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CHAPTER 05
Land and Soils

Shannon LNG Limited
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Shannon Technology and Energy Park
Environmental Impact Assessment Report

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5. Land & Soils

5.1 Introduction

This chapter of the EIAR assesses and evaluates the potentially significant effects on the land, soils and geology of the Proposed Development site and surrounding area from the Proposed Development.

Hydrogeology-related impacts are assessed under Chapter 06 – Water.

In order to assess baseline conditions, a desk-based review of publicly available information and previous site investigation data pertaining to the Proposed Development site was carried out. In assessing potential significant impacts associated with construction and operational phases of the Proposed Development on land, soils and geology, AECOM has considered both the importance of the attributes and the predicted scale and duration of likely impacts.

5.2 Competent Expert

This assessment has been undertaken by Kevin Forde, Associate Hydrogeologist in the AECOM Ground, Energy and Transaction Services team and has more than 28 years' post-graduate experience. He graduated with an honour's degree in Geology (1991) and has since earned a post graduate diploma in Computing (UCC, 1992) and a Masters in Hydrogeology (UCL, 1993). He has extensive experience of ground contamination assessment and remediation for both public and private sector clients involving environmental due diligence, pre-construction site investigation, EIAR, contaminated land remediation and construction phase soil waste management.

5.3 Legislation and Policy

This chapter has been prepared with reference to the following:

- European Union Water Framework Directive (WFD) (2000/60/EC). The following legislation in Ireland governs the shape of the WFD characterisation, monitoring and status assessment programmes in terms of monitoring different water categories, determining the quality elements and undertaking characterisation and classification assessments:
  - European Communities (Water Policy) Regulations, 2003 (S.I. No. 722 of 2003);
  - European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. No. 9 of 2010).
- European Communities Environmental Objectives (Groundwater) (Amendment) Regulations, 2016 (S.I. No. 366 of 2016);
- 'Guidelines for Preparation of Soils, Geology, Hydrogeology Chapters of Environmental Impact Statements' (Institute of Geologists Ireland (IGI), 2013);
- European Communities, Environmental Impact Assessment of Projects – Guidance on the preparation of the Environmental Impact Assessment Report' (EC, 2017); and
- European Communities, Environmental Impact Assessment of Projects – Guidance on Scoping (Directive 2011/92/EU as amended by 2014/52/EU) (EC, 2017).

5.4 Methodology

This assessment meets the requirements for an EIAR as outlined in the relevant National and EU legislation (EU, 2014, Stationery Office, 2018). This chapter has been prepared in accordance with the following documents:

- Environmental Protection Agency (EPA) Draft guidance document 'Guidelines on the Information to be Contained in Environmental Impact Assessment Reports', (EPA, 2017);
- European Commission guidance document 'Environmental Impact Assessment of Projects;
- Guidance on the preparation of the Environmental Impact Assessment Report' (European Commission, 2017);
- EPA 'Guidelines on the information to be contained in Environmental Impact Statements', 2002;

- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements, (EPA, 2003); and
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment, Government of Ireland, 2018;
- The Institute of Geologists of Ireland guidance document 'Guidelines for Preparation of Soils, Geology, Hydrogeology Chapters of Environmental Impact Statements (IGI, 2013).

5.4.1 Study Area

The study area with regard to land and soils encompasses the entire area within the boundary of the Proposed Development site.

5.4.2 Determination of the Baseline Environment

The baseline land and soils environment has been determined from desktop review and a site walkover survey.

The following is a list of sources of information consulted for use in this chapter:

- Geohive website[1] for historical Ordnance Survey of Ireland (OSI) maps of 1:2,500 scale and 1:10,560 scale (1837 to 1913) and aerial photographs (1995, 2000, 2005, 2013 and 2018);
- Geological Survey of Ireland (GSI) website[2] for Public Viewer Geoheritage, Geotechnical, Geochemistry, Geohazards Natural Resources (Minerals/ Aggregates) and Groundwater mapping;
- EPA website[3] for groundwater information;
- Environmental Sensitivity Mapping (ESM) website for soil and water data[4];
- Previous site investigation reports (ARUP, 2007; Halcrow, 2007);
- Local authority web portals; and
- Topography survey map (AECOM, March 2020).

5.4.3 Determination of Sensitive Receptors

The sensitivity of the existing environment identifies the ability of the receptor to respond to potential effects. Receptors have been identified during the baseline study and a qualitative assessment has been used to assign a sensitivity rating from low to extremely high based on the TII's 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes' (TII, 2009). Assigning a sensitivity rating (Table 5-1) considers an attribute's likely adaptability, tolerance and recoverability, as well as their designation.

With regards to natural resource use, the materials themselves have been identified as the sensitive receptors. Consuming materials impacts upon their immediate and (in the case of primary materials) long-term availability; this results in the depletion of natural resources and adversely impacts the environment.

Table 5-1 Estimation of Importance of Geological Attributes

Importance	Criteria	Typical Examples
Extremely High	Attribute has a high quality or value on an international scale	
Very High	Attribute has a high quality or value on a regional or national scale	**Soil and Geology:** Geological feature rare on a regional or national scale (Natural Heritage Area, NHA) or of high value on a local scale (County Geological Site)

[1] http://map.geohive.ie
[2] http://www.gsi.ie
[3] http://gis.epa.ie/EPAMaps/
[4] https://airomaps.geohive.ie/ESM/

Importance	Criteria	Typical Examples
	Degree or extent of soil contamination is significant on a national or regional scale Volume of peat and/ or soft organic soil underlying route is significant on a national or regional scale*	Large existing quarry or pit Proven economically extractable mineral resource
High	Attribute has a high quality or value on a local scale Degree or extent of soil contamination is significant on a local scale Volume of peat and/ or soft organic soil underlying route is significant on a local scale*	**Soil and Geology:** Contaminated soil on site with previous heavy industrial usage Large recent landfill site for mixed wastes Geological feature of high value on a local scale (County Geological Site) Well drained and/ or highly fertility soils Moderately sized existing quarry or pit Marginally economic extractable mineral resource
Medium	Attribute has a medium quality or value on a local scale Degree or extent of soil contamination is moderate on a local scale Volume of peat and/ or soft organic soil underlying route is moderate on a local scale*	**Soil and Geology:** Contaminated soil on site with previous light industrial usage Small recent landfill site for mixed wastes Moderately drained and/ or moderate fertility soils Small existing quarry or pit Sub-economic extractable mineral resource
Low	Attribute has a low quality or value on a local scale Degree or extent of soil contamination is minor on a local scale Volume of peat and/ or soft organic soil underlying route is small on a local scale*	**Soil and Geology**: Large historical and/ or recent site for construction and demolition wastes Small historical and/ or recent landfill site for construction and demolition wastes Poorly drained and/ or low fertility soils Uneconomically extractable mineral resource

* Relative to the total volume of inert soil disposed of and/ or recovered

Source: Based on criteria outlined within the TII's Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (TII, 2009)

5.4.4 Describing Potential Effects

The methodology used for describing the potential effects considers the 'quality' of the effects (i.e. whether it is adverse or beneficial), the 'probability' of the event occurring and the 'duration' of the effects (i.e. whether it is short or long term) as per Section 3.7.3 and Table 3.3 of the EPA's draft guidelines (EPA, 2017).

Specific assessment criteria and typical examples for soil and geology (based on information within the TII's 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes' (TII, 2009)) are outlined in Table 5-2.

Table 5-2 Criteria and Examples for Describing Potential Effects on Land and Soils Environment

Magnitude of Effect	Criteria for Effects	Typical Examples (Positive and Negative)
Large Adverse	Results in loss of attribute	Soil and Geology: Loss of high proportion of future quarry or pit reserves Irreversible loss of high proportion of local high fertility soils Removal of entirety of geological heritage feature Requirement to excavate/ remediate entire waste site Requirement to excavate and replace high proportion of peat, organic soils and/ or soft mineral soils beneath alignment
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Soil and Geology: Loss of moderate proportion of future quarry or pit reserves Removal of part of geological heritage feature Irreversible loss of moderate proportion of local high fertility soils Requirement to excavate/ remediate significant proportion of waste site Requirement to excavate and replace moderate proportion of peat, organic soils and/ or soft mineral soils beneath alignment
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Soil and Geology: Loss of small proportion of future quarry or pit reserves Removal of small part of geological heritage feature Irreversible loss of small proportion of local high fertility soils and/ or high proportion of local low fertility soils Requirement to excavate/ remediate small proportion of waste site Requirement to excavate and replace small proportion of peat, organic soils and/ or soft mineral soils beneath alignment
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Soil and Geology: No measurable changes in attributes
Minor Beneficial	Results in minor improvement of attribute quality	Minor enhancement of geological heritage feature
Moderate Beneficial	Results in moderate improvement of attribute quality	Moderate enhancement of geological heritage feature
Major Beneficial	Results in major improvement of attribute quality	Major enhancement of geological heritage feature

Source: Based on 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes' (TII, 2009)

5.4.5 Significance of Effects

A qualitative approach was used to determine the significance of effects as per the EPA's draft guidance determination figure (Figure 3.5; page 53). Due account was taken of both the sensitivity of the attributes (Table 5-1) and the description of the potential effect (Table 5-2). It shall be noted the control measures such as sealed drainage, as outlined in Chapter 02 – Project Description, have been considered as embedded mitigation in the project design and their application has been assumed in determining the significance of the effect. Mitigation measures have then been devised for each potential complete pollutant linkage (comprising a source, pathway and receptor).

Table 5-3 Significance Ratings

		Magnitude of Effect			
		Negligible	**Small**	**Moderate**	**Large**
Importance of Attribute	**Extremely High**	Imperceptible	Significant	Profound	Profound
	Very High	Imperceptible	Significant/ Moderate	Profound/ Significant	Profound
	High	Imperceptible	Moderate/ Slight	Significant/ Moderate	Severe/ Significant
	Medium	Imperceptible	Slight	Moderate	Significant
	Low	Imperceptible	Imperceptible	Slight	Slight/ Moderate

With regards to use of natural resources, the following significance criteria have been used:

Table 5-4 Significance Criteria for Assessment of Natural Resource Usage

Effect	Criteria for Effects of Material Assets Used	Significance
Major	Large decrease material assets availability greater than 5% of current baseline potentially causing significant burden to the national material asset market.	Significant
Moderate	Moderate decrease in material asset availability between 2% and 5% of current baseline potentially causing moderate burden to the national material asset market.	
Minor	Minor decrease in material asset availability between 0.1% and 1.9% of current baseline causing a minor burden to the national material asset market.	Not Significant
Negligible	Negligible decrease in material asset availability less than 0.1% of current baseline causing insignificant burden to the local and regional material asset market.	

5.4.6 Limitations and Assumptions

AECOM has reviewed and appended a number of previous site investigation reports as part of this assessment. These investigation reports were undertaken by third parties and AECOM takes no responsibility for the conclusions presented in those reports. The reports were undertaken to provide geotechnical recommendations for previous approved scheme designs, although provide useful information with regard to the Proposed Development.

5.5 Baseline Environment

5.5.1 Site Area Description

The Proposed Development site covers an area of approximately 41 ha (or 52 ha including the offshore elements) and is described in Chapter 02 – Project Description.

The Proposed Development site predominantly comprises grassland on the southern shore of the Shannon Estuary with offshore elements of the scheme consisting of the jetty, the site wastewater outfall pipe and seawater intake and discharge at the FRSU.

The Proposed Development site is in a predominantly agricultural area, with the following surrounding land uses noted:

- Immediately to the north is the Shannon Estuary;
- To the east is forestry and agricultural land;
- To the south is agricultural land and the L1010, with infrequent residential properties; and
- To the west is agricultural land, beyond which is coastline.

A number of minor drainage channels are present on the location of the proposed LNG Terminal, with longer features crossing the proposed access road. These are described in further detail in Chapter 06 – Water.

5.5.2 Site History

A review of publicly available mapping suggests the Proposed Development site and the surrounding area have historically been in predominantly agricultural use.

5.5.3 Topography

The north-east of the Proposed Development site slopes relatively uniformly from approximately 35 m above Ordnance Datum (m OD) in the southeast to a clifftop at approximately 5 m OD in the north. On the west of the Proposed Development site, the land generally slopes from southeast to northwest. The parcel of land which will be occupied by the proposed access road is undulating, with topographic highs at approximately 22 m OD.

5.5.4 Quaternary Deposits

GSI mapping indicates that the local quaternary deposits comprise predominantly ‘till derived from Namurian sandstones and shales’. Small amounts of alluvium are also depicted at the Proposed Development site, while no quaternary deposits are mapped in pockets on the north of the Proposed Development site, where bedrock is indicated to outcrop. A meltwater channel is mapped crossing the south of the access road and skirting the southwestern site boundary.

Soils mapping indicates the soils beneath the Proposed Development site generally comprise acid brown earths/ brown podzolics of the Kilrush soil series. The soils across the majority of the Proposed Development site are classified as ‘well drained’, with pockets of ‘poorly drained’ soils on the north and south. Where present, subsoils are classified as of low permeability and are assessed by GSI as having no aggregate potential, other than areas of alluvium along the Ralappane Stream mapped as having Low or Very Low granular aggregate potential.

Soils and stream sediments in the vicinity of the site have not been mapped under the GSI TELLUS soil geochemical sampling programme.

The shallow geology of the Proposed Development site has been studied during previous investigation works on site, with a more detailed description provided in Section 5.5.9 below.

5.5.5 Bedrock

According to the GSI database, the bedrock underlying the Proposed Development site is described as mudstone, siltstone and sandstone of the Shannon Group, being of Namurian age. The bedrock is seen to outcrop at the coast along the majority of the site’s northern boundary.

Risk of erosion along the coastline of the Proposed Development was assessed in the 2007 offshore assessment and concluded that very limited episodic erosion not requiring foreshore protection occurs above high water level along short sections of the coastline, leading to proposed onshore works being set back 10m from the cliff edge.

The Proposed Development site is not located in a Geological Heritage area, according to GSI mapping, and GSI consultation indicates there are no County Geological Sites in the vicinity. There are no GSI geotechnical sites, recorded landslide/ geohazard events, mineral localities or active quarries mapped within the Proposed Development site.

The northeastern part of the Proposed Development site is mapped as having High to Very High crushed rock aggregate potential. Two historic quarries are mapped on the east side of Ardmore Point, 350-400 m east of the Proposed Development site.

Major faulting is not recorded on GSI mapping but local faulting is referenced in a site investigation report for the Proposed Development site, which is reviewed in Section 5.5.9 below, along with a more detailed interpretation of the bedrock geology.

5.5.6 Radon Potential

According to the EPA's online Radon Map, the Proposed Development site is located in an area where <1% of homes are estimated to be above the reference level of 200 becquerels per cubic metre (Bq/m^3). Radon potential risk is therefore considered 'Low'.

5.5.7 Hydrogeology

GSI mapping indicates that groundwater in the bedrock is classified as a 'Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones'. Groundwater vulnerability varies across the site from 'Moderate' to 'Rock at or near Surface or Karst'.

A more detailed assessment of the Proposed Development site's hydrogeology is provided in Chapter 06 – Water.

5.5.8 Designations

There are no recorded Integrated Pollution Prevention and Control (IPPC) Licences, Industrial Emissions (IE) Licences, Discharge Licences, Licensed Waste Facilities or Landfill Sites recorded within 1 km of the Proposed Development site.

The Shannon Estuary to the north is designated as a Special Protection Area (SPA) and a candidate Special Area of Conservation (cSAC). The cSAC extends inland immediately to the west of the Proposed Development site. A Proposed Natural Heritage Area (pNHA) is located approximately 150 m to the west.

On the 21st December 2010, foreshore leases for an jetty and a construction materials jetty were obtained. Foreshore licences were also obtained for a seawater intake and outfall system and storm water outfall pipe in December 2010.

5.5.9 Site Investigation

Onshore (ARUP, 2007) and offshore (Halcrow, 2007) site investigations were undertaken in 2006 and 2007, with key findings detailed below:

5.5.9.1 Onshore Site Investigation

The onshore investigation is included as Appendix A5-1 (Vol. 4) and comprised:

- Twenty six rotary coreholes;
- Thirty one trial pits;
- Six geologging holes, to determine the condition and orientation of bedrock continuities;
- Scan lines along the coastal section;
- One pump test; and

- 2-D Resistivity, Electromagnetic and Seismic Refraction Geophysical Survey.

The geotechnical testing was undertaken in the context of the then-proposed construction of four LNG tanks, but the report provides useful information with regards to the geological properties of the Proposed Development site.

The geology encountered during site investigation can be summarised as follows:

Table 5-5 Geology Encountered during Onshore Investigation

Stratum	Extent	Thickness	Description	Properties
Topsoil	Entire site	0.1 m-0.8 m	Generally brown topsoil with grass roots	No testing of the properties of the topsoil was undertaken as part of the investigation. May be suitable for re-use in landscaped areas.
Upper Till	Encountered in all but two trial pits. Inferred extent was across majority of site, with exception of narrow strips to north, south and west	0.7 m-4.2 m	Orange/ brown/ grey sandy very gravelly clay/ silt and clay with many angular to sub-rounded cobbles and boulders of siltstone and shale rock fragments. The material was noted to be very granular and was considered likely to be a glacial debris flow deposit.	Based on geophysical data, the Upper Till was divided by ARUP into two distinct layers, one which was soft to firm, and the other firm to soft. Groundwater was encountered within the Upper Till in a number of trial pits, with flows described as being from seepage to slow. Permeabilities of 3 to 4 x 10^{-6} m/s were calculated for the Upper Till. Natural moisture contents within the Upper Till were recorded between 8% and 40%. Despite its high granular content (>65%), Atterberg Limits testing indicated it behaves as a clay/ silt and clay. CBR tests undertaken showed the Upper Till loses strength rapidly with increasing moisture content.
Inter-Glacial Deposits	Small pocket on western boundary (recorded in trial pits TP09, TP10 and TP13	0.2 m-2.0 m	Laminated sands and silts and gravels with rounded to subangular cobbles and boulders, considered to be fluvioglacial in origin.	The laminated silts were recorded by ARUP to be firm in consistency, with the sands and gravels described as coarse and medium dense. Groundwater was encountered in trial pits TP09 and TP10, but not in TP13. ARUP noted the material was unstable, with trial pit walls collapsing in TP10 and TP13 and running silt in TP09 undermining the overlying clay stratum.
Lower Till	West of site	0.3 m-9.8 m	Stiff to very stiff dark grey/ black, gravely clay/ silt with many subrounded cobbles. ARUP concluded from observations of cliffs on the northern site boundary that the deposit was a lodgement till, deposited at the base of a moving ice sheet, as it was sheared into the upper weathered layers of the mudstone bedrock.	The till was recorded as still to very stiff in trial pits, with geophysical results indicating it to be firm to stiff. No water seepages or strikes were recorded within this material and was indicated to be of low permeability. Similar to the Upper Till, despite its high granular content, the material was described as cohesive based on Atterberg limits testing. Similar to the Upper Till, lower Till was considered very susceptible to deterioration in wet conditions.
Bedrock (Shannon Group)	Entire site. Mudstone-siltstone and sandstone were noted to underlie the west of the site,	Depth not proven.	Sandstone, siltstone and mudstone. Rotary corehole logs recorded argillaceous (clay) bands in the mudstone and interbedded in the siltstone-sandstone	The interpretative report referenced the presence of a number of inactive suspected faults, oriented in a northwest-southeast direction. It was reported these had been identified in a previous report by Weston Geophysical Engineers (2007) 'Probabilistic

Stratum	Extent	Thickness	Description	Properties
	while sandstone and siltstone were dominant on the eastern site section.		beds, with some clay-filled fractures noted. Shallowest in east of site (0.75 m bgl), with depth to top of bedrock generally increasing to the west (9.8 m of overburden recorded in borehole RC25)	Seismic Hazard Analysis for the Tarbert/ Ballylongford LNG Project'. ARUP's Interpretation of geologging revealed that planar failure in cut slopes will be controlled by joint sets J1-J3, wedge failure by J2-J5 and toppling failure in J6-J8. A distinct weathered zone was noted to be difficult to delineate in the rock mass, possibly due to its interbedded and locally faulted nature. The material was described as relatively resistant to crushing and reasonably durable. The bedrock was classified as moderately strong uniaxially, with a weak to moderately weak tensile strength. Groundwater was encountered in the upper fractures/ weathered zone of the bedrock and artesian conditions were noted in a number of isolated locations across the site. Permeability testing was undertaken in a number of locations, with permeabilities of 2 x 10^{-6} m/s calculated in the sandstone, 1 to 5 x 10^{-6} m/s in the siltstone and 1 to 8 x 10^{-5} m/s in the mudstone.

On the basis of permeability testing, ARUP concluded that shallow soils are of relatively low permeability, except in areas with lenses that have higher sand or gravel content. The overburden was considered to act as a confining layer, confining groundwater to the upper fractured bedrock zone.

The report concluded that the soils and geology encountered were favourable for the construction of the then-proposed LNG plant, indicating the then proposed tanks could be founded on the bedrock and that all excavated material will be suitable for re-use as general or structural fill.

It was recommended that earthworks be undertaken in drier summer months, in view of the sensitivity of the overburden to moisture content. For the same reason, it was recommended even, inclined surfaces be maintained on cut and fill surfaces to prevent rutting and water pooling.

The report highlighted it will be prudent to undertake additional investigation at the detailed design stage in order to address any potential data gaps.

5.5.9.2 Offshore Site Investigation

The offshore investigation is included as Appendix A5-2 (Vol. 4) and comprised:

- Fourteen rotary cored boreholes from a jack-up platform in the near offshore area ;
- In-situ sampling and testing; and
- Geophysical investigation.

The investigation was undertaken to inform the geotechnical design of the offshore infrastructure in two targeted areas (jetty and a previous materials jetty). Planned offshore boreholes for a previous 650m jetty design could not be completed in 2007, due to the presence of thick, soft sediments further offshore, and the jetty design was subsequently shortened.

The offshore site investigation encountered four distinct layers, which are summarised below in order of increasing depth:

- Alluvial Deposits: very soft to soft, brown sandy silt, with minor amounts of shells and shell fragments. This stratum was encountered in a number of locations in close proximity to the proposed jetty, and a geophysical survey found it thickened in an offshore direction from the shoreline, potentially to a thickness of 26 m;
- Upper Glacial Till: generally medium dense to very dense brown to grey gravelly sand and sandy gravel, with some clays and silts and frequent cobbles and boulders. Occasionally comprised stiff

to very stiff brown gravelly clays with minor amounts of sand. Encountered in the majority of locations from seabed to depths of between 2 m and 6 m;

- Lower Glacial Till: Similar to the Upper Glacial Till, but darker and denser/ stiffer; and
- Bedrock: Mainly interlayered sandstone, siltstone and mudstone and shale. Encountered in all fully completed boreholes. Logs revealed great variability in terms of types of bedrock encountered.

Geotechnical testing was undertaken in order to inform foundation recommendations for the offshore jetty structure. Deep foundations in the form of end-bearing steel pipe piles, most likely driven, were proposed for the support of marine structures. It was noted the abundance of cobbles and boulders in the overburden materials may necessitate the use of downhole hammers or drilling techniques in locations. Piles required for breasting and mooring dolphins are expected to be drilled and socketed into bedrock.

Jetty approaches were indicated to be supportable on conventional shallow footing type foundations. Such foundations can be founded on glacial till soils or controlled, compacted structural fill.

5.5.9.3 Environmental Sensitivity Mapping

The ESM Strategic Environmental Assessment (SEA) mapping tool indicates the Proposed Development site to have a low to very low sensitivity with respect to soils and geology.

5.5.9.4 Summary of Baseline Conditions

A summary of baseline conditions at the Proposed Development site is presented in below.

Table 5-6 Summary of Baseline Conditions

Item	Description
Context	The onshore portion of the Proposed Development site is currently largely undeveloped grassland, which covers an area of approximately 41 hectares (or 52 hectares including the offshore area). The land does not appear to have been intensively managed and is currently in use predominantly as grazing land, with tillage for barley reported in areas to the south and west of the Proposed Development site. The Proposed Development site is generally underlain by Till deposits over bedrock of the Shannon Group. The bedrock outcrops on the northern boundary. The offshore portion of the Proposed Development is situated in the Shannon Estuary coastal marine environment.
Character	The land is agricultural and no significant contamination of soils is anticipated based on previous uses. Shallow soils were generally found to act as cohesive materials, with strength reducing rapidly with increasing moisture content. The offshore area is currently undeveloped. The Proposed Development site is surrounded by a mixture of agricultural land, forestry, rural housing, public road, with the Shannon Estuary to the north. No EPA IPPC or IE licenced facilities were identified within 1 km of the Proposed Development site.
Significance	The Proposed Development site consists of agricultural land in agricultural setting. Land use of this nature is abundant within the local area, with agricultural land of a similar nature to the south, east and west. The Proposed Development site is not in a Geological Heritage Area and no active quarries or mineral locations are mapped within 2 km. The onshore Proposed Development site has not been designated as a pNHA. The offshore Proposed Development (jetty and outfall pipe) extends into the Shannon Estuary to the north, which is a cSAC and SPA. The cSAC extends inland immediately to the west of the site.
Sensitivity	Ground conditions beneath the onshore and offshore portions of the Proposed Development site generally consist of topsoil overlaying Till deposits over bedrock. Upper Till is present across the majority of the site to depths of up to 4.2 m. Inter-glacial deposits and Lower Till were also recorded on the west of the Proposed Development site. The Lower Till becomes significantly thicker offshore (up to 20 m thick) and the depth to top of bedrock rock 300-400 m offshore is deeper than -35 m OD. The bedrock consists of mudstone, siltstone and sandstone of the Shannon Group and is classified as a ‘locally important aquifer, which is moderately productive in local zones’. Groundwater vulnerability varies across the onshore Proposed Development site from ’Moderate’ to ‘Rock at or near Surface or Karst’. Overall, the soils and geology are considered to be of low environmental sensitivity.

5.6 Characteristics of the Proposed Development

5.6.1 Project Description

The Proposed Development is outlined in Chapter 02 – Project Description, and comprises the following 5no. key elements:

- Offshore Floating Storage Regasification Unit (FSRU) including LNG Vaporisation Process Equipment;
- Offshore jetty and access trestle;
- Wastewater outfall pipe, extending offshore to below low tide level
- Onshore support facilities, including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator, fire water system;
- Onshore Above Ground Installation (AGI) including odorisation equipment; and
- Onshore Power Plant and Battery energy storage system (BESS) facility.

The onshore elements of the Proposed Development are to be constructed mainly at a platform level of 18 m OD in the north of the site.

The offshore portion of the Proposed Development is situated in the Shannon Estuary coastal marine environment and the jetty and access trestle extend northward to a deep water channel, with the jetty platform aligned with the tidal current direction.

5.6.2 Construction Activities

Construction of the LNG terminal and Power Plant is expected to take approximately 32 months. The civil works of relevance to soil and geology will mainly be carried out during the 10 month enabling phase and include the following activities:

5.6.2.1 Excavation and Infilling to Prepare Development Platform

The overburden will be, in places, quite thin and to create the level platforms for the entire LNG and Power Plant facility, approximately 480,000 m³ 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 18 m OD.

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 will 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 Proposed Development site.

It is anticipated the approaches to the jetty will be supported on abutment structures on shallow foundations. The approach areas will require to be stripped of surficial materials ahead of works. Where unsuitable materials are encountered at subgrade or abutment foundation level, these shall be replaced with structural Fill.

Offshore development will include significant work over water and the jetty will consist of steel pipe piles and rock socket installation, construction of pile caps and installation of precast concrete decking, with in-situ concrete toping.

Approximately 26,000 tonnes of imported aggregate will be delivered from local quarries along the L1010 from the Tarbert direction, to facilitate the formation of access roads during construction.

5.6.2.2 Piling of Foundations

Based on previous geotechnical investigations and the current design, it is anticipated the jetty and outlet structure will be constructed with steel piles, likely in a combination of driven and bored piles, although the exact methodology will be confirmed at detailed design stage.

Typically, the construction of the jetty would be staged from the water using floating barges and self-elevating platforms (jack-ups), assisted by tugboats. Other smaller equipment such as compressors, generators, and land-based machines will also be used. A temporary loading/ mooring facility has been included in the proposed jetty design to allow a mooring point for the construction floating plant.

The construction materials would consist of steel tubular piles, structural steel fabrications, precast concrete elements, reinforcing steel and in-situ concrete. Other elements of the marine structures (pile caps, beams, and deck planks) will largely be precast concrete.

A proportion of the piles supporting the jetty would be drilled and socketed into the rock to ensure stability of the jetty. Spoils from the drilling operation would be conveyed to the surface via reverse-circulation through the drill stem and contained within designated scows or other vessels. Pile installation and construction of the roadways and platform deck would most likely advance outward from shore.

The use of precast concrete would be maximised, while the use of *in situ* concrete would be minimised to reduce any potential environmental impacts on the Shannon Estuary. Any in-situ concrete work would be staged in a manner to prevent concrete from entering the water. Piles would be pre-fabricated as much as possible to minimize in-water construction.

The onshore buildings are generally proposed to comprise pre-engineered/ manufactured structural steel structures which may be founded directly on rock; through rock-socketed piles; or directly on shallow soils/ fill, dependent on the findings of geotechnical testing.

Pile arisings will be reused onshore as landscaping material on the north-eastern boundary of the site forming a screening berm approximately 2 m high, subject to chemical suitability assessment.

5.6.2.3 Proposed outfall pipe

A drainage outfall pipe from the site into the Shannon Estuary is proposed and will discharge surface water, groundwater, treated foul water and used firewater from the proposed development. It will consist of a 900mm diameter concrete drainage pipe laid in a trench across the foreshore and extending below low water mark. A foreshore licence for an outfall pipe at the proposed location was secured in December 2010 and any marine notices will be applied for to the Shannon Foynes Port Company as required.

Areas of disturbance of the cliff and foreshore will be minimised and 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. The works will not result in any impact on the amenity use of the foreshore or adjacent marine area.

Surplus material excavated from the trench will be removed and incorporated as in earthworks on the adjacent terminal development works and it is proposed to backfill the excavated trench with concrete suitable for underwater use. Care will be taken not to spill or dispose of concrete on the foreshore..

The disturbance to the foreshore as a result of the discharge of drainage water through the outfall pipe is also considered to be small. The volume being discharged through the outfall pipe is negligible by comparison to the volume of water flowing through the estuary. Given the nature of the ground conditions at the discharge point, no negative impact due to erosion or deposition of material is expected.

5.6.2.4 Installation of Process and Utility Equipment, Piping and Instrumentation

The installation of process equipment and utilities is likely to require the excavation of trenches. This may necessitate the breaking out of rock, using excavator-mounted rock breaking equipment. It is anticipated the excavated rock may be used as fill in other site areas.

5.6.2.5 Construction of Buildings and Site Landscaping

Once foundations have been installed, construction of buildings will commence from the development platform level.

Any areas of site landscaping will be formed using site-won topsoil, where possible.

5.6.3 Operational Activities

During operation of the Proposed Development, ships carrying LNG will berth alongside the FSRU at the jetty and unload directly to the FSRU. The LNG vaporisation process equipment to regasify the LNG to natural gas will be onboard the FSRU. The heat for LNG vaporisation will be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate.

The storage or use of hazardous materials during the operational phase of the Proposed Development will be limited to:

- Diesel – Firewater pumps, black start generator and emergency generators will be powered by diesel; and
- Chemical odorant – Odorant NB, a liquid odorant consisting of a tertiary butyl mercaptan (78-82%) and dimethyl sulphide (18-22%) which is classified as Toxic to the aquatic environment (Category 2) (Hazard Code H411) will be stored onshore under a nitrogen gas blanket in two bunded bulk tanks (each 22.3 m^3 capacity) at the Ralappane AGI Gas Metering/ Odorization Area and will be injected into the gas stream under controlled conditions.
- Minor quantities of maintenance oils, greases, lubricants, cleaning chemicals, etc. A designated chemical cage is included within the design of the proposed warehouse/ workshop building;

LNG itself is not considered to be a potential source of contamination to soils, because in view of its extremely low vaporisation temperature (approximately -160°C) it will never be present as a liquid or solid under ambient conditions.

Ancillary construction will include access roads, internal roads, car parking, workshop, entrance security guardhouse, and landscaping. The internal road network will service access and egress for all site buildings.

The Proposed Development site access will be from the L1010 to the south of the site.

5.7 Embedded Mitigation Measures

The assessment of impacts assumes the implementation of embedded control measures, as set out in Chapter 02 – Project Description. These will include use of precast concrete components where possible in the offshore area, routing of road runoff from the approach road north to the Power Plant and LNG Terminal rather than to natural drainage leading to the Ralappane Stream, separation of sealed road drainage from other stormwater drainage, the provision of an attenuation system, including a Class 1 interceptor fitted with control valves and a firewater impoundment basin, and provision of designated bunded storage facilities for potentially-contaminating chemicals and fuels.

5.8 Assessment of Impact and Effect

An analysis of the potential impacts of the Proposed Development on the land, soils, geology and hydrogeological environment during the construction and operational phases is outlined below. Due to the inter-relationship between land, soils and water (hydrology), the following impacts will also be considered applicable to Chapter 06 – Water and Chapter 16 – Waste.

5.8.1 Construction Phase

5.8.1.1 Changes to Topography – Excavation and Infilling

Beneath the Proposed Development footprint a process of 'cut and fill' will be employed in order to level the footprint of the proposed buildings and infrastructure and achieve the desired 18 m OD platform level from which to commence construction works.

To reach the desired level on the south of the Proposed Development site, it will be necessary to cut into the bedrock, through mechanisms such as blasting. Filling, where possible using site-won materials, will be required on the north of the Proposed Development site to raise the land to the platform level. A retaining wall will be constructed along a portion of the northern boundary of the platform above foreshore level.

The estimated cut and fill volumes are presented in Table 5-7 below.

Table 5-7 Earthworks Volumes

	Cut (m^3)	Fill (m^3)
Topsoil	35,000*	35,000
Soil	356,054	437,115
Rock	81,062	-
Total	472,115	472,115

*Excess topsoil will be placed on the laydown area or spread onsite

The 'cut and fill' operation at the Proposed Development will produce an estimated 472,115 m^3 of material consisting of overburden soil and rock spoil. This material is likely to be largely reusable as Class 2 Cohesive general fill. All surplus material will be processed (screened/ crushed) and reused on-site and there is no intention to import soil material to the Proposed Development site.

The visual impact of the Proposed Development is considered in Chapter 10 – Landscape & Visual Impact.

Excavation and infilling impacts will result in a **permanent direct** effect of **neutral** quality which will have an **imperceptible** effect on the character of the environment but is certain to occur and **irreversible**. This is considered to be a **moderate** effect on a soil environment of **low** sensitivity and the significance of the effect is considered **slight.**

5.8.1.2 Use of Natural Resources

All excavated material will be reused onsite and no import of soil is expected. However, 26,000 tonnes of aggregate will be sourced from local quarries to facilitate construction of access roads. These will be delivered along the L1010 from the Tarbert direction. The sourcing of these aggregates from reputable, authorised quarries is mandated by applicant requirements and for ensuring regulatory compliance. Sources of material may include the following:

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

Aggregates are natural non-renewable resources and their use results in depletion of the national stock of these resources. According to the Irish Concrete Federation (ICF), Ireland produces approximately 36 million tonnes of aggregates annually (ICF, 2019), of which the Proposed Development's required 26,000 tonnes represent just 0.07%.

Onshore and offshore pile arisings will be reused on the site as landscaping materials on the north-eastern boundary of the site forming a screening berm approximately 2 m high, subject to chemical suitability.

Use of natural resources will result in a **permanent direct** effect of **neutral** quality, as it will be **imperceptible** within the wider environment but is certain to occur and **irreversible**. Therefore, use of

natural resources is considered to be a **small** effect on an environment of **low** importance and the significance of the effect is considered **imperceptible.**

5.8.1.3 Accidental Spills and Leaks

During construction of the Proposed Development, there is a risk of accidental pollution incidents from the following sources:

- Spillage or leakage of stored oils and fuels;
- Spillage or leakage of oils and fuels from construction machinery or site vehicles; and
- Spillage of oil or fuel from refuelling machinery on site.

Accidental spillage can potentially result in the impact of soils underlying the Proposed Development site. This is considered a **direct negative** effect and, if it occurs, will be confined to one-off releases. The impact can alter the character of soil and/ or groundwater at the local site but will be **temporary** in nature, as minor spills would likely be attenuated by natural processes (sorption/dilution/dispersion). The impact will therefore result in a **small adverse** effect on a **low** importance soil environment and the significance of the effect will be **imperceptible** with regard to soils.

The potential for accidental spills and leaks to impact on the hydrological and hydrogeological environment is considered in Chapter 06 – Water and also in the Major Accidents to the Environment (MATTE) section of the Quantitative Risk Assessment submitted to the Health and Safety Authority as part of this application.

5.8.1.4 Use of Concrete and Lime

Lime and concrete (specifically, the cement component) is highly alkaline and any spillage can impact soil quality. The activities most likely to result in contamination include concreting during piling and building construction. This impact is also considered in Chapter 06 – Water, in the context of its impact on the groundwater and surface water environment.

The impact can result in a **direct** effect of **negative** nature and **temporary** duration given it is only associated with the construction programme, which is temporary in nature. Impacts on soils associated with the use of concrete and lime are considered unlikely to occur and, shall they occur, are likely to be rare events. Therefore, it is considered to be a **small** effect to a **low** importance soil environment and the significance of the effect is **imperceptible.**

5.8.1.5 Impacts of Soils and Geology on the Proposed Development

In addition to assessing the potential impacts the Proposed Development may have on the soil and geology environment, it is also necessary to consider the potential impacts of the soils and geology on the Proposed Development.

Shallow Soils

The main onshore infrastructure will be constructed on a part of the Proposed Development site where the superficial soils comprise predominantly glacial till. Two types of glacial till have been identified on the Proposed Development site although composition-wise they are very similar. Based on geotechnical performance testing, both were expected by ARUP to provide a reasonable substrate for fill construction and for foundations for light-weight structures. Heavy settlement-sensitive structures may be founded on rock, either directly or by means of rock-socketed piles.

It has been concluded in previous site investigation reporting that the glacial till loses its shear strength and bearing capacity to a high degree with even a slight increase in water content. The upper several metres of till sediments at the seabed were reported to be Soft to Very Soft at 2 of 14 boreholes in the 2007 offshore site investigation, with other soft sediments, interpreted as alluvium rather than till, reported at the further offshore attempted drilling locations and inferred from offshore geophysical surveys.

Glacial till and greywacke sandstone have been shown to be a relatively non-aggressive material in terms of sulphate and chloride, so that no particular precautions are likely to be required for protecting concrete and other construction materials in contact with it.

It is noted that the Proposed Development provides the opportunity to study and document regional glacial geology through cutting and foundation pit exposures in the glacial deposits and bedrock, which will add to the national records.

Shallow soils are therefore considered to have a neutral to favourable impact on the Proposed Development and to be a **minor beneficial** effect on a **low** importance soil environment, and the significance of the effect is **imperceptible**.

Bedrock

The bedrock beneath the Proposed Development site has not been identified as of particular importance. The Proposed Development site is not located in an area of Geological Heritage and there are no active quarries or mineral localities recorded within 2 km.

As the Proposed Development retaining wall and platform level will be above the main coastal bedrock outcrop area, with the exception of the main site outfall, the Proposed Development will not impact the main coastal bedrock outcrop areas.

Geotechnical site investigation has previously been undertaken onsite, in the context of a previously proposed scheme. It was concluded that the unweathered siltstone and sandstone bedrock was expected to provide a competent foundation medium.

Bedrock quality is therefore considered to have a **moderate favourable** effect on the Proposed Development on a **low** importance bedrock environment, and the significance of the effect is **slight**..

5.8.2 Operational Phase

5.8.2.1 Accidental Spills and Leaks

Diesel fuel tanks for the fire water pumps and generators will be stored within bunded areas

Spills during fuelling can in theory discharge to ground; however, this will be prevented from entering the soil around the generators, as drainage will be directed to an oil/ water interceptor prior to discharge to the storm water drainage system. In addition, there will be a shut off valve from the generator yard to the external surface water drainage network. These measures will significantly reduce the likelihood of soil or groundwater contamination from spills and the impact of accidental spills

Accidental emissions of diesel or other hazardous substances can cause contamination should they enter the soil environment. They will be considered to be **direct negative** effects of temporary duration given that they will be confined to one off releases. This is considered to be a **small adverse** effect to a **low** sensitivity environment and the significance of the effect is **imperceptible**.

5.8.2.2 Removal of Land from Agricultural Use

The removal of land from agricultural or other potential beneficial uses can result in a **permanent direct** effect on existing land use in the area. The total hardstanding area is estimated to cover 14 ha, with the remainder left unsurfaced, landscaped or developed into attenuation ponds.

The removal of agricultural land can be considered to be **permanent** and the effect is considered **negative**; however, it is likely to be of **low** magnitude given the Proposed Development site is located within an agricultural setting where land use is predominantly of agricultural nature. This is considered to be a **small** effect to an environment of **low** significance and the significance of the effect is **slight**. Additional information on impacts on land use and properties can be found in Chapter 15 – Material Assets.

5.8.2.3 Seismic Hazard

A study of the seismic hazard potential carried out in 2007 indicated the Proposed Development is located in a structurally stable bedrock terrain, which earth record indicates is largely aseismic and that the tsunami risk for this site located within an estuary protected from the ocean is negligible.

5.8.2.4 Radon Hazard

The Proposed Development site is located in an area where <1% of homes are estimated to be above the reference level of 200 becquerels per cubic metre (Bq/m^3). Radon potential risk is therefore considered ‘Low’.

5.9 Cumulative Impacts and Effects

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 – Planning and Development.

5.9.1 Summary of Schemes Considered in Cumulative Impact Assessment

5.9.1.1 LNG Pipeline

Permission was granted in 2009 for a pipeline to connect the Proposed Development site to the existing national gas network near Foynes, Co. Limerick. The application was accompanied by an EIAR.

No significant residual effects were identified to geology and soils in the EIAR for the LNG pipeline. A revised assessment of the permitted pipeline will be included within the required future application for consent under section 39A of the Gas Act 1976 (as amended).

5.9.1.2 Data Centre Campus

As part of the Masterplan, 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.

5.9.1.3 220 kV and Medium Voltage (10/ 20 kV) Power Transmission Networks

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 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 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.

5.9.2 Construction Impacts

Individual impacts from the Proposed Development and other schemes considered can result in **small** effects on a **low** sensitivity environment; therefore, the significance of the effect has been assessed as **imperceptible** or **slight**. As outlined in Section 5.8 above, mitigation measures proposed to manage and control potential impacts during the Proposed Development will reduce the potential magnitude and significance of effects.

Taking account of mitigation measures proposed, the cumulative impacts of all schemes proceeding can result in **small** effects on a **low** sensitivity environment geological environment and the effect has been assessed as imperceptible or **slight**.

5.9.3 Operational Impacts

The individual impacts from the Proposed Development and cumulative schemes to land and soil can result in effects ranging from **negligible to small** and mitigation measures proposed to manage and control potential impacts during operation will further reduce the magnitude of effects and significance of effects.

The cumulative operational effect of the Proposed Development and cumulative schemes are considered to be **slight**.

5.10 Mitigation and Monitoring Measures

Mitigation measures associated with both the construction and operational phases of the Proposed Development are outlined below. Due to the inter-relationship between land, soils and water (hydrology) the following mitigation measures discussed will be considered applicable to Chapters 05 and 06. Waste Management (Chapter 16) is also deemed an interaction in some of these considerations.

5.10.1 Construction Phase

In order to prevent/ minimise potential significant effects, a number of mitigation measures will be adopted as part of the construction works onsite. The main areas of potential impact and mitigation measures are set out below:

- Geotechnical design;
- Soil excavation and filling - Control of soil/ rock excavation and fill placement works;
- Pile installation – Minimisation of sediment disturbance
- Accidental spills and leaks – Fuel and chemical handling, transport and storage;
- Use of concrete and lime – The use of lime, concrete and cement during pad foundation, jetty, outfall, road and culvert construction; and
- Use of natural resources – Sources of fill and aggregates for the project.

5.10.1.1 Construction Environmental Management Plan

An OCEMP has been prepared for the Proposed Development which incorporates relevant environmental avoidance or mitigation measures to reduce potential environmental impact. The OCEMP will be modified and extended by any relevant construction related requirements imposed as conditions of any planning permission granted as a result of this application. The OCEMP will include a Waste Management Plan and Surface Water Management Plan, to be prepared in accordance with Department of Environment, Community & Local Government guidelines (DoECLG, 2006) and any construction-related requirements imposed as conditions of any planning permission granted. It will also include details of proposed environmental monitoring for the duration of the construction works, be this good practice or as a planning condition requirement, be this good practice or as a planning condition requirement.

5.10.1.2 Geotechnical Design

Prior to commencement of the Proposed Development, site investigation results will be used to inform the geotechnical design. Foundation solutions will be designed based on the properties of the underlying soils and bedrock, appropriate methodologies will be selected for the excavation of bedrock and foundation design will be finalised. Where necessary, further detailed site investigation will be undertaken to provide design parameters for the Proposed Development.

5.10.1.3 Soil Removal and Compaction

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 runoff to soils. The OCEMP outlines 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 OCEMP will contain the following mitigation measures that will be implemented during the construction phase:

- 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 m^3 of topsoil is expected to be removed, stockpiled and reused on site during the proposed development works;
- Of this 35,000 m^3 of topsoil, 13,745 m^3 is expected to be used as backfill and the remaining 21,255 m^3 will be used to cover the lay down area on completion of constructions and also used in landscaping or to form berms.
- 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;
- 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.
- Segregate different grades of soil where they arise and topsoil will first be stripped from any land to be used for storing subsoil; and
- Minimise movements of materials within the stockpiles in order to reduce the degradation of the soil structure.

Although there was no visual or olfactory evidence of contamination reported in soils during the geotechnical site investigation works, all excavated materials will be visually assessed for signs of possible contamination such as staining or strong odours. Should any unusual staining or odour be noticed, this soil will be segregated and samples of this soil analysed for the presence of possible contaminants in order to determine an appropriate disposal outlet.

Soils, pile arisings and crushed rock will be tested for their chemical and geotechnical suitability prior to use as fill. Fill placement and compaction will be undertaken in line with defined procedures and will be inspected by a geotechnical engineer.

As the glacial till loses its strength with increasing moisture content, the OCEMP will also include the following mitigation measures for earthworks:

- Maintain an even inclined surface on cut and fill surfaces to prevent the formation of ruts and hollows (which may promote ponding);
- Defer final shaping and trimming of formation levels until immediately prior to placement of surface dressing;
- Undertake earthworks in glacial till in times of dry weather, where possible; and
- Manage groundwater and surface water flows through drainage channels.

5.10.1.4 Pile installation

The piles supporting the offshore structures are expected to be end bearing and will be driven piles into till sediment, where possible, to minimise sediment mobilisation. Cobbles and boulders in the till may require the use of drilled piles in places and drilled, rock-socketed piles will be used for the first section of the approach trestle (where overburden sediments are thin) and for the breasting and mooring dolphins. Drilled piles will be installed using reverse circulation techniques to minimise temporary impacts from drill cuttings or grout on the estuary. Piles will be prefabricated as much as possible to minimise in-water construction and pile installation will likely advance outward from the shoreline.

In situ grouting of precast jetty members and construction of in-situ reinforced concrete trestle roadways and jetty platform deck will be managed to prevent wet concrete from entering the estuary.

5.10.1.5 Bedrock Excavation

Where bedrock is to be removed as part of the cut/ fill exercise on the Proposed Development site, it is anticipated that rock breaking and blasting may be required to achieve the 18 m OD formation level. Mitigation measures relating to the associated noise impacts are set out in Chapter 10 – Noise and Vibration. Groundwater seepages from bedrock cut faces will be managed by surface water drainage swales installed close to the toe of the cut faces.

5.10.1.6 Fuel and Chemical Handling

In order to prevent spillages to ground of fuels, and to prevent any consequent soil or groundwater quality impacts, it will be necessary to adopt mitigation measures during the construction phase, which include:

- Designating a bunded storage area at the contractor's compound for all oils, solvents and paints used during construction. Oil and fuel storage tanks will be bunded to a volume of 110% of the capacity of the largest tank/ container within the bunded area. Drainage from the bunded area will be diverted for collection and safe disposal. All containers within the storage area will be clearly labelled, so that appropriate remedial action can be taken in the event of a spillage. When moving drums from the bunded storage area to locations within the Proposed Development, a suitably-sized spill pallet will be used for containing any potential spillages during transit;
- Refuelling of construction vehicles and the addition of hydraulic oils or lubricants to vehicles, will take place in a designated area, which will be away from surface water gullies or drains. Spill kit facilities will be provided at the fuelling area in order to provide for accidental releases or spillages in and around the area. Any used spill kit materials will be appropriately disposed of using a hazardous waste contractor; and
- Where mobile fuel bowsers are used on the Proposed Development, i.e. in the event of a machine requiring refuelling outside of the designated area, fuel will be transported in a mobile, double-skinned tank. Any flexible pipe, tap or valve in this tank will be fitted with a lock where it leaves the

tank and locked shut when not in use. The pump or valve will also have a lock and be locked shut when not in use. Each bowser will carry a spill kit and each bowser operator will have spill response training.

5.10.1.7 Control of Concrete and Lime

Ready-mixed concrete will be either produced onsite in a batching plant or brought to the Proposed Development by truck. 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, to surface water courses or to the marine environment.

The pouring of concrete will take place within designated areas as required, using a geosynthetic material to prevent concrete runoff into the soil. Washout of concrete-transporting vehicles will take place at an appropriate facility offsite where possible. Alternatively, where washout takes place onsite, it will be carried out in carefully-managed onsite wash out areas.

5.10.1.8 Sources of Aggregates and Clean Fill for the Project

While it is anticipated all excavated materials will be re-used on site for the Proposed Development, 26,000 tonnes of aggregate will be brought to site for construction of the access road. In addition, there is potential for small quantities of clean fill materials to be required to facilitate other construction works, for example, where site-won soils or crushed rock are not of sufficient geotechnical or chemical quality for re-use. The source of this fill material will be vetted in order to ensure that it is of a reputable origin and that it is 'clean' (i.e. will not introduce contamination to the environment).

All potential suppliers will be vetted for the following criteria:

- Environmental management status; and
- Regulatory and legal compliance status of the company.

Clean fill material will be sourced from suppliers which comply with the above requirements. If recycled aggregate is used as imported fill, rigorous chemical testing will be undertaken to confirm that it is 'clean' (i.e. will not introduce contamination to the environment).

5.10.1.9 Earthworks

It is recommended that earthworks be undertaken in dry weather, where possible, in view of the sensitivity of the overburden to moisture content. For the same reason, it is recommended even, inclined surfaces be maintained on cut and fill surfaces to prevent rutting and water pooling.

5.10.2 Operational Phase

5.10.2.1 Fuel and Chemical Handling

All hazardous or water-polluting materials will be handled or stored in a manner to prevent/ minimise potential impact on soil.

With regard to the emergency back-up generators associated with the Proposed Development, the diesel will be stored in fuel tanks in bunded areas. Bunding will also be provided for each transformer bay.

If a leak from one of the fuel storage tanks were to occur this will be identified by the leak detection system that will be present on each tank. The generator will be disabled in this event and the fuel will be allowed to collect within the bund

All bunds will provide 110% capacity, automatic emptying of rainwater and have valved discharge points.

Secondary containment will also be provided for other hazardous materials to be stored onsite, such as maintenance oils, odorants and cleaning chemicals.

Spill kits will be located at strategic points around the Proposed Development in order to ensure a quick response to any spillages shall they occur. Any used spill kits will be disposed of using a hazardous waste disposal contractor and in accordance with relevant EU and Irish waste management legislation. The EPA Guidance Note 'Storage and Transfer of Materials for Scheduled Activities' (EPA, 2004) shall be taken into account when designing material storage and containment onsite.

5.10.2.2 Environmental Management Plan

An environmental management plan will be prepared for the Proposed Development during the operational phase incorporating all mitigation measures and emergency response measures, as described in this assessment.

5.11 Do Nothing Scenario

Should the Proposed Development not take place, the soils and geology will remain in their current state and there will be no change.

5.12 Residual Impacts and Effects

5.12.1 Construction Phase

The implementation of mitigation measures highlighted above will significantly reduce the likelihood and magnitude of the potential effects on land and soils occurring during the construction phase. The magnitude of the potential residual effects during construction phase is therefore considered to be **negligible** on an environment of **low** sensitivity, therefore the significance of the potential effect of the Proposed Development is considered to be **imperceptible** on the surrounding land and geological environment.

5.12.2 Operational Phase

The implementation of measures inherent to the building design and mitigation measures highlighted above will significantly reduce the likelihood and magnitude of the potential effects on land and soils occurring during the operational phase. The magnitude of the potential residual effects during construction phase is therefore considered to be **negligible** on an environment of **low** sensitivity, therefore the significance of the potential effect of the Proposed Development is considered to be **imperceptible** on the surrounding land and geological environment.

5.13 Decommissioning Phase

As outlined in Chapter 02 – Project Description, in the event of decommissioning, measures will be undertaken by the Applicant to ensure that there will be no significant, negative environmental effects from the closed LNG Terminal and Power Plant. Examples of the measures that will be implemented are outlined in Section 2.9.12, Chapter 02 – Project Description. As a result, additional potential impacts and associated effects arising during the decommissioning phase are not anticipated above and beyond those already assessed during the construction phase.

5.14 Summary

The Proposed Development site covers an area of approximately 41 ha (or 52 ha including the offshore elements) and comprises grassland on the southern shore of the Shannon Estuary, with a jetty and outfall pipe extending into the marine environment. Onshore and offshore geological/ geotechnical site investigations were undertaken at relevant locations on the Proposed Development site in 2006 and 2007.

Soil deposits comprise predominantly ‘till derived from Namurian sandstones and shales’ with small amounts of alluvium in localised areas, up to 4.2 m thick in total. Groundwater was encountered in place within the till, with low rates of inflow. Permeabilities of 3 to 4 x 10^{-6} m/s were calculated for the upper till. Geotechnical testing showed the upper till loses strength rapidly with increasing moisture content and behaves like a clay/ silt and clay, despite its high granular content. The lower till layer overlying bedrock is stiff and is of low permeability and no water strikes were recorded in this material.

The bedrock underlying the Proposed Development site is described as mudstone, siltstone and sandstone of the Shannon Group, of Namurian age, with siltstone and sandstone predominating in the area of the proposed jetty, LNG Terminal and Power Plant construction. The bedrock outcrops along the majority of the site’s northern boundary. Groundwater in the bedrock is classified as a ‘Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones’. Groundwater was encountered in the upper fractures/ weathered zone of the bedrock and topographically-driven artesian conditions were noted in a number of isolated locations across the Proposed Development site.

Groundwater vulnerability varies across the Proposed Development site from 'Moderate' to 'Rock at or near Surface or Karst' and depth to rock onshore varies from 0.75 m in the east of the Proposed Development site to up to 9.8 m, with the top of bedrock becoming deeper with increasing distance offshore.. A number of inactive faults orientated from northwest to southeast were inferred in the area. Bedrock permeabilities were moderate and ranged from 1×10^{-5} to 5×10^{-6} m/s depending on rock type. The bedrock is described a moderately strong, crushable and suitable for use as aggregate and engineered fill onsite.

Radon, seismic and tsunami potential risks are considered 'Low'.

Soils and geology encountered at the Proposed Development site are considered favourable for the construction of the proposed LNG plant, with most plant founded on bedrock at the cut platform level of 18 m OD and all excavated soil and rock material (of the order of 480,000 m^3) will be suitable for re-use onsite as general or structural fill or for landscaping. The ESM SEA mapping tool indicates the Proposed Development site to have a low to very low sensitivity with respect to existing soils and geology.

Construction stage spill and leaks, including the use of concrete and lime products and fuels, are expected to give rise a low impact on a low sensitivity environment, if managed in accordance with the OCEMP. The significance of any effect arising from this is slight.

The impact will therefore result in a **small adverse** effect on a **low** importance soil environment and the significance of the effect will be **imperceptible** with regard to soils.

Other construction phase risks arise from excavation, pile construction, rock breaking and material stockpiles on the site in terms of rock slope stability and silt runoff. Driven piles will be used offshore where possible to minimise sediment mobilisation and bored piles will be installed using reverse circulation techniques to minimise temporary impacts from drill cuttings or grout on the estuary. Pile arisings will be used onshore as to form a landscaping berm on the north-eastern edge of the site, subject to chemical suitability. The removal of land from agricultural or other potential beneficial uses is considered a permanent direct effect. Temporary storage of soil and crushed rock will be stored in low sensitivity areas distant from the shoreline, drainage systems, retained drainage channels or areas subject to flooding and will be carefully managed in accordance with the OCEMP to prevent potential negative effect on the receiving environment.

Operational Phase risks to soils and geology will arise principally from diesel fuel tanks for the fire water pumps and generators which will be managed by siting this equipment within bunded areas resulting in a low risk of impact to a low sensitivity environment and the significance of any effect is **slight**.

Mitigation measures associated with both the construction and operational phases of the Proposed Development have been proposed, which may also interact with waste management and water aspects of the development.

An OCEMP has been prepared for the Proposed Development which incorporates relevant environmental avoidance or mitigation measures to reduce potential environmental impact.

Construction Phase mitigations include:

- Foundation solutions will be designed based on the properties of the underlying soils and bedrock;
- Temporary storage of soil/ crushed rock will be managed to prevent potential negative impact on the receiving environment;
- Soils will be tested for their chemical and geotechnical suitability prior to re-use as fill;
- Fill placement and compaction will be undertaken in line with defined procedures and will be inspected by a geotechnical engineer;
- Concrete use and wash-out areas will be in designated area with measures to prevent alkaline wastewaters or contaminated storm water to the underlying subsoil, surface watercourses or to the marine environment; and
- Any fill material brought on to Proposed Development site will be vetted in order to ensure that it is of a reputable origin and that it is 'clean' (i.e. will not introduce contamination to the environment).

Operational Phase mitigations include:

- Handling all hazardous or water-polluting materials in a manner to prevent/ minimise potential impact on soil;
- Secondary containment and spill kits will be provided for other hazardous materials to be stored onsite, such as diesel fuel, chemical odorant, maintenance oils and cleaning chemicals; and
- An Environmental Management Plan will be prepared for the operational phase.

Cumulative impacts arising from the related LNG Pipeline, Data Centre Campus and medium voltage (10/ 20kV)/ 220kV power supply developments envisaged under the Master Plan were considered and no significant cumulative effects were identified to geology and soils. These developments will be subject to separate EIARs. The cumulative operational effect of the Proposed Development and cumulative schemes are considered to be slight.

Should the Proposed Development not take place, the soils and geology will remain in their current state and there will be no change.

The residual effect of the Proposed Development on the surrounding land and geological environment is considered to be imperceptible at both the construction and operational phases.

Table 5-8 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 Effect Significance
Construction	Changes to Topography – Excavation and Infilling	Low	Excavation and reuse of 480,000 m^3 of soil and rock. Permanent, direct, irreversible moderate effect	Neutral	All surplus material will be processed (screened/ crushed) and reused onsite and there is no intention to import soil material to the Proposed Development site. 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 runoff to soils. Movement of material will be minimised in order to reduce degradation of soil structure and generation of dust. The OCEMP will outline proposals for the excavation and management of excavated material.	Slight
Construction	Use of Natural Resources	Low	Excavation and reuse of 480,000m^3 of soil and rock. Permanent direct Irreversible effect, of neutral quality	Negligible	All excavated material will be reused onsite. Offshore pile arisings will be reused onshore as landscaping material to form a berm on the north-eastern edge of the site, subject to chemical suitability. 26,000 tonnes of aggregate will require to be brought to site from local quarries for the formation of access roads during construction. The source of this fill material will be vetted in relation to the environmental management status and regulatory and legal compliance status of the originating facility and include appropriate chemical testing if derived from recycled fill material. Certain to occur and irreversible, but will be imperceptible within wider environment.	Not significant
Construction	Accidental Spills and Leaks Spillage or leakage of stored oils and fuels; Spillage or leakage of oils and fuels from construction machinery or site vehicles; and Spillage of oil or fuel from refuelling machinery on site.	High	Adverse impact on soils underlying the Proposed Development site. Direct negative small effect of temporary duration	Medium	Spillages are unlikely to occur and, if they occur, will be confined to one-off releases. Hazardous materials will be controlled via the OCEMP and stored in bunded areas. Low impact on a low sensitivity environment and the significance of the impact is slight. In order to prevent spillages to ground of fuels, and to prevent any consequent soil or groundwater quality impacts, it will be necessary to adopt mitigation measures during the construction phase, which include: • Designating a bunded storage areas and handling procedures for all oils, solvents and paints used during construction; • Refuelling of construction vehicles and the addition of hydraulic oils or lubricants to vehicles, will take place in a designated area with appropriate facilities; and • Refuelling outside of the designated area will be via a mobile double skinned tank with lockable fittings and an onboard spill kit.	Imperceptible
Construction	Use of Concrete and Lime	Low	Lime and concrete (specifically, the cement component) is highly alkaline and can impact soil quality during piling and building construction. Direct small effect of negative nature and temporary duration	Medium	Hazardous materials will be controlled via the OCEMP and stored in bunded areas. A suitable risk assessment for wet concreting will be completed prior to works being carried out, which will include measures to prevent discharge of wet concrete, grout, alkaline wastewaters or contaminated storm water to the underlying subsoil or to the marine environment. Washout of concrete-transporting vehicles will take place at an appropriate facility off site where possible, alternatively, where washout takes place onsite, it will be carried out in carefully-managed onsite wash out areas. Potential for low impact on a low sensitivity environment and the significance of the impact is slight.	Imperceptible
Construction	Impact on Soil/ Geology	Low	Slight to moderate beneficial effect	Neutral	The opportunity to study and document regional glacial geology through cutting and foundation pit exposures in the glacial deposits and bedrock, which will add to the national records. Shallow soils are therefore considered to have a neutral to favourable effect on the Proposed Development and to be a minor beneficial effect on a low importance soil environment, and the significance of the effect is imperceptible. Unweathered bedrock is expected to provide a competent foundation medium, therefore bedrock quality is therefore considered to have a moderate favourable impact effect on the Proposed Development in a low importance bedrock environment, and the significance of the effect is slight.	Imperceptible to slight
Operational	Accidental Spills and Leaks	Medium	Spills during fuelling at diesel fuel tanks for the fire water pumps and generators can in theory discharge to ground. Direct negative small effect of temporary duration (given that they will be confined to one off releases).	Medium	All hazardous or water-polluting materials will be handled or stored in a manner to prevent/ minimise potential impact on soil. Secondary containment and spill kits will be provided for other hazardous materials to be stored on site, such as maintenance oils and cleaning chemicals. Diesel fuel tanks for the fire water pumps and generators will be stored within bunded areas. Fuel will be prevented from entering the soil around the generators, as drainage will be directed to an oil/ water interceptor prior to discharge to the storm water drainage system. In addition, there will be a shut off valve from the generator yard to the external surface water drainage network.	Imperceptible

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 Effect Significance
Operational	Removal of Land from Agricultural Use	Low	The Proposed Development is located in a 603 acre landbank that is zoned for industrial development and will cover a development area of 41 ha of the overall site (excluding offshore elements). The total hardstanding area is estimated to cover 14 ha, with the remainder unsurfaced, landscaped or attenuation ponds. The removal of land from agricultural or other potential beneficial uses is considered a permanent, direct, small negative effect.	Medium	The removal of agricultural land can be considered to be permanent and the impact is considered negative; however, it is likely to be of low magnitude given the site is located within an agricultural setting where land use is predominantly of agricultural nature.	Slight

5.15 References

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