Beaufort Sea; at the closest point (63 m), received levels were 151 dB re 1 μPa_{rms} and 145 dB re 1 $\mu Pa^2 \cdot s$ L_E (Blackwell et al. 2004). Other seal species seem less tolerant of pile driving, at least at their haul-out sites. Remote video monitoring showed that harbour seal haul-out behaviour was affected by pile driving at an offshore wind farm (Nysted) in the western Baltic (Edrén et al. 2004, 2010). The authors found a short-term reduction in the number of seals hauled out at nearby beaches during periods with pile driving vs. no pile driving. Sound levels were not measured, and observations of seals in the water were not made. The authors suggest that seals may have spent more time in the water because this is a typical response to disturbance, or the seals may have used an alternate haul-out site. However, both aerial surveys and remote video monitoring did not show a long-term decrease in the number of seals hauled out from baseline conditions to the construction period (Edrén et al. 2004, 2010; Thomsen et al. 2006). Harbour seals did not seem to be affected by pile driving noise during construction activities in San Francisco Bay (Caltrans 2004).

Similarly, Teilmann et al. (2006) noted that the reactions of harbour seals to construction activities appeared to be short-term because aerial surveys did not reveal any decrease in overall abundance during the 2002–2003 construction period or the 2004–2005 operation period (Teilmann et al. 2006). However, Skeate et al. (2012) suggested a likely link between windfarm construction (e.g., pile driving) and a statistically significant decrease in the number of hauled out harbour seals nearby. At the Horns Rev wind farm, no seals were observed during ship-based surveys in the wind farm during pile driving (Tougaard et al. 2006c). However, animals were sighted in the wind farm during other construction activities, although at apparently lower numbers than during baseline conditions (Tougaard et al. 2006c). Bailey et al. (2010) suggested minor disturbance within 14 km (based on a threshold of $L_{p,pk\text{-}pk}$ 160 dB re 1 μPa), and major disturbance within 215 m (based on a threshold of $L_{p,p\text{-}p}$ 200 dB re 1 μPa) of pile driving activities for harbour and grey seals. Russell et al. (2016) reported displacement of harbour seals during piling when received levels were between $L_{p,pk\text{-}pk}$ 166 and 178 re 1μPa. Although displaced during active pile driving, harbour seals were then observed to return to a normal distribution (distribution measured during the non-piling scenario) within 2 h of cessation of pile driving (Russell et al. 2016).

The limited available evidence indicates that marine mammals, like humans, show less annoyance to occasional noise pulses with a given peak level than they do to continuous noise at that same level (Richardson et al. 1995). Although blasting on land could have potential effects on marine mammals, small explosive charges were “not always effective” in moving bottlenose dolphins away from sites in the Gulf of Mexico where larger demolition blasts were about to occur (Klima et al. 1988). Captive false killer whales (*Pseudorca crassidens*) showed no obvious reaction to single noise pulses from small (10 g) charges (Akamatsu et al. 1993). Several additional studies found limited or no effects on odontocetes (Jefferson and Curry 1994) or baleen whales (Fitch and Young 1948; Payne 1970; Payne and McVay 1971; Lien et al. 1993).

Hearing Impairment

Although it is unlikely that continuous noise from vessels, drilling, and vibratory pile driving would be strong enough to cause hearing damage or other injuries in marine mammals, impulsive sounds from pile driving and blasting could theoretically have auditory effects on marine mammals. There is a possibility some marine mammals could suffer from PTS or TTS when exposed to impact pile driving sounds. There are empirical data on the sound exposures that elicit onset of TTS in captive bottlenose dolphins, belugas, and porpoise. The majority of these data concern non-impulse sound, but there are some limited published data concerning TTS onset upon exposure to pile driving (e.g., Kastelein et al. 2015, 2016), a single pulse of sound from a watergun (Finneran et al. 2002), and to multiple pulses from an airgun

(Finneran et al. 2015). A detailed review of TTS data from marine mammals can be found in Southall et al. (2007, 2019).

Kastelein et al. (2015, 2016) reported TTS in the hearing threshold of a captive harbour porpoise during playbacks of pile driving sounds; although the pulses had most of their energy in the low frequencies, multiple pulses caused reduced hearing at higher frequencies in the porpoise. Unlike in the Kastelein et al. (2015, 2016) experiments, during project activities an animal would be able to move away from the sound source, as avoidance behaviour has been demonstrated for many marine mammals subjected to loud sounds, thereby reducing the potential for impacts to their hearing ability. There is no specific evidence that exposure to pulses from pile driving or other activities in unrestricted environments is likely to lead to PTS for any marine mammals. Similarly, Nowacek et al. (2013) concluded that current scientific data indicates that seismic airguns (an impulsive source like impact pile driving) have a low probability of directly harming marine life, except at close range.

The following summarizes some of the key results for sounds other than pile driving regarding bottlenose dolphins and porpoise. Recent information corroborates earlier expectations that the effect of exposure to strong transient sounds is closely related to the total amount of acoustic energy that is received. Finneran et al. (2005) examined the effects of tone duration on TTS in bottlenose dolphins. Bottlenose dolphins were exposed to 3 kHz tones (non-impulsive) for periods of 1, 2, 4 or 8 s, with hearing tested at 4.5 kHz. For 1-s exposures, TTS occurred with sound exposure levels (L_E) of 197 dB, and for exposures >1 s, L_E >195 dB resulted in TTS (L_E is equivalent to energy flux, in dB re 1 µPa$^2 \cdot$ s). At an L_E of 195 dB, the mean TTS (4 min after exposure) was 2.8 dB. Finneran et al. (2005) suggested that an L_E of 195 dB is the likely threshold for the onset of TTS in dolphins exposed to tones of durations 1–8 s (i.e., TTS onset occurs at a near-constant L_E, independent of exposure duration). That implies that, at least for non-impulsive tones, a doubling of exposure time results in a 3 dB lower TTS threshold.

The assumption that, in marine mammals, the occurrence and magnitude of TTS is a function of cumulative acoustic energy (L_E) is probably an oversimplification (Finneran 2012). Kastak et al. (2005) reported preliminary evidence from pinnipeds that, for prolonged non-impulse noise, higher L_Es were required to elicit a given TTS if exposure duration was short than if it was longer, i.e., the results were not fully consistent with an equal-energy model to predict TTS onset. Mooney et al. (2009a) showed this in a bottlenose dolphin exposed to octave-band non-impulse noise ranging from 4–8 kHz at L_p of 130–178 dB re 1 µPa for periods of 1.88–30 min. Higher L_Es were required to induce a given TTS if exposure duration was short than if it was longer. Exposure of the aforementioned bottlenose dolphin to a sequence of brief sonar signals showed that, with those brief (but non-impulse) sounds, the received energy (L_E) necessary to elicit TTS was higher than was the case with exposure to the more prolonged octave-band noise (Mooney et al. 2009b). Those authors concluded that, when using (non-impulse) acoustic signals of duration ~0.5 s, L_E must be at least 210–214 dB re 1 µPa$^2 \cdot$ s to induce TTS in the bottlenose dolphin.

On the other hand, the TTS threshold for odontocetes exposed to a single impulse from a watergun (Finneran et al. 2002) appeared to be somewhat lower than for exposure to non-impulse sound. This was expected, based on evidence from terrestrial mammals showing that broadband pulsed sounds with rapid rise times have greater auditory effect than do non-impulse sounds (Southall et al. 2007). Schlundt et al. (2000) reported that stimuli levels between 192 and 201 dB 1 µPa were necessary to induce TTS in bottlenose dolphins when exposed to intense 1-s tones at various frequencies. The conclusion that the TTS threshold is higher for non-impulse sound than for impulse sound is somewhat speculative. The available TTS data for impulse sound are extremely limited, and the TTS data from the bottlenose dolphin exposed to non-pulse sound pertain to sounds at 3 kHz and above. Follow-on work has shown that the L_E necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012).

For one harbour porpoise tested, the received level of airgun sound that elicited onset of TTS was lower than for the bottlenose dolphin. The porpoise was exposed to single pulses from a small (20 in^3) airgun, and auditory evoked potential methods were used to test the animal's hearing sensitivity at frequencies of 4, 32, or 100 kHz after each exposure (Lucke et al. 2009). Based on the measurements at 4 kHz, TTS occurred upon exposure to one airgun pulse with received level $L_{p,p\text{-}p}$ ~200 dB re 1 $\mu Pa_{pk\text{-}pk}$ or an L_E of 164.3 dB re 1 $\mu Pa^2 \cdot s$. If these results from a single animal are representative, it is inappropriate to assume that onset of TTS occurs at similar received levels in all odontocetes (*cf.* Southall et al. 2007). Some cetaceans may incur TTS at lower sound exposures than are necessary to elicit TTS in the bottlenose dolphin.

Insofar as we are aware, there are no published data confirming that the auditory effect of a sequence of sound pulses received by an odontocete is a function of their cumulative energy. Southall et al. (2007) considered that to be a reasonable, but probably somewhat precautionary, assumption. It is precautionary because, based on data from terrestrial mammals, one would expect that a given energy exposure would have somewhat less effect if separated into discrete pulses, with potential opportunity for partial auditory recovery between pulses. However, as yet there has been little study of the rate of recovery from TTS in marine mammals, and in humans and other terrestrial mammals the available data on recovery are quite variable. Southall et al. (2007) concluded that—until relevant data on recovery are available from marine mammals—it is appropriate not to allow for any assumed recovery during the intervals between pulses within a pulse sequence. However, recent data have shown that the L_E required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010; Finneran and Schlundt 2011). For example, Finneran et al. (2015) reported no measurable TTS in bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative $L_{E,}$of ~195 dB re 1 $\mu Pa^2 \cdot s$. Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated pulses with variable received levels. At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy even though that energy is received in multiple pulses separated by gaps. A data gap remains concerning the exposure levels necessary to cause TTS in toothed whales when the signal is a series of pulsed sounds, separated by silent periods.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Two California sea lions did not incur TTS when exposed to single brief pulses with received levels of L_p ~178 and 183 dB re 1 µPa and total energy fluxes (L_E) of 161 and 163 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2003). However, initial evidence from more prolonged (non-pulse and pulse) exposures suggested that some pinnipeds (harbour seals in particular) incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999, 2005; Ketten et al. 2001). Kastak et al. (2005) reported that the amount of threshold shift increased with increasing L_E in a harbour seal. They noted that, for non-impulse sound, doubling the exposure duration from 25 to 50 min (i.e., a +3 dB change in L_E) had a greater effect on TTS than an increase of 15 dB (95 vs. 80 dB) in exposure level. Mean threshold shifts ranged from 2.9–12.2 dB, with full recovery within 24 h (Kastak et al. 2005). Kastak et al. (2005) suggested that, for non-impulse sound, exposure levels resulting in TTS onset in three species of pinnipeds may range from L_E 183–206 dB re 1 $\mu Pa^2 \cdot s$, depending on the absolute hearing sensitivity. As noted above for odontocetes, it is expected that—for impulse as opposed to non-impulse sound—the onset of TTS would occur at a lower cumulative exposure level given the assumed greater auditory effect of broadband impulses with rapid rise times. Insofar as we are aware, there are no data to indicate whether the TTS thresholds of other pinniped species are more similar to those of the harbour seal or to those of the two less-sensitive species. Harbour seals may be able to decrease their exposure to underwater sound by swimming just below the surface where sound levels are typically lower than at depth (Kastelein et al. 2018).

Other Physiological Effects

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al. 1993; Ketten 1995). Intense shock waves, because of their high peak pressures and rapid changes in pressure, can cause severe damage to animals. The most severe damage takes place at boundaries between tissues of different density. Different velocities are imparted to tissues of different densities, and this can physically disrupt the tissues. Gas-containing organs, particularly the lungs and gastrointestinal tract, are especially susceptible (Yelverton et al. 1973; Hill 1978). Lung injuries can include laceration and rupture of the alveoli and blood vessels, which in turn can lead to hemorrhage, creation of air embolisms, and breathing difficulties. Intestinal walls can bruise or rupture, with subsequent hemorrhage and escape of gut contents into the body cavity. Although hearing damage and other physical injuries have been reported for cetaceans (e.g., (Ketten et al. 1993; Ketten 1995) and pinnipeds (Fitch and Young 1948; Danil and St. Leger 2011) subjected to explosions, the charges for the proposed project would be detonated on land and would not create shock waves in the water.

Fish Species Assessed

A number of Ireland's native diadromous species pass through the Lower Shannon Estuary on their way to or from freshwater spawning grounds or reside there for feeding as they mature. These include four species of conservation interest in the area, namely twaite shad (*Allosa fallax fallax*), sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), and Atlantic salmon (*Salmo salar*). These are all listed on Annex II of Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (EU Habitats Directive). The Habitats Directive ensures the conservation of a wide range of rare, threatened, or endemic species in Europe. Core habitat areas for Annex II species are designated as SCIs, which must be managed corresponding to the species' ecological requirements. The SCIs for twaite shad, sea lamprey, river lamprey, and Atlantic salmon that occur in the Lower Shannon Estuary have in turn been designated as a SAC. Additionally, the twaite shad and the sea lamprey are listed under Annex V, which mandates that EU Member States are required to manage exploitation of the species so that conservation status remains favourable (EU Commission 2021).

Fish stock surveys were conducted by Inland Fisheries Ireland in September to November 2008 and in October 2014 in the Upper and Lower Shannon Estuary using either a beach seine, fyke net, or beam trawl (Kelly et al. 2015). Within the Upper Shannon Estuary, 15 and 22 species of fish were recorded during 2008 and 2014, respectively, and flounder, sprat and sandy goby were the most abundant species during the 2014 survey. Within the Lower Shannon Estuary, 31 fish species were recorded in a 2008 survey and 29 were recorded in 2014. Out of these species, sprat was the most abundant, followed by sand goby, thick-lipped mullet, and sand smelt (Kelly et al. 2015). European eels (*Anguilla anguilla*) were caught in the Upper Shannon Estuary in 2008 and 2014, and the Lower Shannon Estuary in 2014 only (Kelly et al. 2015).

Twaite Shad

Twaite shad is an anadromous fish and member of the herring (Clupeidae) family that is distributed across the north-eastern Atlantic, with Iceland as the northernmost extent of its range, Morocco as the southernmost, and the Baltic Sea as the easternmost (Aprahamian et al. 2003). They are listed as least concern globally on the IUCN Red List (IUCN 2021) but as vulnerable in the Ireland Red List (King et al. 2011), a version of the IUCN Red List (using the same population status evaluations) in which regional species population statuses in Ireland are assessed, established by the National Parks and Wildlife Service. Adult twaite shad generally migrate from the marine environment into freshwater environments to spawn from February in the south of its range to May and June in the north (Davies et al. 2020). In Ireland, shad typically spawn during April–June (Quigley 2017). The river migration period can last for three months, and seaward migration occurs for surviving adults after spawning and for young-of-the-year in the summer and autumn (Maitland and Hatton-Ellis 2003; Davies et al. 2020). Four rivers in Ireland have been shown to support spawning grounds and spawning populations of twaite shad including the Munster Blackwater and the three rivers within the Barrow-Nore-Suir river system (King and Roche 2008; Quigley 2017; Davies et al. 2020; Gallagher et al. 2020), entries to which are located on the southwestern coast of Ireland.

Sea Lamprey and River Lamprey

Sea lamprey and river lamprey are anadromous species found in the Northern Hemisphere. The sea lamprey is listed as near threatened in the Ireland Red List (King et al. 2011), but as least concern globally on the IUCN Red List (IUCN 2021), and the river lamprey is listed as least concern on both Red Lists. Their populations are declining in Ireland and Europe due to overharvesting, habitat destruction, and the loss of spawning and nursery grounds from the construction of anthropogenic barriers blocking upstream access (Igoe et al. 2004; Bracken et al. 2018). For example, Silva et al. (2019) found that sea lampreys in the River Ulla experience a mean delay of 6.3 days per river obstacle during upstream migration. Lampreys typically spend their first years (two to eight for sea lampreys, three to five for river lampreys) in freshwater before migrating out to sea following a period of metamorphosis (Igoe et al. 2004). During this period of metamorphosis, lampreys will spend up to ten months without feeding and will begin early feeding in estuarine or coastal waters (Silva et al. 2012). Sea and river lampreys return to freshwater as adults and will spawn in areas with fast-flowing water and gravel bottoms where they can create shallow depressions or nests. All lampreys are semelparous and will die after a single spawning event (Bracken et al. 2018).

Sea lampreys are found in all suitable rivers in Ireland and have been particularly noted in the River Shannon, River Suir, River Nore, River Moy, and the River Corrib (Igoe et al. 2004). On the Mulkear River, a main tributary of the River Shannon, adult sea lamprey have been found spawning over nests until mid-May, and most adults leave by early August (Igoe et al. 2004). A study by Bracken et al. (2018) used environmental DNA (eDNA) to identify critical habitat for sea lamprey in Ireland. The eDNA sampling technique allows for the detection of low-density species and enables more effective and accurate deployment of resources and time allocation when collecting biological samples. Over a three-year period (2015-2017), they surveyed two different catchments in Ireland that included the Munster Blackwater and the Mulkear, the latter of which forms part of the Lower River Shannon SAC. Sea lamprey spawning aggregations and habitat use within both catchment areas were confirmed following eDNA collection, and eDNA concentrations were higher within the Mulkear catchment (Bracken et al. 2018). River lampreys are less apparent than sea lampreys due to smaller body size, and documentation of distribution information in

Ireland is less thorough, although its riverine range seems to largely overlap with that of the sea lamprey (Igoe et al. 2004). Key populations of river lamprey have been documented in the Mulkear River, and large numbers have been recorded in the Lower River Shannon and its tributaries. Additionally, they inhabit rivers including the Slaney, Barrow, Nore, Munster Blackwater, Laune, and Boney (Igoe et al. 2004), and lamprey larvae have been found in the Mulkear and Munster Blackwater rivers (Gallagher et al. 2020).

Atlantic Salmon

Atlantic salmon is an anadromous species that is found in Europe and North America. Adult salmon migrate from the sea into rivers to spawn, usually in the same river that they spent time as a juvenile (Cefas 2021). Salmon require clean, well oxygenated rivers with gravel beds for the female to bury her eggs in redds. Spawning in Europe typically takes place from November to December. Juveniles hatch as alevins, emerge from the redds as fry, and grow into parr. After approximately four years, parr become smolt through a process called smoltification and migrate to sea where they can mature (Cefas 2021). Atlantic Salmon are listed as vulnerable in Europe under the IUCN Red list (IUCN 2021) and in Ireland under the Ireland Red List (King et al. 2011). Atkinson et al. (2020) studied the effects of river obstacles to anadromous species including Atlantic salmon and concluded that the removal of river obstacles such as bridges, culverts, would improve connectivity between river catchments and habitats.

Atlantic salmon has been observed spawning in the Lower Shannon Estuary and its tributaries. Catch and release studies of Atlantic salmon have estimated that the annual rod catch between 2009-2013 in the Mulkear, a large tributary of the Shannon catchment, was 970 salmon, while the Feale had an annual catch average of 1,350 (Gargan et al. 2015). Salmon monitoring programs conducted in the Shannon River Basin district since 2007 have concluded that three rivers (the Feale, Kilmastula, and Old Shannon) meet the conservation threshold of 17 salmon fry/5 min during electrofishing surveys showing healthy juvenile salmon abundance (Gargan et al. 2020).

European Eel

The European eel is not listed as part of the EU Habitats Directive; however, it is considered critically endangered on the IUCN Red List (IUCN 2021) and the Ireland Red List (King et al. 2011) and is listed as a CITES Appendix II species, meaning the species is not currently threatened with extinction but trade is controlled to prevent this from occurring (CITES 2021). European eels are a catadromous species that undergo five principal stages throughout their life history including the leptocephalus, glass eel, elver, yellow eel, and silver eel (adult) stages. Adult eels spawn in the Sargasso Sea, and larvae and leptocephali drift on the Gulf Stream until they are transported across the Atlantic Ocean (Arai et al. 2006). Leptocephali metamorphose into glass eels and then elvers, with both stages typically arriving on the Irish coast during December and increasing in numbers during spring (Moriarty 1999). At this point they typically migrate upstream, approximately six to eight months after hatching, with elvers using freshwater habitats to grow into yellow eels and mature as silver eels. O'Connor (2003) reported that the main movement of eels in the Shannon Estuary occurs during February and March.

Not all eels undergo full upstream migration and are instead estuary-dependent, relying entirely on the estuarine environment for food resources, shelter, and nursing grounds. The estuarine environments in Ireland, however, are limited by high altitude land patterns; therefore, most eels are constrained during their growth period to either freshwater or marine environments (Arai et al. 2006). Mature adults will then migrate downstream to the sea in autumn with possible continuation through late spring.

The River Shannon is Ireland's largest river system, and it has a network of lakes which are important habitats for the European eel. Within the river system, otolith analysis has determined that male silver eels are 11 years old on average, and females are 15 years old (McCarthy et al. 2008). Stocking programs of juvenile eel have been in place to address adverse effects of the Shannon hydropower structures on eel recruitment and were most successful during the 1970s and 1980s; however, there are still steady declines in both yellow and silver eel populations in the Shannon system (McCarthy et al. 2008). The fishery for European eel in the River Shannon is long established, with detailed records dating from 1960 onwards (McCarthy et al. 1999).

Hearing

All fish have hearing and skin-based mechanosensory systems, such as the inner ear and the lateral line, that provide information about their surroundings (Popper et al. 2019a; Putland et al. 2019). While all fish are likely sensitive to particle motion, not all fish (e.g., cartilaginous fish, such as sharks and jawless fish) are sensitive to the sound pressure component. Potential effects of exposure to anthropogenic sound on fish can be behavioural, physiological, or pathological.

Several authors have reviewed the hearing ability of fish (e.g., Popper and Fay 1993, 2011; Popper et al. 2014, 2019a; Putland et al. 2019). At least two major pathways for sound transmittance between sound source and the inner ear have been identified for fish. The most primitive pathway involves direct transmission to the inner ear's otolith, a calcium carbonate mass enveloped by sensory hairs. The inertial difference between the dense otolith and the less-dense inner ear causes the otolith to stimulate the surrounding sensory hair cells. This motion differential is interpreted by the central nervous system as sound. The second transmission pathway between externally received sounds and the inner ear of fish is via the swim bladder, a gas-filled structure that is much less dense than the rest of the fish's body. The swim bladder, being more compressible and expandable than either water or fish tissue, will differentially contract and expand relative to the rest of the fish in a sound field. The pulsating swim bladder transmits this mechanical disturbance directly to the inner ear.

Some fish have been described as being hearing "generalists" or "specialists" where generalists conventionally detect sound to no more than 1-1.5 kHz and only detect the particle motion component of the sound field. Whereas specialists detect sounds above 1.5 kHz and detect both particle motion and pressure. However, Popper and Fay (2011) have suggested that the terms be dropped due to vagueness in the literature, and that the most common mode of hearing in fishes involves sensitivity to acoustic particle motion via direct inertial stimulation of the otolith organs. Additionally, they found that any possible sensitivities to pressure were the result of the presence of a swim bladder in the fish and that hearing sensitivity may be enhanced if the fish has a specific connection between the inner ear and the swim bladder (Popper and Fay 2011).

Popper and Fay (2011) have also noted that there is a range of hearing abilities across fish species that is like a continuum, presumably based on the relative contributions of pressure to the overall hearing abilities of a species. One end of this continuum is represented by fish that only detect particle displacement because they lack pressure-sensitive gas-filled body parts (e.g., swim bladder). These species include elasmobranchs (e.g., sharks) and jawless fish, and some teleosts including flatfish. Fish at this end of the continuum are typically capable of detecting sound frequencies <1.5 kHz (e.g., Casper et al. 2003; Casper and Mann 2006; 2007; 2009). The other end of the fish hearing continuum is represented by fishes with highly specialized otophysic connections between pressure receptive organs, such as the swim bladder, and the inner ear. These fishes include some squirrelfish, mormyrids, herrings, and otophysan fishes (freshwater fishes with Weberian apparatus, an articulated series of small bones that extend from the swim bladder to the inner ear). Rather than being limited to 1.5 kHz or less in hearing, these fishes can typically hear up to several kHz. One group of fish in the anadromous herring sub-family Alosinae (shads and menhaden) can detect sounds to well over 180 kHz (Mann et al. 1997, 1998, 2001). This is one of the widest hearing ranges of any vertebrate that has been studied to date. While the specific reason for this very high frequency hearing is not totally clear, there is strong evidence that this capability evolved for the detection of the ultrasonic sounds produced by echolocating dolphins to enable the fish to detect, and avoid, predation (Mann et al. 1997; Plachta and Popper 2003). All other fishes have hearing capabilities that fall somewhere between these two extremes of the continuum. Some have unconnected swim bladders located relatively far from the inner ear (e.g., salmonids, tuna) while others have unconnected swim bladders located relatively close to the inner ear (e.g., Atlantic cod, *Gadus morhua*).

Potential Impacts of Anthropogenic Sounds

Anthropogenic sounds can have important negative consequences for fish survival and reproduction if they disrupt an individual's ability to sense its soundscape, which often tells of predation risk, prey items, or mating opportunities (Fay 2009). Potential negative effects include masking of key environmental sounds or social signals, displacement of fish from their habitat, or interference with sensory orientation and navigation. These effects can generally be classified as behavioural, physiological, or pathological.

Behavioural effects refer to temporary and (if they occur) permanent changes in behaviour (e.g., startle and avoidance behaviour). Behavioural effects include changes in the distribution, migration, mating, and catchability of fish. Physiological effects involve temporary and permanent primary and secondary stress responses, such as changes in levels of enzymes and proteins. Pathological effects involve lethal and temporary or permanent sub-lethal injury. The three categories are interrelated in complex ways. For example, it is possible that certain physiological and behavioural changes could potentially lead to an ultimate pathological effect on individuals (i.e., mortality).

Impulsive Noise

In a review of studies on the effects of anthropogenic sound on fish, specifically those produced by pile driving, Hastings and Popper (2005) summarized behavioural, physiological, and pathological effects on multiple fish species, as well as gaps in knowledge in the context of fish, which is largely a topic that still requires further research. High intensity pile driving noise has potentially lethal and sublethal effects on fish, but previous studies often lack quantification, evidence of delayed mortality, or consistent results, as well as suggesting that results may be highly species-specific, thereby making extrapolation of results difficult (Hastings and Popper 2005; Popper and Hastings 2009).

The most common behavioural responses to anthropogenic noise are avoidance, alteration of swimming speed and direction, and alteration of schooling behaviour (Vabø et al. 2002; Handegard and Tjøstheim, 2005; Sarà et al. 2007; Becker et al. 2013). A study conducted by Harding et al. (2016) investigated the behavioural and physiological impacts to Atlantic salmon from additional noise of impact pile driving compared to ambient control conditions. Atlantic salmon have a swim bladder that only detects particle motion, and it is not used in hearing. This means that salmon are susceptible to barotrauma that involves particle motion, not sound pressure (Popper et al. 2014). Atlantic salmon are known to detect low frequency sounds below 380 Hz which coincides with the dominant frequencies produced during piling operations (100 Hz to 2 kHz). Therefore, construction projects using pile driving may have the potential to interact with multiple Atlantic salmon life stages (Harding et al. 2016). In the study, Harding et al. (2016)

performed laboratory-based experiments using underwater playback of pile driving noise to Atlantic salmon with a hydrophone positioned 10 cm above the bottom of the tank (water depth: 1 m) and a Sony PCM-M10 24-bit recorder (96 kHz sampling rate). Pile driving noise levels were between L_p 149.4-153.7 dB re 1µPa. The results showed that there were no observed differences in salmon behaviour when exposed to additional piling noise during experiments (Harding et al. 2016). Similar studies have also found that juvenile coho salmon displayed no avoidance behaviour from exposure to a real impact-piling event when positioned in cages that were positioned close to the noise source (Ruggerone et al. 2008; Harding et al. 2016). However, other studies did show behavioural effects in response to impulsive pile driving sounds on European seabass (*Dicentrarchus labrax*), including increased startle responses, swimming speeds, diving behaviours, school cohesion (Neo et al. 2014), and increased opercula beat rates (a sign of stress), increased energy expenditure on alert and defensive behaviours (e.g. inspection of the experimental area), as well as decreased inspection of possible predators (Spiga et al. 2017).

Physiological effects in fish due to pile driving and other sounds reviewed by Hastings and Popper (2005), although difficult to quantify, suggest that sublethal acoustic stressors, including vibratory sounds and increased background noise, may lead to increased stress chemicals, reduced fitness, and increased vulnerability to predation or other environmental pressures. Significant tissue damage in several fish species has been recorded in response to pile driving, primarily to the swim bladder or any air-filled structures, similar to effects from blasting (Caltrans 2004), but these results have not been consistently reproduced (Hastings and Popper 2005). Various studies have reported trauma to brain and neurological tissues, eyes, and blood vessels, including quantified studies by Hastings (1990, 1995) showing mortalities of goldfish after 2-hour continuous wave exposure (250 Hz, 204 dB re 1 µPa - peak) and of blue gouramis after 0.5-hour continuous wave exposure (150 Hz, 198 dB re 1 µPa - peak). Laboratory pile driving studies demonstrated swim bladder damage in Chinook salmon and documented tissue damage in other species (Halvorsen et al., 2012). A similar study saw ruptured swim bladders and/or kidney hemorrhaging in fish which had been exposed to ~96 pile strikes with a single-strike L_E of 183 dB (Casper et al. 2017). Casper et al. (2017) found that physical injuries sustained by the fish increased in both severity and number as the cumulative sound exposure level increased with a higher energy of each pile strike and total number of strikes.

Auditory structures have also been affected by pile driving sounds in the form of hearing loss as temporary or permanent threshold shifts, with observed losses in hearing and recovery times varying widely across species. While extreme caution in extrapolation of results is recommended by Hastings and Popper (2005), overall results suggest that limited exposure to high-intensity pile driving sounds is unlikely to result in mortality and any threshold shifts are likely to be temporary. Fish may also recover more quickly from hearing damage than other groups such as marine mammals due to the ability to regrow sensory hair cells (Simmonds and MacLennan 2005).

Blasting can produce high peak pressure waves that can cause immediate mortality and significant physical damage to fish, primarily to the swim bladder, as well as to the kidneys, liver, spleen, and sinus venosus. Effects are typically greater to fish with smaller body sizes, and damage can occur to fish eggs and larvae as well (Yelverton et al. 1975, Hastings and Popper 2005; Mahtab et al. 2005). Different types of pressure waves created by explosives decay at different rates, and distance and media through which the wave passes (e.g., onshore soil types) will affect attenuation and require detailed modeling to assess distances of disturbance (Mahtab et al. 2005).

Non-impulsive Noise

Continuous low intensity sounds produce largely behavioural changes in fish. Neo et al. (2014), which showed behavioural effects on European seabass (*Dicentrarchus labrax*) due to impulsive pile driving sounds, showed the same effects in response to acoustically equivalent continuous pile drilling sounds, but behavioural recovery times were significantly slower from intermittent sounds (i.e., pile driving) compared to continuous sounds (i.e. drilling). This suggests that the timing of acoustic disturbances is an important factor in impacts, not just cumulative acoustic energy. Spiga et al. (2017) observed similar differences in behavioural effects on European seabass between impulsive pile driving and continuous drilling noise disturbances, with drilling sounds resulting in a lower frequency of startle responses and quicker recovery times of normal predator-related behaviours. Continuous vibratory pile driving sounds were monitored in a harbour in Scotland in order to assess potential impacts to Atlantic salmon in important adjacent riverine habitats, and these produced received L_p between 142 and 155 dB re 1 µPa from source levels between L_p 173 and 185 dB re 1µPa in the immediate harbour area (Hawkings 2005). Effects to salmon were not directly observed, but sound levels from vibratory pile driving sounds were within hearing ranges of fish and posed potential risk to normal migration behaviours of nearby Atlantic salmon.

Vessel noise, which typically occurs at low frequencies thereby largely overlapping with the hearing ranges of fish (Popper and Fay 2011, Duarte et al. 2021), is another source of non-impulse sound which may elicit behavioural changes in fish. Startle and avoidance responses to vessel noise have been well documented (Simmonds and MacLennon 2005). A study by Nedelec et al. (2016) on the threespot damselfish (*Dascyllus trimaculatus*) observed increased ventilation rates and hiding behaviours in response to playback of vessel noise recordings, but also recorded development of tolerance (i.e., a trend toward normalcy in ventilation and hiding behaviour) of the vessel sounds with time. Vessel sounds and the resultant increased background noise level have also produced reduced predator detection and consequent increased mortality via predation, masking of vocalizations and important auditory cues and messages, and increased physiological stress (Simpson et al. 2016; Stanley et al 2017; Duarte et al. 2021). de Jong et al. (2020) also surmised that continuous sounds, such as those from heavy ship traffic, were mostly likely to cause stress, masking, and hearing loss rather than intermittent sounds.

Impact Assessment Methods

The proposed activities associated with the marine construction and operation of the LNG terminal have the potential to impact marine mammals and fish, mainly through the introduction of noise to the marine environment. In the sections below, we describe the methods used to determine the area within which animals may be exposed to sounds above threshold levels that could cause various levels of impact, such as potential injury or behavioural disturbance. For bottlenose dolphins, we then estimate the number of animals likely be present in this region of the Shannon Estuary. By applying that estimate to the area predicted to be exposed above threshold levels, we arrive at the number of potential disturbance or injurious exposures of bottlenose dolphins to the various project activities. This provides a quantitative measure of potential impacts upon which to base further assessment of overall impacts. Quantitative assessment of potential impacts to other species is limited by available data on the absolute abundance of those species in the project area, quantitative criteria for assessing impacts, or both. The main sources of data used in deriving the estimates are described in the next subsections.

Various assumptions had to be made to conduct the acoustic modeling regarding equipment and likely activity scenarios, as not all details were available at the time of the analysis. Similarly, we have made simplifying assumptions such as calculating a spatially uniform dolphin density and applying it throughout a year when there are likely spatial and seasonal differences in densities that would lead to, for example, lower exposure estimates during the winter compared with summer. In addition, it should be recognized that there are a number of limitations and uncertainties associated with TTS and PTS criteria for marine mammals (NMFS 2018). As described in the previous section (*Behavioural Effects*), behavioural responses can also be quite variable and influenced by the ecological context in which the sounds are encountered. Factors such as the life stage and activity state of the animal, nature and novelty of the sound, and spatial relationship to the sound can all affect the response of marine mammals (Ellison et al. 2012). Thus, as with all similar assessments, there are some uncertainties associated with the results of this study.

Acoustic Modeling of Project Activities

Acoustic modeling specific to the project site and activities was conducted by VG (2021). Several different scenarios and project activities were modeled at various positions as summarized in Table 2. Further details can be found in VG (2021). The scenarios range in complexity from a single activity like impact pile driving during construction in Scenario C1 to Scenario E, which involves multiple sources during the operational phase that is based on the offloading scenario, with the addition of a transiting cargo ship and moored ship. It is important to note the temporal duration and frequency of occurrence for each of these scenarios, which are described in the final column of Table 2. Some activities may produce strong sounds but only for brief periods of time and relatively infrequently. The temporal aspects of these activities and the sounds they produce play and important role in interpreting potential impacts.

Acoustic modeling used VG's survey mapping methodology, which calculates sound propagation along a number of transects (in this case, 15 transects from each of Position A and B) that are chosen to represent various bathymetric profiles with different sound propagation characteristics. Sound propagation took into account the bathymetry, tide level, seabed properties, and sound speed profile of the water column. The modeling resulted in sound propagation estimates for the various locations and activity scenarios. The distance along the various transects to the thresholds was determined, as well as the area to the thresholds. In general, the modeling results are expected to be representative of the vast majority of operations; however, there may be instances where either the equipment used or sound propagation conditions may vary from the modeling results.

Marine Mammals

Density of Bottlenose Dolphins in the Project Area

Since no bottlenose dolphin density estimates have been reported in previous studies and the available data collected from shore and via boat-based surveys do not lend themselves to determining a density using standard line-transect methodologies, we used the dolphin population size and areas in which they typically occur to calculate a density. Rogan et al. (2000) divided the Shannon Estuary into 4 Zones based on occurrence of dolphins. For our calculations, we used Zone 4, the zone farthest to the east where the proposed terminal would be constructed, as the area component to the density calculation (number of dolphins per unit area). Rogan et al. (2000) also reported that 13% of the dolphin population typically occurs within Zone 4. Thus, 13% of the current estimated population size of 145 individuals (as provided by Baker et al. 2018a) was assumed to occur in Zone 4. By dividing 13% of the current population (~19 animals) by the area of Zone 4 (35 km^2), we calculated a density of 0.54 dolphins/km^2 in Zone 4.

Table 2. Construction and operational scenarios that were modeled by VG (2021), and their associated activities and durations. Underlined activities produce impulsive sounds.

Project Phase	Acoustic Modeling Scenario[1]	Activities[2]	Modeling Location (Position)[3]	Activity Duration and Frequency of Occurrence
Construction	C1	<u>Impact pile driving</u>[4]	Marine Terminal (A)	60 min per pile, (2640 strikes per pile), Up to one pile per day
Construction	C2	Vibratory pile driving with support vessels	Marine Terminal (A)	*Vibratory piling*: 20 min per pile, up to one pile per day *Support vessels*: 1 jack-up rig (100% operation time), 1 crane barge (100% operation time), 1 tug (20% sailing, 80% idling), 1 crew boat (10% operation time)
Construction	C3	Socket drilling with support vessels	Marine Terminal (A)	Drilling: up to 25 h per pile, up to one pile per day *Support vessels*: 1 jack-up rig (100% operation time), 1 crane barge (100% operation time), 1 tug (20% sailing, 80% idling), 1 crew boat (10% operation time)
Construction	C4	<u>Blasting – onshore</u>[4]	Marine Terminal (A)	Single instantaneous event, up to one per day
Operations	A	Stationary FSRU emitting hull-radiated noise continuously, including noise from seawater cooling pumps	Marine Terminal (A)	Continuously for 24 h, 7 days a week.
Operations	B	FSRU with offloading LNGC tied to it and one idling tug	Marine Terminal (A)	Up to 35 h once per week
Operations	D	Approaching/Departing LNGC assisted by 4 transiting tugs, along with FSRU	LNGC and tugs: 1,150 m northwest of terminal (B) FSRU: (A)	15 min, one approach and one departure per week
Operations	E	FSRU together with an offloading LNGC and 4 sailing tugs, plus cargo ship sailing in the middle of the estuary at 10 knots and a ship moored at Moneypoint	FSRU and tugs: (A) Sailing cargo ship: middle of estuary Moored ship: Moneypoint	*FSRU*: continuously for 24 h *Offloading LNGC and idling tug*: 24 h. *Transiting LNGC and 4 sailing/engaged tugs*: 15 min *Sailing cargo ship*: 15 min *Moored ship*: 24 h Event may occur for 15 min once per week

[1] See VG (2021).

[2] Source levels are provided in Table 1.

[3] See Figure 1 *in* VG (2021).

[4] Impact piling and blasting were modeled without support vessels to avoid mixing impulsive and non-impulsive sounds.

We also considered an alternative source for the density calculation. Baker et al. (2018b) estimated ~25% of the population (~36 individuals) could use the inner estuary between Kilrush and Aughinish. As the inner estuary covers 338 km^2, the density based on this paper is 0.11 dolphins/km^2. To be conservative, we used the estimate derived from Rogan et al. (2000) described above, 0.54 dolphins/km^2.

Acoustic Thresholds

The NPWS (2014) has published *Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters*. Although this document discusses the acoustic threshold criteria recommended by Southall et al. (2007), it does not provide specific acoustic thresholds to be used in Irish waters. NPWS however does require a 1-km monitored/mitigation zone for marine mammals during pile driving activities, unless information specific to the project is available to inform the mitigation distance and is approved by the Regulatory Authority. The 1-km zone is to be monitored by an experienced and qualified marine mammal observer and pile driving cannot commence if marine mammals are detected within the 1-km zone around pile being driven. In this assessment, we have assumed the monitoring and mitigation measures described in NPWS (2014) for pile driving will be implemented during the relevant construction activities.

As there are no specific threshold criteria for use in Irish or EU waters at this time, for this assessment we use the threshold criteria set forth by the U.S. National Marine Fisheries Service (NMFS) in their *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2016, 2018) to assess the effects of noise on the hearing of marine mammals (Table 3). The thresholds for TTS and PTS onset (where PTS onset is considered the point at which injury or mortality becomes possible and is defined as "Level A" harassment in the U.S. Marine Mammal Protection Act) for marine mammals for impulsive sounds use dual metrics of cumulative sound exposure levels (over 24 h; expressed here as $L_{\mathrm{E,24h}}$) and peak sound pressure levels (expressed here as $L_{\mathrm{p,0\text{-}pk}}$). NMFS recommends that the largest distance of the dual criteria is used to calculate distances to potential injurious exposures. For non-impulsive sounds a single metric of $L_{\mathrm{E,24h}}$ is recommended (Table 3).

Different PTS and TTS thresholds are provided for various hearing groups and include the use of frequency weighting functions. Frequency weighting functions are used to assess potential auditory effects of sounds by taking into account the animal's hearing sensitivity to different frequencies (NMFS 2018). For example, MF-weighting is the auditory frequency-weighting function used for various species of marine mammals assigned to the "mid-frequency" category that includes bottlenose dolphins, HF-weighting is the function assigned to "high-frequency" species such as harbour porpoise, and PW-weighting is assigned to phocid pinnipeds underwater.

Also provided in Table 3 are the behavioural thresholds that are currently used by NMFS. The disturbance thresholds (termed "Level B" harassment in U.S. regulations) are unweighted (also referred to as "flat-weighted") received $L_{\mathrm{p,rms}}$ of 160 dB re 1 µPa for impulsive sounds and 120 dB re 1 µPa for non-impulsive sounds (NMFS 2019). However, NMFS has recently started to incorporate the use of frequency weighting into disturbance threshold calculations as well (NMFS 2021), since this approach allows more realistic assessment of potential behavioural responses.

Table 3. NMFS in-water acoustic thresholds for disturbance, TTS, and PTS for different marine mammal hearing groups (Source: NMFS 2018, 2019).

		Acoustic Thresholds			
		Impulsive Sounds		Non-Impulsive Sounds	
Marine Mammal Hearing Group	**Generalized Hearing Range**	**PTS Onset**	**TTS Onset**	**PTS Onset**	**TTS Onset**
Level A Criterion – PTS Onset					
Low-frequency cetaceans (LF)	7 Hz to 35 kHz	$L_{p,0\text{-}pk}$: 219 dB $L_{E,p,LF,24h}$: 183 dB	$L_{p,0\text{-}pk}$: 213 dB $L_{E,p,LF,24h}$: 168 dB	$L_{E,p,LF,24h}$: 199 dB	$L_{E,p,LF,24h}$: 179 dB
Mid-frequency cetaceans (MF)	150 Hz to 160 kHz	$L_{p,0\text{-}pk}$: 230 dB $L_{E,p,MF,24h}$: 185 dB	$L_{p,0\text{-}pk}$: 224 dB $L_{E,p,MF,24h}$: 170 dB	$L_{E,p,MF,24h}$: 198 dB	$L_{E,p,MF,24h}$: 178 dB
High-frequency cetaceans (HF)	275 Hz to 160 kHz	$L_{p,0\text{-}pk}$: 202 dB $L_{E,p,HF,24h}$: 155 dB	$L_{p,0\text{-}pk}$: 196 dB $L_{E,p,HF,24h}$: 140 dB	$L_{E,p,HF,24h}$: 173 dB	$L_{E,p,HF,24h}$: 153 dB
Phocid pinnipeds Underwater (PW)	75 Hz to 75 kHz	$L_{p,0\text{-}pk}$: 218 dB $L_{E,p,PW,24h}$: 185 dB	$L_{p,0\text{-}pk}$: 212 dB $L_{E,p,PW,24h}$: 170 dB	$L_{E,p,PW,24h}$: 201 dB	$L_{E,p,PW,24h}$: 181 dB
Level B Criterion – Disturbance					
Behavioural disruption for impulsive noise (e.g., impact pile driving, blasting)			$L_{p,rms}$: 160 dB		
Behavioural disruption for continuous noise (e.g., vibratory pile driving, vessel noise, drilling)			$L_{p,rms}$: 120 dB		

The acoustic propagation modeling conducted by VG (2021) for this project applied weighting to $L_{p,rms}$ and $L_{E,24h}$ values. Even with the application of frequency-weighting functions to established disturbance thresholds, behavioural responses are complex and often context dependent, such that some individuals may respond at lower received levels, while others will not respond until received levels are above the threshold. Alternative threshold and approaches, including probability of response curves and multiple step functions to describe the likelihood and severity of responses are under consideration by regulatory bodies, but no new criteria have been finalized.

Estimation of Exposures

To determine the number of individuals potentially exposed to the specified threshold levels we multiplied the estimated dolphin density by the area potentially exposed to sounds above the threshold levels. For example, the number of dolphins potentially exposed above disturbance thresholds, or "disturbance exposures", are calculated by multiplying the dolphin density (0.54 dolphins/km^2) by the area around the activity where received $L_{p,rms}$ ≥160 dB or ≥ 120 dB are predicted to occur for impulsive and non-impulsive sound, respectively. Similarly, the number of individuals potentially exposed above PTS thresholds, or "PTS exposures" are based on the multiplication of the density of dolphins by the area around the activity where received levels of sound were modeled to exceed $L_{p,0\text{-}pk}$ 230 dB or $L_{E,MF,24h}$ 185 dB for impulsive sound and $L_{E,MF,24h}$ 198 dB for non-impulsive sound. The same calculations were made using the areas potentially exposed above TTS thresholds to calculate "TTS exposures".

In cases where the calculation results in a value of less than one individual it can be interpreted as the probability of an individual being exposed to a single occurrence of that event. For instance, if it is calculated that 0.1 dolphins may be exposed above the PTS threshold from a certain activity, then there is a 10% chance that a dolphin would be exposed during any single occurrence of that activity. And if that activity were to occur 10 times, then it would be reasonable to expect that a single dolphin might be exposed over the course of all ten occurrences combined.

However, since calculations that rely on density estimates do not always adequately reflect species that tend to occur in groups, we also provide estimates based on exposures of dolphin groups using the mean group size of ~6.2 ± 3.1 individuals as a worst-case scenario for potential exposures. As sightings of other marine mammal species in the Shannon Estuary are limited, meaningful densities, group sizes, or estimates of frequency of occurrence were not available. Thus, assessment of potential impacts to these species are qualitative in nature.

Fish

Acoustic Thresholds

Popper et al. (2014) provided acoustic thresholds for various impulsive sound sources, such as pile driving (Table 4). The sound levels expected to cause mortality and potential mortal injury during in-water explosions are $L_{p,0\text{-}pk}$ 229–234 dB (Popper et al. 2014). For non-impulsive sounds, Popper et al. (2014) only provides quantitative thresholds for fish with swim bladders involved in hearing; relative risks from continuous sounds for other fish groups are also provided as shown in Table 5.

Table 4. Acoustic thresholds and relative risk for impact pile driving for various fish hearing groups (Source: Popper et al. 2014).

	Acoustic Thresholds for Pile Driving			
	Mortality and Potential Mortal Injury	Impairment		
Type of Fish		Recoverable Injury	TTS	Behaviour
No swim bladder (particle motion detection)	$L_{p,0\text{-}pk}$: >219 dB $L_{E,p,24h}$: >213 dB	$L_{p,0\text{-}pk}$: >213 dB $L_{E,p,24h}$: >216 dB	$L_{E,p,24h}$: *>>186 dB*	(N) High; (I) Moderate; (F) Low
Swim bladder is not involved in hearing (particle motion detection)	$L_{p,0\text{-}pk}$: >207 dB $L_{E,p,24h}$: 210 dB	$L_{p,0\text{-}pk}$: >207 dB $L_{E,p,24h}$: 203 dB	$L_{E,p,24h}$: *>186 dB*	(N) High; (I) Moderate; (F) Low
Swim bladder involved in hearing (primarily pressure detection)	$L_{p,0\text{-}pk}$: >207 dB $L_{E,p,24h}$: 207 dB	$L_{p,0\text{-}pk}$: >207 dB $L_{E,p,24h}$: 203 dB	$L_{E,p,24h}$: *186 dB*	(N) High; (I) High; (F) Moderate
Eggs and larvae	$L_{p,0\text{-}pk}$: >207 dB $L_{E,p,24h}$: >210 dB	(N) Moderate; (I) Low; (F) Low	(N) Moderate; (I) Low; (F) Low	(N) Moderate; (I) Low; (F) Low

(N) = near or tens of metres from the source; (I) = intermediate or hundreds of metres from the source; (F) = far or thousands of meters from the source.

Table 5. Acoustic thresholds or relative risk of continuous sounds such as shipping for various fish hearing groups (Source: Popper et al. 2014). Relative risk (high, moderate, low) is given for fish at three distances from the source.

Type of Fish	Mortality and Potential Mortal Injury	Impairment: Recoverable Injury[1]	Impairment: TTS[1]	Behaviour
No swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Moderate (F) Low
Swim bladder is not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Moderate (F) Low
Swim bladder involved in hearing (primarily pressure detection)	(N) Low (I) Low (F) Low	170 dB_{rms} re 1 µPa for 48 h	158 dB_{rms} re 1 µPa for 12 h	(N) High (I) Moderate (F) Low
Eggs and Larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Moderate (F) Low

[1] Criteria are presented as sound pressure since no data are available for particle motion.
(N) = near or tens of metres from the source; (I) = intermediate or hundreds of metres from the source; (F) = far or thousands of meters from the source.

Impact Assessment Results

Here we present results from the acoustic modeling of areas potentially exposed above the threshold levels and the number of animals potentially present within those areas. As noted in the Methods section, bottlenose dolphins were the only species with quantitative estimates of abundance in the project area. Thus, they are the only species for which estimates of the number of individuals that could potentially be exposed to sounds above disturbance thresholds during the construction and operational phases of the project are provided. The disturbance exposure estimates would primarily involve temporary changes in behaviour. Also provided are the exposure estimates for TTS. Although PTS or other injuries are not expected because of the relatively small distances and monitoring and mitigation measures that would be implemented, the results of those calculations are also presented for completeness.

Marine Mammals

Construction

Impulsive sounds from pile driving reached the PTS and TTS threshold criteria for bottlenose dolphins at distances up to 94 m and 786 m, respectively (Table 6). Given these relatively short distances and the low density of dolphins, daily (or per event) PTS and TTS exposures from impact pile driving were <1. As noted previously, when the calculated number of exposures from a given event is less than one, it should be interpreted as the probability of exposing a single animal during that given event. To understand the likelihood of exposure across all of the planned impact piling we multiplied the per event exposure estimates by the number of impact piling events (203); this resulted in 2 exposures above the PTS criterion and 88 exposures above the TTS criterion. Implementation of monitoring and mitigation measures (NPWS 2014) as planned will further reduce the very low potential for PTS or TTS exposures calculated here.

For harbour porpoise, impact pile driving activities also have the potential to cause auditory impairment, with PTS possible within 3163 m and TTS possible within 7640 m (Table 7). The same is true for harbour seals, but the distances are substantially shorter (Table 8). In both cases, these distances result from the cumulative sound exposure ($L_{E,P,24h}$) criteria, which means that individuals of these species would have to remain within those distances the entire 60 min duration of pile driving to experience such effects.

Neither of the non-impulsive sounds from construction activities (vibratory pile driving or socket drilling) reached the threshold criteria for potential PTS or TTS for bottlenose dolphins (Table 6). For harbour porpoise and harbour seal, the $L_{E,P,24h}$ TTS threshold distance extended to 604 m and 84 m for socket drilling (Scenario C3). As noted for the impact pile driving $L_{E,P,24h}$ thresholds, an individual animal would need to remain within those distances for the entire duration of the event, a full day (24 h) in this case, which is highly unlikely.

The very low likelihood that any marine mammals will be exposed above PTS or even TTS thresholds means that most potential impacts are likely to be through behavioural disturbance. For impact pile driving, the distance to the MF-weighted behavioural threshold of $L_{\mathrm{p,rms}}$ 160 dB occurred at locations up to 138 m away and over an area of ~0.04 km^2 (Table 6; Fig. 2c). A similar distance was estimated for the socket drilling scenario (118 m), and a negligible 2 m distance was estimated for vibratory pile driving (Table 6). When the areas exposed above these levels were multiplied by the bottlenose dolphin density, less than one daily disturbance exposure is expected to result from any of the construction activities (Table 6). If one pile is driven in a 24-h period and a total of 203 piles are expected to be driven during the project, then the exposure estimate for disturbance over the course of the construction period from all impact pile driving would sum to a total of four individuals. For socket drilling, it was estimated that there could be up to three total disturbance exposures over the course of pile installation.

Alternatively, if we assume that at least one exposure would occur each day of pile installation (203 days) and that each exposure would involve an entire group of dolphins (average of 6.2 ± 3.1 individuals), then there could be 1259 disturbance level exposures (range 629–1888) during pile installation activities.

The modeled distances to disturbance thresholds from construction activities for HF-cetaceans (Table 7) were similar to those of bottlenose dolphins, while quite a bit larger for seals (Table 8). Given the low frequency of occurrence of these species in the Shannon Estuary, it is likely that only a few individuals, if any, would be disturbed by sounds produced during construction activities.

Table 6. Threshold criteria, distances and areas to thresholds, and exposure estimates for bottlenose dolphins during various Shannon LNG project construction activities using *MF-weighted* modeling results for assessing potential PTS and disturbance. Impact pile driving and onshore blasting are impulsive sounds, whereas vibratory pile driving and drilling are continuous sounds.

	C1 - Impact Pile Driving	C4 - Onshore Blasting	C2 - Vibratory Pile Driving Plus Support Vessels	C3 - Socket Drilling Plus Support Vessels
Disturbance				
Threshold MF-weighted (dB)	160	160	120	120
Max. distance to threshold (m)	138	-	2	118
Area within threshold (km^2)	0.038	-	2.369E-06	0.025
PTS				
PTS threshold $L_{E,p,MF,24h}$ (dB)	185	185	198	198
Max. Distance to PTS $L_{E,p,MF,24h}$ threshold (m)	94	-	-	-
Area within $L_{E,p,MF,24h}$ threshold (km^2)	0.020	-	-	-
PTS threshold $L_{p,0\text{-}pk}$ (dB)	230	230	-	-
Max. Distance to PTS threshold $L_{p,0\text{-}pk}$ (m)	-	-	-	-
Area within PTS $L_{p,0\text{-}pk}$ threshold (km^2)	-	-	-	-
TTS				
TTS threshold $L_{E,p,MF,24h}$ (dB)	170	170	178	178
Max. Distance to TTS $L_{E,p,MF,24h}$ threshold (m)	786	-	-	-
Area within $L_{E,p,MF,24h}$ threshold (km^2)	0.808	-	-	-
TTS threshold $L_{p,0\text{-}pk}$ (dB)	224	224	-	-
Max. Distance to TTS threshold $L_{p,0\text{-}pk}$ (m)	-	-	-	-
Area within TTS $L_{p,0\text{-}pk}$ threshold (km^2)	-	-	-	-
Occurrence of activity	1 pile per day; total 203 piles^	1 blasting event per day	20 min per pile	25 h per pile
Disturbance Exposures*				
Daily exposures	0.020	0	1.276E-06	0.013
Total exposures	4.140	0	2.590E-04	2.724
PTS exposures*				
$L_{E,p,MF,24h}$	0.011	0	0	0
$L_{p,0\text{-}pk}$	0	0	-	-
TTS exposures*				
$L_{E,p,MF,24h}$	0.435	0	0	0
$L_{p,0\text{-}pk}$	0	0	-	-

- not applicable or sounds did not reach threshold.

*Exposure calculations are based on the affected area x dolphin density of 0.54 dolphins/km^2.

^ Number of piles and piling rate are estimated and subject to weather, construction technology, and other considerations.

Table 7. Threshold criteria and distances to thresholds for high-frequency cetaceans during various Shannon LNG project activities for assessing potential harm and disturbance.

	Construction				Operation			
	C1 - Impact Pile Driving	C4 - Onshore Blasting	C2 - Vibratory Pile Driving Plus Support Vessels	C3 - Socket Drilling Plus Support Vessels	A - FSRU	B - FSRU with Offloading	D - LNGC Approach/ Depart	E - Cumulative Sound
Disturbance								
Threshold HF-weighted (dB)	**160**	**160**	**120**	**120**	**120**	**120**	**120**	**120**
Max. distance to threshold (m)	77	-	-	110	76	77	988	802
PTS								
PTS threshold $L_{E,p,HF,24h}$ (dB)	**155**	**155**	**173**	**173**	**173**	**173**	**173**	**173**
Max. Distance to PTS $L_{E,p,HF,24h}$ threshold (m)	3163	-	-	-	-	50	-	50
PTS threshold $L_{p,0\text{-}pk}$ (dB)	**202**	**202**	-	-	-	-	-	-
Max. Distance to PTS threshold $L_{p,0\text{-}pk}$ (m)	-	-	-	-	-	-	-	-
TTS								
TTS threshold $L_{E,p,HF,24h}$ (dB)	**140**	**140**	**153**	**153**	**153**	**153**	**153**	**153**
Max. Distance to TTS $L_{E,p,HF,24h}$ threshold (m)	7640	-	-	604	50	564	222	564
TTS threshold $L_{p,0\text{-}pk}$ (dB)	**196**	**196**	-	-	-	-	-	-
Max. Distance to TTS threshold $L_{p,0\text{-}pk}$ (m)	-	-	-	-	-	-	-	-

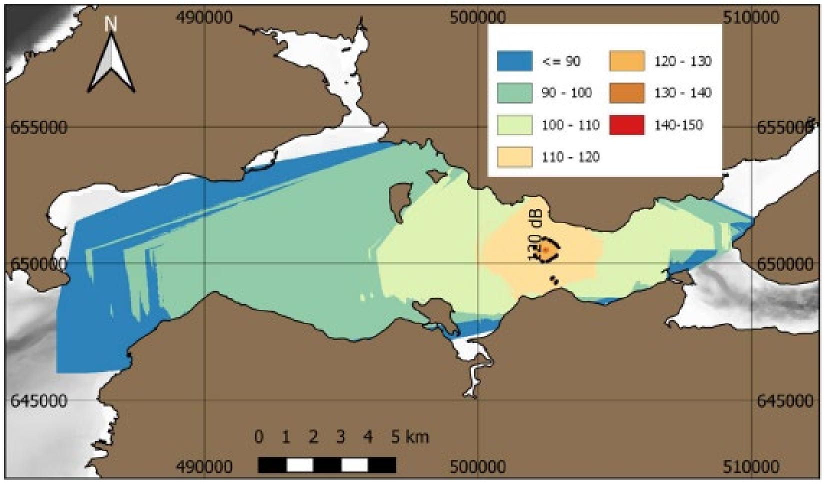
"-" means sounds did not reach above the threshold.

Table 9. Threshold criteria and distances to thresholds for phocid pinnipeds during various Shannon LNG project activities for assessing potential harm and disturbance.

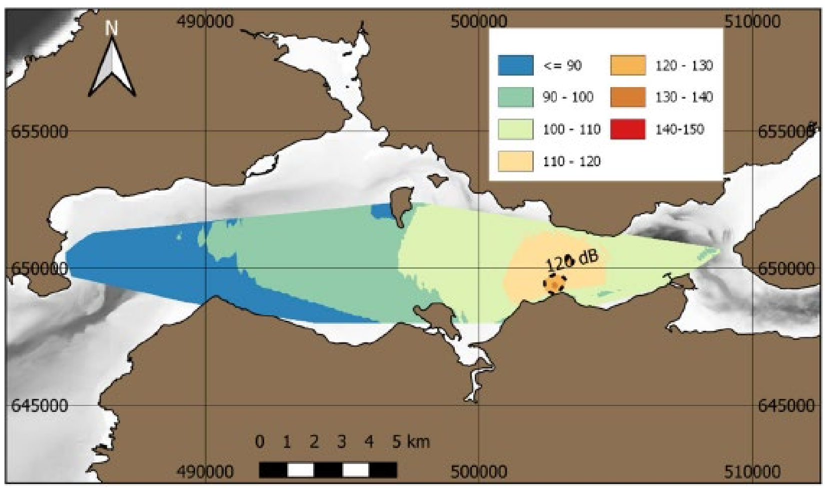
	Construction				Operation			
	C1 - Impact Pile Driving	C4 - Onshore Blasting	C2 - Vibratory Pile Driving Plus Support Vessels	C3 - Socket Drilling Plus Support Vessels	A - FSRU	B - FSRU with Offloading	D - LNGC Approach/ Depart	E - Cumulative Sound
Disturbance								
Threshold PW-weighted (dB)	**160**	**160**	**120**	**120**	**120**	**120**	**120**	**120**
Max. distance to threshold (m)	937	75	737	368	549	554	2797	1922
PTS								
PTS threshold $L_{E,p,PW,24h}$ (dB)	**185**	**185**	**201**	**201**	**201**	**201**	**201**	**201**
Max. Distance to PTS $L_{E,p,PW,24h}$ threshold (m)	590	-	-	-	-	-	-	-
PTS threshold $L_{p,0\text{-}pk}$ (dB)	**218**	**218**	-	-	-	-	-	-
Max. Distance to PTS threshold $L_{p,0\text{-}pk}$ (m)	-	-	-	-	-	-	-	-
TTS								
TTS threshold $L_{E,p,PW,24h}$ (dB)	**170**	**170**	**181**	**181**	**181**	**181**	**181**	**181**
Max. Distance to TTS $L_{E,p,PW,24h}$ threshold (m)	4010	-	-	84	-	116	-	116
TTS threshold $L_{p,0\text{-}pk}$ (dB)	**212**	**212**	-	-	-	-	-	-
Max. Distance to TTS threshold $L_{p,0\text{-}pk}$ (m)	-	-	-	-	-	-	-	-

"-" means sounds did not reach above the threshold.

(a)



(b)



(c)

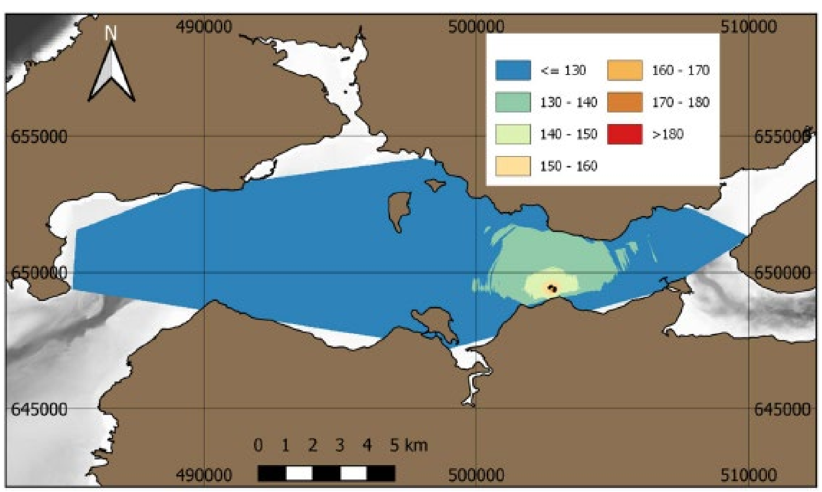


Figure 2. Sound contour map of $L_{p,rms}$ (MF-weighted, "Max-over-depth") for (a) Scenario D (FSRU with approaching LNGC and four tugs), (b) Scenario E (cumulative sound scenario), and (c) Scenario C1 (impact pile driving). Values in dB re 1 µPa.

Operations

None of the non-impulsive sounds from operational activities reached the threshold criteria for potential PTS for bottlenose dolphins (Table 7). Although modeling estimated a slight possibility of TTS based on the $L_{E,p,MF,\ 24h}$ TTS criterion (within 41 m of the activity for the entire duration of the activity) on a daily basis from offloading activities (Scenario B) and the cumulative scenario (Scenario E), exposure estimates were still less than 1 individual when summed over the course of 1 year.

TTS is a possibility for harbour porpoise during all operational scenarios at distances ranging from 50 m to 564 m (Table 7), while PTS is only possible within 50 m of the offloading and cumulative scenarios (Scenarios B and E). No PTS is expected in seals from operational activities, but TTS may be possible within 116 m from the offloading and cumulative sound scenarios (Table 8).

Acoustic modeling estimated that out of all of the scenarios, Scenario D (an approaching LNGC with four tugs) would create the largest area ensonified above the MF-weighted behavioural threshold of $L_{\mathrm{p,rms}}$ 120 dB (Table 10; Fig. 2a). The area ensonified by sounds from the approaching LNGC and tugs is estimated to be ~0.6 km^2 as it travels along its path from a point 1,150 km from the FSRU. The next largest impact area was estimated for Scenario E (cumulative scenario), for which the behavioural threshold would be exceeded at locations up to 939 m away over an area of 0.4 km^2 (Table 10; Fig. 2b).

The disturbance exposures of bottlenose dolphins were higher for operational activities than for construction activities. Although daily exposures were still calculated to be less than 1, it was estimated that there could be between 1 and 34 individuals behaviourally disturbed each year across the four operational scenarios (Table 10). Alternatively, if we assume that at least 1 behavioural disturbance exposure of an average-sized group of dolphins could occur each day during the various operational activities, the disturbance exposures would be 2263 animals for the FSRU operation (Scenario A), 645 exposures during LNGC approach/departure (Scenario D), and 322 exposures for the offloading and cumulative sound scenarios (Scenarios B and E).

An approaching LNGC with four tugs (Scenario D) resulted in the longest estimated distance (up to 988 m away) to the HF-weighted behavioural disturbance threshold ($L_{\mathrm{p,rms}}$ 120 dB). The 802 m distance for the cumulative sound scenario (Scenario E) was the next largest. Similarly, for seals, the PW-weighted $L_{\mathrm{p,rms}}$ 120 dB distance resulting from the LNGC approach was the largest and could extend up to 2797 m away, which was followed by the cumulative scenario (Scenario E) at 1922 m (Table 10). As noted in the previous section, the infrequent occurrence of these species in the estuary makes the likelihood of disturbing individuals quite low, despite the longer distance to threshold levels compared to bottlenose dolphins.

Table 10. Threshold criteria, distances and areas to thresholds, and exposure estimates for bottlenose dolphins during various Shannon LNG project operations activities using *MF-weighted* modeling results for assessing potential disturbance, PTS, and TTS. All sounds produced by operational activities are considered continuous.

	A - FSRU	B - FSRU with Offloading	D - LNGC Approach/ Depart	E - Cumulative Sound
Disturbance				
Threshold MF-weighted (dB)	120	120	120	120
Max. distance to threshold (m)	112	113	983	939
Area within threshold (km²)	0.031	0.031	0.601	0.440
PTS				
PTS threshold $L_{E,p,MF,24h}$ (dB)	198	198	198	198
Max. Distance to PTS $L_{E,p,MF,24h}$ threshold (m)	-	-	-	-
Area within $L_{E,p,MF,24h}$ threshold (km²)	-	-	-	-
TTS				
TTS threshold $L_{E,p,MF,24h}$ (dB)	178	178	178	178
Max. Distance to TTS $L_{E,p,MF,24h}$ threshold (m)	-	41	-	41
Area within $L_{E,p,MF,24h}$ threshold (km²)	-	0.003	-	0.003
Occurrence of activity	Continuous	Once per week	15 min twice per week	Once per week at most
Disturbance exposures*				
Daily exposures	0.017	0.017	0.324	0.237
Weekly exposures	0.116	0.017	0.648	0.237
Yearly exposures	6.037	0.881	33.683	12.320
PTS $L_{E,p,MF,24h}$ exposures*	0	0	0	0
TTS $L_{E,p,MF,24h}$ exposures*	0	0.002	0	0.002

- sounds did not reach threshold.

*Exposure calculations are based on the affected area x dolphin density of 0.54 dolphins/km².

Fish

Construction

Fish could experience PTS, TTS or other injury from impact pile driving activities, with fish that use their swim bladder for hearing, such as Twaite shad, being more susceptible to potential effects than other types of fish. For fish that use their swim bladder for hearing, as well as for fish eggs and larvae, mortalities could occur within 142 m of impact pile driving, whereas TTS is possible within ~2 km of impact pile driving (Table 11). Blasting is expected to introduce sound pressure levels into the water of up to $L_{p,o\text{-}pk}$ 207 dB (VG 2021). As the threshold for mortality and potential mortal injury is $L_{p,o\text{-}pk}$ 229–234 dB, no mortalities are expected from blasting for fish in any hearing groups.

Fish without a swim bladder or those whose swim bladder is not involved in hearing have a moderate risk of behavioural disturbance within hundreds of metres during pile driving (Table 5). The risk of behavioural disturbance is also moderate for fish without a swim bladder exposed to blasting sounds. For fish that have a swim bladder involved in hearing, the risk becomes high within hundreds of metres from impact pile driving, whereas fish without swim bladders and those not involved in hearing are only at high risk of behavioural disturbance within tens of metres from impact pile driving (Table 5).

Operations

Based on the thresholds for continuous sounds from Popper et al. (2014) for fish that have swim bladders involved in hearing, none of the sound levels from the modeled activities have the potential to cause injury. TTS is also unlikely during activities emitting non-impulsive sound, as sound levels would have to be $L_{p,rms}$ 158 dB for 12 h. The cumulative sound scenario is the only activity that is close to producing such levels (up to $L_{p,rms}$ 160 dB; see VG 2021), but as this is a multiple-source scenario, and not all the sources would be emitting sound for 12 h, it is unlikely that this threshold level would be reached. For fish eggs, larvae, and fish that have no swim bladders or their swim bladders are not involved in hearing, the risk of injury or TTS is low at distances of hundreds of metres from the source. At tens of metres, the risk of injury is still low, but the risk of TTS for those types of fish is moderate.

The risk of behavioural disturbance is low for all of the fish hearing groups, including eggs and larvae, when exposed to impulsive or continuous sounds thousands of metres from the source (Table 5). However, the potential for behavioural disturbance for all types of fish is moderate at hundreds of metres from a continuous sound source. For fish that use their swim bladder for hearing, the risk of behavioural disturbance within tens of metres from a continuous sound source is high.

Table 11. Distances to threshold criteria for fish during various Shannon LNG project activities using *unweighted* modeling results for assessing potential harm. Thresholds for pile driving from Popper et al. (2014).

	Impact Pile Driving				
	Mortality and potential mortal injury		Recoverable Injury		TTS 186 dB
	$L_{p,0\text{-}pk}$	$L_{E,p,24h}$	$L_{p,0\text{-}pk}$	$L_{E,p,24h}$	$L_{E,p,24h}$
No swim bladder (e.g., lampreys)	**>213:** 42 m	**>219:** 25 m	**>213:** 42 m	**>216:** 46 m	2041 m
Swim bladder not used for hearing (e.g., salmon)	**>207:** 85 m	**210:** 97 m	**>207:** 85 m	**203:** 232 m	2041 m
Swim bladder used for hearing (e.g., shad)	**>207:** 85 m	**207:** 142 m	**>207:** 85 m	**203:** 232 m	2041 m

Discussion

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound, as we have done here. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner, as animals tend to move away from loud sound sources before the sound level is at or above the threshold.

Although two potential PTS exposures have been estimated for bottlenose dolphins from impact pile driving over the course of all pile driving activity, no PTS or other injuries would be expected because of the relatively short distance (94 m) to the threshold criteria and the monitoring and mitigation measures that would be implemented. Monitoring and mitigation measures would follow those in the NPWS (2014) guidance and would lower the likelihood of impacts from construction activities. Although PTS was modeled to be a possibility relatively far from impact pile driving (up to 3163 m) for harbour porpoise, these cetaceans rarely occur within the Shannon Estuary.

Monitoring and mitigation measures during project construction would include the use of qualified marine mammal observers to monitor during sub-tidal piling operations, and the commencement of piling would be delayed if the observers sight any marine mammals within 1,000 m of the site for 30 min prior to the planned start of piling. Since impact piling cannot always be stopped immediately if a marine mammal approaches once piling has commenced, some potential for impacts would remain, including potential for TTS. Nonetheless, the 1,000-m mitigation zone is overly precautionary given that the MF-weighted PTS threshold was modeled to occur out to a maximum distance of 94 m.

During operations, the PTS and TTS thresholds that could be exceeded by the activities are all based on accumulated sound over a period of time (sound exposure levels). This means that individuals would have to remain within the predicted distances for the entire duration of the activity, or for at least 24 h if the activity lasts longer than a day, in order to experience TTS or PTS. Additionally, the operational scenarios often involved multiple sources operating in different locations. This means that the distances calculated are not continuous in all directions around any one of the sources, resulting in gaps where received sound levels would be below the threshold levels. These factors, along with the highly mobile nature of marine mammals means that it is very unlikely that any marine mammals will experience PTS or even TTS from the planned activities.

Using the available information on dolphin abundance and distribution within the Shannon Estuary, we have estimated that there are likely to be very few daily instances of bottlenose dolphins (or other marine mammals) being affected via disturbance during either construction or operational activities associated with the Shannon LNG project. For all construction activities, and most of the operational scenarios, distances to disturbance thresholds would be less than 140 m. Since the location where the in-water structures will be installed and the immediate vicinity around that are not known to be important feeding or calving areas, temporary avoidance at these distances is not likely to have significant impacts. In addition, strong impulsive sounds from impact pile driving would occur over relatively short periods of time (1 h per day, or 4% of the time), leaving most of the time available for undisturbed movements through the area. Similarly, the two operational scenarios with disturbance threshold distances of almost 1 km, Scenarios D and E, would only occur for relatively short periods of time (less than 1 h per day) and infrequently (up to 3 times per week). The temporal aspects (limited duration and infrequent occurrence) of these most potentially behaviourally disruptive activities mean they are unlikely to substantially disrupt important marine mammal behaviours that might occur in this region of the estuary. Since dolphins are highly mobile within the estuary and operations will occur over many years, it is likely that all individuals in the population could be exposed at some point in time to noise from the project. Nonetheless, the potential disturbance exposures likely would have no more than a minor effect, such as localized short-term avoidance of the area around the activities by individual animals and no effect on the population.

Our analysis method used MF-weighting for estimating potential disturbance exposures since it emphasizes the frequencies that are of most relevance to bottlenose dolphins. However, Kastelein et al. (2015, 2016) reported that harbour porpoise (an HF cetacean) hearing sensitivity was reduced when exposed to multiple impulsive pile-driving sounds with most energy at low frequencies. These findings suggest that there could be potentially greater impacts of LF sounds on bottlenose dolphins than expected. Nonetheless, exposure estimates based on group size are almost certainly overestimates, and there is no indication that the project activities would be likely to cause significant harm to individuals or the population.

The population of bottlenose dolphins in the Shannon Estuary has remained stable for the past 20 years and has demonstrated evidence of long-term fidelity and seasonal residency despite inhabiting a busy and noisy region with various industrial activities, such as ferry traffic and shipping (Ingram 2000; Ingram and Rogan 2002; Englund et al. 2007, 2008; Rogan et al. 2018). Thus, it is anticipated that the dolphins in the vicinity of the project would likely habituate to the sounds produced during project activities as they have to other similar noise and vessel traffic in the estuary. Habituation of bottlenose dolphins to noise has been shown to occur elsewhere. For example, in Aberdeen Harbour, Scotland, an area with high vessel activity, bottlenose dolphins showed a change in normal behaviour around boats, but rarely left the area; this type of response suggested habituation and tolerance, especially due to the estuary's importance for prey availability (Sini et al. 2005).

Although there is some indication that fish (especially those with swim bladders used in hearing) within hundreds of metres of impact pile driving could be at high risk of disturbance or even potentially experience injury or TTS, impact piling would occur for a relatively short duration (60 min) for each pile, once per day. Thus, impact pile driving is unlikely to hinder fish migration, and for most fish, the distances within which mortality and/or mortal injuries could occur are relatively small and should not impact the overall populations if these types of effects were to take place. Although continuous sounds during project construction and operation have little likelihood of causing injury or TTS in fish, fish that use their swim bladder for hearing could potentially be at high risk of disturbance near those sound sources. It is possible that the continuous noise emission from the FSRU during project operation could cause fish to avoid the immediate area around the FSRU, but avoidance behaviour would likely be restricted within tens of metres from the FSRU.

In summary, the proposed construction and operational activities associated with Shannon LNG are similar to other activities that currently occur routinely within the estuary and are therefore unlikely to have adverse effects that could impact populations of marine mammals or fish in the long-term. The most potentially impactful activity on marine mammals and fish during construction would be impact pile driving because of the potential for PTS in marine mammals and injury or mortality in fish, but this would be of limited duration and impacts will be mitigated in multiple ways. Additionally, there is no evidence to suggest that the project site provides critical habitat for bottlenose dolphins (Berrow et al 2020) so avoidance of these activities would be unlikely to have significant impacts. During operations, underwater sounds would be created by vessel traffic and contribute to the pre-existing ambient noise within the estuary. The cumulative sound scenario and approaching/departing LNGC have the largest distances to behavioural disturbance thresholds during operations, but both scenarios would occur only briefly up to 3 times per week, and only if other vessels are located within the vicinity of the project site. Once the other power stations located in the Shannon Estuary shut down, there would be even less potential for cumulative effects from the proposed activities and existing shipping activities occurring in the estuary. In addition, harbour porpoise and grey seals rarely occur in the Shannon Estuary, and harbour seals are uncommon. Thus, any effects from project activities are expected to be minor, temporary, and localized to the area immediately around the terminal, with no long-term effects on marine mammal or fish populations.

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Appendix 6

Marine Mammal Monitoring Reports

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract started in April 2020 and will run until September 2020

Fieldwork included:

i) SAM at two sites
ii) Weekly VP watches
iii) Input into Ocean Noise Monitoring
iv) Recovery of lost CPODS

i) SAM – two CPODs deployed at same location as earlier monitoring which is consistent with previous EIS for Shannon LNG. Deployments were on acoustic releases (Sonardyne LRT) to avoid interference and keep away from strong currents. CPODs will be recovered in first week of June 2020.

Monitoring Site	Date Deployed	Date Recovered
LNG 1	3 April 2020	Early June 2020
LNG 2	3 April 2020	Early June 2020

ii) Weekly VP watches – weekly watches have been carried out successfully in good sea conditions. Watches were conducted from Ardmore Point. Sightings of bottlenose dolphins were recorded on 3 of the 7 watches to date. On one occasion, (9 May) images suitable for photo-id were captured from land. On two occasions, the IWDG RIB was also on the water and on one occasion (9 May) captured images for photo-id of those dolphins seen off Ardmore Point.

Date	Time started	Duration (minutes)	Sightings
3 April 2020	14:00	240	0
8 April 2020	12:00	360	2
15 April 2020	12:00	360	0
23 April 2020	12:00	360	5
28 April 2020	12:30	360	0
9 May 2020	13:00	360	3
14 May 2020	12:00	360	0

iii) Input into Noise Monitoring – Simon Berrow had two calls regarding methodology for acquiring ocean noise data. One with Brendan O'Connor of Aquafact and a Zoom call with Aquafact and Lloyds Registry. Aquafact will be carrying out fieldwork.

iv) Recovery of lost CPODs – A commercial diver (Shay Clancy) was engaged to dive on the site of the lost CPODs (LNG1 and LNG2). This was carried out at low water on 14 and15 May. A circular search pattern of 15m radius of the waypoints was conducted. Visibility was good (2-3m) and the diver on both dives located the current CPOD deployment but unfortunately not the missing CPODs.

Future Tasks

We will continue with weekly VP watches. CPODs are to be recovered during the first week in June and replaced with new deployment.

The data from the current deployment will be added to the current collected dataset and modelled for input into the EIA/NIS.

Dr Simon Berrow, IWDG Project Manager
17 May 2020

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract started in April 2020 and will run until September 2020

Fieldwork included:

i) SAM at two sites

ii) Weekly VP watches

i) SAM – two CPODs deployed at same location as earlier monitoring which is consistent with previous EIS for Shannon LNG. Deployments were on acoustic releases (Sonardyne LRT) to avoid interference and keep away from strong currents. CPODs were recovered on 1 June 2020 and re-deployed 2 June. This deployment will last 3 months and are due for recovery early September

Monitoring Site	Date Deployed	Date Recovered	Date Deployed	Proposed Recovery
LNG 1	3 April 2020	1 June 2020	2 June 2020	Early September
LNG 2	3 April 2020	1 June 2020	2 June 2020	Early September

ii) Weekly VP watches – weekly watches have been continued in good sea conditions. Watches were conducted from Ardmore Point. Sightings of bottlenose dolphins were recorded on 6 of the 12 watches to date. On two occasions, (9th of May and 17th of June) images suitable for photo-id were captured from land.

On two occasions, the IWDG RIB was also on the water and on one occasion (9 May) captured images for photo-id of those dolphins seen off Ardmore Point. On the 21 May the watch ended after 120 minutes due to unsuitable weather conditions (sea-states 2 and 3), similarly, a watch for marine mammals was not conducted during week 9 due to unsuitable weather conditions.

Date	Time started	Duration (minutes)	Sightings
3 April 2020	14:00	240	0
8 April 2020	12:00	360	2
15 April 2020	12:00	360	0
23 April 2020	12:00	360	5

28 April 2020	12:30	360	0
9 May 2020	13:00	360	3
14 May 2020	12:00	360	0
21 May 2020	12:30	120	0
27 May 2020	12:00	360	1
1 June 2020	11:00	360	2
Week 9	No Watch	-	-
17 June 2020	09:30	360	2
25 June 2020	12:00	360	0

Future Tasks

We will continue with weekly VP watches through to September.

CPODs are to be recovered in early September.

SAM data will be modelled by Joanne O'Brien with environmental variables such as diel, tidal and data as factors.

Visual data will be explored as well as historical data collected by the IWDG including tour boat data to exlore use of the site by bottlenose dolphins.

Preparation of marine mammal report will be started to inform EIA/AA to be prepared by Aquafact.

Dr Simon Berrow, IWDG Project Manager
1 July 2020

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract started in April 2020 and will run until September 2020

Fieldwork included:

i) SAM at two sites
ii) Weekly VP watches

i) SAM – two CPODs deployed at same location as earlier monitoring which is consistent with previous EIS for Shannon LNG. Deployments were on acoustic releases (Sonardyne LRT) to avoid interference and keep away from strong currents. CPODs were recovered on 1 June 2020 and re-deployed 2 June. This deployment will last 3 months and are due for recovery early September

Monitoring Site	Date Deployed	Date Recovered	Date Deployed	Proposed Recovery
LNG 1	3 April 2020	1 June 2020	2 June 2020	Early September
LNG 2	3 April 2020	1 June 2020	2 June 2020	Early September

ii) Weekly VP watches – weekly watches have been continued in good sea conditions. Watches were conducted from Ardmore Point. Sightings of bottlenose dolphins were recorded on 7 of the 16 watches to date. On two occasions, (9th of May and 17th of June) images suitable for photo-id were captured from land.

On three occasions, the IWDG RIB was also on the water and on one occasion (9 May) we captured images for photo-id of those dolphins seen off Ardmore Point. On the 21 May the watch ended after 120 minutes due to unsuitable weather conditions (sea-states 2 and 3), similarly, a watch for marine mammals was not conducted during weeks 9 and 14 due to unsuitable weather conditions.

Date	Time started	Duration (minutes)	Sightings
3 April 2020	14:00	240	0
8 April 2020	12:00	360	2
15 April 2020	12:00	360	0
23 April 2020	12:00	360	5
28 April 2020	12:30	360	0

9 May 2020	13:00	360	3
14 May 2020	12:00	360	0
21 May 2020	12:30	120	0
27 May 2020	12:00	360	1
1 June 2020	11:00	360	2
Week 9	No Watch	-	-
17 June 2020	09:30	360	2
25 June 2020	12:00	360	0
Week 12	No Watch	-	-
1 July 2020	10:00	270	0
10 July 2020	12:00	360	0
Week 14	No Watch	-	-
23 July 2020	14:45	300	0
31 July 2020	13:00	360	1

Future Tasks

We will continue with weekly VP watches through to September.

CPODs are to be recovered in early September.

SAM data will be modelled by Joanne O'Brien with environmental variables such as diel, tidal and data as factors.

Visual data will be explored as well as historical data collected by the IWDG including tour boat data to explore use of the site by bottlenose dolphins.

Preparation of marine mammal report is underway which will inform the EIA/AA to be prepared by Aquafact.

Dr Simon Berrow, IWDG Project Manager
1 August 2020

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract started in April 2020 and will run until September 2020

Fieldwork included:

a. SAM at two sites
b. Weekly VP watches

i) SAM – two CPODs deployed at same location as earlier monitoring which is consistent with previous EIS for Shannon LNG. Deployments were on acoustic releases (Sonardyne LRT) to avoid interference and keep away from strong currents. CPODs were recovered on 1 June 2020 and re-deployed 2 June. This deployment will last 3 months and are due for recovery early September.

Monitoring Site	Date Deployed	Date Recovered	Date Deployed	Proposed Recovery
LNG 1	3 April 2020	1 June 2020	2 June 2020	Early September
LNG 2	3 April 2020	1 June 2020	2 June 2020	Early September

ii) SAM data has been modelled and is being incorporated into the Marine Mammal Report.

iii) Weekly VP watches – Watches were conducted from Ardmore Point in good sea conditions. Data up to and including 30 August will be used in the Marine Mammal Report.

iv) Sightings of bottlenose dolphins were recorded on 9 of the 18 watches to date. On two occasions, (9 May and 17 June) images suitable for photo-id were captured from land.

v) On an additional two occasions, the IWDG RIB was also on the water during dedicated watches (9 May, 30 August) and obtained images suitable for photo-id of the same dolphins seen off Ardmore Point during the dedicated watch. This provides information on the individual dolphins that use the waters off Ardmore Point.

Date	Time started	Duration (minutes)	Sightings
3 April 2020	14:00	240	0
8 April 2020	12:00	360	2
15 April 2020	12:00	360	0
23 April 2020	12:00	360	5
28 April 2020	12:30	360	0
9 May 2020	13:00	360	3
14 May 2020	12:00	360	0
21 May 2020	12:30	120	0
27 May 2020	12:00	360	1
1 June 2020	11:00	360	2
Week 9	No Watch	-	-
17 June 2020	09:30	360	2
25 June 2020	12:00	360	0
Week 12	No Watch		-
1 July 2020	10:00	270	0
10 July 2020	12:00	360	0
Week 14	No Watch	-	-
23 July 2020	14:45	300	0
6 August 2020	13:00	360	0
18 August 2020	13:30	360	2
30 August 2020	13:00	360	1

Future Tasks

We will continue with weekly VP watches through to end of September.

CPODs are to be recovered in early September and redeployed until November to make the full 12 months SAM dataset.

SAM data up to June has been modelled by Joanne O'Brien with environmental variables such as diel, tidal and data as factors.

Visual data has been explored as well as historical data collected by the IWDG including tour boat data to assess use of the site by bottlenose dolphins.

Preparation of marine mammal report to inform EIA/AA is nearly completed and a draft wil be sent to NFE before finalising report to Aquafact.

Dr Simon Berrow, IWDG Project Manager
2 September 2020

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal

Bottlenose dolphin in the Shannon estuary, July 2020 © Simon Berrow/IWDG

IWDG Consulting

Final Report to New Fortress Energy

(Ref: SHLL-IE-20180000045)

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal

Simon Berrow, Sibéal Regan and Joanne O'Brien

Irish Whale and Dolphin Group,
Merchants Quay, Kilrush, County Clare

Citation: Berrow, Simon, Regan, Sibéal and O'Brien, Joanne (2020) Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal. Report to New Fortress Energy. Irish Whale and Dolphin Group. 29 pp.

Executive Summary

The Irish Whale and Dolphin Group (IWDG) were contracted by New Fortress Energy to monitor the use of the site of the proposed LNG terminal at Ardmore Point, Co Kerry on the south side of the Shannon Estuary by bottlenose dolphins. The proposed Shannon LNG terminal and marine facility operates wholly within the Lower River Shannon Special Area of Conservation with bottlenose dolphins as one of the qualifying interests. Thus a high level assessment of the potential impacts of this proposed development on the dolphins and their habitats is essential.

A combination of land-based Vantage Point (VP) watches and static acoustic monitoring (SAM) was used to describe the use of the site by bottlenose dolphins and any other marine mammals (seals) present, and their distribution and relative abundance at the site. Dedicated watches were carried out each week between April and September 2020 from Ardmore Point. Watches were carried out in good sea-states, defined as ≤2 and a six hour tidal cycle. One CPOD was deployed at two sites for a period of 12 months at the proposed development area to collect SAM data.

Between April and August 2020, a total of 23 watches were carried out from Ardmore Point. Dolphins were observed from Ardmore Point during 13 (56%) of watches, with a total of 21 sightings ranging from 1-4 groups per watch. Mean group size (±SD) recorded was 6.2±3.1 dolphins. Most sightings were of groups off Moneypoint and near the ferry, west towards Sacttery Island and mid-channel with six sightings (26.1%) within 500m of Ardmore Point. The sightings within 500m of Ardmore Point were all travelling and did not stop at the site. Probable foraging activity was observed on one occasion. Dolphins rarely exhibited social behaviour while travelling past Ardmore Point. The dolphins observed off Ardmore Point were all travelling, most slowly and did not stop at the site. Probable foraging activity was observed on one occasion. Dolphins rarely exhibited social behaviour while travelling past Ardmore Point. On six occasions individual grey seals were recorded, with most within 500m of the watch site.

A total of four SAM deployments took place over the study period. Monitoring took place 266 days from LNG 1 and 250 days from LNG 2 between August 2019 and May 2020. Dolphins were recorded on 62% of days at both locations and the number of cumulative dolphin positive minutes were similar across the two sites. Durations per day ranging from 0-44 minutes with a peak during October 2019. There was a significant effect of season at LNG1 with fewer detections during winter compared to other seasons and more detections in the evening and on a flood tide. The only significant variable at LNG2 was increased detections in the evening, despite a similar overall number of detections at both sites. There is no evidence that 2020 was an atypical year. Indeed these data were similar to that obtained at the same site during 2006 to 2007 and we are confident that these data represent the use of the site by dolphins

SAM data were consistent with a similar study carried out between 2006 and 2007. Over the 266 day deployment period analysed in this report dolphins were recorded on 62% of days at both sites. This compares to on 65% of days at LNG1 and 35% of days at LNG2 during the study between 2006 and 2007 (238 and 103 days sampled at each site). Mean DPM per day at LNG1 and LNG2 in the present study was 4.4 and 3.6 compared to 4.7 and 4.1 in 2006-2007. Despite the differences in sensitivities and detection ranges between T-PODs used in 2006-2007 and the CPODs currently used in the Shannon estuary, the results are quite consistent.

Visual observations suggested that dolphins did regularly pass through the site but rarely stopped for any prolonged period. SAM data supported this with most detections of short duration though occasionally they occurred for longer periods. It is clear from the SAM data that dolphins regularly use the proposed site of the LNG terminal. The site is likely used as a transition corridor where dolphins regularly move between the inner and outer estuary. There is no evidence that the proposed development site is a critical habitat for bottlenose dolphins but is an important part of the range of the "inner" estuary sub-group. This information needs to be taken into account when making risk assessments and ensure the no significant impacts on the dolphins or their habitat occurs.

1.0 Introduction

The Irish Whale and Dolphin Group (IWDG) were contracted by New Fortress Energy to monitor the use of the site of the proposed LNG terminal at Ardmore Point, Co Kerry on the south side of the Shannon Estuary by bottlenose dolphins. The proposed Shannon LNG terminal and marine facility operates wholly within the Lower River Shannon Special Area of Conservation (Site Code 002165) with bottlenose dolphins as one of the qualifying interests. Thus a high level assessment of the potential impacts of this proposed development on the dolphins and their habitats is essential. This marine mammal report will be used to inform the EIA and AA of the proposed development which will be carried out by Aquafact International Services.

The study of bottlenose dolphins involved:

i. Weekly visual land-based monitoring in favourable weather conditions
ii. Static Acoustic Monitoring to assess the current use of the site by bottlenose dolphins
iii. An assessment of risk to the Shannon dolphin population
iv. Recommendations to inform EIA/NIS

Bottlenose dolphins in the Shannon Estuary

The Shannon Estuary is one of the most important habitats for bottlenose dolphins in Ireland. Research on this population has been carried out since 1993 (Berrow et al. 1996) and has shown that the dolphins are resident, i.e. they are present in the estuary throughout the year, genetically discrete compared to bottlenose dolphins found elsewhere in Irish waters (Mirimin et al. 2011) and the estuary is an important calving area (Ingram 2000; Baker et al. 2018). Bottlenose dolphins are the only cetacean species to be regularly recorded within the estuary, upriver from Kilbaha, Co. Clare, with the highest concentrations found off Kilcredaun Head in the outer Estuary, and off Moneypoint and Tarbert power stations in the middle of the estuary (Ingram and Rogan 2002). Berrow (2009) suggested that dolphins also occur frequently upriver, during both summer and winter. Occasional sightings of minke whale and harbour porpoise occur in the outer estuary and on one occasion (June 2018) a group of two harbour porpoise were photographed east of Scattery Island, but this is exceptional.

The Shannon Estuary is a busy waterway with bulk carriers, fishing vessels and recreational craft utilising its sheltered waters. Due to its depth the estuary provides ideal shipping access to the largest vessels entering Irish waters (180,000-200,000 deadweight tonnage) while servicing six main terminals and handling up to 1,000 ships per annum carrying 10-12 million tons of cargo especially towards the ports at Foynes and Limerick (Anon, 2019). The Shannon Estuary is also a major centre of industry with an alumina smelting plant at Aughinish and two power stations located at Money Point and Tarbert in the mid-estuary. The River Shannon catchment includes large areas of farmland and several tributary rivers providing potential sources of eutrophication and contamination (Berrow et al. 2002).

Bottlenose dolphins (*Tursiops truncatus*) are resident in the Shannon Estuary, with the same individuals recorded throughout the year. The population is genetically discrete (Mirimin et al. 2011) and restricted to the Shannon Estuary and adjacent Tralee and Brandon Bays (Levesque et al. 2016). The abundance of dolphins in the estuary is known from a number of estimates carried out since 2007 using mark-recapture modelling of photo-id data. Estimates ranged from 140±12 in 2006 to 107± 12, CV = 0.12 in 2010 but are consistent (Ingram 2000; Ingram and Rogan 2003; Englund et al. 2007; 2008; Berrow et al. 2012; Rogan et al. 2015: 2018). A discovery curve using data collected by IWDG between 2011 and 2015 suggested all animals in the population were captured during this period, providing an abundance of 145 extant individuals (Blásquez et al. 2020).

Use of Site of the Proposed LNG terminal by Bottlenose Dolphins: 2006-2007

Static Acoustic Monitoring (SAM) of bottlenose dolphins using T-PODs was carried out at the proposed LNG site between June 2006 and June 2007 as part of an earlier environmental assessment of the proposed Shannon LNG terminal (Berrow 2007). A total of 341 days of SAM data were gathered in total from the two sites (LNG1 = 239 days and LNG2 = 102 days), which resulted in 120 acoustic encounters with dolphins and a total of 530 Detection Positive Minutes recorded. These encounters were short, with a modal duration of 1 minute and a mean of around 4 minutes at each site. Encounter rate declined from 2.8 encounters per day in June to around 0.20 encounters per day in December-March. There was evidence of an increase in detection rate in June 2007. Both the frequency and duration of detections decreased from September through the autumn and winter.

Most encounters (84%) were detected at LNG 1 with only 19 encounters (16%) at LNG 2. Of the 120 encounters, 64 (53%) were logged during darkness, which was consistent at both sites. Of the 19 encounters from LNG 2, on 12 (63%) occasions dolphins were detected at LNG 1 on the same day but on only two occasions (11%) within 10 minutes of dolphins being logged at LNG 1. On four occasions there were dolphins detected at LNG 2 but not on LNG 1 on the same day.

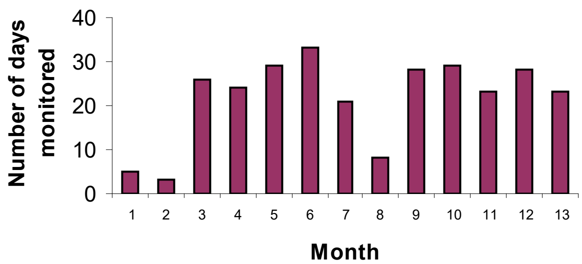


Figure 5a. Total number of monitoring days at LNG 1

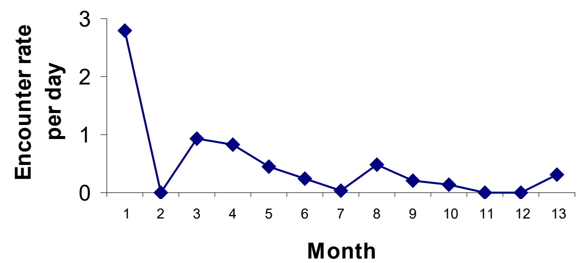


Figure 5b. Dolphin encounter rate per month at LNG 1

Figure 1. Monthly encounters of bottlenose detections from SAM data collected at LNG1 from June 2006-June 2007 (from Berrow 2007)

Monitoring data at LNG 2 (n=102 days) was only collected from September to November 2006 and February to June 2007 (Fig 6a) with no data during the winter months of December and January. The peak in September 2006 was due to six encounters being recorded during three consecutive days. Despite good monitoring data from February and March 2007 (Fig 6b) there were no acoustic detections during this period.

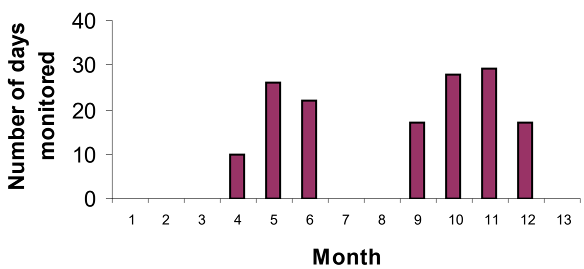


Figure 7a. Total number of monitoring days at LNG 2

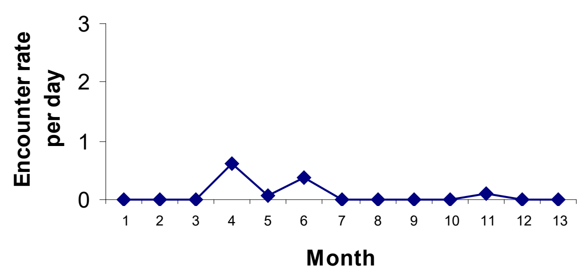


Figure 7b. Dolphin encounter rate per month at LNG 2

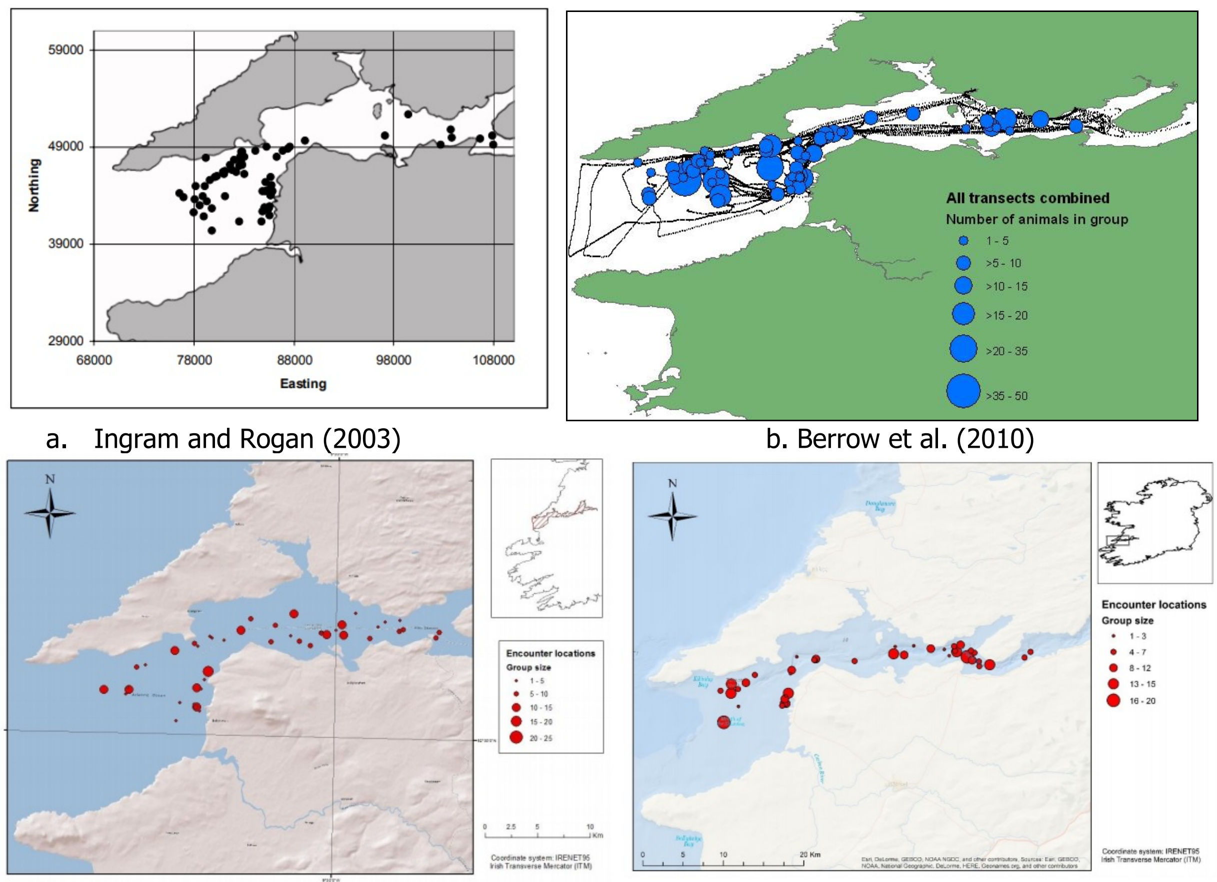
Figure 2. Monthly encounters of bottlenose detections from SAM data collected at LNG2 from June 2006-June 2007 (from Berrow 2007)

Mean (±SD) Detection Positive Minutes/day of monitoring was calculated at 1.6±2.4 at LNG1 (n= 239 days) and 0.5±0.8 at LNG 2 (n= 102 days). The mooring at LNG 2 is in shallow water (maximum 8m at mean high water) in the mouth of a shallow bay. Thus the detection range of the hydrophone at this location may be restricted and there may also be tidal restrictions on when dolphins can fully enter the bay lead to a decrease in the number of detections.

Use of site from boat-based visual data

Dedicated surveys

Surveys of bottlenose dolphins have been carried during a number of studies. NPWS funded surveys to derive abundance estimates were carried out between July and September 2003 (Ingram and Rogan 2003) with three sightings adjacent to the proposed LNG terminal site (Fig. 3a). Berrow et al. (2010) carried out 12 transects between July and October 2010 and recorded only one sighting off the proposed LNG terminal site (Fig. 3b). Surveys carried out between June and October 2015 and 2018 reported three sightings adjacent to the proposed LNG terminal site. Most sightings in the middle-estuary were off Tarbert, upriver of the site (Figs 3c and 3d).



a. Ingram and Rogan (2003)

b. Berrow et al. (2010)

c. Rogan et al. (2015)

d. Rogan et al. (2018)

Figure 3a-d. Sightings of bottlenose dolphins during dedicated boat-based surveys from 2003-2018.

The only study to present sightings data across both summer and winter was carried out by Englund et al. (2007). A total of nine surveys were carried out from June to September 2006 with 304 sightings, while there were only 64 sightings during 20 surveys carried out between October 2006 and April 2007.They showed that dolphin distribution was similar though with fewer sightings during winter, with sightings in the estuary adjacent to the proposed LNG terminal (Fig. 4). Berrow (2009) reported a group of 1-15 individuals socialising off Ardmore point in December 2003 during winter surveys (Fig. 4b).

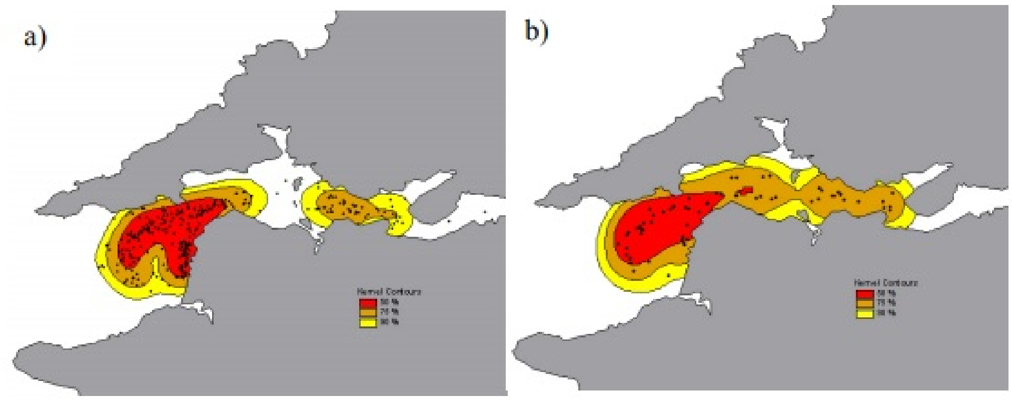


Figure 4a-b. Dolphin distribution (a) summer months (May to September) and b) winter months (October to April) from Englund et al. (2007)

Bottlenose dolphin sightings from dolphin tour-boats

Commercial dolphin-watching has been carried out in the middle and outer estuary since 1995 (Berrow and Holmes 1999). These dolphin-watching vessels are required to complete trip records as part of their permission to operate within the SAC. There is some bias associated with this dataset as tour-boat operators tend to look in known areas for the dolphins and often get sightings reported before leaving port. However, these records provide an oversight on where dolphins are located and also provide a platform for photo-identification by IWDG researchers. Data from 2000-2010 (excluding 2003 and 2004) were mapped into 2x2km grid cells to identify hot-spots of dolphin activity (Christophe and O'Connor, unpubl. data). These are areas with more sightings than expected from sightings effort. They also identify "cold-spots" with fewer sightings than might have been expected given tour-boat effort. This shows that the water adjacent to the proposed land-site of the LNG terminal and site of the proposed jetty is used by bottlenose dolphins but is not considered a "hot-spot" (Fig. 5). The terminal site is however only 2.8km across the estuary from a well-known hotspot off Moneypoint Power Station.

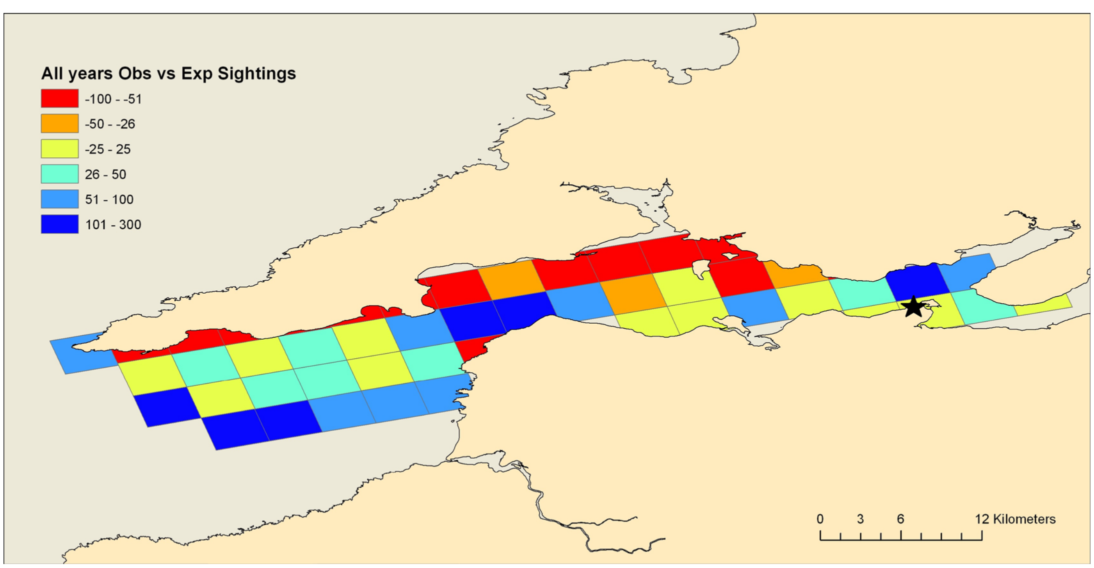


Figure 5. Observed v Expected distribution of bottlenose dolphins from tour boat data collected between 2000-2010 (excluding 2003 and 2004). Black star indicates site of the proposed LNG terminal.

2.0 Methodology

A combination of land-based Vantage Point (VP) watches and static acoustic monitoring (SAM) was used to describe the marine mammal community, its distribution and relative abundance at the site. The survey site is shown in Figure 6.

2.1. Land-based Vantage Point Watches

Dedicated watches were carried out each week between April and September 2020 from Ardmore Point on the Kerry side of the estuary (Figure 2), which is around 20m above sea-level. Watches were carried out in good sea-states which, for bottlenose dolphins, is defined as ≤2 and where possible over a 6 hour tidal cycle. Optics used included 8x40 and 10x50 binoculars and a Kowa TSH telescope with x20W eyepiece. This provided the ability to detect dolphins from up to about 4km from the VP in good sea-state. If no suitable weather windows occur within a week then the watch was slipped to the following week.

Figure 6. Vantage Point watch sites

Figure 7. View from vantage point watch site at Ardmore Point

Full scans across the estuary, west to Scattery and Carrig Islands and east to Kilkerrin Point, were carried out each 30 minutes with both binoculars and telescope (each scan was from left to right and the next right to left) while between scans the water was watched with naked eye and any disturbances of the water checked through binoculars or telescope. Their behaviour was described according to Baker et al. (2017a).

To investigate whether dolphin presence was influenced by tidal state a Generalised Linear Model (GLM) was used, with a binomial distribution and logit link, using R, version 4.0.3 (2020-10-10) and the ggfortify package. A GLM was used because the data has a non-normal distribution (the response variable, dolphin presence, was recorded as binary present/absent (1/0) data. The ggplot2 package was used to plot both raw dat. A dispersion index (ratio of residual deviance to residual DF) is not useful for binary data. Therefore, the binnedplot() function from the arm package was used to assess the binned residuals in the model. The predict function was used to generate predict response and was plotted using the HH package.

In model 1 tide was classified into slack low (L), flooding (F), slack high (H) and ebbing (E) tides. This was achieved by allocating the hour before and after slack high as H. The hour before and after slack low were categorised as L. All hours between L and H were classified as F. All hours between H and L were classified as E.

In model 2 tide was classified based on hours since high tide, whereby at 0 the tide is slack low, between +0.5 and +5.5 it is flooding, +6 is slack high and between -0.5 and -5.5 it is ebbing.

The dataset was then reduced to remove *NAs* under the variable group-size to explore the effect of tide on group size. Using the ggfortify package, a GLM with a Poisson distribution and a log link was chosen for the dolphin group size count data. The model was found to be overdispersed (dispersion index = 1.78). A quasipoisson distribution was chosen instead and the newly fitted model allowed a dispersion parameter of 1.62. The predict function was used to plot predicted response and was plotted using the HH package.

2.2. Static Acoustic Monitoring

One C-POD was deployed at two sites for a period of 12 months to the east and west of the propose development area (Figure 8). The deployment sites were consistent with monitoring carried out for the original EIA/NIS (Berrow 2007) where two sites were monitored using T-PODS (an earlier version of the C-POD). Multiple C-PODs were used to enable us to swap units on recovery for immediate re-deployment.

C-PODs

The C-POD (Fig. 9) is a fully automated, SAM system which can detect porpoises, dolphins and other toothed whales by recognising echolocation click trains these animals make in order to detect their prey, orientate themselves and interact with one another. These units are designed and manufactured by Chelonia Ltd and they are the only commercially available instruments with click train recognition software, which produces fully automated, accurate data on the behaviour and identification of odontocetes (see http://chelonia.co.uk). A single C-POD can monitor both porpoise and dolphins simultaneously through identifying characteristic click parameters which can be assigned to either harbour porpoise or dolphin species. Once deployed at sea, C-PODs operate in a passive mode and are constantly listening for tonal clicks within a frequency range of 20 to 160 kHz. When a tonal click is detected, the C-POD records the time of occurrence, centre frequency, intensity, duration, bandwidth and frequency of the click.

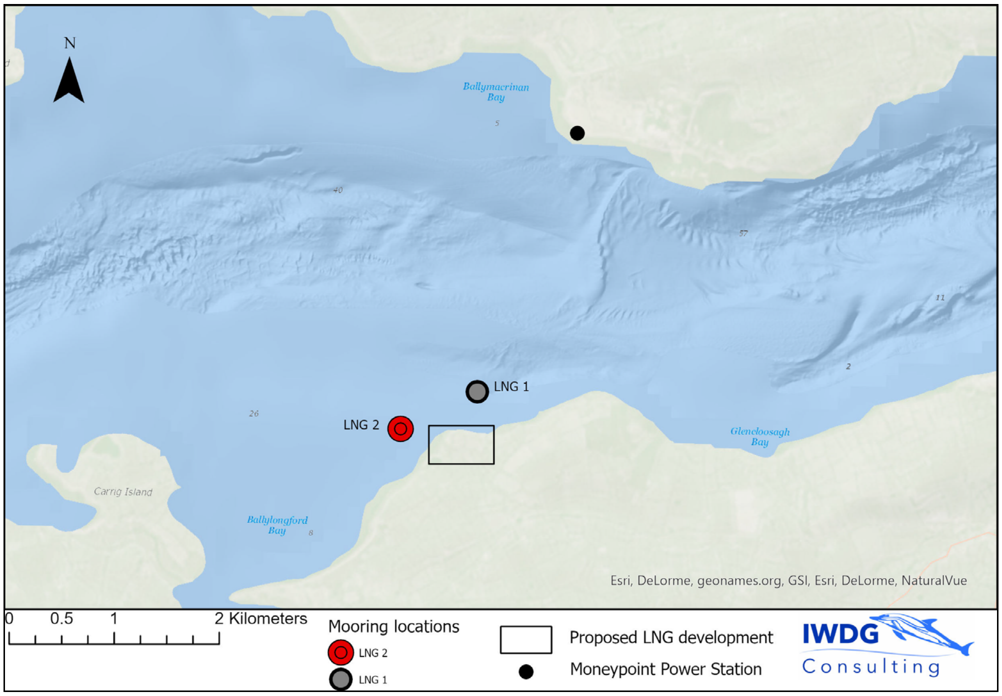


Figure 8. Map of the proposed LNG development site, mooring locations and the control site off Moneypoint

Internally, the C-POD is equipped with a Secure Digital (SD) flash card, and all data are stored on this card. Dedicated software, C-POD.exe, provided by the manufacturer, and is used to process the data from the SD card when connected to a PC via a card-reader. This allows for the extraction of data files under pre-determined parameters as set by the user. Additionally, the C-POD also records temperature over its deployment duration. It should be noted that the C-POD does not record actual sound files, only information about the tonal clicks it detects.

The C-POD detector is a sound pressure level detector with a threshold of 1Pa peak to peak at 130 kHz, with the frequency response shown below (Figure 5 www.chelonian.co.uk). The detection distance for bottlenose dolphins in the Shannon Estuary was estimated at 798±61m (with 75% of groups recorded <400m) by O'Brien et al. (2013).

Figure 9: C-POD unit by Chelonia Ltd

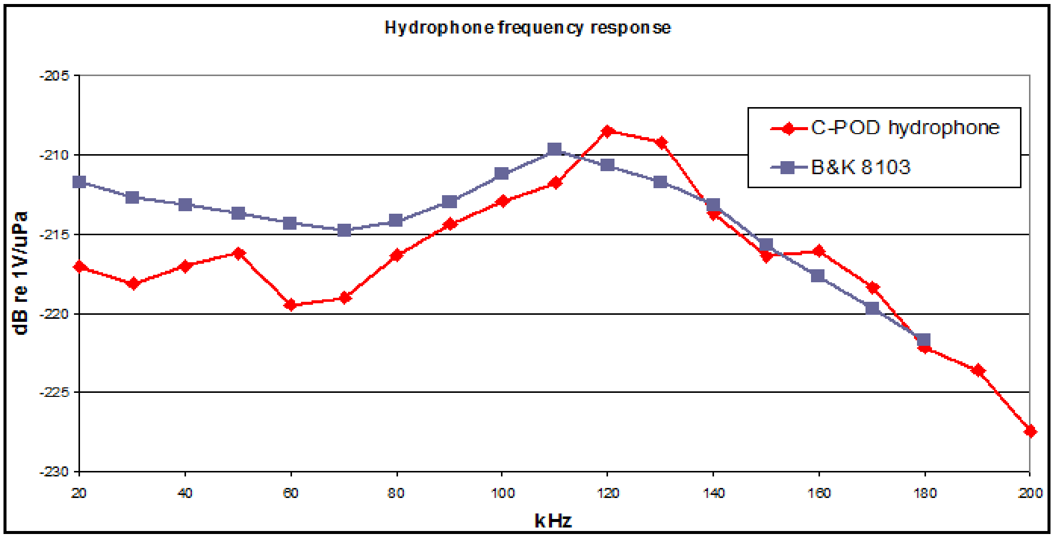


Figure 10: Threshold for detection across various frequency bands between 20 and 200 kHz for the C-POD (note 1Pa p-p is the SI unit for pressure and correctly represents the threshold) © Chelonia Ltd

Through the C-POD.exe software (example Figure 10), data can be viewed, analysed and exported. Additionally, the software can be used to change settings of individual SD cards. The software includes automatic click train detection, which is continually evolving as Chelonia Ltd receives more feedback from their clients. C-POD.exe can be run on any version of Windows and requires an external USB card reader, which reads the SD card into the directory. Version 2.044 (October, 2014) was used for all analyses. C-POD.exe software allows the user to extract click trains under five classification parameters but only the porpoise like category was used for this analysis of the long-term dataset.

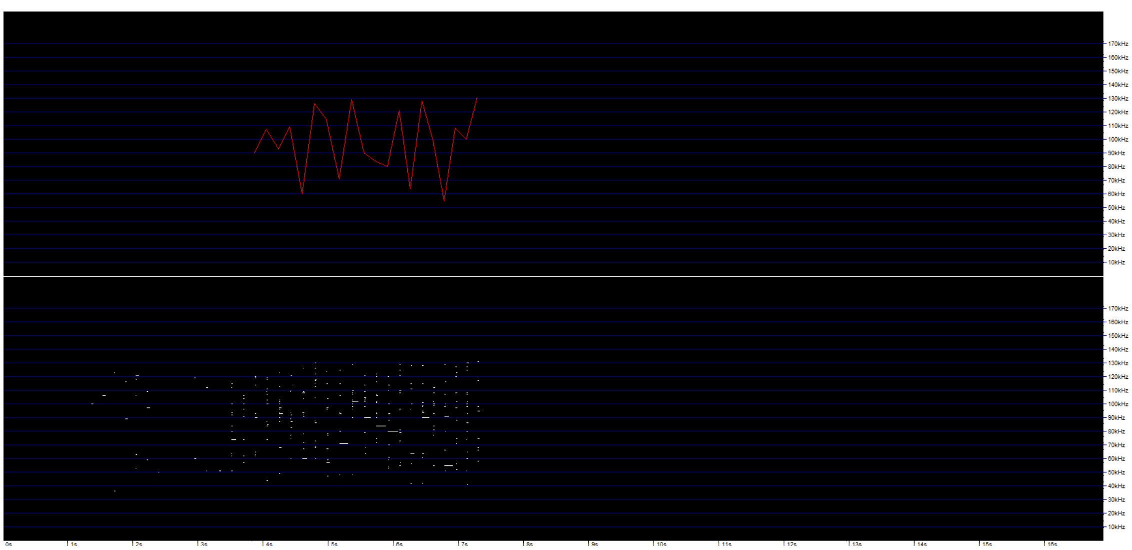


Figure 11: Screen grab of C-POD.exe, showing a bottlenose dolphin click train

SAM is independent of weather conditions once deployed and thus ensures high quality data is collected but only at a small spatial scale. C-PODs can be deployed on a mooring for 3-4 months before recovery and downloading of data. These data can be analysed as detection positive minutes (DPM) to generate an acoustic index of activity. This technique provides large datasets to enable changes in activity to be identified at high resolutions. DPM's provide high quality data on seasonal, diel and tidal occurrence.

Data can be compared across sites, before during and after impacts following the BACI (before, after, control, impact) type design similar to Carstensen et al. (2006).

C-POD calibration

Calibration of SAM equipment is important in order to compare results across units. Chelonia LTD, the manufacturers of C-PODs, calibrate all units to a standard prior to dispatch. These calibrations are carried out in the lab under controlled conditions and thus Chelonia highly recommend that further calibrations are carried out in the field prior to their employment in monitoring programmes instead of further tank tests (Nick Tregenza *pers comms*). All C-PODs deployed during this present study were calibrated during field trials in the Shannon Estuary as part of regular monitoring of equipment performance by the IWDG.

Field calibrations are important where projects employ several units aimed at comparing detections across a number of sites. If units of differing sensitivities are used, then these data do not truly reflect the activity at a site. For example, a low detection rate may be attributed to a less sensitive C-POD, with a lower detection threshold, which in turn leads to a lower detection range, while the opposite holds for a very sensitive unit. It is fundamental that differences between units are determined prior to their deployment as part of any project, to allow for the generation of correction factors which can be applied to the resulting data. Field trials should be carried out in high density areas in order to determine the detection function (O'Brien et al. 2013). The field calibration of new and existing units are always carried out off Moneypoint (across the estuary from the proposed LNG site) and are carried out annually by the IWDG.

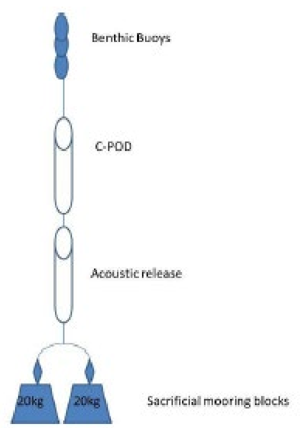


Figure 12. Mooring design and Sonardyne© acoustic release equipment used during the study (O'Brien *et al.* 2013)

Environmental variables

Upon recovery of the CPODs, data were extracted under two categories;

1) Narrow Band High Frequency (NBHF) (porpoise band) and
2) Other (dolphin band) using the C-POD.exe software (Version 2.044, October, 2014).

These data were in the form of Excel.csv files using C-POD.exe software and analysed as Detection Positive Minutes (DPM) across hourly segments. Each hour of SAM monitoring was categorised according to season, diel, tidal cycle, tidal phase. Diel was categorised across 4 classes (Morning, Day, Evening and Night), according to the times of sunrise and sunset (www.timeanddate.com/sun/). Hourly data segments were further categorised into each of the four tidal states (High, Low, Flood and Ebb) using Tarbert Island times, where three hours were assigned to each state (one hour either side of the hour, Low and High tide, flood and ebb in between). Files were further split to correspond with tidal phase (spring and neap cycles) using admiralty data (WXTide 32) where two days either side of the highest tidal height was deemed spring, and two days either side of the least difference in tidal height between high and low tide was deemed neap, all other days were classified as transitional.

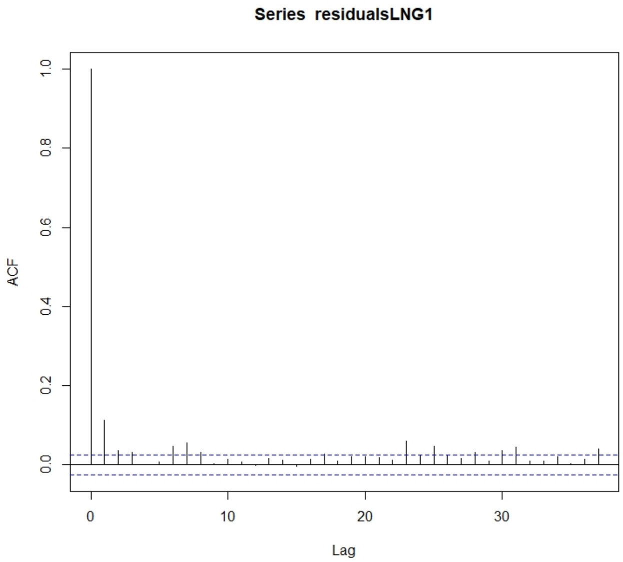


Figure 13. Autocorrelation function (ACF) plot of model residuals for LNG1 where some of the lags cross the 95% confidence bounds, but the correlation is below 0.2 indicating that the data is not temporally auto-correlated. It should be noted that ACF is always 1 at lag 0.

Statistical Modelling

Dolphin detections from both locations were transformed into a binary dataset where 1 was assigned to an hour with detections and 0 to where there are no detections (DOL.DPM). This binary dataset was then used for the Presence/Absence analysis. A binomial GLM with a logit link function was used to model the probability of dolphin presence at both locations based on recommendations by Zuur et al. (2009). Predictors were tested for collinearity by examining the variance inflation factor (VIF) values using the *corvif* function in R where collinearity was detected using a VIF cut-off value of 3 (Zuur et al. 2009; 2013).

To determine whether autocorrelation was present in any of the models, patterns in the residuals were examined using an autocorrelation function (ACF) plot. If various lags cross the 95% confidence bounds and have significant correlation, then independence is violated (Nuuttila et al. 2017; Zuur et al. 2009). Nuutila et al. (2017) also used a correlation threshold of 0.2 in the ACF plot to determine whether there was temporal autocorrelation in in the models (Figure 13, example of and ACF plot from LNG1). In this study, the number of lags crossing the 95% confidence bounds and the magnitude of the correlation were both used to assess whether model residuals were temporally auto-correlated. Examples of how ACF plots were used to assess autocorrelation in this study are shown in Figures 9. For models where no autocorrelation was found, the nested GLM where all explanatory variables were significant were retained as the final model.

3.0 Results

Land-based Visual Monitoring

Between April and August 2020, a total of 23 watches were carried out from Ardmore Point. No watches were carried out during weeks 9, 12, 14 and 19 due to poor sea conditions prevailing (Table 1). Watch duration was less than the 360 minutes planned on five occasions due to weather, visibility or sea conditions deteriorating through watch to a state (sea-state >3), that was not suitable for detecting dolphins. A range of tidal states were sampled from ebbing and flooding tides and slack high and low water (Table 1).

Dolphins were observed from Ardmore Point during 13 (56%) of watches, with a total of 21 sightings of bottlenose dolphin ranging from 1-4 groups per watch. Mean group size (±SD) of all groups recorded during watches was 6.2 ± 3.1 dolphins.

Table 1. Date and duration of watches carried out from Ardmore Point VP from April to August 2020

Date	Time started	Tidal state (HW)	Duration (minutes)	Dolphin Sightings
3 April 2020	14:00	-1 to +3 hrs	240	0
8 April 2020	12:00	-2 to +4 hrs	360	2
15 April 2020	12:00	+1 to -5 hrs	360	0
23 April 2020	12:00	-1 to +5 hrs	360	4
28 April 2020	12:30	-3 to +3 hrs	360	0
9 May 2020	13:00	-1 to +5 hrs	360	3
14 May 2020	12:00	+3 to -3 hrs	360	0
21 May 2020	12:30	-4 hrs	120	0
27 May 2020	12:00	+3 to -3 hrs	360	0
1 June 2020	11:00	-4 to + 2 hrs	360	1
Week 9	No Watch	-	-	-
17 June 2020	09:30	-6 hrs	360	2
25 June 2020	12:00	+3 to -3 hrs	360	0
Week 12	No Watch	-	-	-
1 July 2020	10:00	+4 hrs	270	0
10 July 2020	12:00	+4 to -2 hrs	360	0
Week 14	No Watch	-	-	-
23 July 2020	14:45	-3 to +3 hrs	300	0
31 July 2020	13:00	-3 to +3 hrs	360	2
6 August 2020	13:00	+1 to -5 hrs	360	0
18 August 2020	13:30	-3 to +3 hrs	360	2
30 August 2020	13:00	-4 to + 2 hrs	360	1
Week 19	No Watch	-	-	-
10 September 2020	10:00	+4 to -4 hrs	360	1
18 September 2020	12:00	-5 to +4.5 hrs	360	1
23 September 2020	07:45	-1 to +1 hrs	360	1
29 September 2020	13:30	-1.5 to +3 hrs	300	1

Sighting rate decreased from April to July from 0.35 sightings per 100 minutes watched to 0.15 then increased in August to 0.27 (Fig 14). A similar pattern was evident in the number of individuals per 100 minutes watched though sightings rate was more consistent during April to June. Sighting effort was consistent with between 1080 and 1650 minutes watched per month. There was more effort in July

(1350 minutes) compared to April through to June (≤1200 minutes) which doesn't explain the decrease in sightings rate.

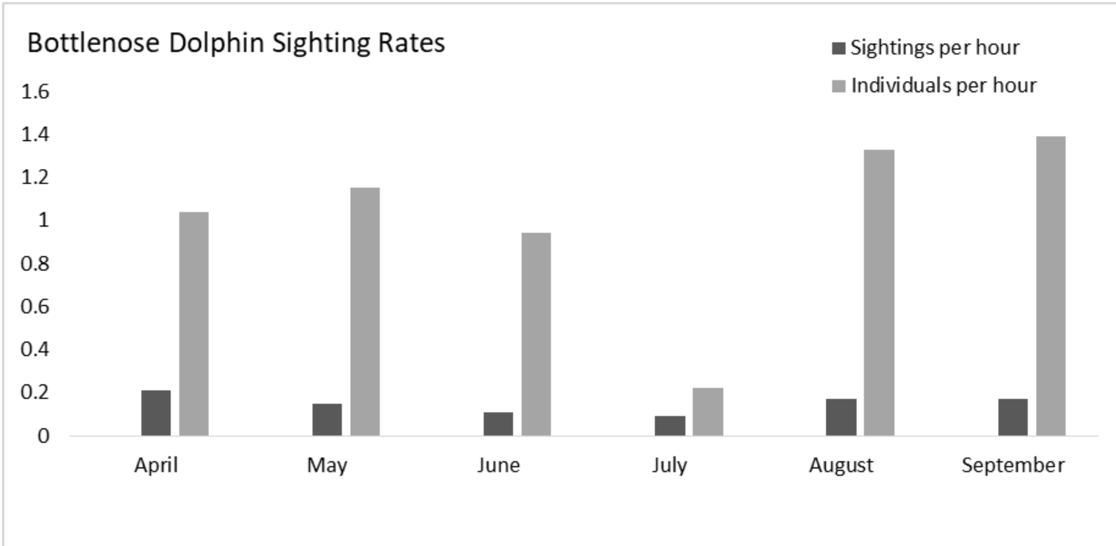


Figure 14. Bottlenose dolphin sighting rates per sighting and per individual during VP effort watches from Ardmore Point (April to September 2020)

Model outputs

Out of a total of 265 scans, conducted between 3 April 2020 and 29 September 2020, bottlenose dolphins were present during 31 scans (12%) (Table 2).

Table 2. Summary of scans carried out during VP watches

Tidal Cycle	Number of BND Positive Scans	Total Scans	Proportion of BND Positive Scans
Slack Low	13	68	0.19
Flooding	5	74	0.07
Slack High	1	44	0.02
Ebbing	12	79	0.15
Total	31	265	0.12

Model 1

The predicted presence of bottlenose dolphins is significantly explained by the variable Tidal state (X^2 =11.45, df = 3, p < 0.001). The predicted proportion of dolphin positive scans was significantly higher during slack low (L) compared to flood (F) (p<0.05) and slack high (H) (p<0.05). Although the predicted proportion of dolphin positive scans is also higher during an ebbing tide (E) compared to a high (H) and flood (F) tide, this is not significant (p>0.05) (Figure 16).

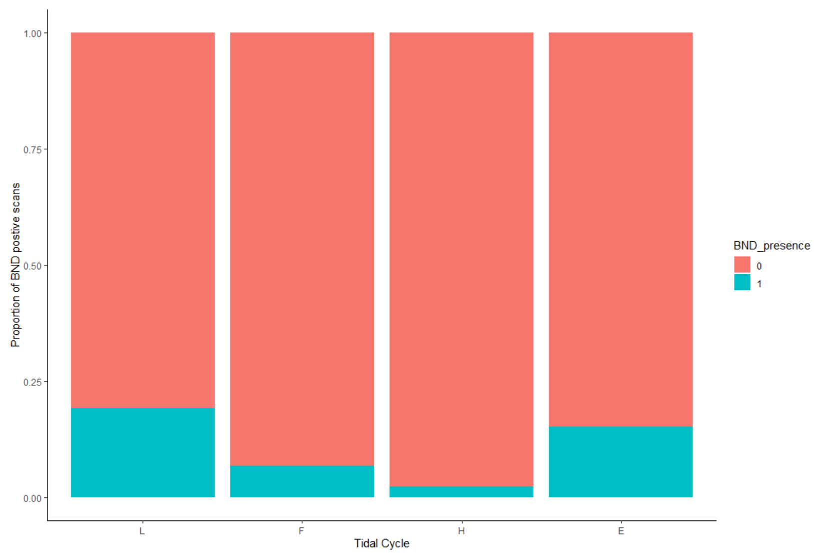


Figure 15. Proportion of Bottlenose Dolphin (BND) positive scans per stage of the tidal cycle (L=low, F=flood, H=high, E=ebb) from the raw data

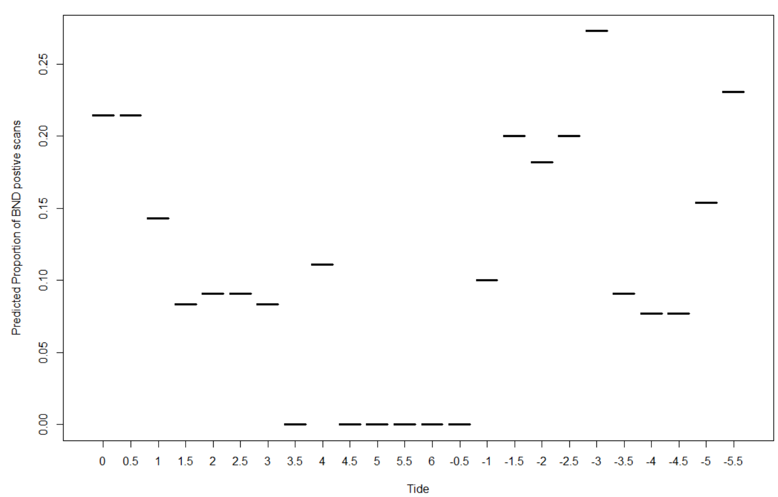


Figure 16. Boxplot of predicted proportions of Bottlenose Dolphin (BND) positive scans per stage of the tidal cycle (L=low, F=flood, H=high, E=ebb) from the modelled GLM data.

Model 2

The predicted presence of bottlenose dolphins was not significantly explained by hours since high tide (χ^2 =21.37, *df* = 23, *p* >0.05). Although a significant relationship between dolphin presence and the stage of tidal cycle was found there were issues with the model which will hopefully improve as more data is gathered. The binned residual plots for model 1 indicated that the expectation that around 95% of residuals fall within the standard error bounds was not met and that there was very little variability in the predicted data, which was also indicated by the flat boxplots (Figure 16).

This could be due to the relatively small sample size (n=265) of the dataset. Binned residual plots work best with large datasets in which data can be categorised into many bins, and the models will be run with additional data collected over the next 6 months.

Group size data

Mean group size across the different tidal stages ranged between 0.11 during slack high and 1.43 during ebbing (Figure 17). The overall mean group size was 0.97 with a standard deviation of 3.06 (Table 2).

No relationship between group size and stage of tidal cycle was found.

Table 1. Summary information on Bottlenose Dolphin (BND) group size.

Tidal Cycle	Mean Group Size	SD Group Size
Slack Low	7.75	3.47
Flooding	8.67	4.04
Slack High	5.00	-
Ebbing	7.10	3.41
Overall	7.5	3.36

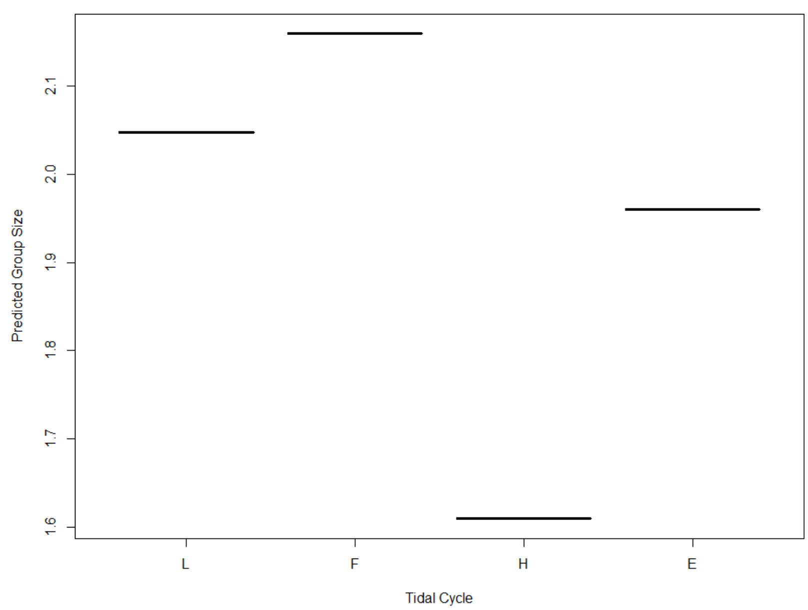


Figure 17. Predicted group size for each stage of the tidal cycle (L-slack low, F=flood, H=slack high, E=ebb).

Location and behaviour off Bottlenose dolphin sightings during VP watches off Ardmore Point

Most sightings of bottlenose dolphins from Ardmore Point were of groups off Moneypoint and near the ferry (43.7%), west towards Sacttery Island and mid-channel (30.4) with six sightings (26.1%) within 500m of Ardmore Point within, or adjacent to, the proposed site. The dolphin sightings within 500m of Ardmore Point were all travelling and did not stop at the site. Probable foraging activity was observed on one occasion. Dolphins rarely exhibited social behaviour while travelling past Ardmore Point (Table 2).

Table 2. Details of dolphin sightings recorded during VP watches carried out from April to September 2020

Date and Sighting No.	Group size	Location	Behaviour
8 April 2020 – Sighting 1	5	Moneypoint	Slow swim, possibly social behaviour
8 April 2020 – Sighting 2	2	Middle of channel Between Killimer and Tarbert	Travelling
23 April 2020 – Sighting 1	5	Moneypoint	Slow swim, possibly social behaviour.
23 April 2020 – Sighting 3	2	**<500 from watch site**	Social (caress), slow travel, did not stop
23 April 2020 – Sighting 4	6	West of Ardmore Point	Feeding (surface rush, breach)
23 April 2020 – Sighting 5	9	Moneypoint	Feeding (surface rush, breach, head-slap)
9 May 2020 – Sighting 1	6	West of Moneypoint	Travelling, individuals were widespread
9 May 2020 – Sighting 2	13	**<500 from watch site**	Travelling at moderate speed, not stop
9 May 2020 – Sighting 3	4	**<500 from watch site**	Travelling at moderate speed, feeding, (surface rush, kerplunk, tailslap)
1 June 2020 – Sighting 2	3	Moneypoint	Feeding (Surface rush, tailslap, kerplunk)
17 June 2020 – Sighting 1	4	West of Moneypoint	Bow riding tanker
17 June 2020 – Sighting 2	10	**<500 from watch site**	Travelling at moderate speed, did not stop
31 July 2020 – Sighting 1	4	**off Ardmore Point <50m**	Slow swim, did not stop
31 July 2020 – Sighting 2	1	East of Moneypoint	Bow riding tanker
18 August 2020 – Sighting 1	6	Moneypoint	Bow riding Dolphin Discovery
18 August 2020 – Sighting 2	7	**<500 from watch site**	Travelling at moderate speed, did not stop
30 August 2020 -Sighting 1	11	Moneypoint	Social and foraging behaviour
10 September 2020 - Sighting 1	6	Moneypoint and mid-channel	slow swim, surface rush, sharking, breach and side slap
18 September 2020 - Sighting 1	8	Moneypoint	Slow travel
23 September 2020 - Sighting 1	7	Off Scattery Island	Slow travel breaching, milling
29 September 2020 - Sighting 1	11	Mid-channel	Slow travel upriver, spread <1000m

On two occasions (9 May, 17 June) images suitable for photo-id were captured from land. On an additional two occasions, the IWDG RIB was also on the water during dedicated watches (9 May, 30 August) and obtained images suitable for photo-id of the same dolphins seen off Ardmore Point during the dedicated watch. This provides information on the individual dolphins that use the waters off Ardmore Point.

A total of 22 individual dolphins were recorded at the proposed development site off Ardmore Point (Table 3). Most were only recorded once but that only means we obtained images of these individuals dolphins which may have been present in other groups but we not photographed, while at least 10 (45%) were recorded on at least two of the four photo-ids sessions. Two of these dolphins were recorded during the first year of the Shannon Dolphin Project in 1993, making them at least 27 years old and an important part of the dolphin community. Ten individuals known since birth were recorded, including four calves born during 2018 and 2019. These dolphins were all part of the "inner" estuary sub-group (Baker et al. 2017b).

Table 3. Identify of individual dolphins recorded off Ardmore Point during dedicated watches

Dolphin ID	23 April (RIB)	9 May (Land)	17 June (Land)	30 Aug (RIB)	Notes
#006	√			√	old animal first recorded in 1993
#008	√	√			old animal first recorded in 1993 (male)
#044		√			adult
#084	√				(adult male)
#118	√				(female)
#173				√	adult
#216		√		√	adult
#236			√	√	adult
#242	√		√		female re-floated in 2011 (O'Brien et al. 2014)
#244			√	√	adult
#312			√	√	(adult male)
#313		√			(adult male)
#801				√	calf of 006 born 2012
#817	√				calf of 242, born 2012
#820		√		√	calf born 2014
#824		√			calf of 044, born in 2014
#862	√		√		older calf born 2015
#880	√			√	calf of 006 born 2018
#881				√	calf born 2018
#886				√	calf born 2019
#887		√			calf born 2019
#890				√	calf born pre 2011

While the primary focus was bottlenose dolphins, all marine mammals sighted were recorded. On six occasions, on six separate watches, individual grey seals were recorded. Most were within 500m of the watch site and on one occasion within 800m (Table 4). Three of the sightings were of seals bottling, which is indicative of sleep/rest, while on three occasions the seal was observed feeding.

Table 4. Details of grey seal sightings recorded during VP watches carried out from April to September 2020

Date and Sighting No.	No individuals	Location	Behaviour
23 April 2020 – Sighting 2	1	<500 m from VP	Slow swim, bottling
27 May 2020 – Sighting 1	1	<500 m from VP	Bottling, feeding (diving, swimming in circles)
01 June 2020 -Sighting 1	1	800 m from VP	Slow swim, bottling
30 August 2020 – Sighting 2	1	<500 m from VP	Bottling, slow swim heading east
23 September 2020 - Sighting 1	1	<50m of Ardmore Pt	foraging
29 September 2020 - Sighting 1	1	<500m drifting west against tide	foraging

Static Acoustic Monitoring

A total of four deployments took place over the duration of the present study but SAM are still deployed at LNG 1 and 2, with the final recovery planned for November 2020. Two locations were monitored, and referred to as LNG 1 and LNG 2 (Figure 8). Monitoring took place 266 days from LNG 1 and 250 days from LNG 2 between 28 August 2019 and 17 May 2020. No data were obtained from deployment 1 (November 2018 and August 2019) as C-PODs were never recovered due to the acoustic releases failing to respond to the release code.

Table 5. Summary of results from SAM at each of the locations

Location	No. of days	Dates	Porpoise	Dolphin	Total	% days detected	Mean DPM/day
LNG 1	266	28 Aug 2019-18 May 2020	66	1,173	1,239	62	4.4
LNG 2	250	28 Aug 2019-17 May 2020	127	904	1,273	62	3.6

Dolphins were recorded on 62% of days at both locations and the number of cumulative dolphin positive minutes were similar across the two sites (Table 5). Durations per day ranging from 0-44 minutes with a peak during October 2019 (Figure 14). Detection Positive Minutes across dolphin and porpoise channels were extracted even though only a few records exist in the estuary for porpoises. As total of 66 "porpoise" detections occurred at LNG 1 while 127 were recorded off LNG 2 (Table 5). These detections were not used in the overall statistical model as they are too few to analysis effectively.

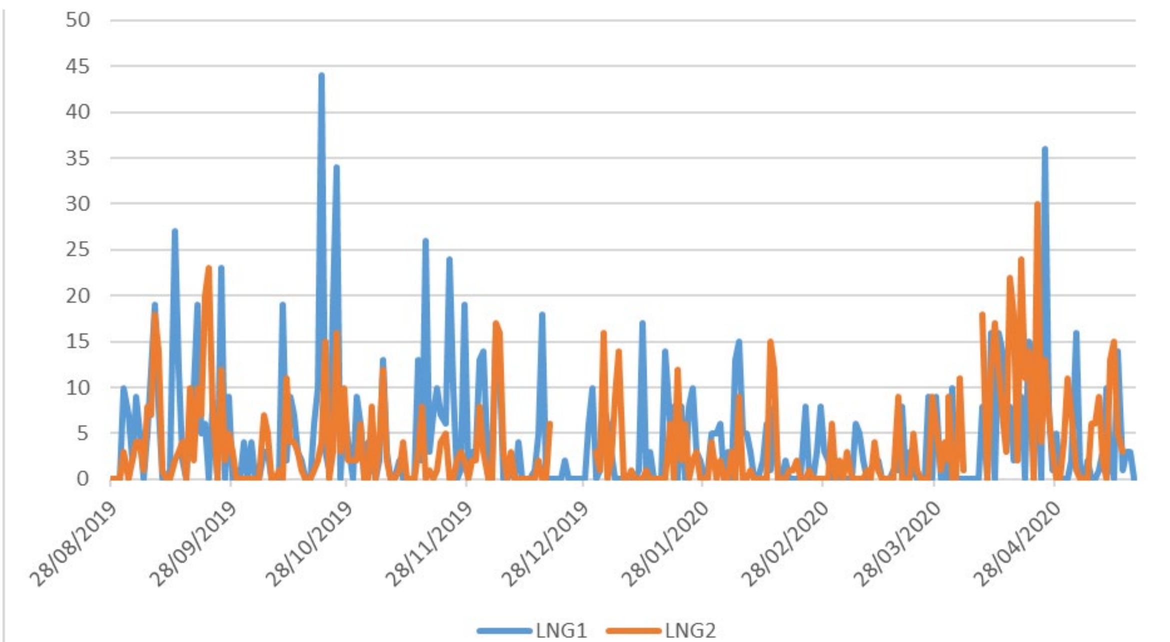


Figure 15. Number of dolphin detections per day recorded across all locations from August 2019 to May 2020 (250-266 days)

LNG1 Monitoring Site

Dolphins were detected on 62% of days monitored at LNG 1 across 266 days. Peaks in detections occurred in October and April (Figure 14). Results from the binomial GLM showed season to have a significant effect with more detections during the spring, summer and autumn. Diel effects were also present with significantly more detections during the evening and at night. Lastly, tidal cycle was also found to have significant effect with more detections during a flood tide (Table 6, Figure 15).

Table 6. GLM output results showing the estimate, standard error, Wald test statistic and P-values for each predictor. Significant variables are denoted with *

Variables	Estimate	SE	Wald	P(>|W|)	Significance
Intercept	-5.86575	0.4825	-12.2	**2e-16**	
Season (relative to Autumn)					
*SeasonSpring	2.711258	0.461759	5.872	4.32e-09	**<0.001**
*SeasonSummer	2.994966	0.498115	6.013	1.83e-09	**<0.001**
*SeasonWinter	1.696768	0.476196	3.563	0.000366	**<0.001**
Diel (Relative to day)					
*DielE	0.525259	0.255115	2.059	0.039503	**<0.05**
DielM	0.130589	0.286156	0.456	0.648134	
*DielN	0.537214	0.195097	2.754	0.005895	**<0.006**
Tidal cycle (relative to Ebb)					
Tidal.cycleL	-0.56185	0.316787	-1.774	0.076131	
Tidal.cycleH	0.003248	0.190119	0.017	0.986370	
*Tidal.cycleF	-0.42947	0.217879	-1.971	0.048704	**<0.05**

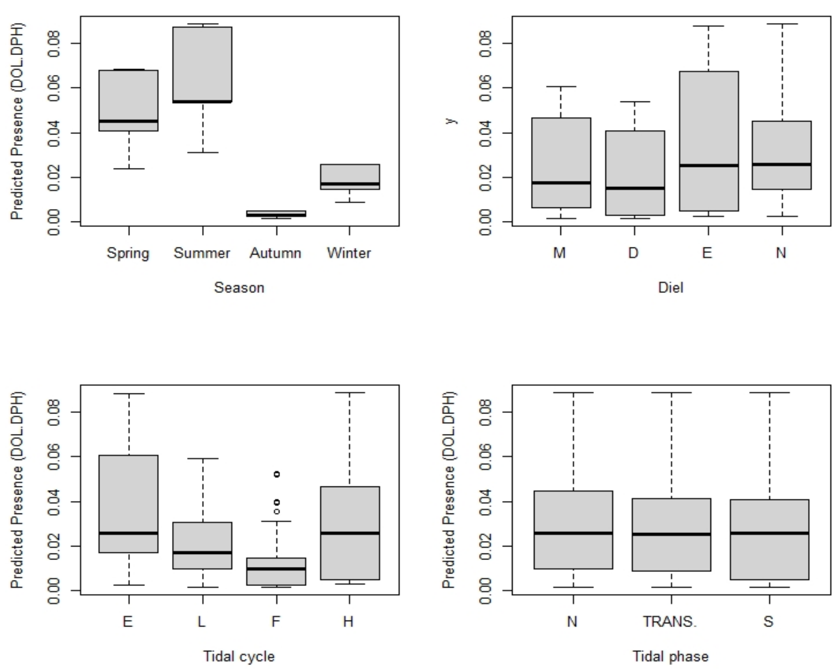


Figure 15. The predicted probability of bottlenose dolphin presence at LNG 1 according to 1. Season, 2. Diel, 3. Tidal cycle and 4. Tidal phase

LNG2 Monitoring Site

Similarly to LNG1 bottlenose dolphins were detected on 62% of days at LNG 2, monitored across 250 days, with peaks similar to LNG 1. Results from the binomial GLM showed neither season, tidal phase or tidal cycle had any significant effect but there were significantly more detections during the evening (Table 7, Figure 16).

Table 7. GLM output results showing the estimate, standard error, Wald test statistic and P-values for each predictor. Significant variables are denoted with *

Variables	Estimate	SE	Wald	P(>|W|)	Significance
Intercept	-2.884936	0.211372	-13.649	**2e-16**	
Season (relative to Autumn)					
SeasonSpring	-0.147524	0.161094	-0.916	0.3598	
SeasonSummer	0.364262	0.228382	1.595	0.1107	
SeasonWinter	-0.319158	0.164482	-1.940	0.0523	
Diel (Relative to day)					
*DielE	0.425449	0.182379	2.333	0.0197	**<0.05**
DielM	-0.159934	0.218827	-0.731	0.4649	
DielN	-0.006086	0.148664	-0.041	0.9673	
Tidal cycle (relative to Ebb)					
Tidal.cycleL	-0.075542	0.171586	-0.440	0.6598	
Tidal.cycleH	0.158787	0.157491	1.008	0.986370	
Tidal.cycleF	0.121639	0.189171	0.643	0.3133	

Comparison with SAM off Moneypoint

SAM data also collected from Moneypoint (2.8 km on the north shore of the Shannon Estuary) concurrent to monitoring of LNG. A random 46 day sample period was used to compare simultaneous monitoring days across all three sites (Between March and May 2020). This showed that detections were similar across all three sites during March and April but an absence of dolphins off Moneypoint was noted in the latter half of April, while detections continued off both LNG sites. However, a non-parametric Kruskal Wallis test (due to a non-normal dataset) (Table 8) showed no significant difference between the three locations showing all three area are regularly used by bottlenose dolphins.

Table 8. Kruskal Wallis output results showing the median, average rank and Z-value across three monitoring locations, LNG 1, LNG 2 and Moneypoint

Location	N	DPM/day	Mean	Median	Ave rank	Z
LNG 1	46	220	4.78	1	67.2	-0.47
LNG 2	46	279	6.07	3	75.1	1.16
Moneypoint	46	156	3.40	2	66.2	-0.69
Overall	138				69.5	

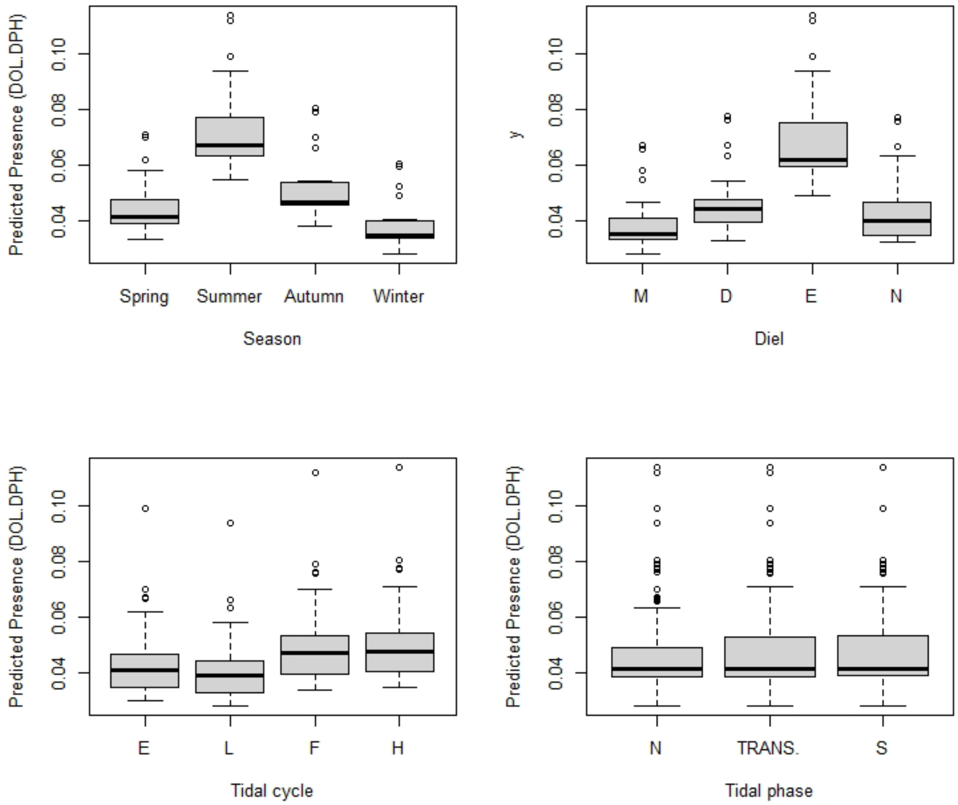


Figure 16. The predicted probability of bottlenose dolphin presence at LNG 1 according to 1. Season, 2. Diel, 3. Tidal cycle and 4. Tidal phase

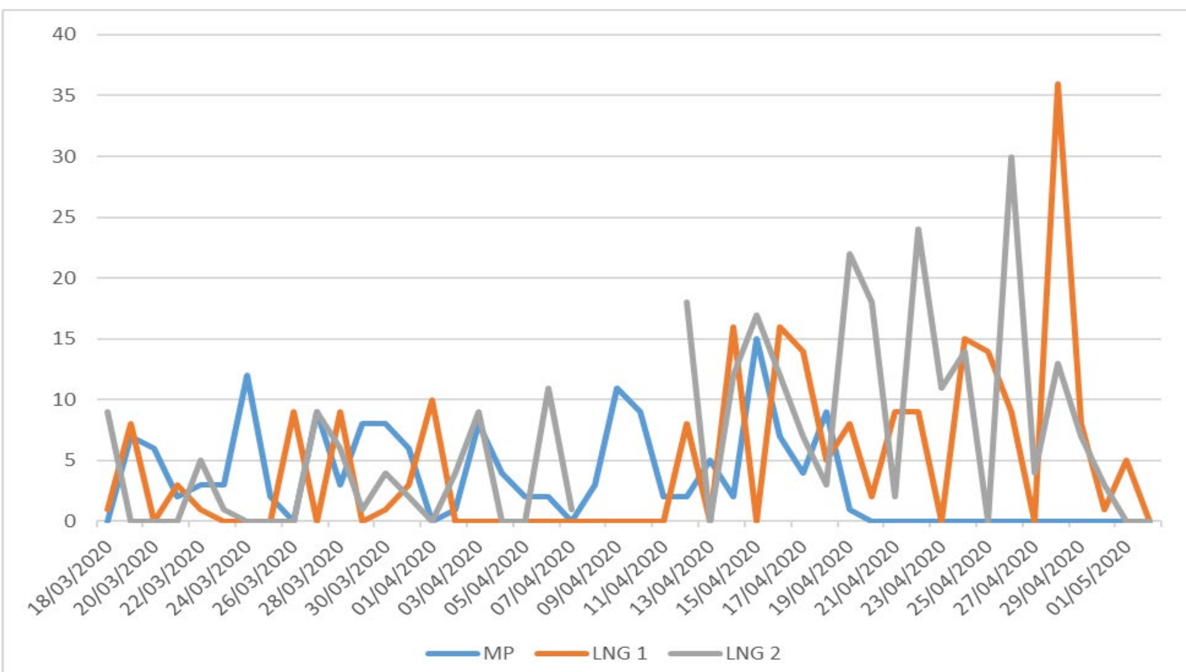


Figure 17. Bottlenose dolphin Detection Positive Minutes (DPM) per day from LNG 1, LNG 2 and Moneypoint

4 Discussion

The IWDG were contracted by New Fortress Energy to assess the use of the proposed site of an LNG terminal off Ardmore Point, Co Kerry by bottlenose dolphins. The dolphins are resident in the estuary with a relatively small population of around 145 individuals. Although the dolphins have been reported throughout the estuary, from Limerick City to the east and off Loop and Kerry Head at the western boundary of the SAC they have also been regularly recorded in Tralee and Brandon Bays outside the SAC. However within this area there are some areas which are more important to dolphins than others. The present study sought to assess the importance of the site of the proposed LNG terminal and jetty to inform environmental impact assessments and planning. It used a combination of visual and acoustic techniques and updated earlier work at the site carried out between 2006 and 2007. As the site is within the Lower River Shannon SAC which list bottlenose dolphins as one of the qualifying interests it is essential that any development does not compromise the sites conservation objectives.

Defining important or "critical" habitats for marine mammals is not straight forward. Critical habitat has been defined as '*habitats that are critical to the survival of the species or community concerned'* (Gibson and Wellbelove 2010). These were described as "*areas or spatial environments that are vital for the day to day survival of individuals of the species and help to maintain a healthy population growth rate*". However, critical habitat should not simply be defined as areas of high animal density. Less densely occupied areas may be more critical to survival, depending on behaviour and population structure, and whether threats in these areas have an impact on the population (Gibson and Wellbelove 2010). Harwood (2001) defined critical habitats as "*in terms of the functioning ecological units required for successful breeding and foraging*".

Ingram and Rogan (2002) delimited critical areas in the Shannon Estuary by using the 50% contour derived from harmonic mean transformation of sighting locations. During this two-year study they showed that dolphins exhibited preferential use of areas of the estuary with the greatest benthic slope and depth (Fig. 18), highlighting the influence of environmental heterogeneity on habitat use by this species. The area off Ardmore Point, although providing benthic slope habitats was not identified as a critical area, however this study is now nearly 20 years old.

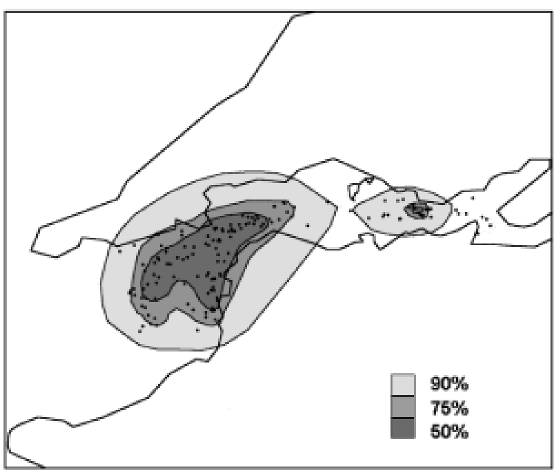


Figure 18. Distribution of bottlenose dolphin sightings within the outer Shannon Estuary. Each encounter location (n = 150) is denoted by a point. Contours are plotted to show the location of 50, 75 and 90% harmonic mean isopleths (from Ingram and Rogan 2002)

Bottlenose dolphin use of the proposed development site

Visual monitoring

A combination of visual monitoring and Static Acoustic Monitoring (SAM) were used to assess dolphin use of the site. A total of 23 land-based watches were carried out between April and September 2020. Watches were carried out every week if sea conditions were suitable and for up to 6 hours each day.

Dolphins were observed from Ardmore Point during 13 (56%) of watches, with a total of 21 sightings ranging from 1-4 per watch. There was a decline in sightings rate in July. There is often a change in dolphin distribution in July and August after the spring run of salmon, which has been associated with prey switching to pelagic species (Barker and Berrow 2015). Mean group size (±SD) off Ardmore Point was 6.2 ± 3.1 dolphins. The dolphins observed off Ardmore Point were all travelling, most slowly and did not stop at the site. Probable foraging activity was observed on one occasion but dolphins rarely exhibited social behaviour while travelling past Ardmore Point, suggesting it is not an area for socialising activity.

Models predicted the proportion of dolphin positive scans was significantly higher during slack low water compared to flood and slack high water. Although the predicted proportion of dolphin positive scans was also higher during an ebbing tide compared to a high and flood tides, this was not significant.

A total of 22 individual dolphins were recorded at the proposed development site off Ardmore Point. Some of these dolphins are the oldest individuals known while 10 calves of known age were also recorded, including four calves born during 2018 and 2019. Although the bottlenose dolphins in the Shannon Estuary are found throughout the estuary some element of habitat partioning is evident. Baker et al. (2017b) carried out movement analysis and showed only 25% of the population of 145 individuals made regular use of the inner estuary. The dolphins frequently recorded in the "inner" estuary which is defined as east of Scattery Island, were also regularly recorded in the outer estuary, but a large proportion of the dolphins recorded in the "outer" estuary (west of Scattery Island) were never recorded in the inner estuary (Baker et al. 2017b). The "inner estuary" group numbers around 30-40 individuals of which over one-half have been recorded within and adjacent to, the proposed development site.

Static Acoustic Monitoring

SAM was used to provide high resolution data of the use of the site by bottlenose dolphins. Two sites within the foreshore lease area were monitored. These sites were consistent with a similar study carried out between 2006 and 2007. Over the 266 day deployment period analysed in this report dolphins were recorded on 62% of days at both sites. This compares to on 65% of days at LNG1 and 35% of days at LNG2 between 2006 and 2007 (Berrow 2007). Mean DPM per day at LNG1 and LNG2 in the present study was 4.4 and 3.6 compared to 1.6 and 0.5 in 2006-2007.

Monitoring at the site in 2006 and 2007 used T-PODs (Timed Porpoise Detector) which were the only available device for this type of work at the time. The C-POD, a digital version of the T-POD, was released in 2009 and O'Brien et al. (2013) conducted trials to compare the efficiency of both devices. They showed that C-PODs recorded seven times more detections than T-PODs during the same deployment period due, for example, to a greater sensitivity and detection range of the C-POD. Thus direct comparison of current detection rates from C-PODs with past acoustic monitoring at the site using T-PODs is not recommended. However it is reasonable to compare the broad overall trends in use of the site by dolphins at the site during these two studies.

During the current study, there was a significant effect of season at LNG1 with fewer detections during winter compared to other seasons and more detections in the evening and on a flood tide. The only significant variable at LNG2 was increased detections in the evening, despite a similar overall number of detections at both sites. These trends were similar to that obtained at the same site during 2006 to 2007 when more detections were recorded during summer compared to the autumn and winter and there were slightly more detections at night at both sites. This suggests that these data do accurately represent the use of the site by bottlenose dolphins.

If we compare the results from the present study to studies carried out elsewhere in the estuary then we can put the use of the site into a wider context. The percent of days with detections is a crude estimate of dolphin presence. The highest occurrence was recorded off Moneypoint Power Station across the estuary from the proposed Shannon LNG site with around 70-80% of days with detections (Table 9).

Detections from the current study (62% of days monitored) were similar to Tarbert (63%) and greater than sites further up river, at which the percent of days with detections declined as you move furthest east.

Table 9. Comparison of results from SAM studies in the Shannon Estuary

Location	Duration (days)	% of days with detections	Detection Positive Minutes	Mean DPM/day (dolphin)	Reference
Moneypoint					
Jan 2009 - Feb 2011	671	73	4245	6.2	O'Brien et al. (2013)
Nov 2011 - Nov 2012	351	80	2737	7.0	O'Brien and Berrow (2012)
July 2016 - Mar 2017	142	54	895	6.3	O'Brien and Berrow (2017)
2009 - 2015	1,720	71			Carmen et al. (in prep)
Tarbert					
July 2016 - March 2017	221	63	2762	12.5	O'Brien and Berrow (2017)
Foynes					
Feb 2009 – Oct 2010	591	41	1,227	-	O'Brien et al. (2013)
Nov 2011 - Nov 2012	288	47	1266	4.4	O'Brien and Berrow (2012)
Apr-Aug 2018	140	34	114	0.8	O'Brien and Berrow (2017)
2009-2014	1,428	39			Carmen et al. (in prep)
Aughinish					
Nov 2011 - Nov 2012	225	31	252	1.0	O'Brien and Berrow (2012)
2011-2014	812	20			Carmen et al. (in prep)
Shannon Airport					
Nov 2011 - Nov 2012	368	21	588	1.5	O'Brien and Berrow (2012)
2011-2013	738	16			Carmen et al. (in prep)
Canon Island					
Apr-Aug 2018	140	4	9	0.06	O'Brien and Berrow (2018)
Ardmore Point					
LNG1 (Jun 2006 - Jun 2007)*	239	65	262	1.6	Berrow (2007)
LNG2 (June 2006 - Jun 2007)*	102	35	35	0.5	Berrow (2007)
LNG1 (Aug 2019-May 2020)	266	62	1239	4.4	This study
LNG2 (Aug 2019-May 2020)	250	62	1273	3.6	This study

*These data were from T-PODs and not C-PODS

A more detailed index is the mean number of Detection Positive Minutes (DPM) per day. Long-term SAM from Moneypoint Jetty returns a mean of around 6-7 DPM/day (Table 9). Detection rates during a shorter study at Tarbert jetty, just upriver of the proposed development site, was greater at 12.5 DPM/day. Further upriver, detections decreased as shown at Foynes, Aughinish and Shannon Airport monitoring sites (Table 9). These data compare to 4.4 and 3.6 DPM/day at LNG 1 and 2 during the present study. Carmen et al. (in prep), analysed click trains recorded at Moneypoint, during a total of 1,720 monitoring days between January 2009 and October 2015. Click trains were recorded across 71% of days monitored, 8.4% trains classified as foraging and showing seasonal variation in foraging suggests that Moneypoint is an important feeding area mainly during winter and spring. The differences in foraging across the tidal phases were relatively small, suggesting little effect on foraging, while tidal cycle, on the other hand, showed increased foraging detections during slack high tides and ebbing tides.

Clearly dolphins regularly occur at the proposed development site but their presence and detections are lower than at known important foraging sites such as Moneypoint (2.8km across the estuary).

Results over a total of 641 days showed that tidal cycle had the greatest effect on detections, with the highest proportion of detections occurring during an ebbing tide and at slack low water. Seasonal differences in bottlenose dolphin presence were found to be significant with winter and summer having a higher detection rate than autumn and spring. Significant variance across diel cycle was attributed to a higher level of detections during the night and morning and significantly more detections during spring compared to neap tides (O'Brien et al. 2013).

Visual observations suggested that dolphins did regularly pass through the site but rarely stopped for any prolonged period. SAM data supported this with most detections of short duration though occasionally they occurred for longer periods. It is clear from the SAM data that dolphins regularly use the proposed site of the LNG terminal. The site is likely used as a transition corridor where dolphins regularly move between the inner and outer estuary.

In conclusion, we have shown that bottlenose dolphins regularly use the waters off Ardmore Point, which is the site of the proposed Shannon LNG terminal. The results from monitoring during 2019-2020 are broadly consistent with results obtained during monitoring at the same site during 2006-2007. Although dolphins were regularly recorded at the site there use seems largely transitory, passing through the site. There was no evidence dolphins are present for long periods or that it is used for foraging. However the site is an important part of the range of the bottlenose dolphins in the Shannon estuary.

The Shannon dolphins are a relatively small, and genetically discrete population and any degradation in this area will impact on the overall quality of the estuary for bottlenose dolphins and it is important that any development should ensure that there is no significant impacts on the dolphin population or its habitats.

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Rogan, E., Garagouni, M., Nykänen, M., Whitaker, A., and Ingram, S. N. (2018). *Bottlenose dolphin surveys in the Lower River Shannon SAC, 2018*. Dublin, Ireland: Final Report to National Parks and Wildlife Service, the Department of Arts, Heritage and the Gaeltacht.
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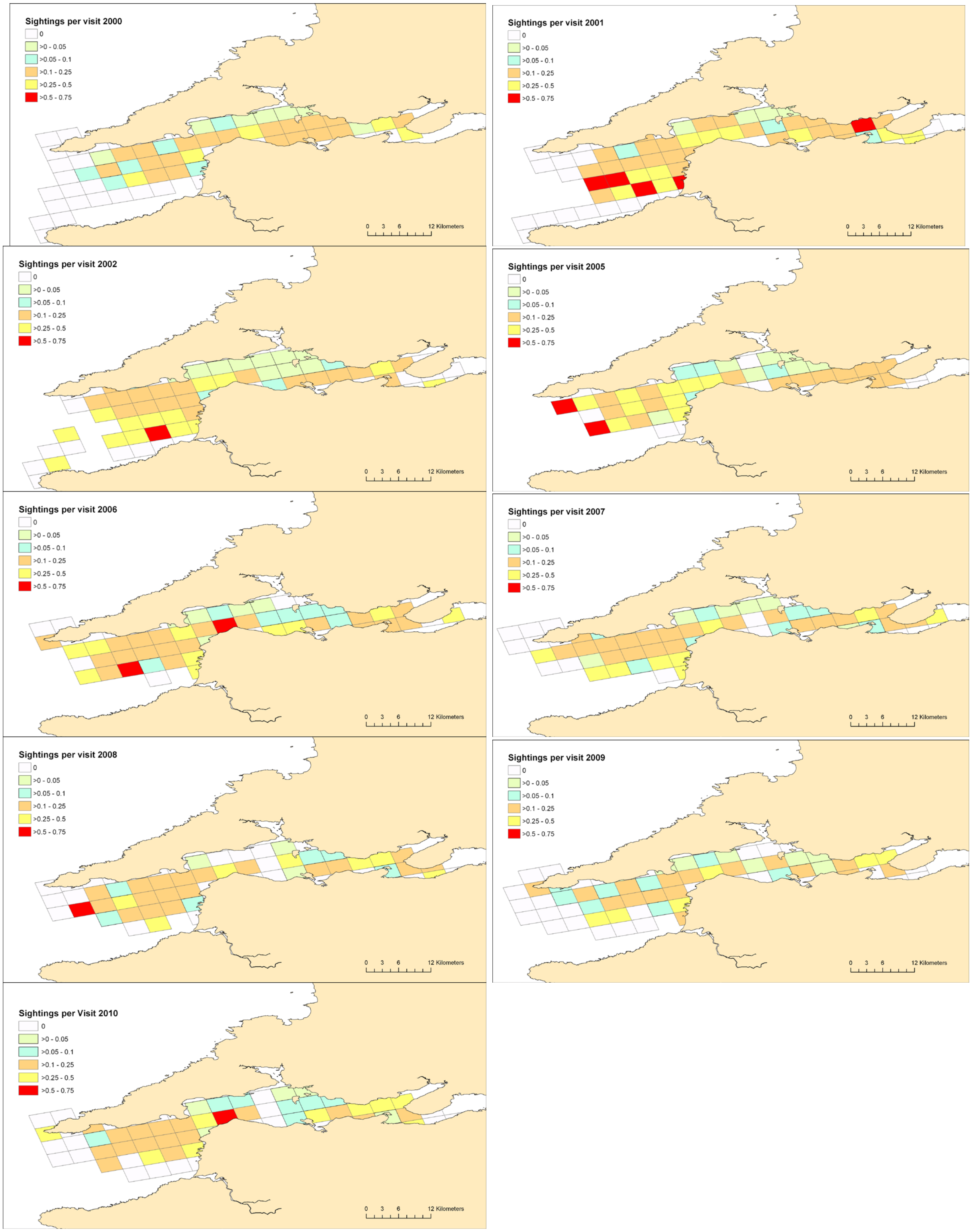
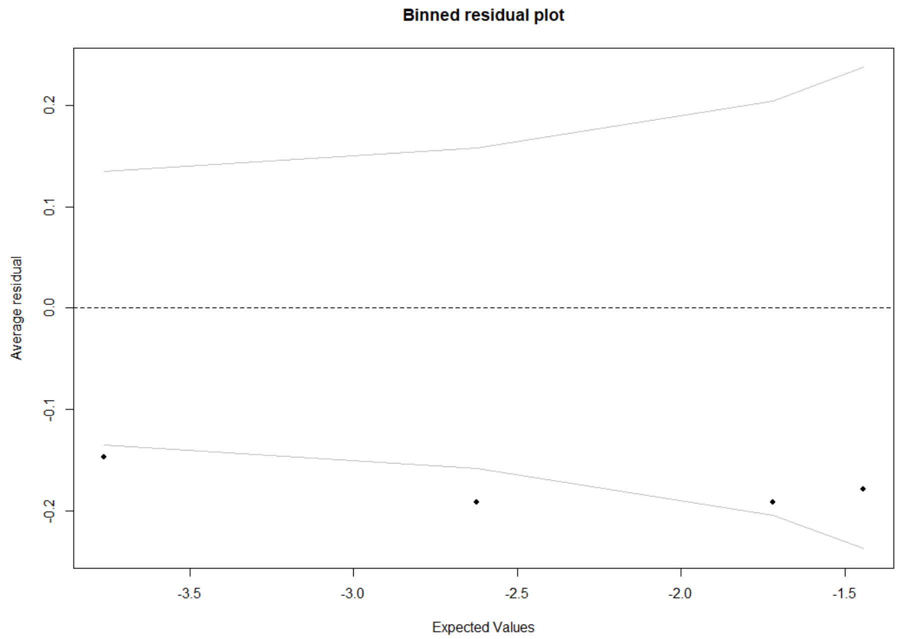
Williams, R., Wright, A. J., Ashe, E., Blight, L. K., Bruintjes, R., Canessa, R., Clarke, K.W., Cullis-Suzuki, S., Dakin, D.T., Erbe, C., Hammond, P.S., Merchant, N.D., O'Hara, P.D., Purser, J., Ranford, A.N., Simpson, S.D., Thomas, L., and Wale, M. A. (2015). Impacts of anthropogenic noise on marine life: publication patterns, new discoveries, and future directions in research and management. *Ocean and Coastal Management*, *115*, 17-24.
Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., and Smith, G. M. (2009). *Mixed effects models and extensions in Ecology with R*. New York, NY: Springer. https://dx.doi.org/10.1007/978-0-387-87458-6.
Zuur, A. F., Hilbe, J. M., and Ieno, E. N. (2013). *A beginner's guide to GLM and GLMM with R. A frequentist and Bayesian perspective for ecologists*. Newburgh, UK: Highland Statistics Ltd.

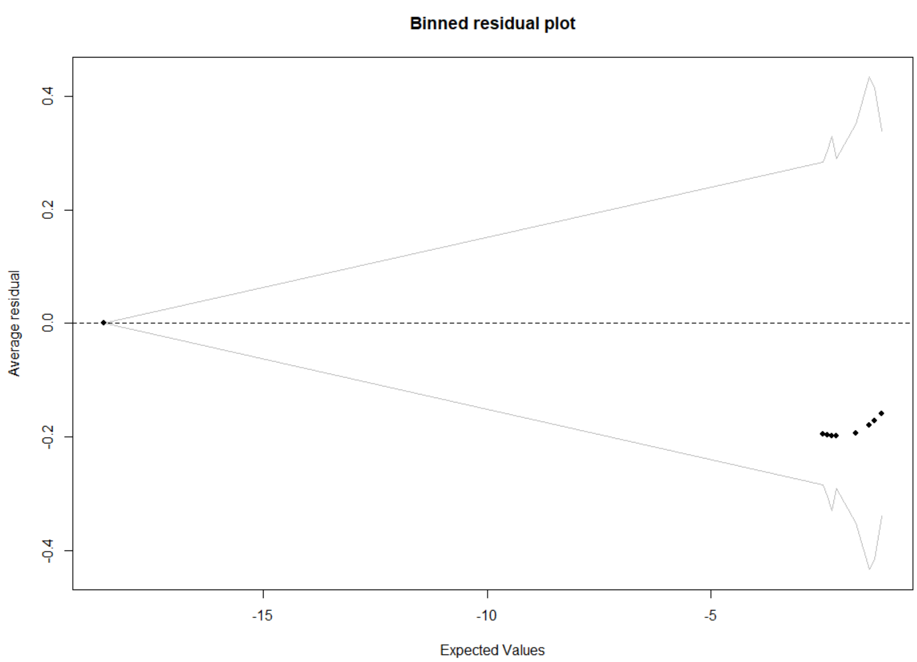
Appendix I: Observed v Expected distribution of bottlenose dolphins from tour boat data 2000-2010 (excluding 2003 and 2004). Source: IWDG Unpubl. data.



Appendix II: Binned residuals produced by the arm package binnedplot() function from modelled VP data



Model 1 indicates that the expectation that around 95% of residuals fall within the standard error bounds was not met



Model 2 indicates that the expectation that around 95% of residuals fall within the standard error bounds is met, but the points are clustered rather than spread put with no apparent pattern

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE02) started in October 2020 and will run until March 2021

Fieldwork

a. Weekly VP watches

Watches were conducted from Ardmore Point in good sea conditions.

Date	Time started	Duration (minutes)	Sightings
7 October 2020	09:45	360	1 BNF
15 October 2020	07:50	360 (240 good)	1 BND, 1 GS
22 October 2020	07:50	360	3 BND, 1 HP
30 October 2020	09:00	360	1 GS

The dolphin known as Muddy Mackerel was photographed on 15 October 2020 foraging in a group of 3 off Ardmore Point.

During watch on 22 October a single harbour porpoise was observed foraging towards the notryh side of the estuary near Moneypoint. It is very unusual to see a porpoise this far up the estuary with the furthest upriver sighting previous to this was just east of Scattery in June 2018.

Harbour porpoise near Moneypoint seen on 22 October 2020

b. Static Acoustic Monitoring

SAM – two CPODs were deployed in September during the previous contract and will be recovered in after 6 November. Although this is only 2 months we feel it is important to recover and change the batteries in the ARs.

Monitoring Site	Date Deployed	Date Recovered	Date Deployed
LNG 1	2 June 2020	6 September 2020	6 November 2020*
LNG 2	2 June 2020	6 September 2020	6 November 2020*

- Indicative date

<u>Future Tasks</u>

Continue weekly VP watches

Recover and redeploy CPODs at LNG1 and LNG2 after 6 November

Dr Simon Berrow, IWDG Project Manager
31 October 2020

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE02) started in October 2020 and will run until March 2021

Fieldwork

a. Weekly VP watches

Watches were conducted from Ardmore Point in good sea conditions.

Date	Time started	Duration (minutes)	Sightings
5 November 2020	07:30	360	1 BND
9 November 2020	10:50	270	1 BND
19 November 2020	9:40	330	2 BND
26 November 2020	09:30	360	1 BND

Dolphins foraging off Moneypoint (5 November 2020).

b. Static Acoustic Monitoring

SAM – two CPODs were deployed in September during the previous contract and recovered on 4 November after 61 days. After moorings replaced and serviced they were re-deployed on 5 November. A full dataset was downloaded from both CPODs.

Monitoring Site	Date Deployed	Date Recovered	Date Deployed
LNG 1	6 September 2020	4 November 2020	5 November 2020
LNG 2	6 September 2020	4 November 2020	5 November 2020

- Indicative date

Modelling Report

SB received draft for comments. Comments sent to BOC and followed up with phone-call looking for technical report on modelling from LR

Future Tasks

Continue weekly VP watches

Dr Simon Berrow, IWDG Project Manager
27 November 2020

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE02) started in October 2020 and will run until March 2021

Fieldwork

a. Weekly VP watches

Watches were conducted from Ardmore Point in good sea conditions. Watch on 17 December had to be cut short after 4.5 hrs as rain become heavy and persistent. No dolphins were seen but none had been seen from the ferry all day either. Only a single seal sp. Observed on watch on 30 December but dolphins had been seen from ferry on flood tide the previous day (29 Dec)

Date	Time started	Duration (minutes)	Sightings
6 December 2020	09:40	330	1 BND
Week 10	No Watch		
17 December 2020	09:45	270	-
Week 12	No Watch		
30 December 2020	11:20	330	1 seal

Dolphins active near wind turbines at Moneypoint (6 December 2020).

b. Static Acoustic Monitoring

SAM – two CPODs were deployed in September during the previous contract and recovered on 4 November after 61 days. After moorings replaced and serviced they were re-deployed on 5 November. A full dataset was downloaded from both CPODs.

Monitoring Site	Date Deployed	Date Deployed	Date Recovered
LNG 1	6 September 2020	5 November 2020	5 February 2021
LNG 2	6 September 2020	5 November 2020	5 February 2021

- Indicative date

Modelling Report

SB received Navigation Risk Assessment from Marico Group but not looked at contents yet.

Future Tasks

Continue weekly VP watches through January 2021

Dr Simon Berrow, IWDG Project Manager
31 December 2020

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE02) started in October 2020 and will run until March 2021

Fieldwork

a. Weekly VP watches

Watches were conducted from Ardmore Point in good sea conditions.

Date	Time started	Duration (minutes)	Sightings
3 January 2021	10:40	360	1 BND
9 January 2021	11:00	300	2 BND + 1 GS
14 January 2021	09:45	360	1 dolphin sighting
22 January 2021	09:30	360	None

Dolphin sighting on 14 January could not be confirmed as bottlenose dolphin and might have been of common dolphins based on size and behaviour. Unfortunately this could not be confirmed.

b. Static Acoustic Monitoring

SAM – two CPODs were deployed in September during the previous contract and recovered on 4 November after 61 days. After moorings replaced and serviced they were re-deployed on 5 November. A full dataset was downloaded from both CPODs.

Monitoring Site	Date Deployed	Date Deployed	Date Recovered
LNG 1	6 September 2020	5 November 2020	5 February 2021
LNG 2	6 September 2020	5 November 2020	5 February 2021

- Indicative date

Modelling Report

SB received Navigation Risk Assessment from Marico Group but not looked at contents yet.

Future Tasks

Continue weekly VP watches through February 2021
Recover and redeploy SAM off Ardmore Point

Dr Simon Berrow, IWDG Project Manager
31 January 2021

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE02) started in October 2020 and will run until March 2021

Fieldwork

a. Weekly VP watches

Watches were conducted from Ardmore Point, Co Kerry.

Date	Time started	Duration (minutes)	Sightings
1 February 2021	12:30	300	1
10 February 2021	10:50	360	1 (GS)
17 February 20201	10:30	330	0
26 February 2021	08:45	360	1 (BND)

Four watches were completed during February, Sea conditions not perfect on 10 and 17 February 2021 overall but good enough to survey the waters off Ardmore for the presence of marine mammals

b. Static Acoustic Monitoring

SAM – two CPODs were deployed 5 November 2020.

Monitoring Site	Date Deployed	Date Deployed	Date Recovered
LNG 1	5 November 2020	6 February 2021	8 February 2021
LNG 2	5 November 2020	-	-

SAM was visited on 6 February for recovery and replacement. The Acoustic Release at LNG 1 responded and released first time and the CPOD was recovered. Unfortunately the Acoustic Release at LNG 2 would not release despite successfully going through the release sequence. The AR continued to range and despite numerous transmission of the release code the AR wouldn't release and stayed on the bottom at 25m water depth.

The site was re-visited on 8 February and a replacement CPOD and Acoustic Release deployed at LNG 1. A second attempt to release the Acoustic Release at LNG 2 was attempted but with the same result.

A triangulation exercise was carried out (Table 1), which can accurately pin-point the position of the AR on the bottom (Figure 1). This enabled a small search area to be defined (Table 2; Figure 2)

Table 1. Positions and distances of AR from 10 locations on surface

No.	Range (m)	Lat	Long.	Ddlat	Ddlong
1	34.4	52 36.160	009 26.403	52.586	-9.44005
2	91.7	52 35.115	009 26.333	52.58525	-9.43888
3	171.7	52 35.178	009 26.243	52.5863	-9.43738
4	227.1	52 35.236	009 26.354	52.58727	-9.43923
5	152.4	52 35.208	009 26.462	52.5868	-9.44103
6	74.3	52 35.127	009 26.435	52.58545	-9.44058
7	107.3	52 35.188	009 26.320	52.58647	-9.43867
8	129.6	52 35.211	009 26.400	52.58685	-9.44
9	186.5	52 35.143	009 26.542	52.58572	-9.44237
10	89.2	52 35.182	009 26.429	52.58637	-9.44048

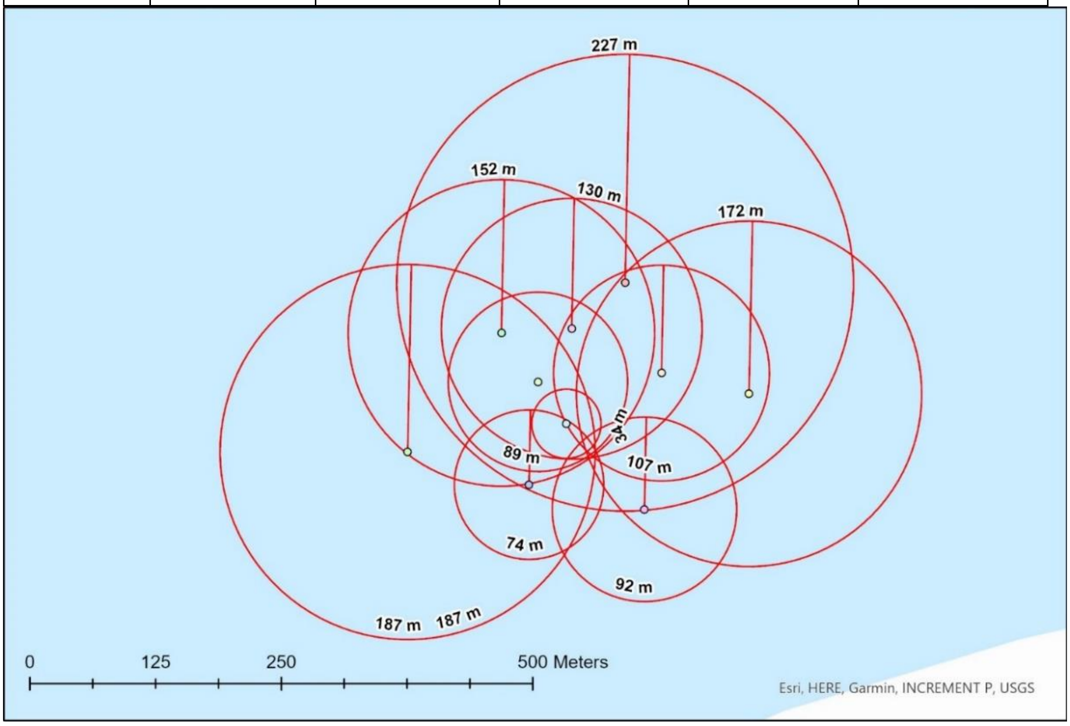


Figure 1. Distances to AR from 10 locations

Table 2. Positions defining search area

WP	dd_Lat	dd_Long	Lat	Long
1	52.5855695	-9.43938	52 35.134	-9 26.363
2	52.5855764	-9.4391192	52 35.135	-9 26.347
3	52.5855796	-9.4388619	52 35.135	-9 26.332
4	52.5854392	-9.4388554	52 35.126	-9 26.331
5	52.5853037	-9.4388529	52 35.118	-9 26.331
6	52.5852921	-9.4390894	52 35.118	-9 26.345
7	52.5852847	-9.4393837	52 35.117	-9 26.363
8	52.5854303	-9.4393802	52 35.126	-9 26.363
9	52.5854373	-9.4391127	52 35.126	-9 26.347

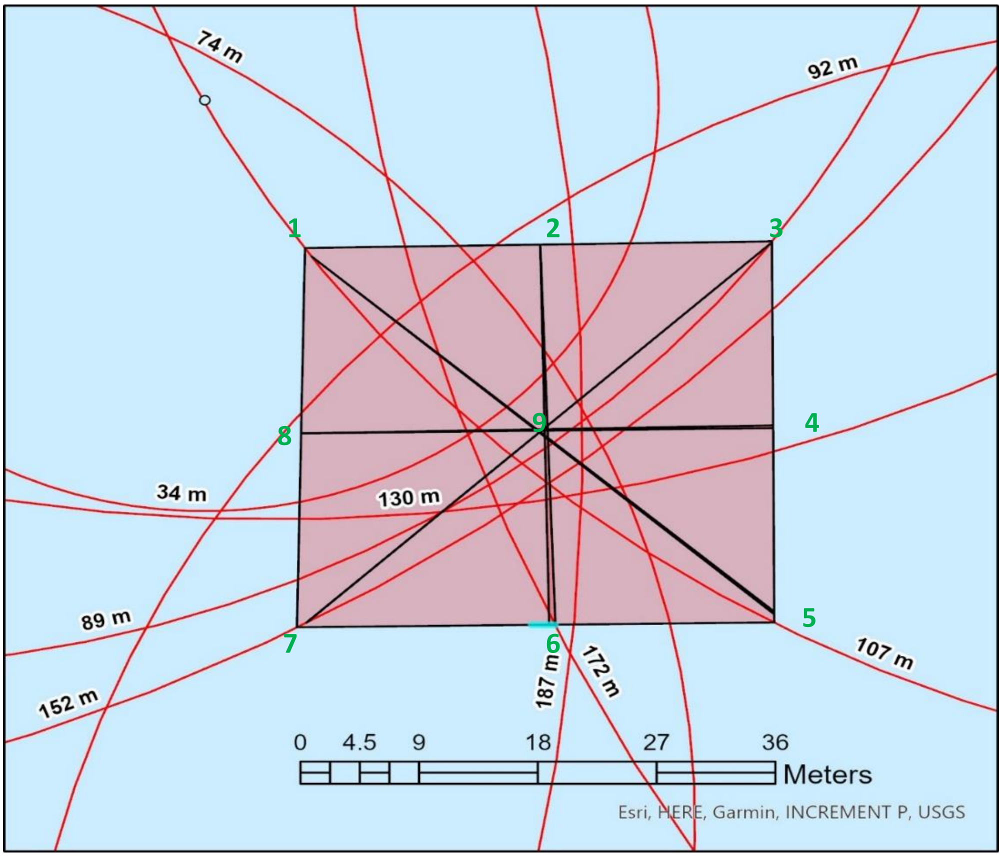


Figure 2. Distances to AR from 10 locations

A diver will be sent down to try and recover CPOD when conditions are suitable. In the meantime the CPOD should still have plenty battery and data storage to continue monitoring.

<u>Future Tasks</u>

i) Continue weekly VP watches through March 2021 (last month of watches)
ii) Deploy diver to recover CPOD and AR at LNG 2 using fixes above
iii) If before early April, redeploy new CPOD
iv) Recover SAM at LNG1 in early April for download and analysis

Dr Simon Berrow, IWDG Project Manager
28 February 2021

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE02) started in October 2020 and will run until March 2021

Fieldwork

a. Weekly VP watches

Watches were conducted from Ardmore Point, Co Kerry.

Date	Time started	Duration (minutes)	Sightings
3 March 2021	09:45	360	0
16 March 2021	10:00	360	1
20 March 2021	09:45	360	2
31 March 2021	10:00	360	0

Four watches were completed during March, Sea conditions were good on all days but viability was limited during watches on 3 and 16 March but good enough to survey the waters off Ardmore for the presence of marine mammals. Bottlenose dolphins were seen on two f the 4 watches but only in small numbers.

This is the final monthly report from the current contract.

<u>Future Tasks</u>

i) Recover SAM at LNG1 and LNG 2 in early April for download and analysis

If no further land-based watches are required then:

ii) Model visual survey data
iii) Prepare draft Final report

Dr Simon Berrow, IWDG Project Manager
31 March 2021

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE03) started in April 2021 and will run until September 2021

<u>Fieldwork</u>

a. Weekly VP watches

Watches were conducted from Ardmore Point, Co Kerry. These complete the land-based monitoring. A total of 50 land-based watches have now been completed since April 2020.

Date	Time started	Duration (minutes)	Sightings
7 April 2021	09:00	390	0
12 April 2021	10:00	390	1
20 April 2021	10:00	360	5
29 April 2021	10:00	300	3

Dolphins were seen on 3 of the 4 watches carried out in April 2021 and were observed passing within 100m of Ardmore point on 12 and 29 April. On 20 April dolphins seen off Ardmore were photographed later from ferry at end of watch.

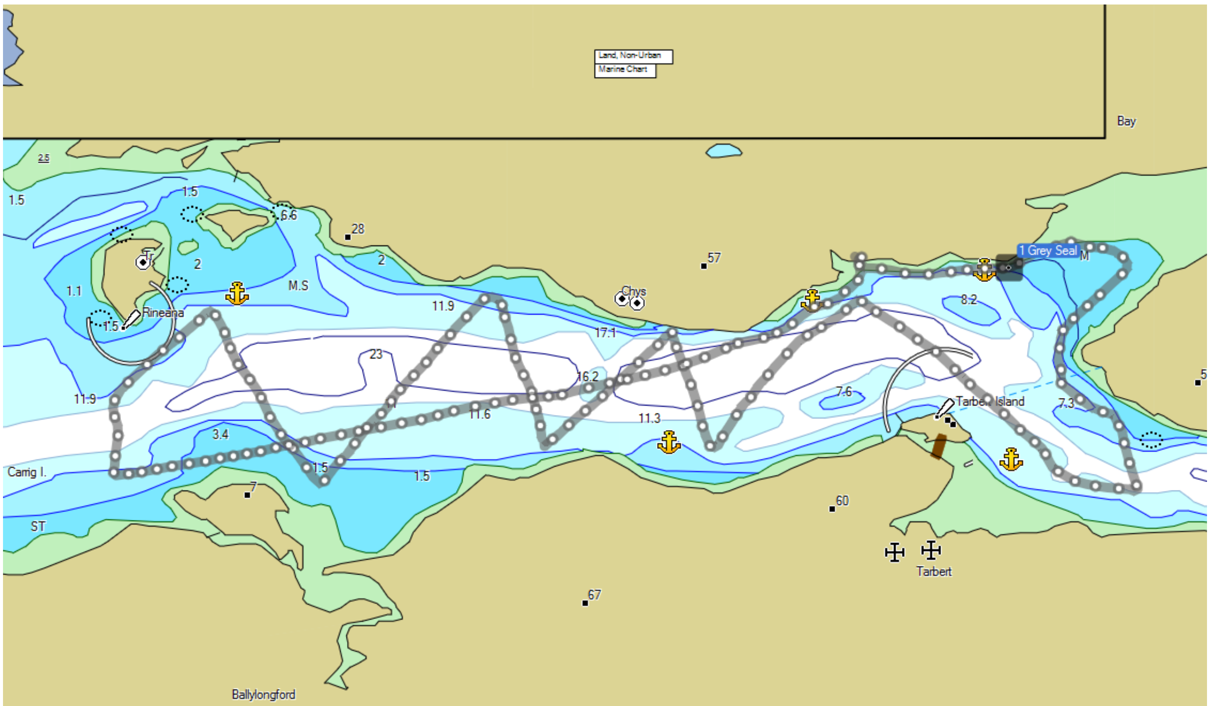
Dolphin images from the Shannon Ferry, 20 April 2021

SAM

Two divers were sent down at LNG 1 on 27 April to try and find SAM. No luck. A second attempt will be carried out after another triangulation exercise. I am still very hopeful of recovery as it is still on site and ranges to the transponder.

Start RIB transects

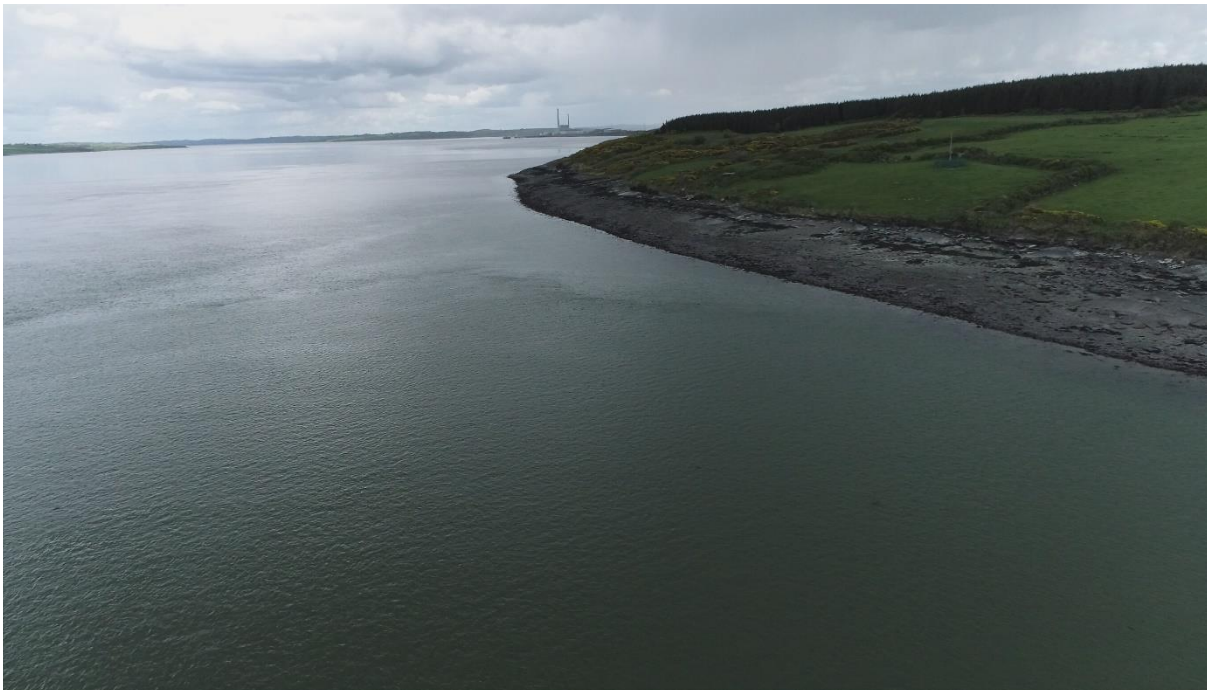
Twice monthly boat transects in water adjacent to Ardmore point are to be started in May 2021x through til September. A pilot transect was carried out in April and a proposed route is shown below. Lines will be staggered on each transect to provide full coverage of the estuary.



Future Tasks

i) Dive LNG1 to recover SAM
ii) Recover SAM at LNG 2 in early May for download and analysis
iii) Deploy additional SAM at LNG 1 in early May
iv) Model visual survey data
v) Start RIB transects

Dr Simon Berrow, IWDG Project Manager
30 April 2021



Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

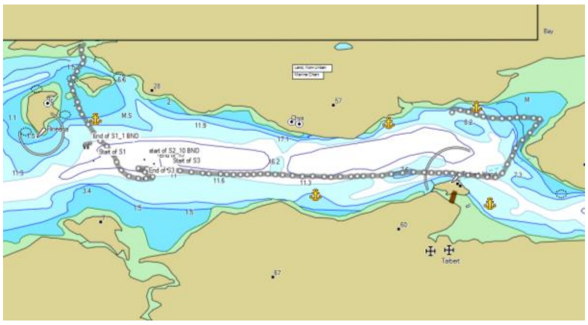
IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE03) started in April 2021 and will run until September 2021

Fieldwork

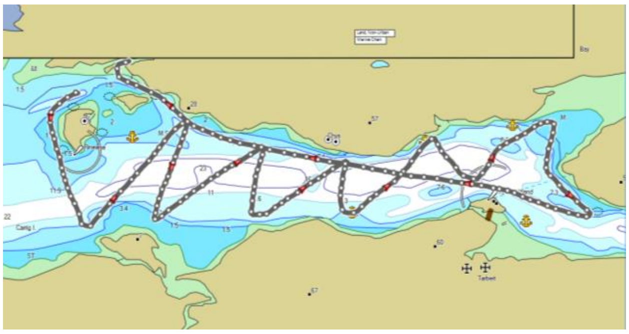
RIB transects

The GPS used on transect 4 on 12 June did not record the entire track line but the normal zig-zag pattern was surveyed. The dolphins recorded as sighting 2 were still present at the same location at the end of the transects and consisted of the same individuals.

Date	Time started	Distance travelled	Sightings
T4: 12 June 2021	11:00	-	2
T5: 30 June 2021	07:30	26.7nmls	0



Transect 4: 12 June 2021



Transect 5: 30 June 2021

Seabird Surveys

Two completed in June. Report sent to Carl Dixon for EIA/NIS.

Date	Time started	Distance travelled
13 June 2021	08:30	54
28 June 2021	15:00	

SAM

Recovery due in mid-August. Divers being organised to try another attempt to recover SAM at LNG2 which did not pop up.

Future Tasks

i) Model visual survey data
ii) Continue RIB transects
iii) Recover lost CPOD at LNG 2
iv) Continue Seabird Surveys in July

Dr Simon Berrow, IWDG Project Manager
30 June 2021

Bottlenose Dolphin Monitoring at the site of the proposed Shannon LNG terminal – progress report to NFE

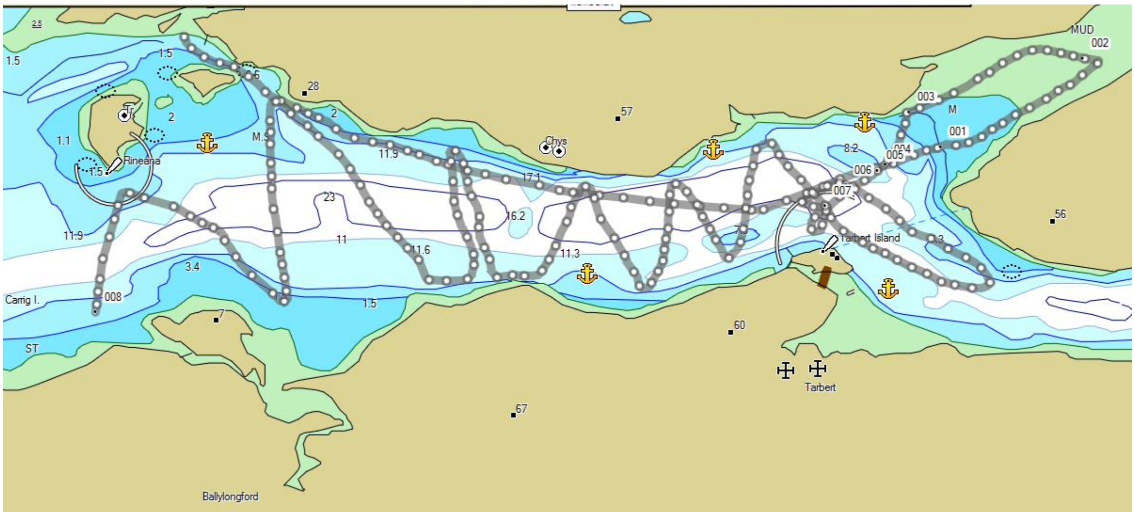
IWDG Consulting were contracted to carry out a second six months monitoring of the bottlenose dolphins at the proposed site of an LNG terminal in the Lower River Shannon SAC. The current contract (IWDG_NFE03) started in April 2021 and will run until September 2021

Fieldwork

RIB transects

A transect was carried out on 16 July but no dolphins were observed. Dolphin were observed off Ardmore Point during a seabird survey on 19 July and images were taken of the individuals present.

Date	Time started	Distance travelled	Sightings
T1: 2 May 2021	11:00	40	2
T2: 14 May 2021	10:30	56	0
T3: 30 May 2021	11:30	50	3
T4: 12 June 2021	11:00	No GPS	2
T5: 30 June 2021	07:30	27	0
T6: 16 July 2021	11:00	33	0



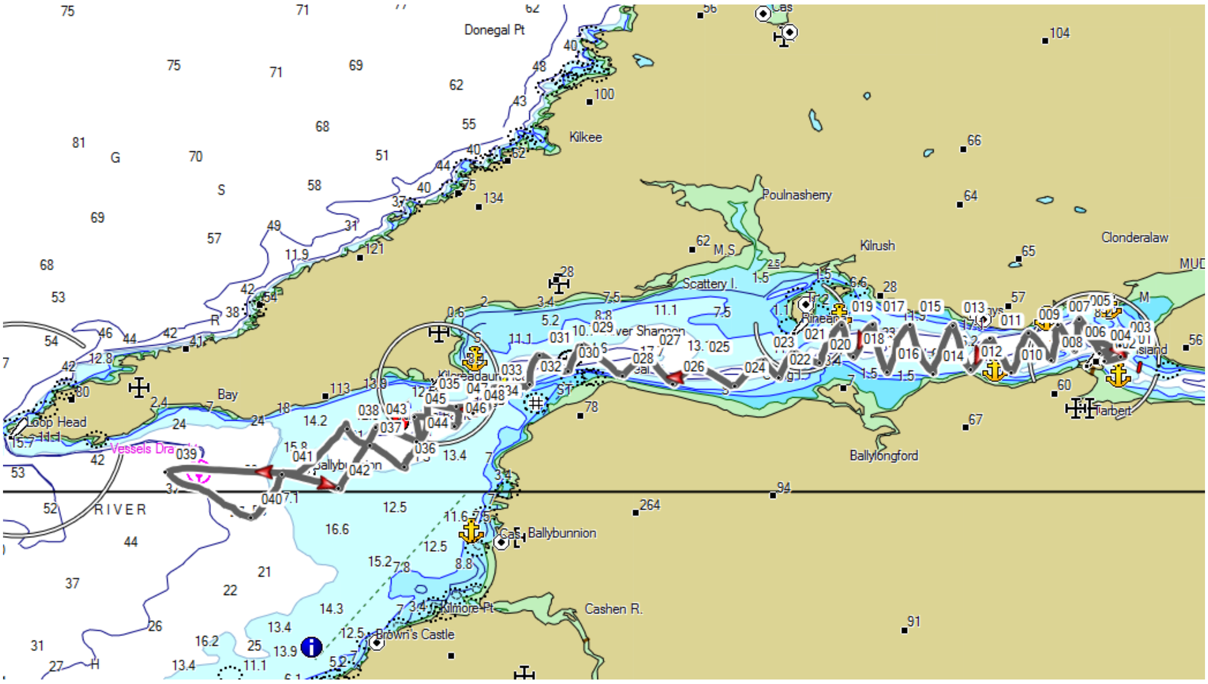
Transect 6: 16 July 2021

Seabird Surveys

Two completed in July. The first on 19 July was shortened due to thick fog, delating the start time and limiting coverage in the outer estuary. The number of rafting and feeding manx shearwaters in the mid-estuary durin gT4 (26 July 2021) was noted.

Date	Time started	Distance travelled (nmls)

T1: 13 June 2021	08:30	54
T2: 28 June 2021	15:00	61
T3: 19 July 2021	10:40	40
T4: 26 July 2021	08:24	50



T4: 26 July 2021

SAM

Recovery due in mid-August. Divers being organised to try another attempt to recover SAM at LNG2 which did not pop up.

Future Tasks

i) Model visual survey data
ii) Continue RIB transects
iii) Recover lost CPOD at LNG 2
iv) Continue Seabird Surveys in August

Dr Simon Berrow, IWDG Project Manager
31 July 2021

Appendix 7

Outline Construction Environmental Management Plan

OUTLINE CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN

PROJECT:	Shannon Technology and Energy Park (STEP)		
LOCATION:	**Ralappane**, Ballylongford, Co. Kerry		
CLIENT:	Shannon LNG Limited		
CONTRACT NO:	TBC	**PLAN PREPARED BY:**	
START DATE:	TBC	**COMPLETION DATE:**	TBC

Schedule OF REVISIONS

Revision No.	Date	Pages/Section Revised	Comment	Approved
Draft AA	07/01/2021	First draft		
00	21/01/2021	Second draft		
01	16/08/2021	Final		

CONTENTS

1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this site-specific Outline Construction Environmental Management Plan (CEMP) is to set out the high-level approach to the management of environmental mitigation measures required during the Construction Stage to minimise or mitigate any impact of construction works on the environment. It has been developed on behalf of Shannon LNG Limited to accompany the planning application to An Bord Pleanála (ABP). This will act as the overarching document ensuring environmental compliance for the development. A detailed CEMP will be prepared by the Main Contractor appointed to undertake the works prior to the commencement on site. The Main Contractor will ensure that the construction works are undertaken in accordance with best practice, the relevant legislation, any conditions imposed in the planning permission for the site and with minimal impact on the environment. This plan does not address the operational phase of the proposed facility.

It is intended that this Outline CEMP and its supporting documentation will address all environmental criteria associated with the works.

1.2 Content of this document

This Outline CEMP provides an overview of the environmental management of the project and identifies the key roles and responsibilities that will ensure the works are carried out in compliance with the Planning Permission and EIAR.

The document also describes the Communication, Training & Awareness programmes associated with the construction works.

All of the information is presented in a comprehensive plan including all figures and mapping required to meet environmental requirements. The documentation has been prepared to allow for ease of update as part of the ongoing review and update of the CEMP. The document is set out in the following structure:

- Section 1: Introduction
- Section 2: Project Details for the Construction Works
- Section 3: Environmental Objectives and Targets
- Section 4: Environmental Responsibilities and Organisation
- Section 5: Non-Conformance, Corrective and Prevention Action Plan
- Section 6: Communications
- Section 7: Training and Awareness
- Section 8: Waste Management Plan
- Section 9: Prescribed Environmental Aspects, Impacts and Mitigation.

1.3 Supporting environmental documentation

The CEMP is supported by a number of documents:

- Environmental Impact Assessment Report (EIAR)

1.3.1 Guidance Documents

The following guidelines and documents have been consulted to draw up general and specific construction management measures:

- H. Masters-Williams et al (2001) Control of water pollution from construction sites. Guidance for Consultants and Contractors (C532). CIRIA;

- Construction Industry Guidelines (such as CIRIA C502 Environmental Good Practice on site);
- BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1: Noise and BS 5228-2:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part2: Vibration (together referred to as B.S. 5228);
- Control of Dust from Construction and Demolition Activities (BRE 2003);
- Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Water (IFI, 2016);
- Environment Agency (2013) The Knotweed Code of Practice. Managing Japanese knotweed on Development Sites (Version 3);
- E. Murnane, A. Heap and A. Swain. (2006) Control of Water Pollution from Linear Construction Projects. Technical Guidance (C648). CIRIA;
- E. Murnane et al., (2006) Control of Water Pollution from Linear Construction Projects. Site Guide (C649). CIRIA;
- Murnane et al (2002) Control of Water Pollution from Construction Sites - Guide to Good Practice. SP156;
- IFI (2016) Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters. Inland Fisheries Ireland, Dublin
- Site Procedure 6 (Above-Ground Oil Storage Tanks) from CIRIA C532 Control of Water Pollution from Construction Sites;
- Pollution Prevention Guidelines No.2 (Above Ground Oil Storage Tanks) from the UK Environment Agency;
- Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes (NRA, 2008a);
- Guidelines for the Treatment of Otters during the Construction of National Road Schemes (NRA, 2008b); and
- Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Roads (NRA, 2010, Rev. 1.).

2. PROJECT DETAILS

2.1 Site location and Construction Works

This Outline CEMP is being produced to accompany the combined LNG Terminal & Power Plant planning application being sought on the Shannon Land Bank, approx. 4km west of Tarbert, Co. Kerry (See Figure 2.1 below) to include the following;

The Proposed Development consists of two main components:

1. Power Plant; and
2. LNG Terminal.

The proposed Power Plant will comprise of:

- Three (3) blocks of Combined Cycle Gas Turbines (CCGT), each block with a capacity of approximately 200 megawatts (MW) for a total installed capacity of up to 600 MW;
- Battery Energy Storage System (BESS);
- High voltage 220 kV Substation;
- Auxiliary Boiler;
- Raw water treatment building;
- Firewater storage tanks and fire water pumps;
- Fuel storage; and
- Ancillary buildings common to both the Power Plant and LNG Terminal.

The proposed LNG Terminal will comprise of:

- An LNG ship in the form of a Floating Storage and Regasification Unit (FSRU), with LNG storage capacity of approximately 170,000 m3 (up to 180,000 m3). The EIAR considers a capacity of up to 180,000 m3. The FSRU is a ship that can store liquefied natural gas (LNG) onboard, and which also is fitted with an onboard regasification unit which can return stored LNG into a gaseous state. The ship will be up to 300 m long, and up to 50 m wide and the height of the vessel including the top of the exhaust stack will be approximately 50 m above sea level. The FSRU will be an existing suitably classified marine vessel that will be modified to ensure it operates in accordance with the terms of the Planning Permission, the Industrial Emissions Licence and all the other relevant statutory approvals required for its operation.
- A jetty with an access trestle, with the jetty comprising an unloading platform, mooring dolphins and breasting dolphins with capacity to accommodate up to four tugboats. They will facilitate safe mooring operations for the FSRU and visiting LNG carriers as required.;
- Onshore receiving facilities including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator, backup power generators fire water system; and
- An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, chromatography, gas metering and pressure control equipment. The AGI will facilitate the export of LNG to the national gas transmission network via the already consented 26 km Shannon Pipeline.

LNG will be delivered to the LNG Terminal by a visiting LNG Carrier (LNGC) which will be moored to the seaward side of the FSRU.

Figure 2.1 LNG Terminal & Power Plant Site Location

Figure 2.2 Site location

2.1.1 Site Access

The contractor will begin by setting out the site entrance as shown in Figure 2.3 as early as possible in the programme consistent with seasonal environmental restrictions and constraints. This operation will begin with the clearance of existing hedgerows and vegetation at the site entrance on the L1010 and progress along the route of the access road to the construction laydown area. This will be followed closely by the excavation of vegetation and topsoil for the access road which follows the existing ground levels and then the placement of crushed stone (to create a 6 m wide access road) to create an initial access and roadway to the construction laydown and jetty area. All topsoil will be retained onsite for future use. Topsoil will be placed in temporary stockpiles at various locations throughout the site for re-use on slopes, with any excess material placed in the vicinity of the contractor's compound (see Figure 2.3). Approximately 26,000 tonnes of imported aggregate will be delivered from local quarries along the L1010 from the Tarbert direction. Sources of material could include:

- Ardfert Quarries, Ardfert, Co. Kerry;
- O'Mahoney Quarries, Tralee, Co. Kerry;
- Roadstone, Foynes, Co. Limerick; and
- Liam Lynch, Adare, Co. Limerick.

It is anticipated that the creation of this initial access will take about 2 to 3 months. Apart from the delivery of materials, the operation will all take place within the site with personnel using mobile plant.

Traffic management measures approved by KCC and An Garda Siochana will be installed prior to the commencement of works to ensure the site access is safe for all road users.

Site preparation will commence with the establishment of safe access and temporary site roads. A perimeter fence will be erected around the site boundary. Fencing will be installed to protect the Ralappane stream. Temporary car parking and site office and other facilities will be established to support the early works which will primarily consist of earth moving. Temporary surface water drainage and silt ponds will be constructed to control runoff from the earthworks stages. Areas within the Proposed Development site, which are not to be disturbed during the construction stage, will be fenced off. The environmentally designated areas are outside the site boundary and will therefore be fenced off by the perimeter fence.

Some hedgerows, bushes and trees, and disused buildings, will also be removed during this phase.

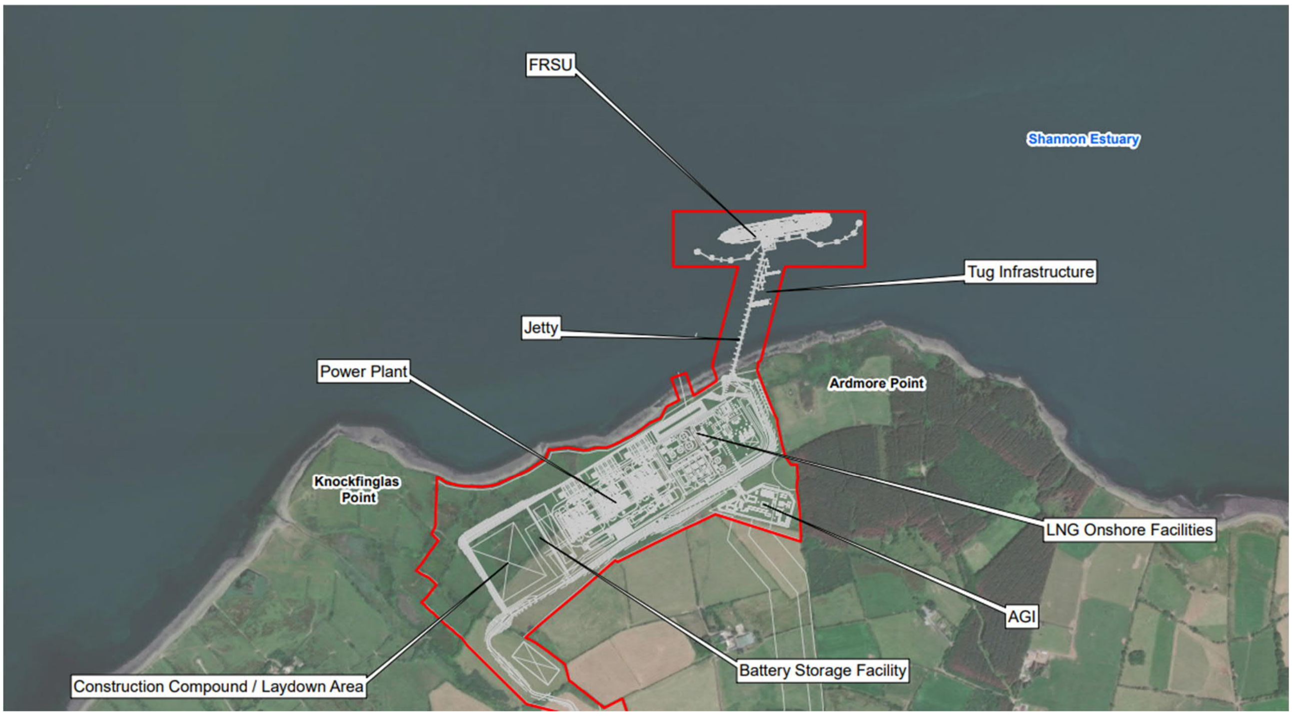


Figure 2.3 Proposed compound location

2.1.2 Project Description

2.1.2.1 Proposed Development

Site Preparation Works shall consist of the following;

- An extensive programme of pre-development licensed archaeological testing will be undertaken in the areas of the site which will be subject to development.
- The establishment of safe access and temporary site roads. A perimeter fence will be erected around the site boundary. Temporary car parking and site office and other facilities will be established to support the early works which will primarily consist of earth moving. Temporary surface water drainage and silt ponds will be constructed to control run-off from the earthworks stages. Areas within the site, which are not to be disturbed during the construction stage, such as the ring fort at the north eastern boundary will be fenced off. The environmentally designated areas are outside the site boundary and will therefore be fenced off by the perimeter fence.
- The overburden will be, in places, quite thin and to create the level platforms for the entire LNG and Power Plant facility, approximately 475,000m³ of overburden soils and rock will be excavated and placed as fill for both the LNG facility and the Power Plant facility. The LNG facility will be constructed to a finish grade elevation of 18m. All excavated material will be used onsite and no import of soil is expected. Excess material is anticipated to be used in the laydown area. It is expected that blasting will be required to excavate some of the rock, which cannot be removed by rock breaking equipment mounted on tracked excavators. The blasting will be carried out in a controlled manner in accordance with a pre-approved plan. The blasting would be carried out in a controlled manner to minimize the noise and ground vibrations. This is done by designing a blast pattern with a small charge in many holes drilled in to the rock at close spacing; the individual charges are then set off in a sequence using an electronic relay so that the maximum charge going off at any instant (this is referred to as the 'maximum instantaneous charge') is only the small amount of charge in any one of the holes. This causes cracks in the rock which allows the rock to be broken up further using mechanical rock breakers; the rock is then excavated using tracked excavators.
- Excess excavated material will be stockpiled for use as engineering fill, landscaping and other uses throughout the site.
- A single laydown area will be established during the earthworks and site preparation phase which will be used by the main follow-on contractors to accommodate temporary construction facilities such as site offices, parking, storage of construction materials and temporary sheds/workshops. Laydown will be constructed of excess cut material and a layer of stone will be placed over a layer of geotextile membrane as required. The laydown area will be suitably drained and any areas which will involve the storage of fuel and refuelling will have paved areas with bunding and hydrocarbon interceptors to ensure that no spillages will get into the surface water or groundwater systems. During the removal of the topsoil and placement of the stone for the laydown area precautions will be taken to minimise run-off into ditches, drains or the stream. When the construction phase is finished the temporary construction facilities will be removed and the stoned areas will be left in place. These areas may be used for future developments (such as a data centre) which would be the subject of a separate planning application and environmental impact statement.

The LNG terminal shall consist of:

- A jetty capable of receiving and providing secure berthing for a Floating Storage Regassification Unit (FSRU), with LNG storage capacity of approximately 170,000 m3 (up to 180,000 m3).

- The jetty head will comprise an unloading platform, six mooring dolphins and four breasting dolphins. The mooring dolphin layout is based on standard industry (Oil Companies International Marine Forum) recommendations for angles of mooring lines. The overall length between outer mooring dolphins will be 400m.
- The trestle, which will connect the jetty head to the shore, will include a roadway for operational and maintenance access. The trestle will be approximately 345 metres long and comprises 23 spans of circa 15 metre length with a width of approximately 11 metres.
- Each of the dolphins will be supported by tubular steel piles. The jetty platform level has been set at +9m OD Malin Head, to be clear of extreme water levels and waves.
- The Infrastructure installed on the Jetty is:
    - Two gas unloading arms on the unloading platform.
    - A 30” (750 mm) gas pipe. The gas piping would run from the unloading arm on the platform along a pipe rack on the western side of the trestle.
    - hydraulic gangway tower to access the FSRU
    - Power Distribution Center (PDC)
    - compressed air system
    - fire system
    - lighting and CCTV security system.
- The GLAs connect to the FSRU to a 30” gas pipe also installed on the Jetty, to transfer the gas from the FSRU to the onshore receiving facility. The arms are composed of rigid pipe sections which can swivel to transfer gas from the FSRU to the gas piping to be installed on the Jetty. The top of the unloading arms would be approximately 30 metres above the deck of the jetty.
- The FSRU shall discharge into the GLAs at a pressure range from 48 to 98 Barg at flowrate up to 22.6 million Sm3/d.
- A firefighting system would be installed to provide firefighting capability at the base of the GLAs and cooling protection for the FSRU hull and equipment on the jetty. This would include:
    - fire towers on the deck, capable of providing cooling to the exposed hull area of the FSRU and surrounding area
    - fire pumps with remote and local start/stop functionality, each capable of delivering full cooling of the pierhead area and the hull of the FSRU.
- An emergency vent may be located on the jetty to relieve pressure from isolated pipework in the event of an emergency disconnect.

The LNG Terminal Onshore Facilities shall consist of:

- Nitrogen generation facility for gas blending;
- Control room building;
- Workshop and maintenance building;
- Black start diesel generator;
- Gas metering and gas regulators;
- Guard house and parking;

- Firewater impoundment basin;
- Wastewater treatment facility (buried);
- On site power generations;
- Instrument air generation unit;
- Fire water storage tanks (2 x 2200 m3);
- Fire water pumps;
- Emergency generators;
- Frequency convertor; and
- Onshore Emergency vent;

The Power Plant shall consist of:

- Shannon LNG is proposing a flexible Power Plant with 3 blocks of CCGT to a combined capacity of up to 600 MW.
- The combined Power Plant facility shall consist of three (3) blocks of CCGT. Each CCGT block with a capacity of up to 200 MW for a total Power Plant capacity of up to 600- MW. Each block comprises of two (2) gas turbine generators, two (2) heat recovery steam generator, a steam turbine generator, and an air cooled condenser.
- The Power Plant will be capable of continuous operation at a full load of up to 600MWe or at part load down to roughly 10-percent of the peak capacity.
- A 120 MW for 1 hour (120 MWhr) battery storage facility shall also be included in the development
- The Power Plant will generate power for its own needs the LNG Terminal, and for sale to the market via the national electricity grid exported via the 220 kV connection.

2.2 Project programme

2.2.1 Key Timelines

Subject to planning consent and other approvals an arbitrary start date of Jan 2023 is taken as a construction start date (however this is subject to change). The whole construction project is broken into 5 sections as per Table 2.2 below which gives the outline of construction period for each section.

Table 2.2 LNG Terminal & Power Plant Projected Construction Schedule

Area	Start On Site	Duration (months)	Completion	Duration From Start Date (Months)
Enabling	Jan 23	10	Oct 23	10
LNG Terminal	+6 months	12	Jun 24	18
220 kV and medium voltage (10/ 20 kV) connections	+8 months	14	Sep 24	21

Area	Start On Site	Duration (months)	Completion	Duration From Start Date (Months)
CCGT - 2 Blocks	+9 months	21	Jun 25	30
CCGT - 1 Block	+ 11 months	18	Aug 25	32

2.2.2 Working Hours

Excluding the jetty construction works, it is anticipated that normal working hours during the construction phase will be as follows:

Start		Finish	
07:30	–	18:00	Monday to Friday
08:00	–	14:00	Saturday

It is proposed to stagger the various shift starting and ending times within the construction complex (for example civil employees 07:30 -17:00, jetty employees 07:45- 17:15, process area mechanical trades 08:00-17:30). This small stagger in shift start and ending times may lessen the impact of traffic peaking within the peak period and allow for a greater spread in traffic flow over the peak periods

The jetty construction works will operate on a 24 hrs basis, 6 days a week with maintenance works on Sundays and over approximately 15.5 months. Security arrangements will also be in place full time.

It may be necessary to work outside of these hours at certain stages of the work. Some working outside of the normal hours will be required to perform certain tasks such as mechanical and hydrostatic testing, inspection duties and commissioning. Certain construction activities may also require 24 hour working at the site. Other reasons for working outside the normal hours will include considerations of safety, weather, tides and subcontractor availability.

Every effort will be made during the detailed project execution planning to minimise the number and duration of night time activities.

Night time working will only be allowed with the advance permission of the County Council. Details of what are to be undertaken (including what type of noisy equipment and for how long) will be submitted with the application to KCC. Timelines for advance permission are be agreed in advance with KCC.

3. ENVIRONMENTAL OBJECTIVES AND TARGETS

1.1 Environmental objectives and targets

The objective of this outline CEMP is to ensure that the development works take place with no likely significant impact on the environment or the surrounding areas and that all environmental conditions that may be outlined as part of a future planning consent and any other consents are adhered to.
Work methodologies and approaches to minimise environmental impact have been established which are consistent with relevant Irish and European environmental guidelines and policies. It is intended that these environmental controls and works methodologies will be the focal point of the environmental management of the project and will ensure the successful environmental performance of activities during the construction of the proposed development.

Specific targets in relation to waste/ water usage/energy usage etc. are to be agreed with KCC in advance of the project.

1.2 Best Practice Guidance Notes to be Followed

All works carried out on the project shall comply with all applicable Irish and European Environmental legislation and all other applicable policies, standards, documents and procedures whether from the Planning Authority or other recognised authorities or bodies such as the National Parks and Wildlife Service (NPWS).

The proposed construction works will be managed in accordance with the appointed contractors Environmental Policy and Management System (EMS). The EMS will be compliant with international Best Practice and Standards and will include a robust assurance process. The EMS shall also be aligned to NFE's corporate Environmental Policy and (STEP) Management System.

4. ENVIRONMENTAL RESPONSIBILITIES AND ORGANISATION

4.1 Environmental roles and responsibilities

An environmental management structure will be established for the construction works. The day to day activities involved in the construction works will be managed by the appointed contractor.

The detailed CEMP shall set out the roles and responsibilities of the principal parties involved in the construction of the proposed project. In addition, it shall outline the lines of communication between the various parties. The roles and responsibilities outlined below are indicative and will be updated upon appointment of Employer's Representatives, Designers and the Contractor.

4.2 Contractor's Site Staff

The responsibilities of the Contractor's site staff shall be outlined in the detailed CEMP; it is possible that some roles may overlap or be carried out by the same person. The staff shall generally entail a Contract Project Manager, a Health and Safety Officer, an Environmental Clerk of Works (EcOW) / Advisor, and a Public Liaison Officer.

4.3 Responsibilities to be Assigned

Key responsibilities to be assigned include:

a) Liaison with Client's Project Manager and Supervising Engineer / Team;

b) The implementation of the CEMP;

c) Management of the overall Project Programme;

d) Co-ordinating the construction teams/contractors;

e) Implementing the Contractor's Safety and Health Plan;

f) Liaison with the client representative staff;

g) Production of Construction Programmes;

h) Liaison with local stakeholders and dealing with any complaints or queries from the public;

i) Maintaining a project diary; and

j) Carrying out duties of Health & Safety Coordinator Construction Stage, implementing the Contractor's Safety and Health Plan and auditing and updating same as necessary.

Particularly with respect to the implementation of environmental protection measures, the following responsibilities are to be assigned:

a) Implementing the Environmental Requirements of the CEMP and updating the CEMP as necessary;

b) Supervising and monitoring the implementation of mitigation measures as necessary;

c) Management of all environmental aspects of the construction works;

d) Ensuring all relevant mitigation measures are implemented as required, particularly those set out within the EIAR, the planning consent, the contract documents and the Natura Impact Statement (subject to any modifications by statutory consent);

e) Ensuring any monitoring requirements are implemented as required;

f) Reviewing monitoring results;

g) Training of staff in all environmental issues;

h) Provision of Tool Box talks to contractors / construction workers as required;

i) Ad hoc- Environmental Inspections;

j) Liaison with the client representative staff;

k) Auditing the construction works from an environmental viewpoint;

l) Maintaining regular contact and liaison with environmental specialists as appropriate;

m) Producing update reports on environmental compliance, if required;

n) Reporting to Kerry County Council on the Contractor’s environmental performance

o) Reporting on any non-compliances, and good housekeeping;

p) Implementing measures for ensuring close out of non-compliances;

q) Overseeing implementation of the CTMP, SWMP, and the CEMP;

r) Carry out waste audits to ensure waste is segregated and controlled, and duty of care is followed with contractors.

5. NON-CONFORMANCE, CORRECTIVE AND PREVENTION ACTION PLAN

Non-conformances are generally issued where there is a situation where legal or contractual limits associated with activities on the project are exceeded, or where there is an internal/external complaint associated with environmental performance.

Non-Conformance within the CEMP system occurs in a situation where essential components of the CEMP are absent or dysfunctional, or where there is insufficient control of the activities and processes to the extent that the functionality of the CEMP in terms of the policy, objectives and management programmes is compromised. Correction is the act of developing or improving where non-conformances have been identified. Prevention is the act of ensuring that non-conformance does not occur.

The CEMP and all its components must conform to the environmental policy, objectives and targets and the requirements of the ISO 14001 management standard. In the event of non-conformance with any of the above, the following must be investigated:

- Cause of the non-compliance;
- Develop a plan for correction of the non-compliance, to be agreed in advance of the contract, with KCC on reporting timelines, and close-outs;
- Determine preventive measures and ensure they are effective;
- Verify the effectiveness of the correction of the non-compliance; and
- Ensure that any procedures affected by the corrective action taken are revised accordingly.

Responsibility must be designated for the investigation, correction, mitigation and prevention of non-conformance. The Supervising Engineer will monitor and investigate non-compliances relating to environmental issues.

6. COMMUNICATIONS

Effective communications are essential to the efficient delivery of the CEMP during the development of the project. Therefore, communications procedures shall be set up from the outset and implemented by the Contractor. The procedure will include at a minimum:

- Identification and details of the person with responsibility for managing communications and complaints.
- An outline of how and when consultation with potentially affected parties will be undertaken, and how potentially affected parties will be informed in advance of works that may have an off-site impact.
- An overview of how a complaint register will be maintained to record the following information: the name and address of any complainant; the time and date the complaint was received; a description of the complaint; the activity or activities and any associated equipment that gave rise to the complaint; the action that was taken to resolve the issues that led to the complaint; the date the complaint was resolved and documentation of complainant's level of satisfaction with the actions to resolve the issue.
- A mechanism for notifying the relevant authority of complaints regarding environmental nuisance (particularly noise and dust) and the actions undertaken to resolve the complaint, and of any non-conformance with the CEMP that results in environmental nuisance.

6.1 Internal communications

An important part of the environmental communications is the training and awareness of project staff to ensure they are suitably informed of environmental aspects associated with the project. The training and awareness structure for project staff shall be compiled by the Contractor and agreed with the Client.

6.1.1 Internal environmental meetings

Environmental matters shall be discussed weekly during the Contractors Team meetings. These meetings shall focus on the performance of construction works with respect to the environment. Issues will also feature on the agenda of more generalised meetings such as weekly progress meetings so that environmental performance and concerns may be raised at management level.

6.1.2 Internal environmental reports

A number of routine environmental reports will also be generated throughout the Construction works process. These reports are to include as described in Table 6.1.

Table 6.1: Internal environmental reports

Report	Description
Environmental Progress Reports	A written log of the environmental performance of construction works. The report will summarise environmental events for the period and include details on environmental incidents and complaints, environmental data such as waste and fuel, environmental monitoring details and areas of concern moving forward on the project.
Environmental Monitoring Reports	A summary report containing the details of any environmental monitoring for the period on aspects such as water quality, dust, noise & vibration.
Environmental Incident Reports	A summary report detailing the cause and extent of a particular environmental incident. The report will include a description of the remedial measures carried out and any recommendations following the incident to avoid future occurrence.
Environmental Audit Reports	A written log of the findings of environmental audits carried out and the actions required to close out any non-conformances that may be raised.

6.1.3 Internal environmental records

The Contractor shall establish, implement and maintain procedure(s) for the identification, storage, protection, retrieval, retention and transferring of records. All environmental activities and events will be logged on dedicated records. These reports are described in Table 6.2.

Table 6.2: Internal environmental records

Record Type	Details
Environmental Weekly Inspection Record	To be completed when carrying out routine environmental inspections.
Environmental Monitoring Reports	Details of environmental monitoring of water quality, dust, noise & vibration.
Environmental Audit Record	To be completed when carrying out routine environmental audits.
Environmental Communication / Complaints Record	To be completed when any notable environmental communication occurs or on receipt of an environmental complaint.
Environmental Induction / Tool Box Talk Register	To be completed by all staff attending an environmental induction.
Environmental Incident Record	To be completed in the event that an environmental incident occurs.
Waste Management	Details of waste volumes, contractor and destination, shall be recorded
Compliance records	Records of communications with any regulator in relation to reports, data, inspections, etc where required in relation to any licences, permits or consents.
Unscheduled communications	Any other records such as unscheduled, ad-hoc, or other relevant communications that have an environmental bearing on the project

6.1.4 Unscheduled communication

Circumstances are likely to occur during the Construction works whereby an unscheduled environmental communication may be required. Events may occur from time to time that cannot be predicted but will require immediate action. Events such as an environmental incident or complaint would be such an event. When events such as these occur an environmental record will be generated and the appropriate course of action will be followed. An unscheduled meeting or report may be required as part of the close out action.

6.2 External communications

6.2.1 Communications personnel

The Contractor will play an important part in all communications relating to the environment and will be made aware of all such communications if they are not the initial point of contact. The Contractor will be the point of contact with regulatory bodies for all queries relating to the environment.

6.2.2 Specific environmental meetings

Regulatory bodies such as KCC, National Parks and Wildlife Service (NPWS), IFI or EPA may undertake environmental site visits from time to time to monitor the implementation of the CEMP and supporting environmental documents. These site visits may involve environmental sampling at certain locations depending on the nature of the site visit.

The frequency of these visits will be at the discretion of the regulatory body concerned. The Contractor and Client Representative (where required) will accompany those in attendance and provide information as required or deal with any issues which may arise on site. Any concern raised during the site visit are to be noted and followed up until they are closed out. The Contractor will ensure that the visiting party have received the appropriate levels of induction and are allowed safe, escorted passage across the site.

6.2.3 Complaints Management

Maintaining open and constructive communications with potentially affected parties can help to reduce conflicts and complaints. Therefore, communications procedures shall be set up from the outset and implemented by the Contractor. The procedure will include at a minimum:

- Identification and details of the person with responsibility for managing communications and complaints.
- An outline of how and when consultation with potentially affected parties will be undertaken, and how potentially affected parties will be informed in advance of works that may have an off-site impact.
- An overview of how a complaint register will be maintained to record the following information: the name and address of any complainant; the time and date the complaint was received; a description of the complaint; the activity or activities and any associated equipment that gave rise to the complaint; the action that was taken to resolve the issues that led to the complaint; the date the complaint was resolved and documentation of complainant's level of satisfaction with the actions to resolve the issue.
- A mechanism for notifying the relevant authority of complaints regarding environmental nuisance (particularly noise and dust) and the actions undertaken to resolve the complaint, and of any non-conformance with the CEMP that results in environmental nuisance.

7. TRAINING AND AWARENESS

7.1 General environmental training and awareness

The Contractor shall be responsible for ensuring that appropriate environmental training is provided to all project personnel and that environmental awareness is continuously promoted throughout the pre-construction enabling phase of the project. Appropriate levels of environmental training and awareness will be provided on the project through the following approaches:

- Environmental Inductions
- Tool Box Talks
- Environmental Labelling and Signage
- Specific Environmental Training or Briefings
- Specific Environmental Awareness Procedure

7.2 Environmental induction

All personnel shall receive an environmental induction before commencing work on the project. The environmental induction will be tailored to suit the tasks and responsibilities of site personnel from management and supervisory level through to site operatives. All project personnel will receive an environmental induction on a scale relevant to their work activities. On completion of the induction, the inductee's will sign a form to provide a record of their attendance at the environmental induction.

During the environmental induction, the contents and requirements of the CEMP will be explained and discussed as well as any additional environmental requirements. The environmental induction will cover the following aspects as a minimum:

- Overview of the project and its key environmental aspects
- Organisational structure for the construction stage of the project and management of environmental issues
- That ALL personnel in the organisation must be aware of their personal responsibilities for environmental matters.
- That key individuals on-site have specific responsibilities to the environment.
- That the environmental induction forms the basic training on the project and that it will be followed up with further environmental training as the need arises.
- That all the relevant environmental information will be given before any job to enable the task to be carried out in an environmentally sound manner.
- That regular communication shall be made via site signage and regular toolbox talks.
- Employee responsibilities: That all employees are responsible for their acts and omissions and shall be held accountable if their actions result in environmental harm.
- Monitoring, Inspection and Auditing: That Construction works will be continuously monitored and inspected by environmental personnel and regular auditing of the works for compliance with the CEMP will be undertaken.
- Waste management: That the project culture is waste minimisation, reuse and recycling. Waste management policies for the project will be explained.
- Surface water management and spill control: That surface water management protection and spill management are very high priorities in all site based job activities.
- Control of nuisance: That noise and dust require particular control measures to minimise impact on the surrounding environment.
- Emergency response procedures: That the procedure, if safe to do so is: STOP, CONTAIN, NOTIFY in the case of an environmental emergency on-site.
- Environmental incident and near miss reporting: That environmental incident such as loss of containment must be reported immediately to the Environmental Manager and or Contracts Manager to identify the cause.

- Environmental Complaints: That a specific procedure will be in place to deal with environmental complaints and that every assistance must be provided to close out any active complaint.
- General environmental good practice: Materials management, storage, site upkeep, maintenance, handling and refuelling of plant and machinery

Following induction all personnel must familiarise themselves with their place of work and the environmental responsibilities associated with their position.

7.3 Tool Box Talks

Tool Box Talks shall be given on a regular basis throughout construction works and may often be specific to a particular activity taking place. Regular tool box talks will ensure site staff are aware of the environmental impacts associated with their work and the appropriate control measures that are required to carry out their work in compliance with the CEMP. On completion of a tool box talk, the employee will sign a form to provide a record of their attendance. Examples of some of the environmental tool box talks required during construction works will include the following;

- Archaeology / heritage
- Resource Usage
- Dust
- Spill Incident Control
- Water discharges
- Ecology (Flora & Fauna, including protected species)
- Watercourse and fisheries protection
- Invasive species
- Visual
- Noise
- Waste
- Community relations
- Energy efficiency

7.4 Environmental labelling and signs

Environmental labelling and signs will be used on site to inform personnel of key environmental requirements and restrictions pertaining to construction activities and to provide information to assist environmental good practice across the site. Examples of the types of signs and labelling include;

- Site environmental rules,
- Environmentally sensitive areas,
- Waste storage facilities/containers,
- Speed restrictions,
- Spill kits for emergency response.

The Contractor shall ensure that all necessary environmental labelling and signage are put in place.

7.5 Specific environmental training

Certain project personnel may be allocated a particular environmental responsibility such as daily visual checks on specifics such as housekeeping within waste skip segregation area, fuel storage area. Specific environmental training may be required to enable this person to carry out the specialist task designated to them.

Likewise, if it is identified that any aspect of environmental protection or monitoring requires more specialist training, the Contractor will authorise such training to go ahead such as basic visual checks that environmental monitoring equipment remains in situ, checking of batteries, etc.

Certain activities will require specific awareness to teach personnel when they shall incorporate the environmental training received into their specific work.

Suggested awareness tool box talks are:

- Water discharges/run-off – Talks to all sub-contractors on the appropriate controls when working in the vicinity of a watercourse and potential run-off from site works
- Nuisance management – Talks to sub-contractors on noise, dust and water management as required during different phases of the project.
- Sensitive neighbours – Talks to sub-contractors on noise, dust and traffic management as required during different phases of the project.
- Control of fuels and oils –Talks to relevant sub-contractors on the appropriate management and use of fuels and oils across the site.
- Waste management – Talks to all sub-contractors on the day to day on-site specific waste management controls.

8. WASTE MANAGEMENT PLAN

A Site-Specific Construction Waste Management Plan (SWMP) will be drafted and submitted to the Client by the Contractor and include any conditions imposed in the planning permission. The implementation of the Waste Management Plan will be the responsibility of the Contractor. The Contractor will be tasked with undertaking a monthly audit of site procedures and operations to ensure the Waste Management Plan is operating as per expectations. Waste will be managed by the Contractor across the site from commencement to completion. No waste will be transported to any facility without the Contractor firstly assessing all paperwork and paying an inspection visit to destination sites. The Waste Contractors will be the only recognised waste contractor to service the site. Day to day management of waste will be documented and revised routinely, as required. The Contractor will control and record all waste material that leaves site, and this data will be presented monthly and available in hard copy upon request. The Contractor will supervise all waste management from project commencement and across all areas of site.

8.1 Waste management policy

At the core of the project the approach will be the principles of the European Waste Hierarchy, refer to Figure 8.1, which prioritises the prevention, recycling and recovery of waste in preference to landfilling. This approach applies to the management of Construction and Demolition (C&D) wastes nationally.

Figure 8.1: Waste Management Hierarchy

The Waste Management Plan is required to address the following elements of the project:

- Analysis of the waste arisings /material surpluses;
- Specific waste management objectives for the project;
- Methods proposed for prevention, reuse and recycling of wastes;
- Material handling procedures; and
- Proposals for education of workforce and plan dissemination programme.

8.2 Objectives of the project

The SWMP shall meet the following requirements of the project:

- To comply with relevant policy and legislation on waste management.
- To set out a framework for the sustainable management of waste materials.
- To maximise the reuse and recovery of material generated by any demolition activities.
- To minimise the volumes of waste from the project being sent to landfill and to maximise recovery.

8.3 Overview of waste streams

The Contractor shall include the anticipated waste streams from the construction works of the LNG Terminal & Power Plant in the SWMP.

Material that is likely to be surplus to requirements and disposed of off-site may include general construction debris, scrap timber and steel, machinery oils and chemical cleaning solutions. In addition, the practice of excessive purchase of materials and equipment to allow for anticipated wastage will be avoided.

It is planned to reuse all spoil and excavated material on site. Typically, excavated material that is unsuitable for use as engineering fill will be used where possible for landscaping and other uses throughout the site thus eliminating the need for off-site disposal.

The site has historically been used for agriculture and consequently it is anticipated that no soil contamination will be encountered. In the unlikely event of any evidence of soil contamination being found during work on site, the appropriate remediation measures will be employed. Any work of this nature would be carried out in consultation with, and with the approval of the Environmental Department of Kerry County Council.

The quantities and volumes of all waste streams must be recorded through the course of the project along with disposal/recovery/reuse route of all materials.

Each of the waste streams shall be segregated and stored in appropriate containers for removal by a suitably permitted haulier. The skips will be located on suitable hard standing material in a designated location on site.

8.4 Prevention, reuse and recycling

Work will be planned to identify and implement ways to prevent, reduce, reuse and recycle waste. The following waste management hierarchy will be used, in order of preference, for management of all construction waste.

- Prevent potential waste
- Reduce/minimise waste
- Reuse materials
- Segregate for off-site recycling
- Segregate for off-site recovery

8.4.1 Waste Prevention

Preventing the generation of waste in the first place is the simplest means of managing the waste. Prevention of waste starts at design where consideration will be given to groundwork (extent of excavation required), sizing project items in line with available materials, and / or liaising with suppliers to supply purpose-made (e.g. plasterboard partition sheet size) and / or prefabricated materials. Only materials necessary for the job will be purchased – a precise product specification will be provided to the supplier to ensure that correct quantity of appropriate product is acquired. Packaging will be taken into consideration – it should be adequate, recyclable, and not excessive. An agreement will be made with the supplier company to facilitate return of excess and/or damaged product and packaging material. Important also is supplier delivery time; where possible this will be as close as practicable to the proposed usage times (e.g. just in time) to reduce the potential of on-site damage. Work packages are to be planned with waste minimisation in mind, particularly where material cutting is required (e.g. measure twice and cut once).

8.4.2 Reduction / Minimisation

Reduction of surpluses, deficits, and waste arisings is important from an economic viewpoint, and is also a key element in effective materials / waste management. Surplus materials include salvage items, aggregate, soil and stones from ground work, unnecessary purchased construction materials, damaged goods, and excess material purchased as part of a package lot. Deficits will occur where an area of the site requires filling (that is not available on site), or where an insufficient amount of construction materials are purchased. Waste will be minimised wherever possible. Good housekeeping will be used to conserve space, minimise material damage, and prevent cross contamination of waste. The entire site will be kept clean from unwanted items and be well organised. All materials will be stored in designated storage areas, with any stacking arrangements supervised by a competent person. All storage facilities will be kept secure and stable, with floors and access routes kept clear at all times.

Suitable and sufficient lighting will be provided at all work areas, storage locations and access routes. The importance of maximising salvage items and minimising working waste (such as off cut and damaged material) will be communicated to all site staff.

8.4.3 Reuse

Every effort will be made to reuse materials on site where practical.

Where reuse is not practical the material will be segregated into individual category type for recycling and/or recovery.

8.4.4 Recycle

Recyclable materials likely to arise include wood, rubble, plasterboard, metal, plastic, cardboard, glass, paper and canteen dry recyclables. These will be segregated on site for more efficient and cost-effective waste management off-site. A designated waste management contractor, to be appointed by the Contractor, for the construction phase and will look to maximise recycling to reduce quantities of waste necessitating recovery.

8.4.5 Other Recovery

Recoverable materials likely to arise include organics, hazardous materials, and the mixed waste fractions. This is to be kept to a minimum where possible.

8.4.6 Disposal

All higher options on the waste management hierarchy will be used to reduce disposal of waste.

8.5 Waste handling

The Contractor will take full responsibility for the identification, source separation, storage and dispatch of their own waste and sub-contractor waste from the site. They will also be responsible for maintaining good housekeeping standards. The Contractor will coordinate these tasks and log housekeeping inspections and communicate any issues to the Authority. In adherence to the SWMP, the Contractor may be audited by the Authority on an on-going basis in conjunction with wider environmental audits.

A designated Waste Compound area will be assigned and clearly signposted on site. It is to contain sufficient quantity of suitably sized labelled skips and bins, as well as adequate skip set-down areas for efficient exchange of skips. This compound shall be kept in a tidy state and secure at all times. A dedicated bunded area within the waste compound to be set up and used specifically for separate hazardous wastes. All leftover materials and waste will be segregated initially into working bins at or near each work area. These working bins will be transported from the work areas, where any materials fit for reuse are taken to the materials storage area, with waste being transferred to larger separate skips in the waste compound for efficient transport from site to relevant destination.

8.6 Mitigation Measures

Notwithstanding the impact from demolition and remediation waste on national waste plans and policies and national capacity being assessed as not significant, the following best practice measures would be implemented to manage the CDW produced by the Proposed Development:

- All wastes will be managed in accordance with Irish waste legislation, and in particular waste will only be transported by hauliers holding a valid collection permit, and will be transported to waste management sites which hold the necessary license, permit, certification or exemption.
- MARPOL Annex V waste (garbage) from LNG carriers or other vessels arriving from outside Ireland will be managed as International Catering Waste (ICW) and managed in accordance with the ICW license held by Shannon Foynes Port Company (current authorised disposal route is to Drehid Landfill, Co. Kildare).
- In accordance with EU, National and Irish national policy and legislation require the waste hierarchy (Figure 8.1) to will be applied to all waste arisings. Widely implemented best practice is to adopt a Site Waste Management Plan (SWMP) to reduce the amount of waste generated and follow the waste hierarchy in for far as practicable. A SWMP will be developed and implemented for the Proposed Development and will, as a minimum include the following details:

    - Statutory requirements, the Applicants corporate requirements, site-wide waste policy and mitigation and monitoring measures defined within this EIAR where applicable to waste management;
    - Waste types and procedures for classification, segregation, containment, storage, transportation and disposal. This will include details on the measures to prevent impacts to the receiving environment. The Contractor will apply the principles of the 'Waste Hierarchy' (Prevention, Preparing for Re-use, Recycling, Other Recovery, Disposal) to minimise waste generation, maximise re-use of site-won materials on-site and minimise the need for disposal of waste. Where re-use is not possible onsite, alternative re-use and recycling options will be sought offsite with the final disposal option;
    - Roles and responsibilities;
    - Training requirements;
    - Waste handling procedures;
    - Waste compound maintenance measures;
    - Emergency planning and response;
    - Monitoring, reporting and document control procedures; and
    - Corrective action process.
- As part of the document control procedures, a comprehensive docketing system (including waste transfer notes) will be detailed in the SWMP. The documentation to be maintained in relation to waste material removed from the site will include the following:
    - The names of the agent(s) and the transporter(s) of the wastes;
    - The name(s) of the person(s) responsible for the ultimate treatment of the wastes;
    - The ultimate destination(s) of the wastes;
    - Written confirmation of the acceptance and treatment of the hazardous waste consignments;
    - The tonnages and List of Wastes (LoW) code for the waste materials;
    - Details of each individual consignment dispatched from the Proposed Development site;
    - Description of waste (cell number/AEC number, stockpile number or origin of waste)
    - Date and time of dispatch from the Proposed Development site
    - Name of haulage company
    - Details of contractor and haulier docket numbers
    - Vehicle registration number and driver name
    - Volume/weight of waste removed
    - Name of waste receiving facility
    - Date and time of arrival at waste receiving facility
        - Details of any rejected consignments;
        - Waste transfer forms for hazardous wastes transferred from the site (stamped at receiving facility); and
        - The transfrontier shipment of waste forms (where exported).
- The SWMP would include procedures for monitoring the overall CDW recovery rate.

8.7 Legal compliance

No waste shall leave site unless a full copy of the Waste Collection Permit and the Facility Licence/Permit has been provided to the Contractor for checking, approval and site filing. The dockets and licences are to be cross-checked prior to waste removal off-site. A log is to be held at site exit detailing each load/skip/container of waste that leaves site. Hazardous waste will not leave the site unless the appropriate Waste Transfer Form (WTF) notification procedure is in place and approved by the Contractor. Waste will not leave site destined for another state (including Northern Ireland) until the appropriate Transfrontier Shipment (TFS) documentation is in place and approved by the Contractor.

All waste legislation of which there are 32 Acts, Regulations and decisions, must be adhered with including, for example:

- Waste Management (Landfill Levy) (Amendment) Regulations 2015
- Waste Management Acts 1996 (as amended)
- Waste Management (Collection Permit) Regulations 2007 and Amendment Regulations 2008 to 2016
- Waste Management (Facility Permit and Registration) Regulations, 2007 (SI No. 821) and Amendment Regulations 2008, 2014, 2015
- Waste Management (Landfill Levy) Regulations 2015
- Waste Management (Licensing) Regulations 2004 and Amendments 2010
- Waste Management (Miscellaneous Provisions) Regulations 1998
- Waste Management (Facility Permit and Regulations) Regulations 2007 and Amendments 2008, 2014, 2015
- Waste Management (Planning) Regulations 1997
- Waste Management (Registration of Brokers and Dealers) Regulations 2008
- Waste Management (Shipment of Waste) Regulations 2007
- European Communities (Shipments of Hazardous Waste exclusively within Ireland) Regulations 2011

8.7.1 Waste Management Companies

The Contractor will ensure that the waste management company will provide a legally compliant service. The Contractor shall ensure that, in compliance with legislation, only authorised vehicles will be used to remove waste from site for prompt transport to an appropriately licensed facility for processing.

All waste management companies will ensure that:

- Persons (incl. vehicle drivers) entering construction sites hold a current Safe-Pass card.
- Vehicles used are properly maintained and in sound working order.
- Bins used are certified, free of defects, clean, and safe to use.
- Lifting gear is appropriately certified for use.
- All waste receptacles exiting the site are appropriately covered to prevent public nuisance or littering.

All waste companies are required to complete an ‘Expectations Regarding Waste Removal’ form detailing collection and destination of all wastes removed from site.

9. PRESCRIBED ENVIRONMENTAL ASPECTS, IMPACTS AND MITIGATION

The construction works at LNG Terminal & Power Plant may pose a risk to the environment and as such, a series of environmental mitigation measures are required to eliminate or mitigate any potential impact. The Contractor will implement these mitigation measures, which will form the basis of the planning consent. This section identifies the aspects and impacts and outlines a list mitigation measures. In addition to these measures, the Contractor is required to comply with all the mitigation measures that will be outlined within the EIAR and the planning consent.

9.1 General Environmental Procedures

The following (minimum) project specific procedures will be developed and employed by the Contractor and their subcontractors for each environmental aspect while working on the project.

9.1.1 Outline of Potential Environmental Procedures

- Awareness & Training
- Environmental Emergency Response
- Record Keeping, Auditing and Monitoring
- Environmental Complaints Procedure
- Archaeology & Architecture (Heritage) Control Plan
- Protection of Biodiversity Control Plan
- Surface Water Management / Discharge Control Plan
- Environmental Emergency Response Plan
- Ground (Soil) Control Plan
- Waste Management Plan
- Visual (Maintenance & Housekeeping) Control Plan
- Noise and Vibration Management Plan
- Air Quality and Dust Minimisation Management Plan
- Resource Usage Plan
- Sensitive neighbours plan
- Landscape and Site Reinstatement Plan

These procedures are listed in this document for illustrative purposes. The Contractor, when appointed, will be responsible for developing these procedures. These procedures will form part of the detailed CEMP and will be continually updated where necessary. These procedures can only be amended by improvement with regards to environmental protection and must take cognisance of all relevant conditions of planning permission.

9.2 Mitigation – Environmental control plans

9.2.1 Archaeology & Architecture (Heritage) Control Plan

An extensive programme of pre-development licensed archaeological testing will be undertaken in the areas of the site which will be subject to development.

Full resolution of all archaeological sites and areas identified during archaeological testing within the Proposed Development boundary will be carried out at the pre-construction phase. All archaeological works (which will be agreed by the Archaeological Consultant and the NMS) will be carried out in compliance with the National Monuments Acts 1930 – 2004 (and Policy and Guidelines on Archaeological Excavation (Department of Arts, Heritage Gaeltacht and the Islands, 1999).

A suitably qualified and licensed Archaeological contractor will be appointed to carry out the archaeological fieldwork. Relevant licences will be acquired from the DoCHG/NMS and the National Museum of Ireland (NMI) for all archaeological works, which will be carried out in accordance with an Overarching Method Statement for Archaeological Works prepared by the Archaeological Consultant and agreed with the NMS. It is anticipated that all archaeological works will be completed prior to enabling works commencing on the site at the start of construction.

Site preparation will commence with the establishment of safe access and temporary site roads. A perimeter fence will be erected around the site boundary. Temporary car parking and site office and other facilities will be established to support the early works which will primarily consist of earth moving. Temporary surface water drainage and silt ponds will be constructed to control run-off from the earthworks stages. Areas within the site, which are not to be disturbed during the construction stage, such as the ring fort at the north eastern boundary will be fenced off. The environmentally designated areas are outside the site boundary and will therefore be fenced off by the perimeter fence.

It is anticipated that the archaeological mitigation programme will commence prior to the start of the main construction works pre enabling works.

During Phase 1 (prior to the enabling works as soon as access is available or during if necessary) – all archaeological sites and areas that require preservation by record will be investigated. This will also determine the scope of further mitigation works. A General Watching Brief (GWB) will be carried out for ground works, such as utility diversions, road diversions and ecology works.

In line with the recommendations for mitigation outlined in the 2008 testing report (Long and O'Malley, 2009), the following specific mitigation measures are proposed for the archaeological sites located within the Proposed Development. The site-specific CEMP will include specific measures included in the EIAR and planning permission. Control measure as a minimum will include:

No.	Control Measures
1.	Areas of excavation around the known archaeological sites and areas will include a 5 m buffer zone as a minimum between the edge of the site and any archaeological features. Should previously unknown archaeological features be identified then the excavation area will be expanded to ensure the 5 m buffer zone is maintained.
2.	It is noted that the archaeological deposits within Area 6 Post-Medieval Habitation site and Area 11 Enclosure are particularly close to the surface and are vulnerable to disturbance. a topographic survey will be carried out in advance of archaeological excavations to record potentially significant anomalies in the ground surface which could otherwise be damaged by plant moving over the area.
3.	The removal of topsoil in parts of Areas 6 Post-Medieval Habitation site and Area 11 Enclosure will be performed by mini-digger to reduce the potential of damage caused by plant tracking over the shallow archaeological features.
4.	A photographic survey and written description of CH6 Well will be carried out in advance of groundworks within the vicinity of this asset. The dismantling of the well will be carried out in an orderly fashion under the supervision of a suitably qualified archaeologist.
5.	In the event of unexpected discovery of potential archaeological material, the works will be stopped, and the Contractor will immediately advise the Employers Representatives. The Contractor will support the full recognition of, and proper excavation and recording of all archaeological soils, features, finds and deposits.
6.	If previously not recorded archaeological material is found during monitoring, then consultations must be held with a certified Archaeologist and the National Monuments Service with regard to any necessary mitigation measures. These measures may involve excavation of the archaeology.
7.	A method statement and licence application for monitoring at site will be submitted to the National Monuments Service (NMS) and the National Museum of Ireland (NMI) and the Archaeologist.

8.	In order to comply with the terms of the monitoring licence a fully illustrated report will be produced for each site, setting out the results of the monitoring works. These reports will be submitted to the NMS, the NMI and to the Archaeologists.
9.	Works will be planned and managed to prevent any damage to local structures.

Phase 2 will take place during later enabling works and in advance of and concurrent with construction) – The GWB will be undertaken in all other areas where it is required, in particular in areas which have not been subject to previous archaeological testing. The construction of the outfall, jetty and other works on the foreshore will also be archaeologically monitored under licence by a suitably qualified and experienced maritime archaeologist.

Phase 3 – a post-excavation assessment will be undertaken in accordance with DoCHG/NMS advice, followed by an appropriate scheme of detailed analysis and reporting. Phase 3 will commence as soon as practicable following completion of the main investigative works.

9.2.2 Protection of Biodiversity Control Plan

There are a number of designated sites located in the surrounding area including the Lower River Shannon candidate Special Area of Conservation, the Ballylongford proposed Natural Heritage Area and the River Shannon and River Fergus Estuaries Special Protection Area (SPA). The Proposed Development includes the installation of a jetty and a outflow pipe that extend into the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA.

Every reasonable effort will be made to ensure that any detrimental environmental effects will be minimised during the construction phase of this project. The site-specific CEMP will be prepared and implemented with the objective of keeping environmental impacts to a minimum, including mitigation measures in the EIAR and planning permission.

Measures will also include standard construction best practice used to manage the risk of potential for loss hydrocarbons such as diesel and hydraulic fluids. Careful supervision of construction operations and general construction practice will reduce the risk from impacts so that the likelihood of impacts is best described as low. The implementation of general construction practice will ensure that the likelihood of pollution in a well-equipped, maintained and managed construction site is low.

9.2.2.1 Terrestrial Flora and Fauna

There will be a direct loss of terrestrial habitats within the development area. Levels of noise and disturbance will increase during the construction period which will cause disturbance to fauna. Uncontrolled or poorly controlled runoff during works could increase levels of suspended solids within the stream, which crosses the site, and thus negatively impact on fish, macro-invertebrates and flora. Pollutants such as hydrocarbons from poorly serviced machinery could potentially reach the water course and impact on its ecological health.

All construction staff, including all sub-contracted workers, will be notified of the boundaries of the designated sites and will be made aware that no construction waste of any kind (rubble, soil, etc.) is to be deposited in these protected areas and that care must be taken with liquids or other materials to avoid spillage. Any works close to the boundary of the site and near the protected sites will require the development of a detailed method statement.

A survey for badgers will be carried out prior to the commencement of works at the site. This will ascertain if there have been any changes in the distribution of badgers within the site. If badger setts are located within the proposed development area at that time, detailed mitigation measures will be implemented.

A preconstruction survey will be conducted no more than 10-12 months in advance of construction for active otter holts or definite signs of usage. The objective of the survey will be to ensure that no new holts have been constructed since the previous survey and to specifically check for breeding holts. All stream side vegetation will be resurveyed at this time.

A small derelict building located close to the shoreline lacks the crevices and spaces which would make it suitable as roosting sites for bats and the presence of bat roosts at this location is considered highly improbable. A survey for bats will be carried out prior to the commencement of works at the Shannon LNG site.

A visual search of the wet grassland habitat, to be removed, will be carried out in the days prior to commencement of development and any frogs will be removed to alternative wet grassland habitat elsewhere on the site under licence from the National Parks and Wildlife Service of the Department of the Environment, Heritage and Local Government.

Blasting is anticipated during site works, some rock breaking and piling will be required. A detailed method statement will be drawn up by an ecologist prior to commencement of works. The method statement will specify the need, if any, for ecological supervision.

In general, the EIAR and NIS will detail how habitats will be retained, protected and managed during the construction and ultimately in the operational phase of the development, and these shall be implemented.

9.2.2.2 Marine Flora and Fauna

The accidental release of sediment and chemical pollutants during the construction of the infrastructure for the Proposed Development may impact habitats and species immediately adjacent to, and upstream and downstream. To avoid negative environmental impacts construction best practice pollution prevention measures will be implemented.

To inform the assessment of the potential impact of the Proposed Development a series of specialist studies were conducted. These included assessments of the of impact of project discharges, underwater noise emissions, and habitats loss on aspects of the marine environment.

The studies showed that discharges from the Proposed Development, which includes wastewater effluents, biocide treated discharge waters and heated water discharge, would not result in significant environmental impacts.

During the construction phase a trenched water outfall will be constructed across the shoreline into the Shannon Estuary, which will result in the direct loss of habitats and associated fauna. In addition, the installation of the jetty piles in the seabed will result in the direct loss of habitats and associated flora and fauna. The loss of habitats and associated flora and fauna pending decommissioning and removal of the outfall and jetty pile is negligible, and will not result in significant effects.

Activities associated with the construction and operation of the LNG Terminal (e.g. pile driving, vessel noise) have the potential to impact fish and marine mammals by introducing sound into the marine environment. The most potentially impactful activity on marine mammals and fish during construction would be impact pile driving because of the potential for injury marine mammals and injury or mortality in fish, but this would be of limited duration and impacts will be mitigated in multiple ways

Impact assessments showed that while there is some indication that fish within hundreds of metres of impact pile driving could be at high risk of disturbance or even potentially experience injury from impulsive sound emission, impact piling would occur for a relatively short duration (60 min) for each pile, once per day. Thus, impact pile driving is unlikely to hinder fish migration, and for most fish, the distances within which mortality and/or mortal injuries could occur are relatively small and should not impact the overall populations if these types of effects were to take place.

Dolphins are present in the vicinity of the site. However, it is thought that the dolphins only use the site for short periods, probably while they are passing through the site. There is no evidence that the site is used as a foraging area. To mitigate potential impact to marine mammal species Shannon LNG will implement relevant impact mitigation and monitoring measures in relation to marine mammals as outlined in DAHG Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (DAHG, 2014);

- Pre-start Observation: Marine mammal observation period of 30 minutes minimum prior to start (or re-start after a break of 30 minutes) of any impact piling and any drilling;
- Start delay due to observation: a gap of at least 30 minutes required between the last observation of a marine mammal and start of operations;
- Observation zone: The observation zone is 1000 m for impact piling and 500 m for drilling (thus impact piling likely to require > 1 marine mammal observer);

- Commence in daylight only: Impact piling and drilling can only start in daylight conditions when visual monitoring can take place (i.e. when wind/wave conditions mean observation is possible: NPWS guidance recommends “sea conditions for effective visual monitoring by MMOs are WMO Sea State 4 (≈Beaufort Force 4 conditions) or less;
- Soft-start: For any source, including equipment testing, exceeding 170 dB re: 1μPa @1m an appropriate ramp-up procedure (i.e., “soft-start”) must be used. This should be a minimum of 20 minutes and no longer than 40 minutes;
- Continuity: once piling or drilling has started it can continue into darkness and does not need to stop even if marine mammals are seen in the observation zone (in fact, an MMO is not required once the sound generating activity starts though continued observation can be

In addition to the relevant mitigation measures detailed in DAHG (2014), Shannon LNG will implement the following measures;

- Piling activities: No simultaneous impact piling;
- Continuity between activities: Pile installation will require a combination of techniques including impact piling, vibratory piling and drilling requiring breaks in activity as equipment is changed. Where an activity progresses to a lower sound level activity – i.e. from impact piling to vibratory piling or drilling, and the break between activities is less than 30 minutes a new period of observation is not required and activities can be considered to be continuous;
- Additional seasonal observation for bottlenose dolphin: For any impact piling taking place during August, an additional MMO will be present at Moneypoint to undertake additional observations for mother-young dolphin pairings. There is known presence of neonatal bottlenose dolphin in the estuary between July and September, peaking in August, and though numbers are low there is potential for presence in the region of the Proposed Development. There will be full communication between the Moneypoint MMO and the construction team to ensure no impact piling commences until animals have moved away from a 1000 m radius observation zone (ensuring the full width of the estuary is observed in August);
- Mitigation measures during blasting: Whilst all blasting is land based there will be propagation of sound into the underwater environment. Thus, the standard mitigation measures for blasting will be adopted as a precautionary measure – qualified MMO, a 1000 m observation zone and an observation period of 30 minutes. As only single blasts will take place in each event (not a series) a soft-start is not included.
- Monitoring: The marine mammal monitoring programme, currently being undertaken by the Irish Whale and Dolphin Group (in the vicinity of the project using CPODs) will be continued into the construction phase for the validation of predictions (based on observations from other studies – see impact assessment) that any animals displaced from an area return after the construction activity stops.

To inform the assessment of the potential impact of the Proposed Development a series of specialist studies were conducted. These included assessments of the of impact of project discharges, underwater noise emissions, and habitats loss on aspects of the marine environment.

9.2.3 Surface Water Management / Discharge Control Plan

During the construction phase the mitigation measures will ensure that no sediment contamination, contaminated runoff or untreated wastewater will enter watercourses on or near the Proposed Development site. Drainage channels and water streams will be clearly identified onsite and shown on method statements and site plans.

Groundwater from the upgradient area to the south discharging onto the main construction site at the cut faces to the south, east and west of the 18 m platform will be intercepted by drainage at the toe of the slopes and diverted away from the active construction areas, to the extent possible. In case of impact by construction activity and machinery, this groundwater will pass through a sediment trap and oil/water separator prior to discharge under licence to the estuary via the outfall.

Temporary surface water drainage and silt ponds would be constructed to control run-off from the earthwork stages. Drains carrying high sediment load will be diverted through silt ponds, located between the construction area and the surface water outfall. Surface water runoff from working areas will not be allowed to discharge directly to the local watercourses or to the estuary. To achieve this, the drainage system and silt ponds will be constructed prior to the commencement of major site works. All design and construction will be carried out in accordance with the Construction Industry Research and Information Association (CIRIA) C532 Control of Water Pollution from Construction Sites Guidance for Consultants and Contractors (CIRIA, 2001). During the construction activities there will be a requirement for diverting rainwater run-off away from the construction areas, into the nearby estuary. Rainwater run-off will be treated to prevent sediment from entering the estuary. Discharge water quality targets will be agreed with Kerry County Council and included in the CEMP. Regular water inspection and sampling regimes will be put in place via the CEMP on the foreshore during construction activity onsite to monitoring compliance with the discharge conditions.

Where possible, excavations will only remain open for limited time periods to reduce groundwater ingress and water containing silt will be passed through a settlement tank/silt pond or adequate filtration system prior to discharge. Discharge consent under the CEMP will be obtained for disposal of ground water arising from pumping or such water may be disposed of as construction site runoff, having first passed through a settlement tank or filtration system, where appropriate. A discharge licence will be required for temporary construction phase storm water discharges to the estuary; operational phase discharges will be regulated under the site's IE Licence.

To minimise impact from material spillages, all oils, chemicals and waste materials will be stored within temporary bunded areas with a volume of 110% of the capacity of the largest tank/container within it. Fuel, oil and chemical filling and draw-off points will be located entirely within the bunded area(s). Drainage from the bunded area(s) will be diverted for collection and disposal.

Vehicle/equipment refuelling and maintenance with hydraulic oil or lubricants will take place in bunded areas where possible. If it is not possible to bring the machine to the refuelling point, fuel will be delivered in a double-skinned mobile fuel bowser. Drip trays will be used to contain spillages with spill kits and hydrocarbon absorbent packs stored in vehicle cabs with operators fully trained in their use. Vehicles and equipment will not be left unattended during refuelling operations. Regular inspection and maintenance of site machinery will be included in the CEMP to minimise the likelihood of losses of hydraulic fluids or fuels to ground during the construction works.

Spoil and temporary stockpiles including stone stockpile areas will be positioned in locations which are distant from drainage systems and retained drainage channels, away from areas subject to flooding. Runoff from spoil heaps will be prevented from entering watercourses by diverting it through onsite settlement ponds and removing material as soon as possible to designated storage areas.

Culverts beneath the access road will be located at or close to the locations of existing natural flow paths to allow existing flows to continue. Lateral drainage will be within shallow geotextile and rock lined drainage channels to avoid the drainage of surrounding soils. The outer perimeter fence line will be set back from the L1010 to avoid crossing watercourses as far as possible. The outer perimeter fencing is not expected to impact surface water flow where two minor watercourses are crossed, as there will not be a requirement for this fencing to be extended below the water's surface. The inner security fence surrounding the Power plant and LNG Terminal will not cross any existing watercourse.

All watercourse crossings will be planned in accordance with applicable guidelines. No permanent watercourse diversions are proposed as part of the Proposed Development.

The access road will be designed to conduct road runoff to an engineered swale adjacent to the west side of the road. This swale will be profiled to grade continuously northward and to transfer the runoff from the access road to the sealed stormwater drainage system at the LNG Terminal and Power Plant area in the north of the Proposed Development.

Silt traps will be placed at crossing points to avoid siltation of watercourses. These will be maintained and cleaned regularly throughout the construction phase. Attention will also be paid to preventing the build-up of dirt on road surfaces, caused by lorries and other plant entering and exiting the Proposed Development site, via wheel washes and road sweepers as required.

Foul sewage arising from kitchen facilities and temporary toilets and sanitary facilities during the Construction Phase on the Proposed Development site will initially be discharged to an onsite receptacle which will be appropriately managed by the service contractor with relevant licences and emptied by tanker on a regular basis for disposal at a licenced waste facility.

It is anticipated that, due to the scale of the Proposed Development, a canteen will be provided onsite during construction. Provisions will be made for a grease trap at the canteen drain outlet and this drain will connect to the onsite receptacle and later to the WWTP. Drumming of waste cooking oil within the canteen will also be provided.

During the construction phase there is a risk of loss of hydrocarbons from vehicles and plant involved in construction activities and subsequent hydrocarbon.

The employment of good construction management practices will serve to minimise the risk of pollution of soil, storm water run-off or groundwater. The Construction Industry Research and Information Association (CIRIA) in the UK has issued a guidance note on the control and management of water pollution from construction sites, Control of Water Pollution from Construction Sites, guidance for consultants and contractors (Masters-Williams et al 2001). The guide is written for project promoters, design engineers and site and construction managers. It addresses the main causes of pollution of soil, groundwater and surface waters from construction sites and describes the protection measures required to prevent pollution of groundwater and surface waters and the emergency response procedures to be put in place so that any pollution, which occurs, can be remedied. The guide addresses developments on green field and potentially contaminated brown field sites.

The construction management of the site will take account of the recommendations of this document to minimise as far as possible the risk of soil, groundwater and surface water contamination.

Site activities considered in the guidance note include the following:

- excavation,
- earthmoving,
- concreting operations,
- spreading of topsoil,
- road surfacing,
- site drainage, and the control and discharge of surface water run-off from the site,
- oil and fuel delivery and storage, and
- plant maintenance

The site-specific CEMP will detail and implement specific control measure as included in the EIAR and planning permission.

General Control Measures

No.	Control Measures
1.	Training of site managers, foremen and workforce, including all subcontractors, in the pollution risks and the preventative measures
2.	Suitable and sufficient site specific risk assessment will be undertaken by a competent person, using the source-pathway-receptor model to identify the site risks
3.	Written procedures to address activities where there will be a particular risk of pollution
4.	Emergency response plan will be developed with responsibility for emergency response identified at the start of the project with spill control equipment readily available
5.	Maintaining the site clean and tidy, with proper collection and storage of waste
6.	Identify all drainage on site and use colour coding to distinguish them: blue for surface water, red for foul, and a red ‘C’ for combined drainage systems.
7.	Develop a site drainage plan detailing the location of identified drains, surface water flows and details of the collection strategy and any necessary treatment of surface water.

8.	Surface water runoff from excavations and exposed soil, as well as dewatering from the soft ground excavation, will be passed through a series of settlement and filtration ponds, to remove excess suspended solids, before being discharged directly to the stream.
9.	Spoil and temporary stockpiles will be positioned in locations which are distant from drainage systems and retained drainage channels, away from areas subject to flooding. Runoff from spoil heaps will be prevented from entering watercourses by interceptor drains, diverting it through onsite settlement ponds. Material will be removed as soon as possible to designated storage areas.
10.	Earthwork activities and site haul roads will be sprayed regularly with water using sprinklers and bowsers to damp down, particularly during periods of dry weather. Measures will be provided to minimise run-off into the pNHA/cSAC;
11.	Water quality monitoring of the discharge will be implemented to demonstrate effectiveness of the measures.
12.	Any proposed discharge area will avoid bare rock, and will only be located where suitable subsoils are present.
13.	No waste materials, oils, paints, other such contaminants, or any washing out of the aforementioned will be allowed into any drain, sewer or water. Oils and fuels will be stored in bunds. Drip trays / plant nappies will be in place for stationary plant.
14.	Regular maintenance, and removal from site of leaking plant or equipment, and dedicated refuelling locations for mobile plant will be set up.
15.	All drainage systems will have inspection chambers and be set up in such a manner as to facilitate effluent isolation from the discharge point, and have an alternative containment system, as may be required in the event that the discharge becomes contaminated.

Implementation of the CIRIA guide's recommendations will ensure that the risk of pollution of groundwater, soils and surface waters, resulting from the construction activities, will be minimised

9.2.4 Works in the Estuary

A significant amount of the jetty construction work will be carried out over open water. The jetty construction contractor will be required to demonstrate that working practices, construction methods and pollution prevention measures will be set in place to prevent pollution from entering the marine environment.

The jetty construction contractor will be required to liaise closely with Shannon Foynes Port Company Harbour Master & Pilotage Superintendent in relation to scheduling of activities.

Vessels required for the work (including barges, scows etc.) will be moored and anchored so as not to interfere with traffic in the navigation channel and in accordance with guidelines established by the Harbour Master and Shannon Foynes Port Company.

Potential impacts to the marine environment from raw concrete will be minimised by maximising the use of pre-cast concrete and minimising the use of in-situ concrete. Any in-situ concrete work will be staged in a manner to prevent concrete from entering the water. Concrete suitable for underwater will be used.

Piles will be prefabricated as much as possible to minimize in-water construction.

Spoil from the drilling operations will be conveyed to the surface via reverse-circulation through the drill stem and collected in designated scows or other storage vessels.

Where the outfall extends beyond the low water mark into the estuary, excavation of rock will be undertaken using an expanding grout placed by divers into drilled holes to pre-split the rock to the required levels and facilitate its removal by long reach excavator bucket. Trenches excavated across the shoreline will be backfilled with concrete suitable for underwater use and the surface will be embedded with cobbles and stone excavated from the trench to minimise the visual impact. The excavated material will be removed from the foreshore and incorporated as part of the earthworks and landscaping for the Proposed Development.

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Excavated material and the spoil from installation of the entrenched outflow pipe will removed from te foreshore and incorporated as part of the earthworks and landscaping ashore..

Section 9.2.2 describes the construction works in the estuary that will introduce sound into the marine environment. Mitigation measures to avoid environmental impacts are also detail.

Additional specific mitigation measures for work in the estuary are listed in Chapter 07A Marine Biodiversity of the EIAR and will be implemented by the Contractor.

9.2.4.1 Invasive Species

Ballast water for the FSRU and LNGC will be managed in accordance with the vessels Ballast Water Management Plan in accordance with Flag State requirements, Shannon Foynes Port Company operating procedures and the provisions of Section 34 of the Sea Pollution (Miscellaneous Provisions) Act 2006 referencing the International Convention for the Control and Management of Ships' Ballast Water and Sediments, which entered into force in September 2017.

The FSRU would initially arrive to the STEP terminal full of LNG and therefore would not be carrying ballast. Ballasting of vessels with the River Shannon is a routine practice and the FSRU would take on ballast water from the river once in operation. There is, therefore, no risk of extra marine pests being introduced to the River Shannon from FSRU ballast water. LNG carriers also would arrive full of LNG and with no ballast water. The LNGC's would take in ballast water in accordance with routine practice.

9.2.5 Environmental Emergency Response Plan

The development of an accident prevention and emergency response plan (including environmental emergencies) shall be the responsibility of the appointed Contractor and Project Supervisor for the Construction Stage (PSCS). This plan shall be appended to the detailed CEMP as an Appendix and shall include all relevant contact details. Control measured shall include as a minimum:

No.	Control Measures
1.	An Environmental Emergency Response Plan Control Plan will be agreed with the Client prior to works commencing on site. The Contractor shall appoint an emergency spill contractor.
2.	A 'Spill Incident' includes: Drips, Stains, Spillage, or Release of any liquid (including oils, soiled water, sewage, paints, resins, cement and chemicals).
3.	All materials and spill-risk activities will be restricted to the least sensitive part of site, greatest distance from surface waters, drainage, etc.
4.	All plant and equipment will be mechanically sound, and operated and maintained in accordance with the manufacturer written recommendations to prevent oil leaks.
5.	All storage tanks and the associated filling areas, and cleaning areas will be located on firm level, impervious ground. No discharge will be allowed from these areas.
6.	Designated secure lock-up bunded facilities will be provided for storage of all hazardous materials (paints, chemicals, gas...etc.). Safety data sheets for materials therein will be available in the storage unit. Onsite storage of all liquids will be kept to a minimum. All materials (hazardous and non-hazardous) will be clearly labelled. This is shown in Appendix 4 Logistics Plan.
7.	Only properly certified, self-bunded metal units will be used for storage of fuel on site.
8.	All liquid containers, static and mobile fuel units, generators and associated hoses will be contained in proper impermeable bund, or contained in spill pallet / tray. Such containment will have capacity of the greater of either: 110% of the largest container within, or 25% of the total volume of materials storage capacity within.
9.	Major plant refuelling will be done at a fixed location. Spill kit will be available during the refuelling. A designated concreted, bunded area will be used for refuelling on site and for unavoidable on site servicing and maintenance (servicing and maintenance will be carried out off-site).
10.	An authorised waste collection company will be employed to clean contents of all bund facilities as required. No such material will be released to land or drain.
11.	Fuel hoses will have a shut off valve and be locked when not in use. The oil filling facility will be such that access for oil filling can only take place with the prior notification of a designated person.
12.	All bunded facilities will be subject to routine inspection to ensure integrity.
13.	Only approved fuel containers (jerry cans) will be used to hold smaller volumes of fuel.

14.	Appropriate quantity of Spill Kit material (‘oil only’ booms and socks) will be retained and available near all material storage points and all drainage channels for use in the event of an environmental incident. Appropriate quantities of Spill Kit material will be available within all mobile equipment.
15.	Local dewatering and collection of groundwater during construction may require disposal. A suitable system for treatment and disposal of groundwater during construction are to be implemented following suitable pollution control and attenuation measures.
16.	The Contractor will also report on any incidents such as spills or leaks and how such incidents were dealt with to mitigate environmental impacts. These reports will be issued to the Client and mitigation measures discussed.

9.2.5.1 Control of concrete

The management of cementitious material on site is required for the protection of transitional waters from any spillages - cement and concrete are toxic to fish. Measures must be taken during all aspects of construction to ensure that no cement or concrete is allowed to enter intertidal waters. A suitable risk assessment for wet concreting will be completed prior to works being carried out, which will include measures to prevent discharge of alkaline wastewaters or contaminated storm water to the underlying subsoil or to the marine environment. Control measure as a minimum to include:

	General
No.	**Control Measures**
1.	The use of concrete with a suitable drying time or appropriate protection of working areas must be used where tidal sequences result in any risk of tidal contact with newly-concreted areas
2.	A suitable risk assessment for wet concreting will be completed prior to works being carried out which will include measures to prevent discharge of alkaline wastewaters or contaminated storm water to the underlying subsoil or to the marine environment.
3.	The pouring of concrete will take place within designated areas as required, using a geosynthetic material to prevent concrete runoff into the soil.
4.	Concrete pouring should only be done in fully-isolated shuttered locations
5.	If concrete is to be made up onsite, then a bunded area at a distance from the sea should be used for this process to minimise to the greatest extent any risk of concrete or concrete product contamination of water
6.	Concrete pours shall not be carried out during forecasted periods of heavy rainfall. Weather forecasts will be monitored during the construction phase. The 24 hour advance meteorological forecasting service from Met Éireann will be used
7.	To reduce the potential for cementitious material entering the Shannon Estuary, concrete pours will be supervised by the Construction Manager, a suitably qualified engineer and the Environmental Manager
8.	To prevent spillages to transitional waters, the surrounding areas will be isolated from the concrete works, prior to the concrete pours taking place, by installing shuttering to contain the concrete. The shuttering will stay in place until the concrete has cured.
9.	The Construction Manager, the Environmental Manager and appropriate engineer will supervise all concrete pours
10.	Works requiring discharge of water from excavations or areas of water which may have come in contact with concrete or cementitious material will require a site Permit to Pump under the CEMP. All such water will be tested for pH by contractors, and discharging water must go through a series of filtration systems before final discharge
11.	The Environmental Manager is responsible for ensuring that appropriate water pollution prevention measures are put in place and that water sampling is carried out. Where standards are breached he/she will carry out an investigation and in conjunction with the Construction Manager, he/she will ensure remedial action is taken and further samples taken to verify that the situation has returned to normal
12.	The Environmental Manager is responsible for ensuring spill kits are readily available in vulnerable locations and that booms for watercourses are long enough and have adequate anchorage.
	Concrete Wash Down Water
No.	**Control Measures**
1.	Pours will not take place during heavy rainfall. Weather forecasts will be monitored during the construction phase. The 24 hour advance meteorological forecasting service from Met Éireann will be used
2.	To reduce the volume of cementitious water, washout of concrete trucks will not take place onsite. Concrete trucks will be washed out off site at the source quarry
3.	To minimise the potential for water quality impacts, no wash down of concrete chutes will be permitted within 200m of the transitional water or any surface water that drains into same
4.	To reduce the volume of cementitious water, only concrete chutes will be washed down onsite. The concrete trucks will wash down their chutes at a designated chute wash down area, preferably in the site compound. The wash down area will consist of a polythene lined bunded area of adequate capacity
5.	Mixing of concrete is to be carried out within a designated bunded area within the site compound where the risk of wash out of concrete to the Shannon Estuary is eliminated. This designated chute wash down area will also be used to effectively treat concrete wash water arising from the washing out cement mixers and the cleaning of tools and equipment
6.	Wash-water from the washing out of mixers and other equipment will be undertaken off-site at the end of each day

9.2.6 Ground (Soil) Control Plan

In the event of any evidence of soil contamination being found during either the excavation or the construction works, appropriate remediation measures will be employed. Any contaminated soil will be delineated, removed and stored on impervious quarantine areas pending testing to confirm appropriate removal and disposal to permitted/licensed waste facilities. Records of disposal will be retained on site for inspection by KCC.

No.	Control Measures
7.	In the event that short term c24-48 hour storage is required the material will be retained in a designated stockpile storage area identified on the relevant site layout drawings.
8.	All excavated soils leaving the site will be recorded using a materials dispatch log detailing the date of transport, vehicle registration, quantity and type of material and destination. Its envisaged no excavated material will leave site.
9.	If contaminated ground is found to be present on a work site the project team will assess the risk in relation to: Mobilising contaminants as a result of the works and potential receptors in the local vicinity which may be impacted upon as a result.
10.	If contaminated ground cannot be avoided the project team will attempt to remediate any arising's on site or remove the contaminated soil to a quarantine area or to a soil treatment facility using a licensed waste contractor. If detailed ground investigation is then required the project team will plan for careful excavation to allow segregation of contaminated land from uncontaminated waste.

Temporary storage of soil will be carefully managed in such a way as to prevent potential negative impact on the receiving environment. Spoil and temporary stockpiles including stone stockpile areas will be positioned in locations which are distant from the shoreline, drainage systems and retained drainage channels and away from areas subject to flooding, so as not to cause potential run off to soils. The CEMP will outline proposals for the excavation and management of excavated material. Movement of material will be minimised in order to reduce degradation of soil structure and generation of dust. In order to minimise the potential environmental impact of stockpiles, the CEMP will contain the following mitigation measures that will be implemented during the construction phase:

No.	Control Measures
1.	Store excavated topsoil and rock for reuse in graded stockpiles less than 2 m high to prevent damage to the soil structure. Other excavated materials of lower engineering quality can be stored in higher piles. The depth of topsoil removal across the site is expected to be 0.15 m and, in total, 35,000 m3 of topsoil is expected to be removed, stockpiled and reused on site during the proposed development works;
2.	Of this 35,000 m3 of topsoil, 13,745m3 is expected to be used as backfill and the remaining 21,255 m3 will be used to cover the lay down area on completion of constructions and also used in landscaping or to form berms.
3.	To help shed rainwater and prevent ponding and infiltration, the sides and top of the stockpiles will be regraded to form a smooth gradient with compacted sides reducing infiltration and silt runoff;
4.	Manage potential silty runoff from stockpiles and excavated area using silt fences and silt traps placed at crossing points to avoid siltation of watercourses on and close to the Proposed Development site. These will be maintained and cleaned regularly throughout the construction phase. Attention will also be paid to preventing the build-up of dirt on road surfaces, caused by lorries and other plant entering and exiting the Proposed Development site.
5.	Segregate different grades of soil where they arise and topsoil will first be stripped from any land to be used for storing subsoil; and
6.	Minimise movements of materials within the stockpiles in order to reduce the degradation of the soil structure
7.	Maintain an even inclined surface on cut and fill surfaces to prevent the formation of ruts and hollows (which may promote ponding);
8.	Defer final shaping and trimming of formation levels until immediately prior to placement of surface dressing;
9.	Undertake earthworks in glacial till in times of dry weather, where possible; and
10.	Manage groundwater and surface water flows through drainage channels. Channels to be regularly inspected to prevent build-up of debris and sediment, particularly at crossing points, fence crossings and where the minor watercourses enter and leave the proposed development site.

9.2.7 Waste (Reduction & Management) Control Plan

A detailed SWMP will be prepared prior to the commencement of the works once a Main Contractor is appointed to undertake the works and will ensure that the waste generated is managed in accordance with best practice, the relevant legislation and with minimal impact on the environment.

The Contractor will be required to develop, implement and maintain a Waste Management Plan during the construction works. A senior manager will be responsible for the waste management plan. He will be competent in waste management, and will receive training, where necessary, such as the CIF/FÁS Construction and Demolition Waste Management module.

Control measures are to include:

No.	Control Measures
1.	In order to comply with the Waste Management Plan in accordance with the provisions of "Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Projects (Department of the Environment, Heritage and Local Government, July 2006)" the contractor will submit a detailed SWMP to the Client and if required to KCC if a requirement of planning permission. The Contractor will ensure the SWMP will include: - planning, - prevention, - management, - duty of care, and - tracking of all project waste.
2.	Construction will be planned to identify and implement ways to prevent, reduce, reuse and recycle waste. The following hierarchy will be used, in order of preference, for management of all construction waste. - Prevent potential waste - Reduce/minimise waste - Reuse and/or recycle materials - Segregate for offsite recycling - Segregate for offsite recovery - Segregate for offsite disposal
3.	Prior to appointment of any waste management contractor or waste facility all necessary documentation such as waste collection permits, waste facility permits, and waste licences will be forwarded to the Contractor for review and approval. Compliant waste management contractors with maximum recycling rates and reduced volumes of waste to landfill rates will be given preference. Audits/site inspection will be carried out by the Environmental Manager, or nominated deputy, of the chosen waste facilities before any waste goes there. This applies to all waste types.
4.	A designated Materials / Waste Compound area will be assigned and clearly signposted on site. This compound will be kept in a tidy state and secure at all times. All leftover materials and waste will be segregated initially into working bins at or near each work area. These working bins will be transported from the work areas, where any materials fit for reuse are taken to the materials storage area, with waste being transferred to larger separate skips for efficient segregation and transport away from site.
5.	A dedicated bunded area within the materials / waste compound will be set up and used specifically for separate hazardous wastes. All bins therein will be well labelled to identify dedicated waste type.
6.	Working skips will be moved appropriately as the project progresses and different types of recyclables arise in order to maximise recycling. All skips will be well labelled to identify dedicated waste type, and suitably positioned to facilitate waste vehicle access.
7.	Work will be planned with waste minimisation in mind. Ordering, sizing, and storage of materials is important to reduce unsuitable product, excess packaging, offcuts and damaged materials.
8.	Waste will not leave site unless a full copy of the Waste Collection Permit and the Facility Licence/Permit has been provided to the Environmental Manager for checking, approval and site filing. The dockets and licences will be cross-checked prior to waste removal off-site. Hazardous waste will not leave the site unless the appropriate Waste Transfer Form (WTF) notification procedure is in place.

9.2.8 Visual (Maintenance & Housekeeping) Control Plan

The following are some of the measures that will be taken to ensure that the site and surroundings are maintained to a high standard of cleanliness:

No.	Control Measures
1.	Parking will be only permitted at designated areas. The Contractor will provide adequate, bicycle and car parking facilities within the Contractors Compound for site workers during construction.
2.	The entire site including all site offices, accommodation and storage facilities will be maintained in a safe, clean and organised condition throughout the project.
3.	A regular program of site tidying will be established to ensure a safe and orderly site
4.	Access and exit routes will be kept clear at all times.
5.	All site users will be briefed on the importance of using site bins to ensure that the site and surrounding areas are not littered. The site will be furnished with sufficient bins that are serviced regularly.
6.	Scaffolding will have debris netting attached to prevent materials and equipment being scattered by the wind,
7.	Food waste will be strictly controlled on all parts of the site,
8.	Loaded lorries and skips will be covered with plastic sheeting and tied down
9.	Internal haul roads will be paved at the earliest possible opportunity and inspected regularly for cleanliness.
10.	Surrounding roads used by trucks to access to and egress from the site will be cleaned regularly using an approved mechanical road sweeper. Roads will be cleaned subject to local authority requirements. Site roads will be cleaned on a daily basis, or more regularly, as required.
11.	Road edges and footpaths will be cleaned using a hand broom with controlled damping.
12.	Wheel wash facilities will be provided with rumble grids to remove excess mud from wheels. These facilities will be located at all exits from the site and away from sensitive receptors and the pNHA/cSAC.
13.	In the event of any fugitive solid waste escaping the site, it will be collected immediately and removed to storage on site, and subsequently disposed-off in the normal manner
14.	A designated secure lock-up facility will be provided for storage of tools, plant and equipment during times that they are not in use.
15.	Keys for mobile plant and equipment will be retained in a secure location during times that they are not in use.
16.	Onsite storage of all liquids will be kept to a minimum. Designated secure lock-up bunded facilities will be provided for storage of all liquid materials (paints, chemicals, gas...etc.). Material safety data sheets and contact details of person responsible for materials therein will be available in the storage unit. All materials (hazardous and non-hazardous) will be clearly labelled.
17.	All site areas will be appropriately designated and clearly signposted (materials storage, waste compound area, etc.).
18.	Only good quality signage will be posted. These will be replaced as deemed necessary by the Contractor.
19.	All temporary structures, fencing, hoarding, bunds, refuelling and fuel storage facility, haul roads, drainage, waste compound area, site security, access control systems, and extra materials will be removed prior to handover of the finished project. All these areas will be reinstated as may be required.
20.	Respectable and safe standards of dress and conduct will be maintained at all times. Management and staff will be courteous in dealing with others, both on and off site. Pride in the management and appearance of the project and the surrounding environment will be shown at all times.

Shannon LNG undertakes to promptly repair any damage to property or services attributable to construction activity and will maintain a dedicated contact point in this regard

9.2.9 Air Quality Control Plan

Construction dust emissions will be controlled via the CEMP. Emissions to air during the earthmoving and construction phases will occur, although the prevailing weather, the size of the site and its distance to sensitive receptors will assist in facilitating the management of any effects. The focus of the control procedures will therefore be to reduce the generation of airborne material.

A community liaison officer will be appointed by Shannon LNG to immediately address any complaints from the public relating to environmental and safety matters.

Dust emissions are likely to arise from the following activities during the construction works:

- Site earthworks;
- Wind blow from temporary stockpiles;
- Handling of construction materials;
- Landscaping; and
- Construction traffic movements.

Good practice site procedures will be adopted to limit dust at the construction site itself and to minimise potential for secondary impacts due to dust and other material, e.g., mud being transported onto the surrounding road network. The degree of active control measures necessary to be adopted at the subject site will depend on the time of year and the weather conditions prevalent at that time. The following 'good practice' measures will be adopted:

No.	Control Measures
1.	The site-specific dust minimisation control plan will take account of all construction activities by adhering to the Building Research Establishment Document Control of Dust from Construction and Demolition Activities. This control plan shall take into account the type of construction activity being carried out in conjunction with but not limited to environmental factors including levels of rainfall, wind speeds and wind direction.
2.	A stakeholder communications plan that includes community engagement before work commences onsite will be developed and implemented
3.	The name and contact details of person(s) accountable for air quality and dust issues will be displayed at the site boundary
4.	All dust and air quality complaints will ne recorded, cause(s) identified, appropriate measures to reduce emissions taken in a timely manner, and the measures taken recorded
5.	Any exceptional incidents that cause dust and/ or air emissions, either on- or offsite, and the action taken to resolve the situation will be recorded;
6.	Daily onsite and offsite inspections will be undertaken to monitor dust, inspection results will be reported and be made available to the planning authority when requested
7.	To supplement visual inspections, dust deposition monitoring will be conducted at a number of locations in the vicinity of the development site (see Figure 9.1 for locations), including adjacent to the pNHA/cSAC using the Bergerhoff method (German Standard VD 2119, 1972). Results will be compared to the TA Luft guidelines. Should an exceedance of the TA Luft limit occur during the construction phase, additional mitigation measures, for example the erection of a screen along the site boundary, will be implemented
8.	The concrete batching plant will be located at the lowest level on site
9.	Earthwork activities and site haul roads will be sprayed regularly with water using sprinklers and bowsers to damp down, particularly during periods of dry weather. Measures will be provided to minimise run-off into the pNHA/cSAC;
10.	Earthworks and exposed areas/ soil stockpiles will be revegetated to stabilise surfaces if at all practical and as soon as practicable
11.	Vehicles and plant with low exhaust emissions will be used and will be serviced regularly. Engines will not be left running unnecessarily. In addition, vehicles will be monitored entering the site for noticeable exhaust emissions and site security personnel will have the power to ban offending vehicles from the site. These measures will minimise PM10 emissions;
12.	The Contractor works zones will be regularly cleaned and maintained as appropriate.
13.	Hard surface roads, under the Contractor's control, will be swept to remove mud and aggregate materials from the surface while any un-surfaced roads will be restricted to essential site traffic only.
14.	Internal haul roads will be paved at the earliest possible opportunity and inspected regularly for cleanliness
15.	Maximum-speed-limits on surfaced and unsurfaced haul roads and work areas will be sign-posted and

	mandatory
16.	Any road within site and off-site areas that has the potential to give rise to dust will be regularly watered, as appropriate, during dry and/or windy conditions.
17.	Vehicles using temporary haul roads will be restricted to 10 km per hour on any un-surfaced site road and on hard surfaced roads to suit the particular site conditions.
18.	Vehicles delivering or removing materials to site and off-site areas which present a risk of spillage of materials likely to give rise to dust or with dust potential will be enclosed or covered with tarpaulin at all times to restrict the escape of dust and or prevent spillages. Skips are to be covered.
19.	Public roads outside the site and off-site areas will be regularly inspected for cleanliness, and cleaned as necessary.
20.	Material handling systems and site stockpiling of materials will be designed and laid out to minimise exposure to winds and in addition storage of unexposed soils will be seeded to prevent friability.
21.	Water misting or sprays will be used as required if particularly dusty activities are necessary during dry or windy periods.
22.	The site will be set up to minimise movement of plant and material, thereby reducing site road degradation and dirt.
23.	Best practicable means will be employed to minimise air blown dust being emitted from the site. This will include covering skips and slack-heaps, wetting with water, seeding ground, covering ground (with tarpaulin or stone), netting of scaffolding, specifying equipment with upwardly pointing exhausts, and any other precautions necessary to prevent dust nuisances. Chemicals will not be used for any dust control operations.
24.	All vehicles, plant and equipment used in relation to the site are to be mechanically sound, operated and maintained in accordance with the manufacturer written recommendations, and switched off when not in use. Machinery exhausts will be positioned at a height to ensure adequate dispersion of emissions.
25.	Site access and egress points will be set up with dust minimisation in mind. Suitable facilities will be provided on site for vehicle cleansing to prevent carriage of dirt onto clean areas and/or off-site.
26.	Wheel Spray Booth or similar system shall be used for all trucks entering and leaving the site during the removal of soil and stone to achieve formation level.
27.	Wheel wash facilities will be provided with rumble grids to remove excess mud from wheels. These facilities will be located at all exits from the site and away from sensitive receptors and the pNHA/cSAC
28.	Areas where materials will be handled and stockpiled will be positioned away from main site access roads. These areas will also be designed to minimise their exposure to wind – all stockpiles shall be kept to the minimum practicable height with gentle slopes.
29.	If necessary, scaffolding will have debris netting attached to prevent materials and equipment being scattered by the wind.
30.	Surrounding roads used by trucks to access to and egress from the site will be inspected regularly and cleaned, using an approved mechanical road sweeper, when required. Roads to be cleaned subject to local authority requirements. Site roads will be cleaned on a daily basis, or more regularly, as required.
31.	Road edges and footpaths will be cleaned using a hand broom with controlled damping.
32.	In the event of any fugitive solid waste escaping the site, it will be collected immediately and removed to storage on site, and subsequently disposed of in the normal manner.

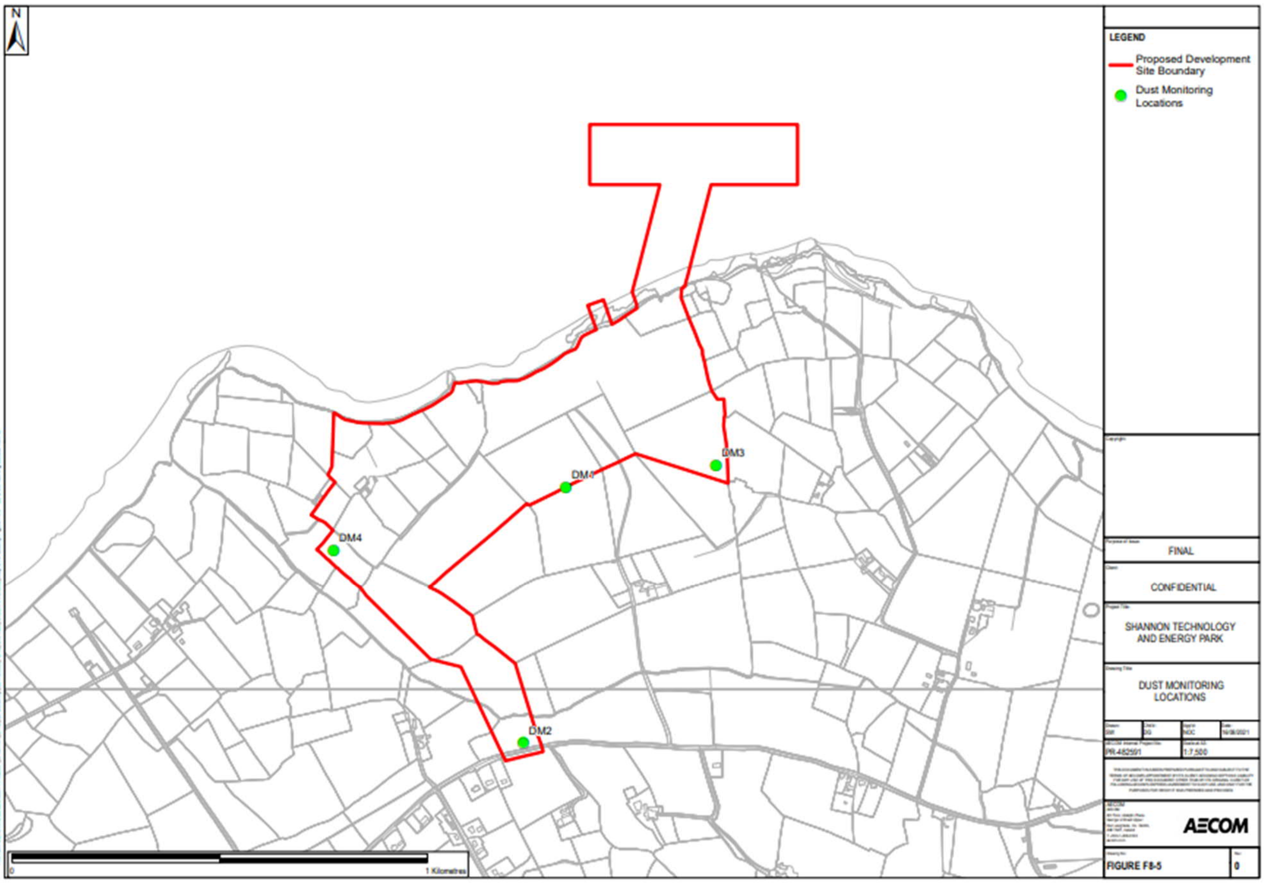


Figure 9.1 Dust Monitoring locations

9.2.10 Noise and Vibration Control Plan

The construction of the Proposed Development is expected to extend up to 32 months , and will result in emissions of noise from activities including earthmoving, blasting, excavations, and construction of facilities, with associated construction traffic on routes to the site.

During the construction phase there will be noise associated with site clearance, site access and internal road construction, site preparation, excavations, drilling/piling, and construction of berth facilities, and process facilities. There will be some excavation of rock at the site, and blasting may be required.
The main noise sources will be excavation equipment, construction vehicles and construction plant operating on site, and associated noise from construction vehicles on roads serving the site.

Approximately three to four long term noise monitoring stations and one to two long term vibration monitors will be set up on the construction site boundary. The exact location of these stations will be determined in due course and will be chosen to best represent noise and/ or vibration emissions in the direction of nearby receptor positions. Monitoring will continue throughout the entire construction phase.

Long term noise monitoring stations will be equipped with an SMS and/ or email alert system so that site staff can be informed of potential exceedances. The results of the monitoring will be recorded and reported to relevant stakeholders in an appropriate manner and frequency, to be agreed in due course.

It is acknowledged the limits presented relate to construction works for road schemes, however it is assumed that noise sensitive receptors are likely to be equally sensitive to construction noise from other project types.

Period	$L_{Aeq,1hr}$ dB	$L_{p(max)\ slow}$ dB
Monday to Friday – 07:00 to 19:00	70	80

Period	$L_{Aeq,1hr}$ dB	$L_{p(max)\ slow}$ dB
Monday to Friday – 19:00 to 22:00	60[1]	65[1]
Saturday – 08:00 to 16:30	65	75
Sundays and Bank Holidays – 08:00 to 16:30	60[1]	65[1]

[1] Construction activity at these times, other than that required in respect of emergency works, will normally require the
explicit permission of the relevant local authority

Source: Guidelines for the Treatment of Noise and Vibration in National Road Schemes *(NRA 2004)*

Table 9.1 Maximum permissible noise levels at the façade of dwellings during construction

A log will be maintained on site of all noise / vibration complaints including those actions taken where trigger limits are exceeded;

- Name and address of complainant
- Time and date complaint was made
- Date, time and duration of noise
- Characteristics, such as rumble, clatters, intermittent, etc.
- Likely cause or source of noise
- Weather conditions, such as wind speed and direction
- Investigative and follow -up actions

The vibration thresholds in the following guidelines shall be followed and adhered to with regard to any potential vibration impacts during construction:

- BS6472: 2008. Guide to Evaluation of Human Exposure to Vibration in Buildings. Part 1: Vibration Sources other than Blasting; and
- BS7385: Part 2 1993: Evaluation and Measurement for Vibration in Buildings-Guide to Damage Levels from Ground-borne Vibration.

In general, the Contractor shall limit the hours during which site activities which are likely to create high levels of noise or vibration. This will be of particular relevance if out-of-hours / night-time work is required.

During construction works, the Contractor shall utilise the following noise abatement measures and comply with the recommendations of BS 5228:2009+A1:2014 - Noise Control on Construction and Open Sites. These measures will ensure that:

No.	Control Measures
1.	Normal working hours within the site will be restricted from Monday to Friday between 07:30Hrs and 18:00Hrs and Saturday between 08:00Hrs and 14:00Hrs unless otherwise stated. Site noise will be minimised at all times, especially at night and at weekends.
2.	When considering noise control at source the following elements will be taken into account: The noise level, and the likely duration of such noise. Noisy activities will be restricted to the appropriate part of site where possible in order to minimise local disturbance. Operations will be organised with regard to the positioning of equipment and the location of haul routes so as to minimise noise impacts. Machines in intermittent use will be shut down in the periods between works or throttled down to a minimum. Where noisy activity will take place near a noise sensitive location the use of noise screens and abatement equipment will be used as a method of minimising disturbance.
3.	Blasting vibration limits will be achieved by limiting the Maximum Instantaneous Charge (MIC) based on the results of trial blasts carried out in accordance with the procedure detailed in BS6472. It is noted there may be blasting charge limits imposed as a result of the underwater acoustic assessment. If these limits differ, the more stringent limit of the two will be adopted
4.	Controls will be in place to limit noise as detailed as follows (items 5 to 16):
5.	Soft-start for any source, including equipment testing, exceeding 170dB re: 1uPa @ 1m an appropriate ramp-up

	procedure (i.e., “soft-start”) must be used. This should be a minimum of 20 minutes and no longer than 40 minutes, for protection of bottlenose dolphins. See 9.2.2.2 Marine Flora and Fauna for further mitigation measures.
6.	All plant and equipment used on site will be the quietest of its type for carrying out the work required and will be maintained in good condition with regard to minimising noise output (this may include the fitting of sound reduction systems). All plant and equipment will be mechanically sound, and operated and maintained in accordance with the manufacturer written recommendations.
7.	Machines, which are used intermittently, will be shut down or throttled back to a minimum during those periods when they are not in use.
8.	Any plant, such as generators or pumps, which are required to work outside of normal working hours, will be surrounded by an acoustic enclosure.
9.	Heavy construction activities will be carried out during daytime hours only and restricted to the conditions of the full planning permission. This may also be subject to agreements made with the Client and local residents.
10.	Any tests or procedures which are known to be potentially noisy will be carried out during daytime hours only.
11.	Compressors will be of the “sound reduced” models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.
12.	Construction plant and equipment will comply with, EC (Construction Plant and Equipment) (Permissible Noise Level) Regulations.
13.	Noise monitoring is to be conducted during critical periods and at sensitive locations to be agreed in consultation with the KCC.
14.	Circumstances where the restriction on hours of work cannot be adhered to e.g. concrete pours, power floating works, etc. In these circumstances the Contractor will provide written agreement with KCC before any works start outside normal hours
15.	Throughout the contract, the supervision of the works will include ensuring compliance with the limits using the methods set out in BS:5228
16.	Good community relations shall be established and maintained throughout the construction process. This shall include informing residents on progress and ensuring measures are put in place to minimise noise and vibration impacts.

9.2.10.1 Blasting Mitigation – Air overpressure

It is expected that blasting will be required to excavate some of the rock, which cannot be removed by rock breaking equipment mounted on tracked excavators It is understood that no more than 3 blasts per day are envisaged. This will only take place during the enabling phase.

With regards the prediction of air overpressure, BS6472 states:

Accurate prediction of air overpressure is almost impossible due to the variable effects of the prevailing weather conditions and the large distances often involved.

Control of air overpressure should always be by its minimization at source through appropriate blast design.

In light of this, to minimise the impact of air overpressure and blasting it is recommended that:

No.	Control Measures
1.	Blasting is carried out in accordance with the principles set out in BS 5607:2017 Code of practice for the safe use of explosives in the construction industry
2.	Ensuring appropriate burden to avoid over or under confinement of the charge
3.	Accurate setting out and drilling
4.	Appropriate charging
5.	Appropriate stemming with appropriate material such as sized gravel or stone chippings
6.	Using delay detonation to ensure smaller maximum instantaneous charges (mics)
7.	Using decked charges and in-hole delays

8.	Blast monitoring to enable adjustment of subsequent charges
9.	Designing each blast to maximize its efficiency and reduce the transmission of vibration
10.	Avoiding the use of exposed detonating cord on the surface in order to minimize air overpressure – if detonating cord is to be used in those cases where down-the-hole initiation techniques are not possible, it should be covered with a reasonable thickness of selected overburden; and
11.	A protocol for community relations with regards blasting is adopted such that prior warning of blasting operations is given to members of the public.

9.2.11 Resource Usage Control Plan

Construction material would be sourced locally as much as possible to minimise the environmental impact of transportation. It is intended that all suitable stone recovered on the site will be reused as hardcore in the building construction and for the rock fill in the embankment. For this purpose, rock crushing and screening plant will be provided. Additional rock, stone and sand materials will be procured from local quarries as required.

Some of the process equipment and structural elements will arrive on site as complete units or sub-assemblies which will be larger than normal construction loads. It is anticipated that most of the units will be delivered by ship to Foynes or another port, and from there transported to the site by road. Some of the units may be 'extra-large loads' and a Garda escort may be required when they are on the road network. The timing of their transport to the site will be chosen to minimise disruption to other roads users.

During the construction phase of the project water will be required for consumption by the construction personnel, for general construction works.

It is predicted that 50 cubic metres of water will be required for the construction workforce at peak. This potable water will be delivered by road and stored in a temporary tank on-site.

The construction of the LNG Terminal will require approximately 110 m3/day at its peak.

Resource controls will include the following:

No.	Control Measures
1.	Measures to control essential resources such as energy, water, transport and general building materials will be managed throughout the project and stipulated in the Site-Specific CEMP.
2.	Site safety and waste management will benefit from more efficient management of site materials.
3.	Signage will be visible in appropriate site areas to serve as a reminder of resource usage to all site staff.
	TRAVEL
4.	Personnel transport associated with the project will be assessed in order to reduce associated carbon expenditure. The Contractor will engage site personnel to encourage the use of green transport options including car-pooling, public transport, walking and cycling.
5.	Material transport associated with the project will be assessed in order to reduce associated carbon expenditure. The Contractor will engage the supply chain to reduce the number of vehicle movements relating to site material.
	ENERGY
6.	Electric power supply for the construction phase will require either a mains substation to be installed or a series of portable site units will be employed.
7.	All offices and drying rooms energy efficiency measures will include: installation of sprung door closers in external doors, awareness notices to save energy, timers on heaters and boilers, sensors/PIR's for lighting where possible and supervision to switch off other lights, computers, etc at the end of the day.
8.	Electrical Meter will be installed to monitor all electrical consumption for the duration of the project.
9.	All diesel used for the duration of the works will be logged.

10.	Documents will be emailed instead of photocopying where possible.
	MATERIALS
11.	Printers will be set to print on both sides of paper.
12.	Reuse of site won material will be promoted. Excavated soil will be reused on site wherever possible to reduce the need for imported fill.
13.	Sustainable materials will be given consideration and used where possible, e.g. reusing site won materials, using locally sourced materials, using Ground Granulated Blast Furnace Slag (GGBS) concrete, purchasing recycled materials, sustainably sourced certified timber.
14.	Material purchasing will include full specification of materials for just-in-time delivery. Unused materials will be returned to supplier on agreement.
15.	Work will be planned to prevent waste of materials.
16.	Material storage and movement will be well organised to prevent damage and waste.
17.	Unnecessary materials will be promptly removed from site for reuse where possible.
	WATER
18.	All water supply will be maintained and fitted with stop taps.
19.	Water meters will be installed to monitor all water consumption for the duration of the project.
20.	Water will be reused where possible.

9.2.12 Sensitive neighbours plan

No.	Control Measures
1.	The Contractor will respect all site neighbours by proactively addressing any concerns.
2.	All work will be carried out with positive consideration to the needs of neighbours and the general public. At all times during construction we will protect the privacy of neighbours and ensure that all site personnel, plant and equipment; including that of all subcontractors, suppliers and visitors will not trespass or cause nuisance to the local environment.
3.	Examination period will be taken in consideration in the programming of the works.
4.	Any complaints received will be managed in a responsible manner. The Contractor will appoint a Community Liaison Officer to co-operate with the Public Relation Officer who will liaise with members of the public.
5.	The specific Construction Traffic Management Plan will be implemented to minimise the effect of the construction traffic on the surrounding network, local community and the environment. The CTMP will be submitted under separate cover in addition to this CEMP.

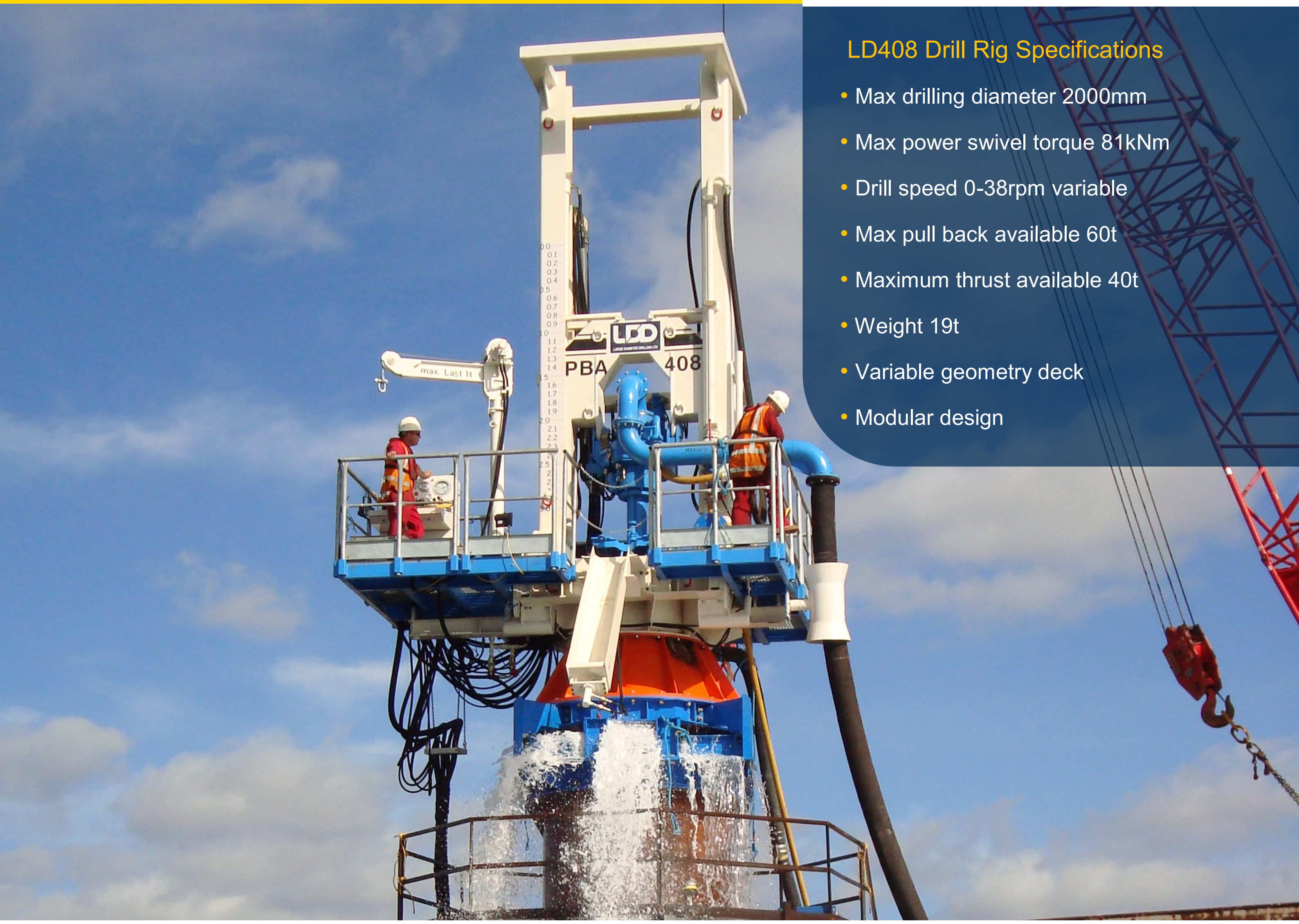
Appendix 8

Datasheet - Reverse Circulation Drilling Rig

LD408

Reverse Circulation Drilling Rig

Range | 1300-2000mm with under-reaming capability



LD408 Drill Rig Specifications

- Max drilling diameter 2000mm
- Max power swivel torque 81kNm
- Drill speed 0-38rpm variable
- Max pull back available 60t
- Maximum thrust available 40t
- Weight 19t
- Variable geometry deck
- Modular design

The LD408 is a reverse circulation drilling rig designed to operate in virtually any soil or rock type. It enables the creation of sockets of up to 1300mm dia. in its standard configuration or up to 2000mm dia. with a cellar deck

The drill is comprised of 4 main sections: Drill gripper, Drill base, Mast and carriage and Power Swivel. The gripper allows connection to the pre-installed pile with sufficient capacity to accommodate the static and dynamic forces the drill rig can generate. It uses compressed air to achieve a secure grip on the pile to prevent movement throughout the drilling process.

The Power Swivel provides the rotation force required to drill the socket to target depth specified by the project. Thrust is provided by the two carriage rams located in the drill mast supporting the carriage.

Down-hole under-reaming can be used to create larger sockets than the standard “fixed” drill bit diameter and sockets can be drilled from vertical to 18° (1:3 rake)

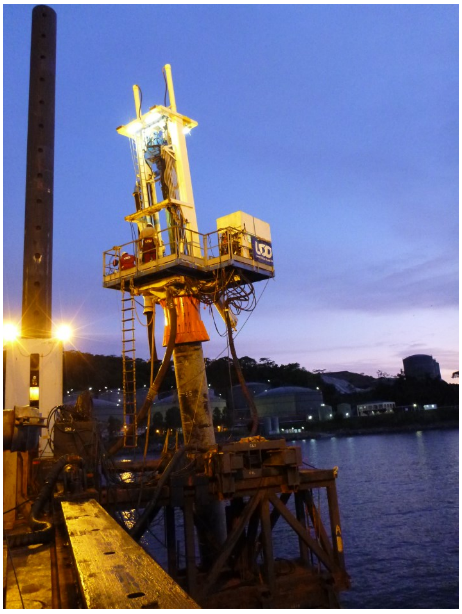
Main applications

- Pier and jetty construction
- Civil engineering projects
- LNG terminals
- Jacket Installations for the Oil and Gas industry
- Drive Drill Drive
- Riser shafts
- Relief Drive/Drill/Drive

Specification for LD408

Max inclination	18 degrees 1 in 3 rake
Weight including rigging and gripper	19t
Drill pipe	NW200 3m lengths
Dimensions	L 5,240 x W 5,120 x H 8,500
Hydraulic power pack rating	176kW
Power pack weight	5.2t

The drill can be mobilised anywhere in the world as it can be broken down into component form, loaded into sea freight containers and reassembled on arrival. Typical assembly and re-commissioning takes **2-3 days**.

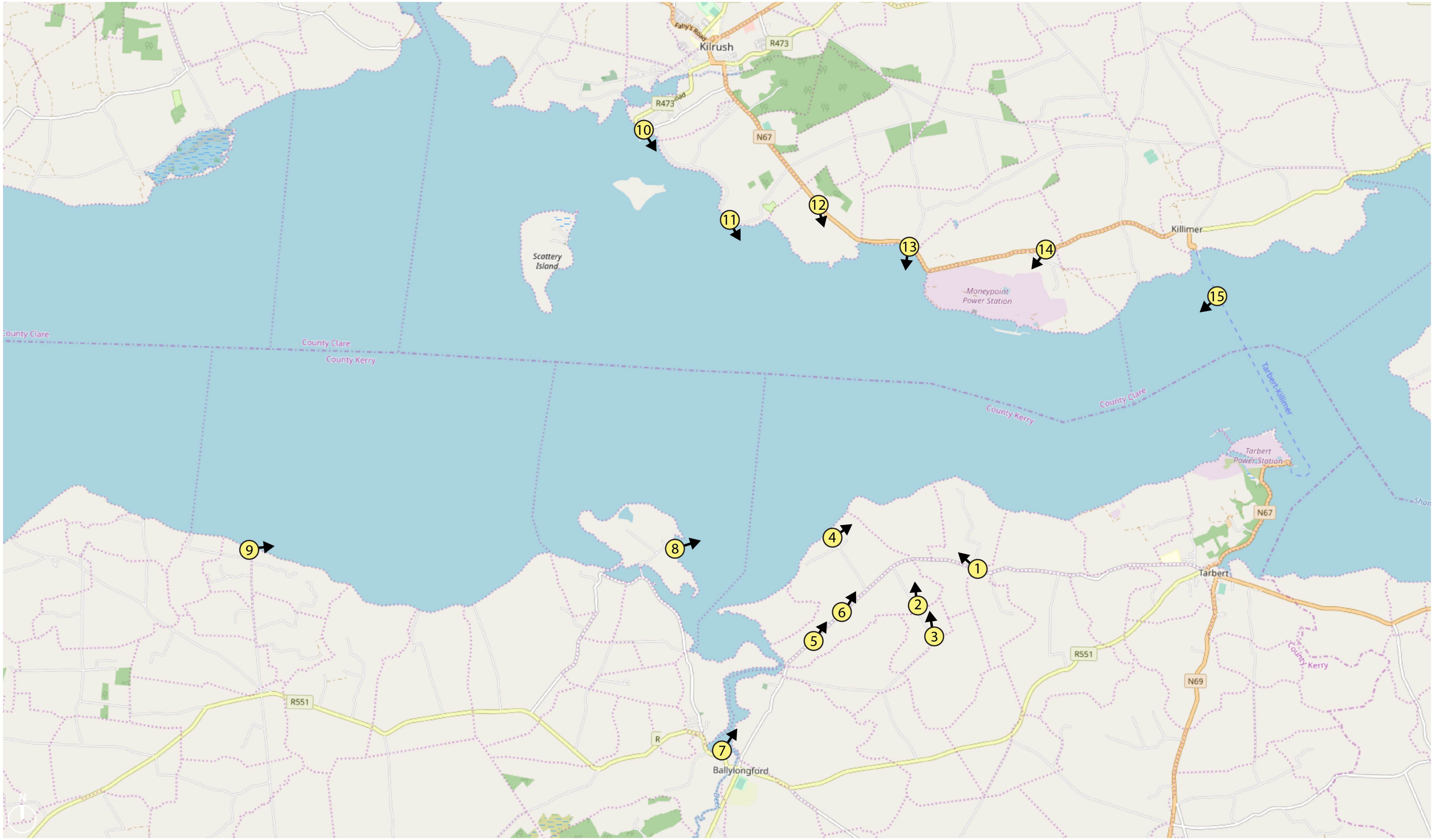


Appendix 9

Photomontages

SHANNON LNG - PROPOSED PHOTOMONTAGE VIEWPOINTS

AECOM Imagine it. Delivered.



Viewpoint locations proposed for photomontages

Shannon LNG – Proposed Viewpoints for Photomontages

Viewpoint	Location	Visual Designation	Reason for selection
1	View North West from L1010 in the townland area of Carhoonakilla	None	View of development from local road in close proximity to the development.
2	View North from L1010, in the townland area of Kilcolgan Upper	None	View of development from public road in close proximity to residential receptors.
3	View North from L1010, in the townland area of Glencullare	None	View of development from public road in close proximity to residential receptors.
4	View North West, in the townland area of Kilcolgan Lower, Ballylongford Bay	None	Open view from nearest road to the proposed development.
5	View North West, from L1010 near Saleen Pier	None	View from Ballylongford towards proposed development.
6	View North West, from L1010, in the townland area of Saleen	None	View of development from local road in close proximity to residential receptors.
7	View North West on the R551, Bridge Street, Ballylongford	Part of the Wild Atlantic Way Route	View of development from public road.
8	View West from Hogan's Point, Carrig Island	None	Open view from Carrig Island adjacent to historic sites.
9	View West from Letter Point, Bunaclugga Bay	None	View from public beach towards proposed development
10	View South East from Cappagh Pier, Coast Road in the townland area of Cappagh	• Scenic Route as identified in Clare County Development Plan 2017-2023 • Part of the Wild Atlantic Way Route	View from designated scenic road towards proposed development
11	View South East from Aylevarroo Point	• Scenic Route as identified in Clare County Development Plan 2017-2023 • Part of the Wild Atlantic Way Route	View from designated scenic road towards proposed development
12	View South East from Moyne Court on N67	• Scenic Route as identified in Clare County Development Plan 2017-2023 • Part of the Wild Atlantic Way Route	Open view from high point near residential area towards proposed development. View from designated scenic road.
13	View South on N67 from Ballymacrinan Bay	• Scenic Route as identified in Clare County Development Plan 2017-2023 • Part of the Wild Atlantic Way Route	Open view towards proposed development from designated scenic road

Viewpoint	Location	Visual Designation	Reason for selection
14	View South West on N67 from Killimer	Part of the Wild Atlantic Way Route	View from high vantage point at the local Church of St. Imy across Moneypoint Powerstation towards proposed development
15	View South West from Killimer Ferry on the River Shannon.	(Part of the Wild Atlantic Way Route – Ferry)	View from Tarbert-Killimer Ferry

Notes

Visibility of the proposed development across the Shannon estuary from County Clare is generally open and extensive along roads near the coast, designated scenic coastal roads and the Wild Atlantic Way.

Visibility from locations within County Kerry will mainly capture sections of the proposed development due to undulating topography and intervening vegetation.

View 1. Existing.

View 1. Proposed.

View 2. Existing.

View 2. Proposed.

View 3. Existing.

View 3. Proposed.

View 4. Existing.

View 4. Proposed.

View 4. Proposed with second ship anchored at the proposed plant.

View 5. Existing.

View 5. Proposed development outlined in red.

View 6. Existing.

View 6. Proposed development outlined in red.

View 7. Existing.

View 7. Proposed.

View 8. Existing.

View 8. Proposed.

View 8. Proposed with second ship anchored at the proposed plant.

View 8. Existing. Focused angle at 33° horizontally.

View 8. Proposed. Focused angle at 33° horizontally.

View 8. Proposed with second ship anchored at the proposed plant. Focused angle at 33° horizontally.

View 9. Existing.

View 9. Proposed.

View 9. Proposed with second ship anchored at the proposed plant.

View 9. Existing. Focused angle at 33° horizontally.

View 9. Proposed. Focused angle at 33° horizontally.

View 9. Proposed with second ship anchored at the proposed plant. Focused angle at 33° horizontally.

View 10. Existing.

View 10. Proposed.

View 10. Proposed with second ship anchored at the proposed plant.

View 11. Existing.

View 11. Proposed.

View 11. Proposed with second ship anchored at the proposed plant.

View 12. Existing.

View 12. Proposed.

View 12. Proposed with second ship anchored at the proposed plant.

View 13. Existing.

View 13. Proposed.

View 13. Proposed with second ship anchored at the proposed plant.

View 14. Existing

View 14. Proposed.

View 14. Proposed with second ship anchored at the proposed plant.

View 15. Existing

View 15. Proposed.

View 15. Proposed with second ship anchored at the proposed plant.

View 15. Existing. Focused angle at 33° horizontally.

View 15. Proposed. Focused angle at 33° horizontally.

View 15. Proposed with second ship anchored at the proposed plant. Focused angle at 33° horizontally.

View 8. Existing

View 8. Proposed. Lights off


View 8. Proposed. Lights on

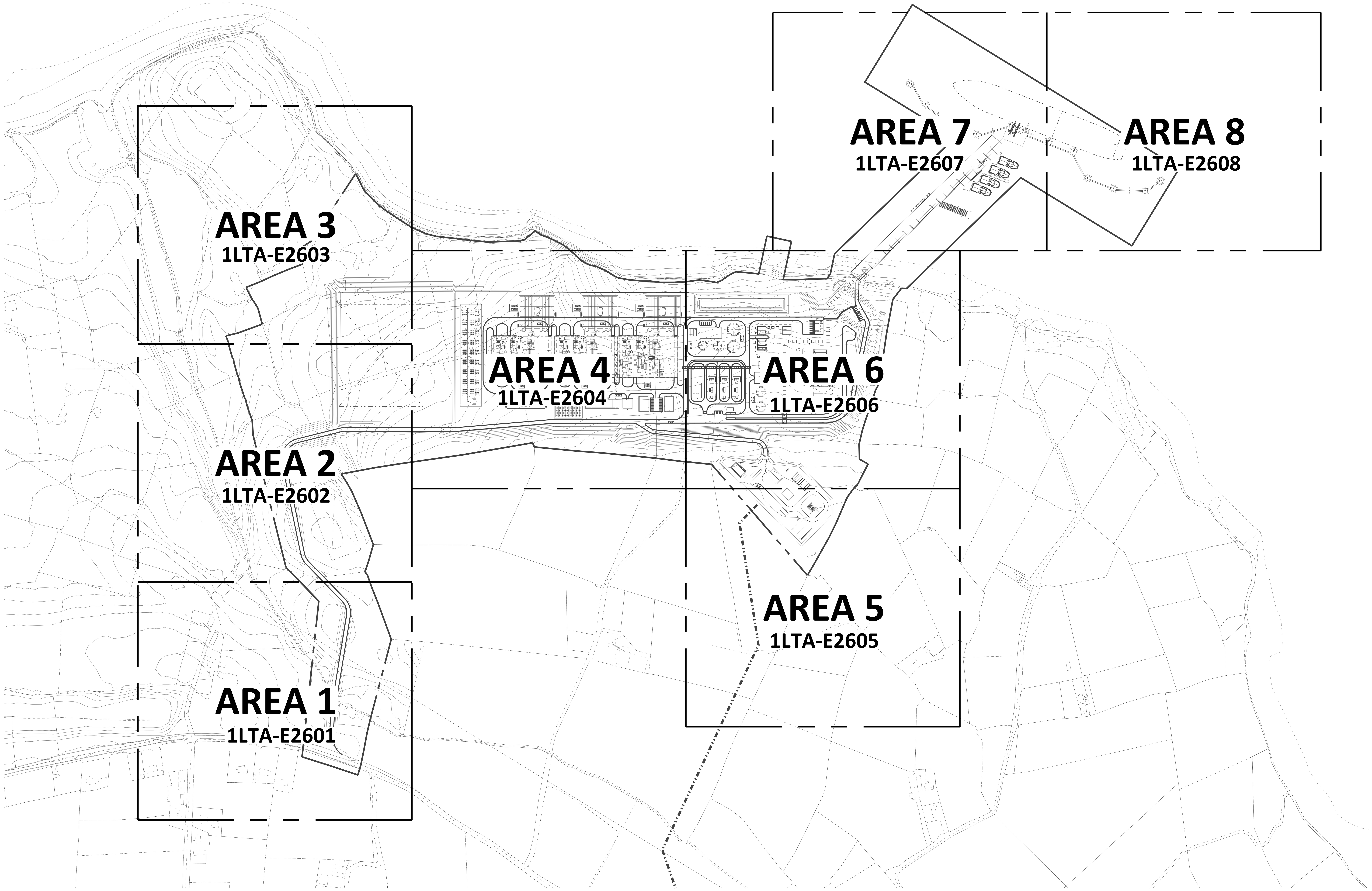
View 12. Existing


View 12. Proposed. Lights off


View 12. Proposed. Lights on

Appendix 10

Lighting Drawings



NOTES

1. OVERALL AREA LIGHTING ARRANGEMENT IS A CONCEPTUAL LAYOUT FOR PLANNING PURPOSES ONLY.
2. THESE DRAWINGS ARE BASE ON THE OVERALLL PLOT PLAN, SEE DRAWING 1GSU-G1002.
3. ALL DIMENSIONS PROVIDED ARE IN METERS UNLESS NOTED OTHERWISE.
4. FOR PROCESS AREAS TYPICAL LIGHTING FIXTURES GENEALLY USED ARE SHOWN. ACTUAL FIXTURE TYPES, QUANTITIES AND LOCATIONS SHALL BE DEFINED IN FUTURE ENGINEERING PHASES.
5. TEMPORARY FLOOD LIGHITNG FOR CONTRUCTION LAY DOWN AND PARKING AREAS SHALL BE DEFINED DURING FUTURE ENGINEERING PHASES.

LEGEND

BLA	26 WATT, 2688 LUMEN, ENCLOSED AND GASKETED INDUSTRIAL LED BRACKET MOUNTED FIXTURE, TYPE I CUT OFF OPTICS, MARINE RATED
BLH	200 WATT, 23,500 LUMEN, ENCLOSED AND GASKETED INDUSTRIAL LED BRACKET MOUNTED FIXTURE, TYPE III CUT OFF OPTICS, MARINE RATED
FVA	26 WATT, 2688 LUMEN, ENCLOSED AND GASKETED INDUSTRIAL LED STANCHION MOUNTED FIXTURE, TYPE I CUT OFF OPTICS, MARINE RATED
FVB	60 WATT, 6,100 LUMEN, ENCLOSED AND GASKETED INDUSTRIAL LED STANCHION MOUNTED FIXTURE, TYPE III CUT OFF TYPE OPTICS, MARINE RATED
FLA	532 WATT, 55,200 LUMEN, ENCLOSED AND GASKETED, LED FLOOD FIXTURE, MARINE RATED
SLA	50 WATT, 7,000 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE II CUT OFF OPTICS, MARINE RATED
SLB	70 WATT, 10,500 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE III CUT OFF OPTICS, MARINE RATED
SLC	210 WATT, 27,200 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE II CUT OFF OPTICS, MARINE RATED
SLD	295 WATT, 35,100 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE V CUT OFF OPTICS, MARINE RATED

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0	15/MAR/2021	ISSUED FOR PLANNING	BMD	BMD		DAC	

BLACK & VEATCH CORP HEADQUARTERS:
11401 LAMAR AVENUE, OVERLAND PARK, KANSAS, USA

BLACK & VEATCH

DESIGNER BMD | DRAWN BMD
CHECKED | DATE

SHANNON LNG LIMITED
SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

KEY PLAN, GENERAL NOTES AND LEGEND
SITE LIGHTING

PROJECT / DRAWING NUMBER: 198291-1LTA-E2600
REV: 1
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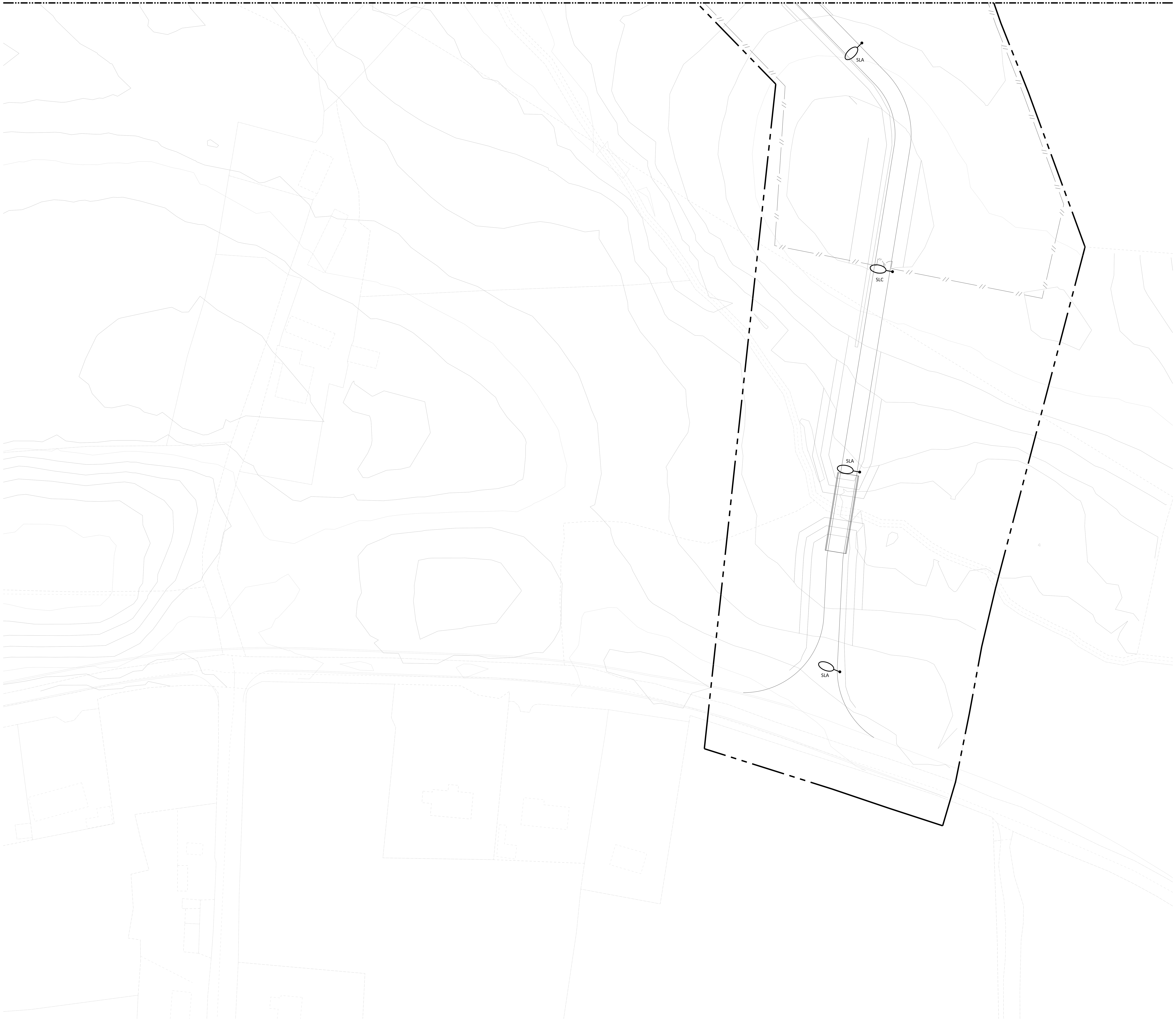

NOTES

1. FOR GENERAL NOTES AND SYMBOL LEGEND SEE DRAWING 1LTA-E2600.

FIXTURE LIST

SYMBOL	DESCRIPTION	COUNT
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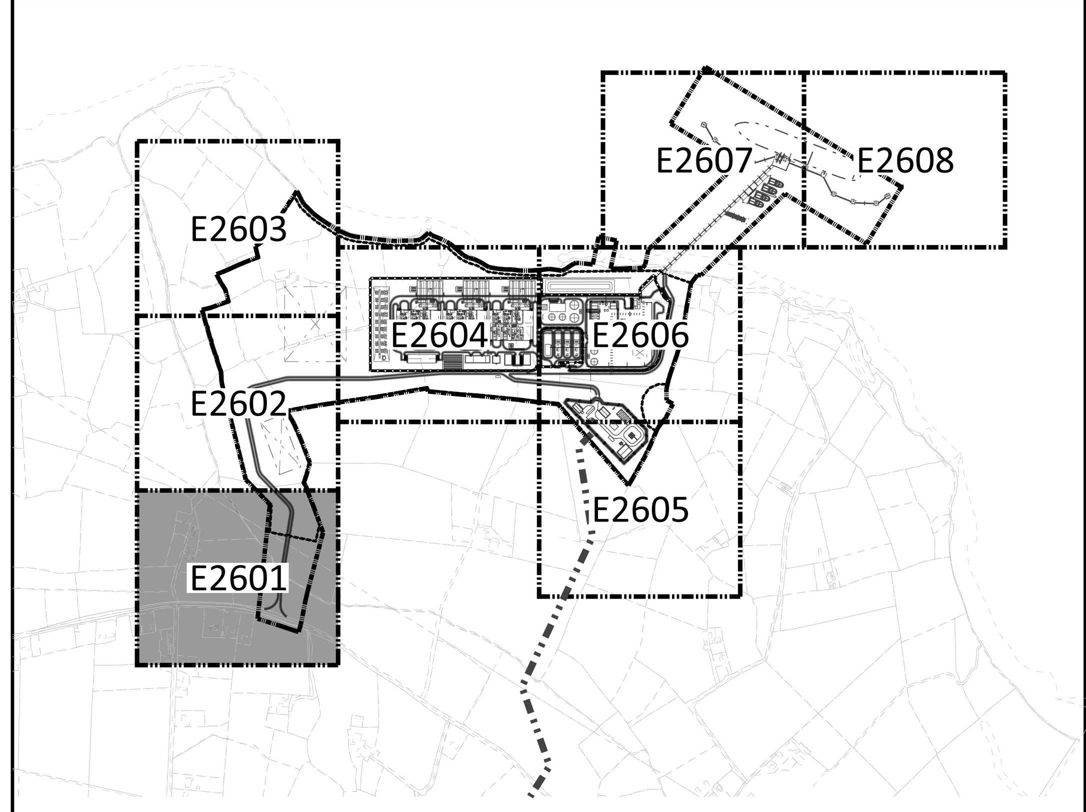
SLC	27,200 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE II OPTICS	1

KEY PLAN



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SCALE IN METERS

BLACK & VEATCH CORP HEADQUARTERS:
11401 LAMAR AVENUE, OVERLAND PARK,
KANSAS, USA

BLACK & VEATCH

DESIGNER BMD
DRAWN BMD
CHECKED
DATE

SHANNON LNG LIMITED
SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

LIGHTING - SITE
PLAN - AREA 1

PROJECT DRAWING NUMBER
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REV
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CODE

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MATCHLINE - FOR CONTINUATION SEE E2601

NOTES

1. FOR GENERAL NOTES AND SYMBOL LEGEND SEE DRAWING 1LTA-E2600.

FIXTURE LIST

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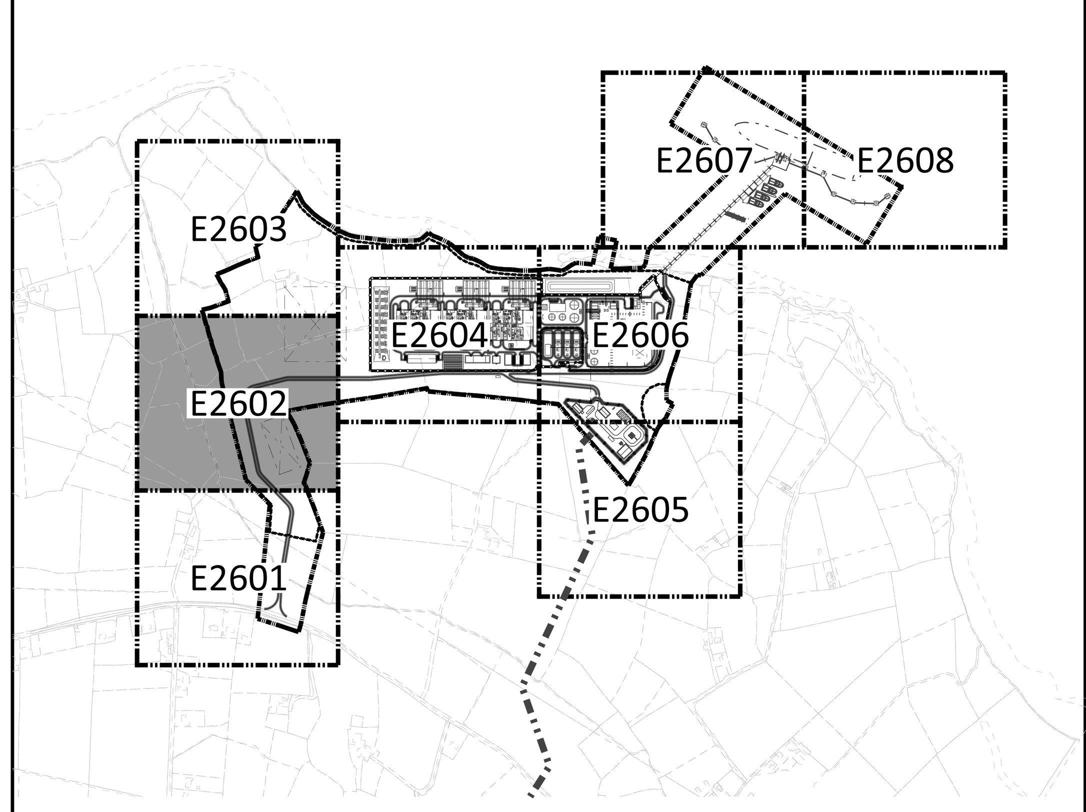
KEY PLAN



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SCALE IN METERS

BLACK & VEATCH CORP HEADQUARTERS:
11401 LAMAR AVENUE, OVERLAND PARK,
KANSAS, USA

BLACK & VEATCH

DESIGNER BMD | DRAWN BMD
CHECKED | DATE

SHANNON LNG LIMITED
SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

LIGHTING - SITE
PLAN - AREA 2

PROJECT / DRAWING NUMBER: 198291-1LTA-E2602 | REV: 1

CODE

AREA

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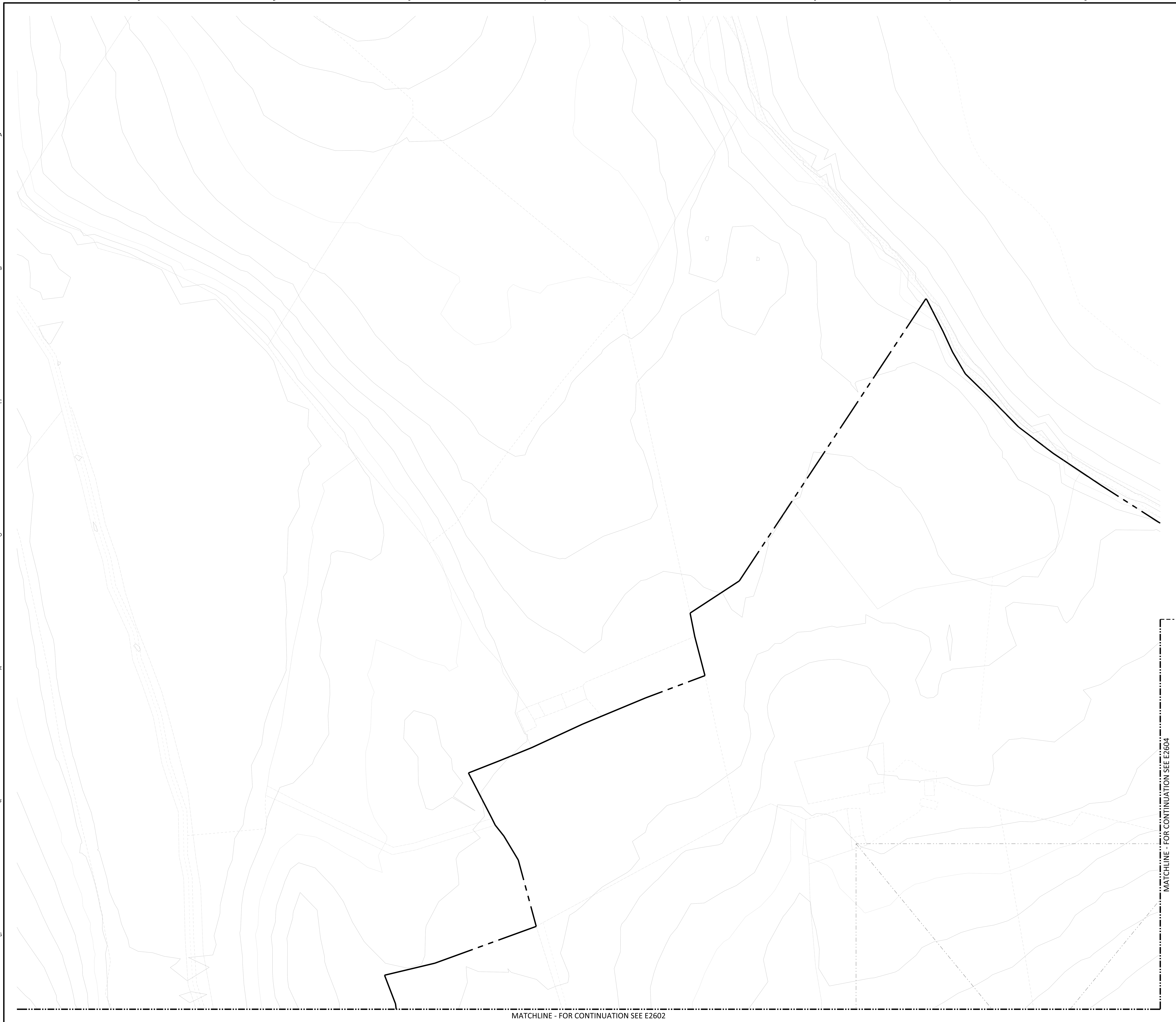
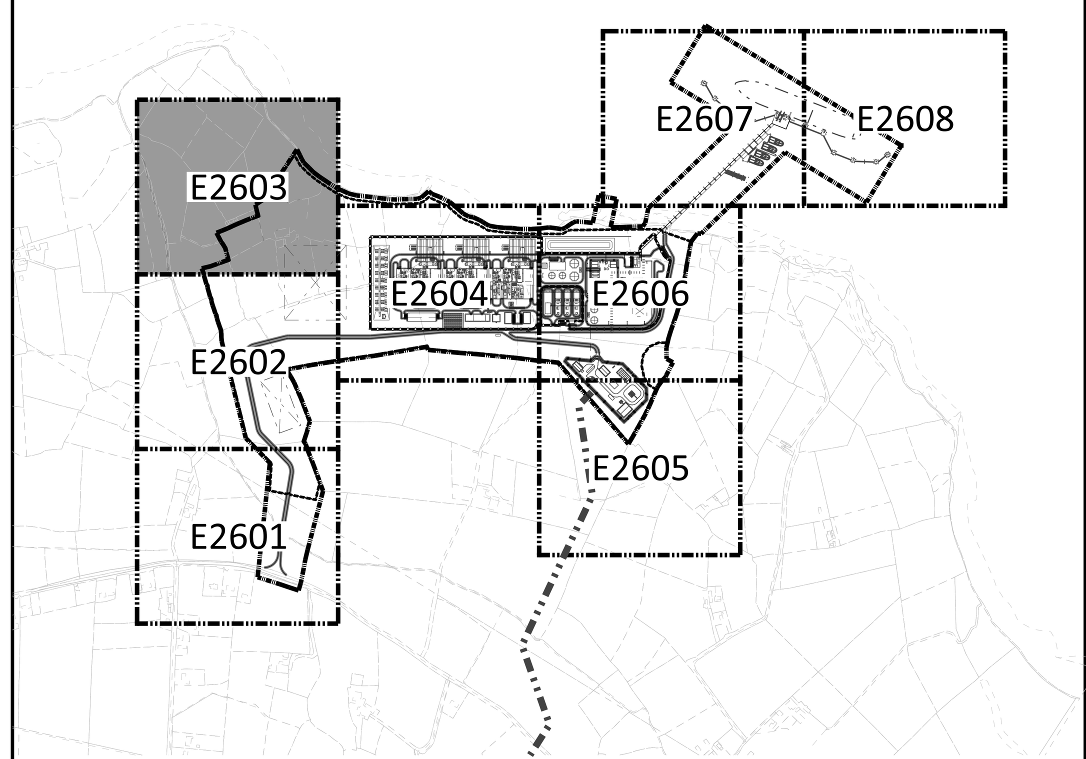


NOTES

1. FOR GENERAL NOTES AND SYMBOL LEGEND SEE DRAWING 1LTA-E2600.

KEY PLAN



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KANSAS, USA

BLACK & VEATCH

DESIGNER BMD | DRAWN BMD
CHECKED | DATE

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SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

LIGHTING - SITE
PLAN - AREA 3

PROJECT DRAWING NUMBER: 198291-1LTA-E2603
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CODE
AREA

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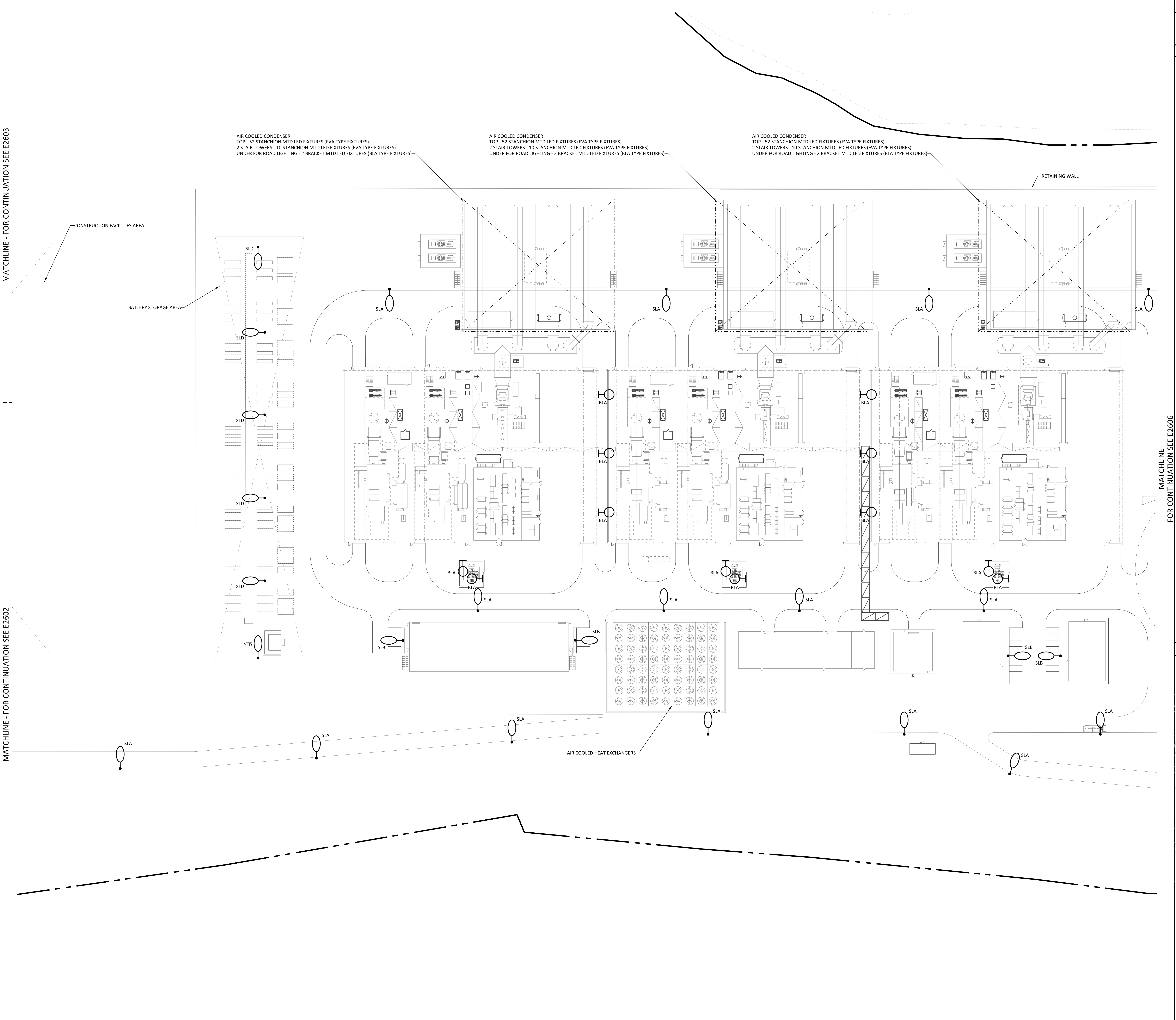

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1. FOR GENERAL NOTES AND SYMBOL LEGEND SEE DRAWING 1LTA-E2600.

FIXTURE LIST

SYMBOL	DESCRIPTION	COUNT
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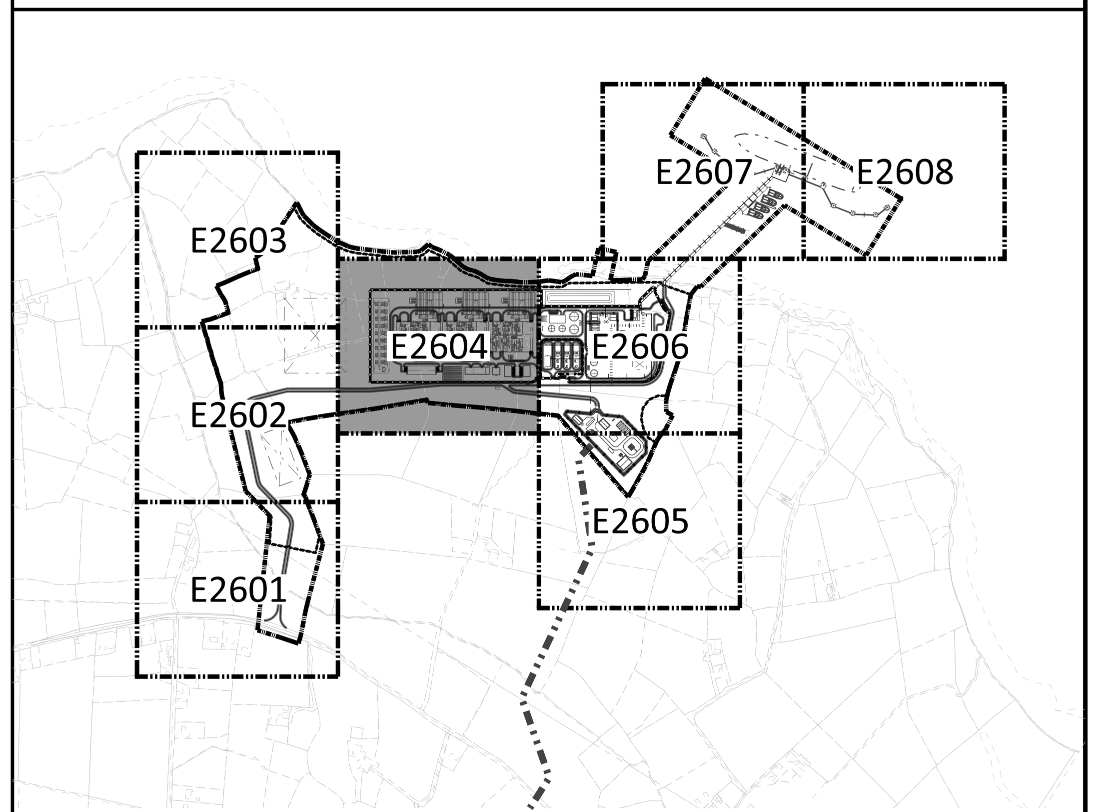
FVA	2688 LUMEN, LED STANCHION MOUNTED FIXTURE, TYPE I OPTICS	156
SLA	7,000 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE II OPTICS	15
SLB	10,500 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE III OPTICS	4
SLD	35,100 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE V OPTICS	6

KEY PLAN



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NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
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0	15/MAR/2021	ISSUED FOR PLANNING	BMD	BMD		DAC	

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BLACK & VEATCH CORP HEADQUARTERS:
11401 LAMAR AVENUE, OVERLAND PARK,
KANSAS, USA

BLACK & VEATCH

DESIGNER BMD | DRAWN BMD | CHECKED | DATE

SHANNON LNG LIMITED
SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

LIGHTING - SITE
PLAN - AREA 4

PROJECT / DRAWING NUMBER: 198291-1LTA-E2604 | REV: 1

CODE | AREA

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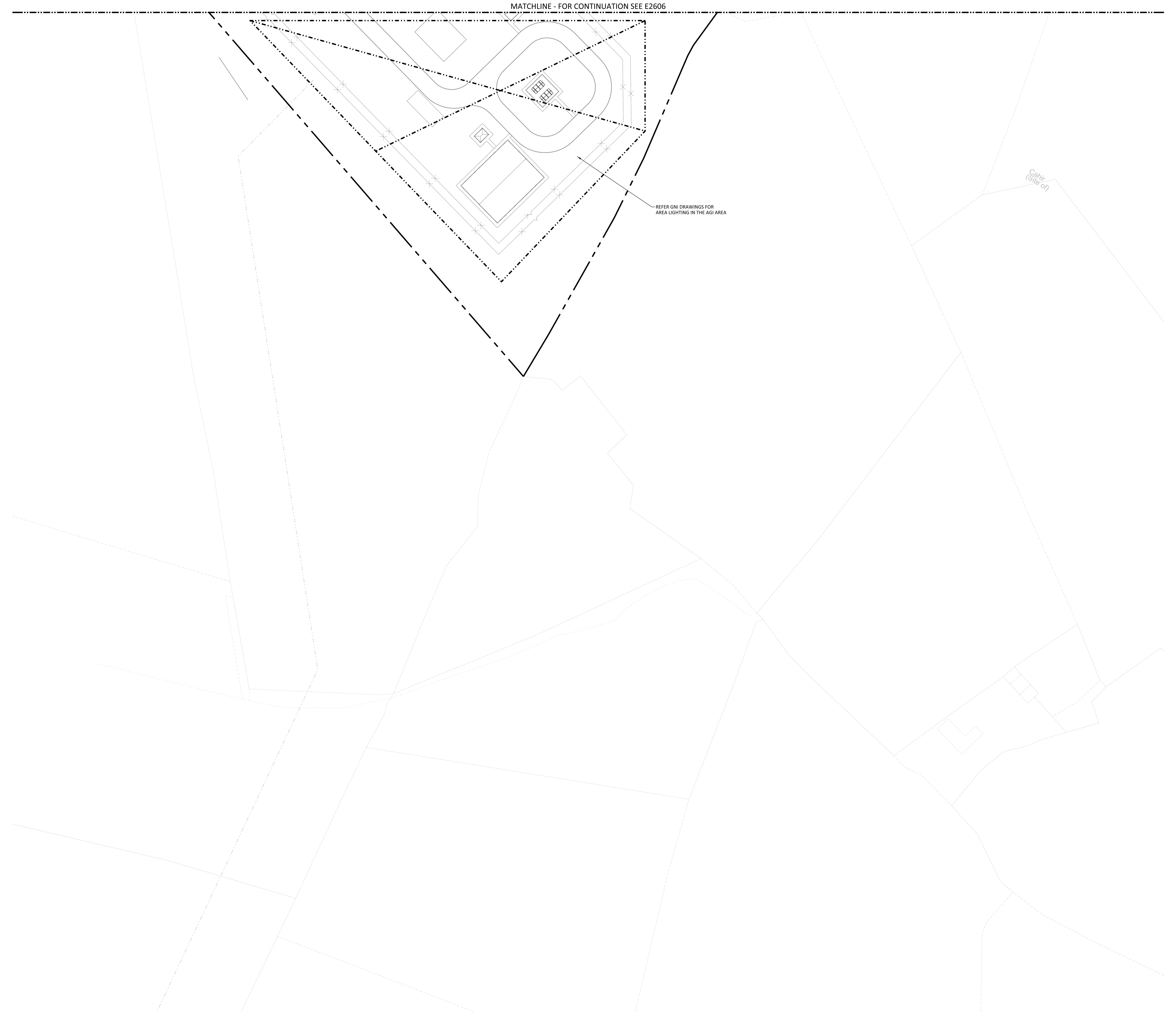

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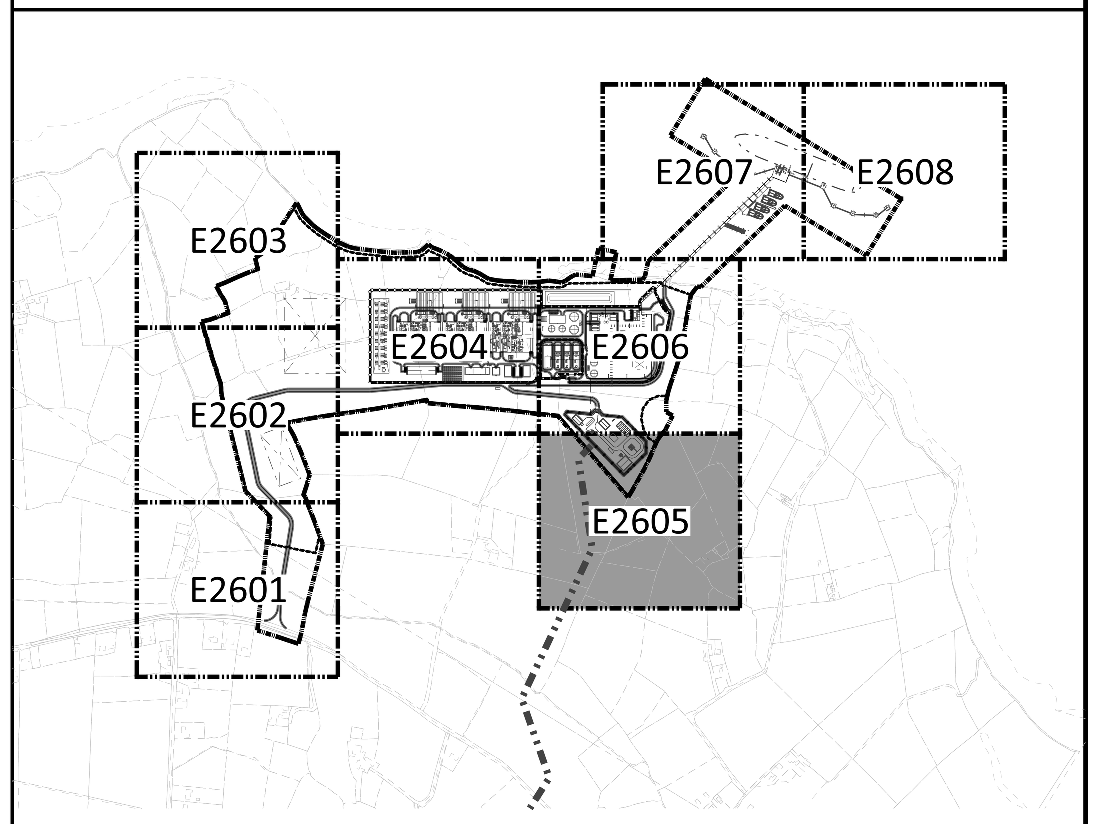

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SCALE IN METERS

BLACK & VEATCH CORP HEADQUARTERS:
11401 LAMAR AVENUE, OVERLAND PARK, KANSAS, USA

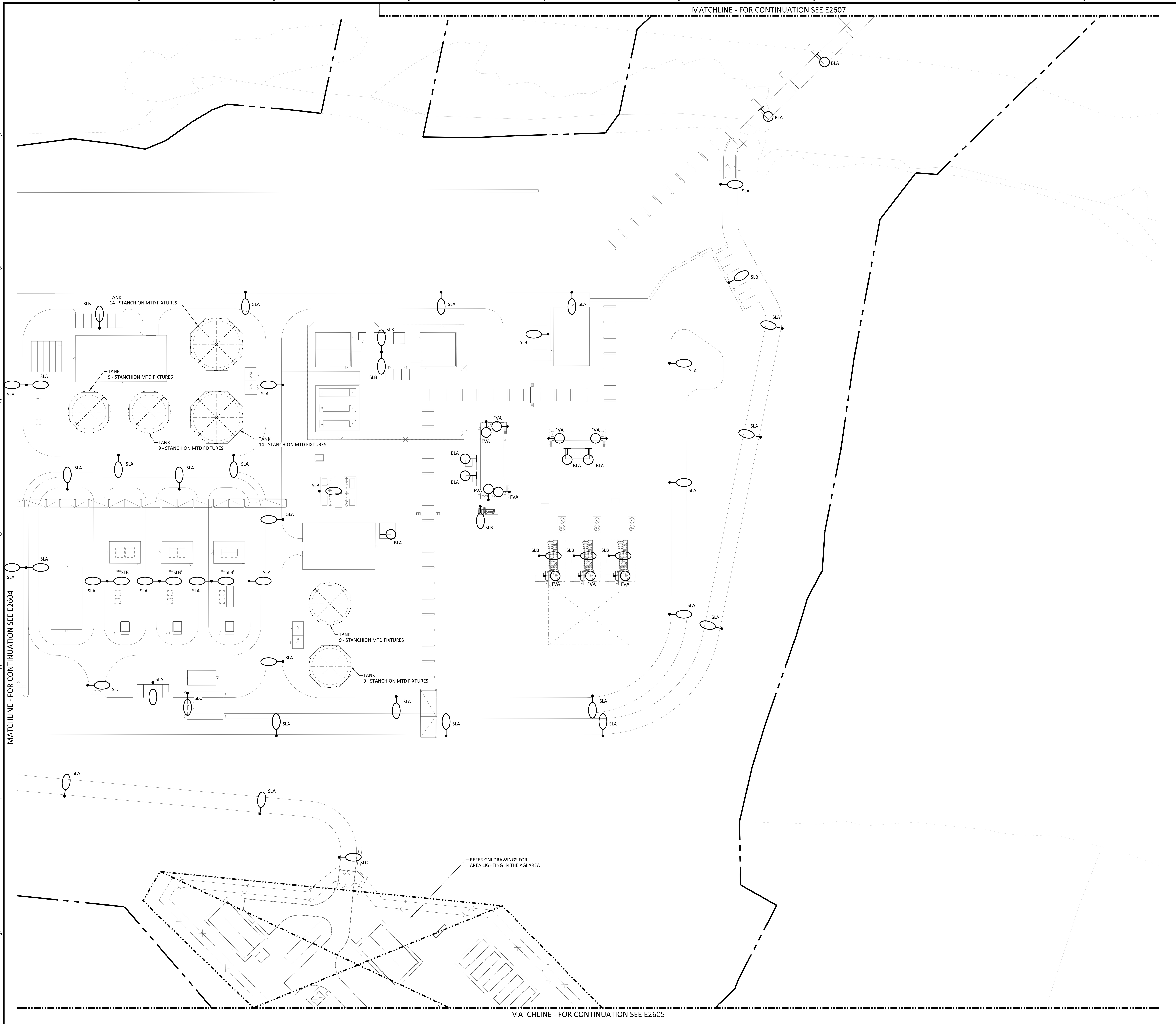
BLACK & VEATCH

DESIGNER BMD
DRAWN BMD
CHECKED
DATE

SHANNON LNG LIMITED
SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

LIGHTING - SITE
PLAN - AREA 5

PROJECT / DRAWING NUMBER: 198291-1LTA-E2605
REV: 1
CODE
AREA



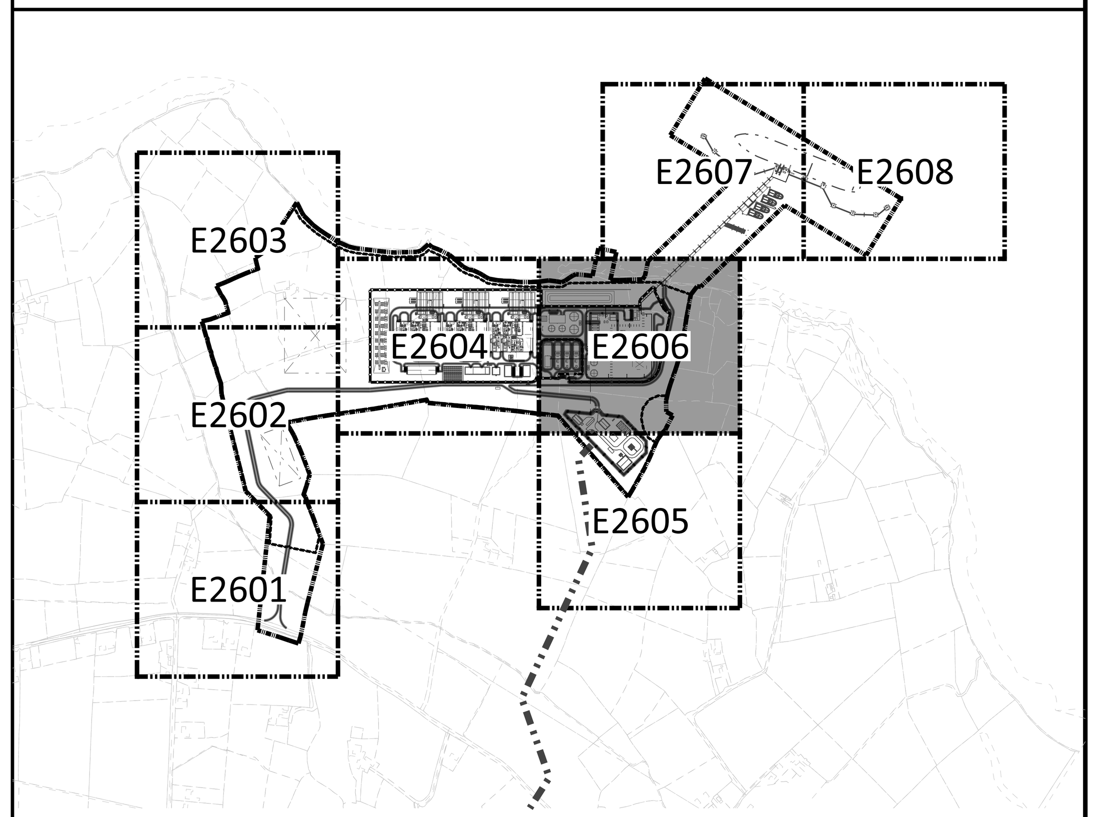
NOTES

1. FOR GENERAL NOTES AND SYMBOL LEGEND SEE DRAWING 1LTA-E2600.

FIXTURE LIST

SYMBOL	DESCRIPTION	COUNT
BLA	2,688 LUMEN, LED BRACKET MOUNTED FIXTURE, TYPE I OPTICS	7
FVA	2,688 LUMEN, LED STANCHION MOUNTED FIXTURE, TYPE I OPTICS	73
SLA	7,000 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE II OPTICS	33
SLB	10,500 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE III OPTICS	13
SLC	27,200 LUMEN, LED ROADWAY LIGHT FIXTURE, TYPE II OPTICS	3

KEY PLAN



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SCALE IN METERS

BLACK & VEATCH CORP HEADQUARTERS:
11401 LAMAR AVENUE, OVERLAND PARK,
KANSAS, USA

BLACK & VEATCH

DESIGNER BMD
DRAWN BMD
CHECKED
DATE

SHANNON LNG LIMITED
SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

LIGHTING - SITE
PLAN - AREA 6

PROJECT / DRAWING NUMBER: 198291-1LTA-E2606
REV: 1
CODE
AREA

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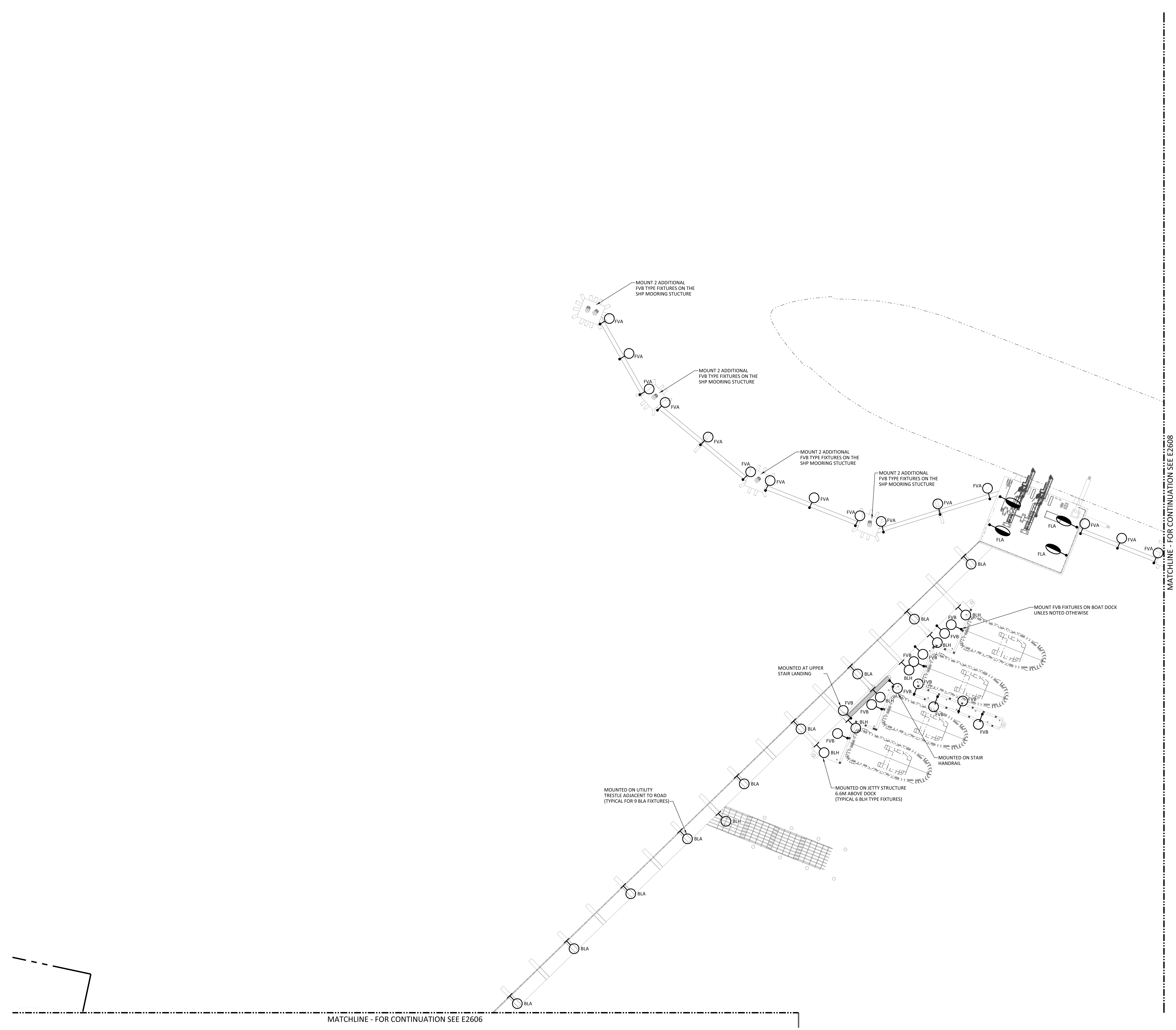


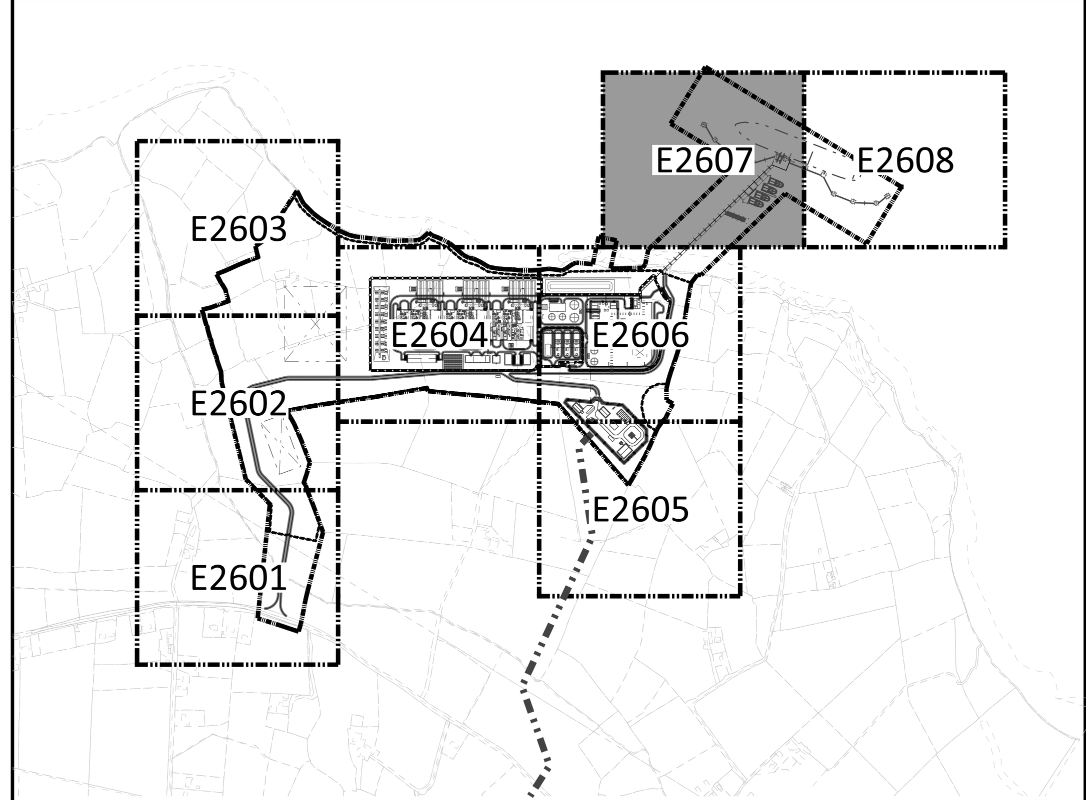
NOTES

1. FOR GENERAL NOTES AND SYMBOL LEGEND SEE DRAWING 1LTA-E2600.

FIXTURE LIST

SYMBOL	DESCRIPTION	COUNT
BLA	2,688 LUMEN, LED BRACKET MOUNTED FIXTURE, TYPE I OPTICS	9
BLH	23,500 LUMEN, LED BRACKET MOUNTED FIXTURE, TYPE III OPTICS	7
FVA	2,688 LUMEN, LED STANCHION MOUNTED FIXTURE, TYPE I OPTICS	15
FVB	6,100 LUMEN, LED STANCHION MOUNTED FIXTURE, TYPE III OPTICS	19
FLA	55,200 LUMEN, LED FLOOD FIXTURE	4

KEY PLAN



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SCALE IN METERS

BLACK & VEATCH CORP HEADQUARTERS:
11401 LAMAR AVENUE, OVERLAND PARK, KANSAS, USA

BLACK & VEATCH

DESIGNER BMD | DRAWN BMD | CHECKED | DATE

SHANNON LNG LIMITED
SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

LIGHTING - SITE
PLAN - AREA 7

PROJECT / DRAWING NUMBER: 198291-1LTA-E2607
REV: 1
CODE
AREA

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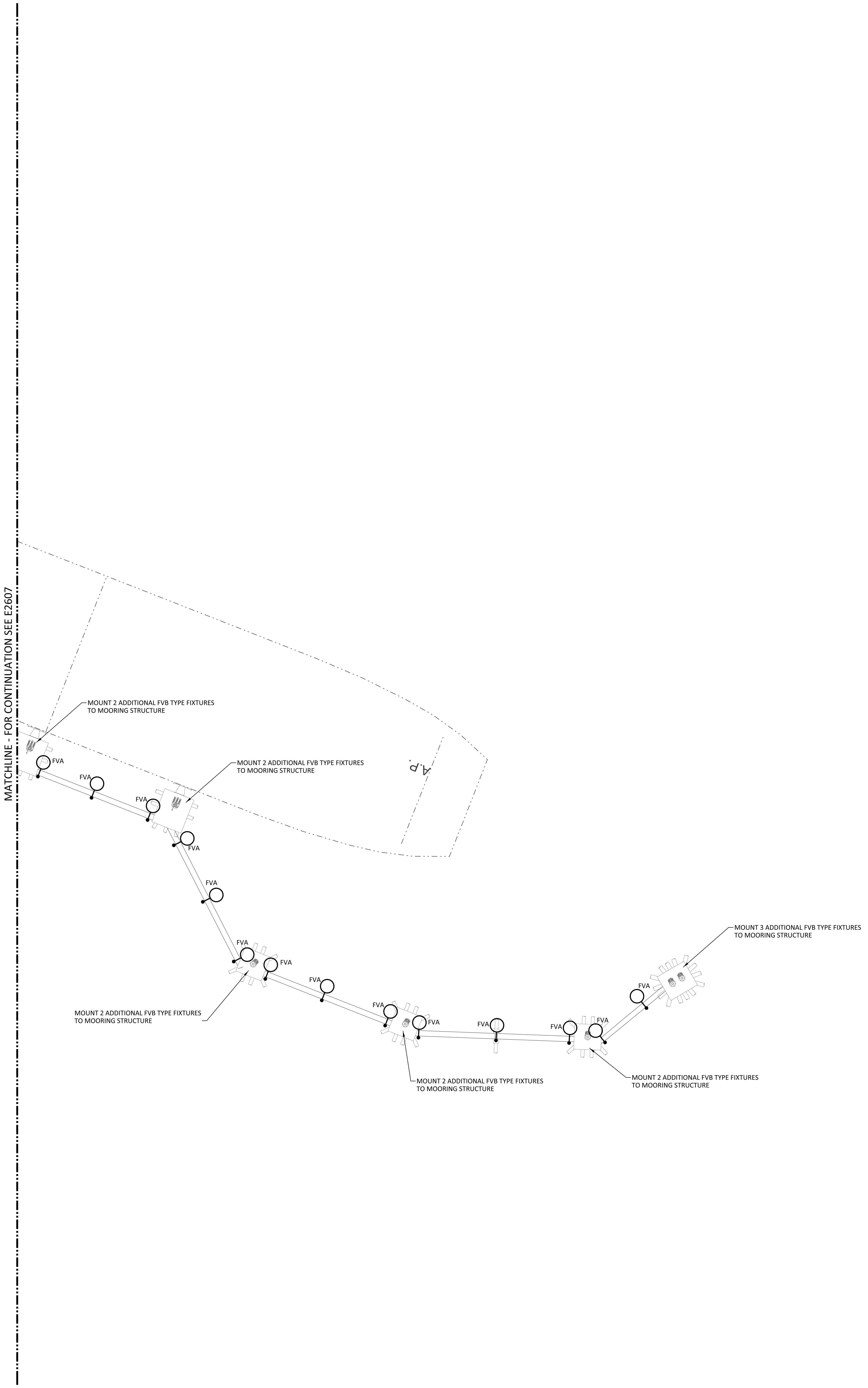


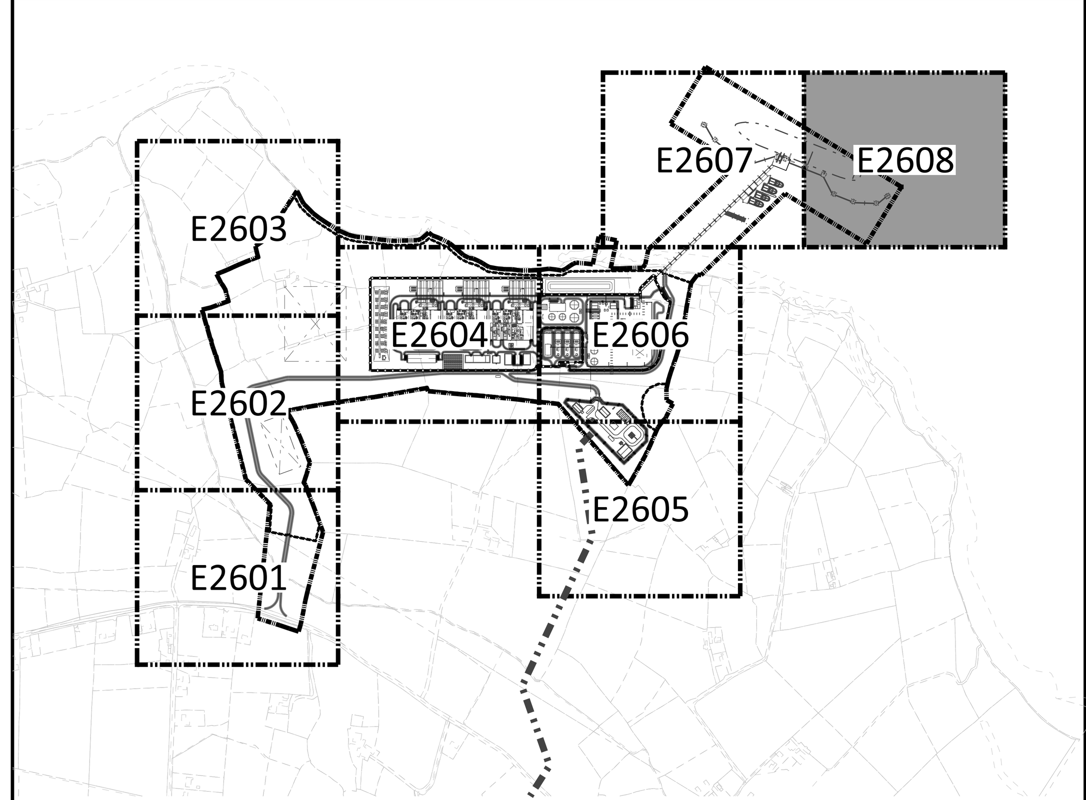
NOTES

1. FOR GENERAL NOTES AND SYMBOL LEGEND SEE DRAWING 1LTA-E2600.

FIXTURE LIST

SYMBOL	DESCRIPTION	COUNT
FVA	2688 LUMEN, LED STANCHION MOUNTED FIXTURE, TYPE I OPTICS	FVA
FVB	6,100 LUMEN, LED STANCHION MOUNTED FIXTURE, TYPE III OPTICS	13

KEY PLAN



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NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
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SCALE IN METERS

BLACK & VEATCH CORP HEADQUARTERS:
11401 LAMAR AVENUE, OVERLAND PARK, KANSAS, USA

BLACK & VEATCH

DESIGNER BMD
DRAWN BMD
CHECKED
DATE

SHANNON LNG LIMITED
SHANNON TECHNOLOGY AND ENERGY PARK (STEP)

LIGHTING - SITE
PLAN - AREA 8

PROJECT
DRAWING NUMBER 198291-1LTA-E2608
REV 1
CODE
AREA

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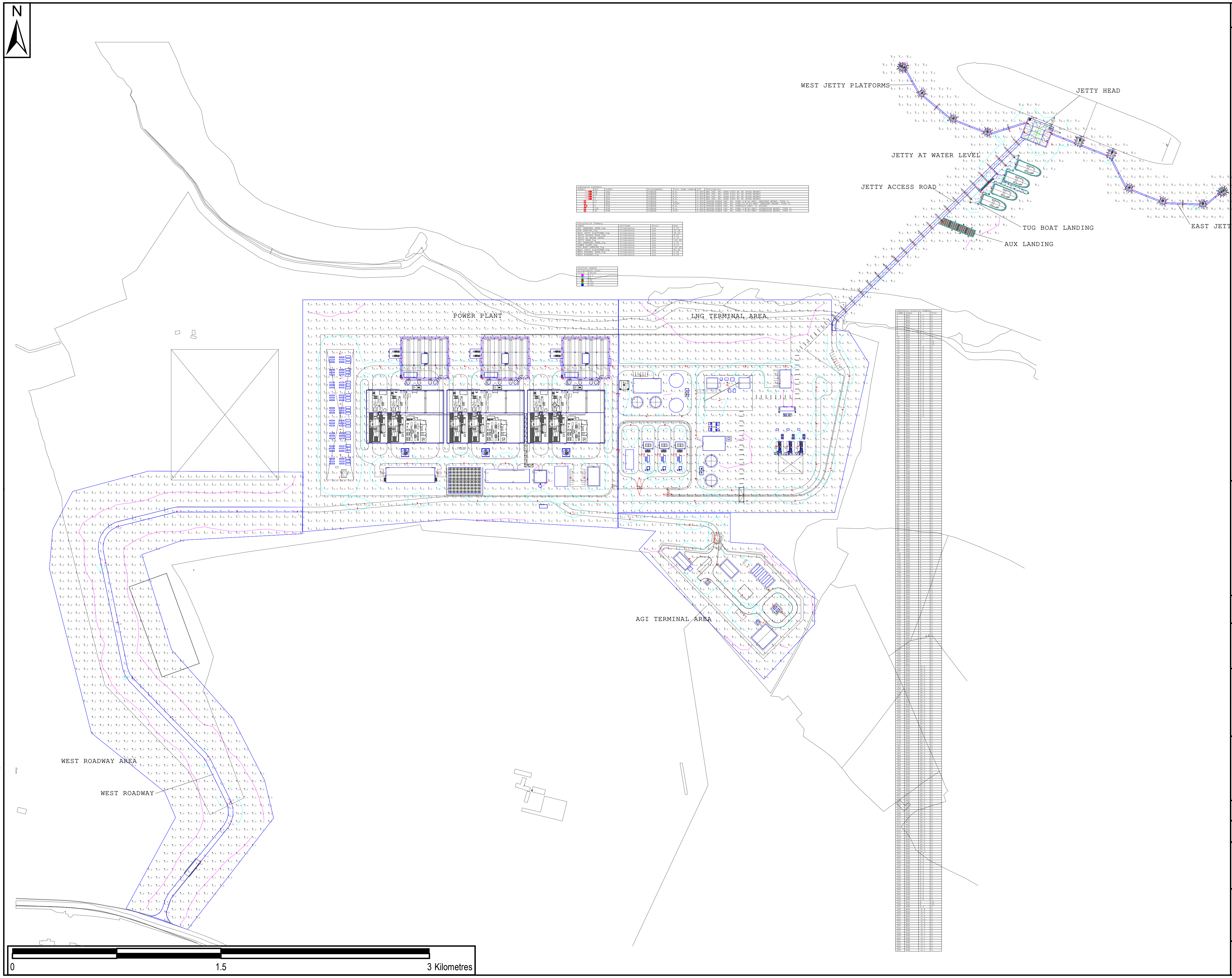

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Purpose of Issue: FINAL

Client: CONFIDENTIAL

Project Title: SHANNON TECHNOLOGY AND ENERGY PARK

Drawing Title: FIGURE F2-7 LIGHTING DESIGN

Drawn:	Chk'd:	App'd:	Date:
XX	XX	XX	XX/XX/XXXX

AECOM Internal Project No:

Scale at A3:

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Drawing No: **FIGURE F2-7**

Rev: **0**