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22. Major Accidents and Natural Disasters

22.1 Introduction

22.1.1 This chapter of the Preliminary Environmental Information (PEI) Report presents an assessment of the Major Accidents and Natural Disaster (MA&ND) that have the potential to arise during the construction, operation and decommissioning of the Proposed Development. This includes an assessment of the reasonably foreseeable worst-case environmental consequences (i.e. the expected significant effects), the measures envisaged to prevent or mitigate the significant adverse effects of such events on the environment, and details of the preparedness for and proposed response to MA&ND hazards and threats relevant to the construction, operation and decommissioning of the Proposed Development

22.1.2 The underlying objective of this assessment is to identify appropriate precautionary actions, to prevent or mitigate potentially significant risks associated with MA&ND.

22.2 Legislation and Planning Policy Context

22.2.1 Regulation 5, Part 4 of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 states that:

"The significant effects to be identified, described and assessed include, where relevant, the expected significant effects arising from the vulnerability of the proposed development to major accidents or disasters that are relevant to that development."

22.2.2 Schedule 4, Part 8 requires an Environmental Statement (ES) to provide:

"A description of the expected significant adverse effects of the development on the environment deriving from the vulnerability of the development to risks of major accidents and/or disasters which are relevant to the project concerned."

22.2.3 The Proposed Development is anticipated to be subject to the Control of Major Accident Hazards (COMAH) Regulations 2015 (HSE, 2015) and the Environmental Permitting Regulations (EPR) 2016.

22.2.4 In accordance with the requirements of Planning Regulations, an assessment of the risk of Major Accidents and Natural Disaster relevant to the Proposed Development is therefore required, together with the measures envisaged to prevent or mitigate the significant adverse effects of such events on the environment and details of the preparedness for and proposed response to such emergencies.

22.2.5 This assessment is a preliminary review, based on the current engineering design documentation. This assessment does not seek to duplicate the assessment of matters covered by other regulatory regimes such as COMAH or EPR, instead it provides a summary of the types of MA&ND hazards and threats anticipated by these regimes, the potential worst-case environmental consequences these could pose and the required mitigation. Further detailed hazard and risk analysis will be included in the Environmental Statement and undertaken throughout the Proposed Development lifecycle, in accordance with the requirements of EPR and COMAH Regulations.

22.2.6 This assessment for the PEI Report has applied Rochdale Envelope principles, which assesses credible, worst-case Major Accidents and Natural Disaster associated with the Proposed Development. This conservative methodology establishes the worst-case scenarios, the risk of which would be reduced to a level as low as reasonably practicable by the design and operation of the facilities. At this stage in the project, safety and control systems have not yet been fully designed for the Proposed Development. However, standard industry approaches to managing risk will be used. In addition, equipment such as process monitoring and safeguarding systems and embedded mitigation such as fire and gas detection, and passive and active fire prevention measures will be installed as required.

22.3 Methodology

Definitions

22.3.1 Major accidents are defined as those that could result in multiple fatalities and serious injuries and/or widespread damage to property and the environment as a result of a single incident. The impact of major accidents can be significant, with the potential to impact people both on and off-site, assets and property on and off-site, and the surrounding environment.

22.3.2 Disasters can be natural, such as earthquakes, landslides and flooding or can be caused by accidental loss of containment, such as leaks which may lead to asphyxiation, fires and/or explosions.

22.3.3 Both natural and accidental causes are considered in this assessment to determine the potential impact of any major accidents or disasters on:

a. population and human health;

b. biodiversity, with particular attention to species and habitats protected under The Conservation of Habitats and Species Regulations 2017 (the Habitats Regulations) (transposing the EU Council Directives on Birds and Habitats (Council Directive 92/43/EEC));

c. land, soil, water, air and climate; and

d. property and material assets, cultural heritage and the landscape.

Guidance

22.3.4 There is no specific guidance available which sets out the approach for undertaking a MA&ND assessment within EIA. However, there is a considerable amount of information and guidance available to developers on the identification and control of major hazards associated with the design and operation of gas fired power stations, the storage and use of chemicals, and major accident hazard pipelines conveying high pressure gases. Comparable facilities have been in operation for many years and employ conventional, established technology to produce electrical power from the combustion of natural gas. The Health and Safety Executive (HSE) publish a number of applicable guidance notes on their website relating to these assets, including

- Emergency planning for major accidents: Control of Major Accident Hazards Regulations 1999 (COMAH), (HSE, 1999);
- Further guidance on emergency plans for major accident hazard pipelines (HSE, 1996); and
- The Control of Substances Hazardous to Health Regulations (HSE, 2002).

22.3.5 Carbon dioxide is not flammable and will not support combustion and compared with many other materials conveyed via major pipelines in the UK, such as natural gas and ethylene, the risks to human health and the environment from events such as explosion are relatively low. However, as the concentration of CO_2 in ambient air or water rises, the hazardous effects on people and the environment increase. The key risk relates to its potential to act as an asphyxiant gas at low-lying locations, should it displace air from these locations due to its higher density. High levels of dissolved CO_2 in water can also result in impacts from acidification and subsequent effects on shell-forming species.

22.3.6 Guidance and best practice information for carbon capture technology and transport via pipeline is available from the Health and Safety Executive (HSE), who have published a number of documents, which are available on a dedicated page available on their website. The guidance includes the following:

- Guidance on conveying carbon dioxide in in pipelines in connection with carbon capture and storage projects (HSE, 2020); and
- CO_2 Pipelines Good Practice Guidelines – Technical Report (HSE, 2013)

22.3.7 The HSE does not currently provide Land Use Planning (LUP) advice for CO_2 capture, transport or storage, and the status of the Proposed Development relating to the Control of Major Accident Hazards (COMAH) Regulations has not been confirmed. However, the HSE is a statutory consultee for all Nationally Significant Infrastructure Projects (NSIPs), such as the Proposed Development therefore consultation with the HSE will be ongoing throughout the design and planning process.

22.3.8 Other guidance that is of relevance to the assessment of MA&ND includes:

- Chemicals and Downstream Oil Industries Forum Guidelines, Environmental Risk Tolerability for COMAH Establishments (CDOIF, 2017);
- Chapter 4 of the Cabinet Office's Emergency Preparedness guidance on part 1 of the Civil Contingencies Act 2004 (hereafter referred to as the 'CCA risk assessment framework') (HM Government, 2006);
- Reducing Risks, Protecting People: HSE's decision making process, (HSE, 1999).

Approach to Assessment

22.3.9 As discussed above, the MA&ND assessment approach differs from the generic EIA methodology in which assessments broadly consider the magnitude of impacts and value/sensitivity of resources/receptors that could be affected in order to classify effects.

22.3.10 The MA&ND assessment identifies the reasonably foreseeable worst-case environmental consequence of a hazard or a threat (i.e. the likely significant effect) on the basis of its potential severity of harm and duration. However as by definition, all MA&ND hazards and threats could result in some form of serious damage and therefore, in significant environmental effect(s), the assessment then considers the likelihood of that hazard or threat occurring. Therefore, the MA&ND assessment focuses on determining the tolerability of the identified risks, whilst taking into account any proposed embedded mitigation measures. The assessment is conducted using a staged approach:

- Identification of hazards and threats based on the concept design work completed to date and in accordance with industry standard approaches to hazard identification;
- Screening of hazards and threats, including the likely significant effect;
- Identification of prevention, minimisation and/or mitigation measures; and
- Identification of residual risks and a conclusion on the tolerability and significance of the residual risk.

Assessment Criteria

22.3.11 Assessment criteria have been developed in accordance with the Chemical and Downstream Oil Industries Forum Guidelines on Environment Risk Tolerability for COMAH Establishments (CDOIF, 2017), which is a common approach adopted in MA&ND assessments in recent applications for NSIPs. Reference is also made to the criteria provided within the CCA risk assessment framework to allow for consistency with future emergency planning at a local level.

22.3.12 In line with Chemical and Downstream Oil Industries Forum Guidelines, the MA&ND assessment characterises threats or hazards against the following categories in order to assign a tolerability and a risk classification to each hazard or threat:

- severity of harm;
- duration;
- consequence; and
- probability.

22.3.13 Severity of harm, duration, and the consequence of a hazard or threat are determined on the basis of a reasonably foreseeable worst-case environmental effect of the event in the absence of mitigation. However, the probability and magnitude of the hazard or threat occurring is also determined whilst considering the proposed mitigation and whether the proposed embedded mitigation measures need augmenting further. This is because mitigation would reduce the likelihood of the maximum severity of harm, duration, consequence, and the frequency of a hazard or threat occurring.

22.3.14 The tolerability of the residual risk is determined by combining the reasonably foreseeable worst-case consequence and probability categories. All residual risks are categorised as 'tolerable', 'tolerable if ALARP'(as low as reasonably practicable) and 'intolerable'.

22.3.15 As a general rule, tolerable and tolerable if ALARP risks are considered as 'not significant' and intolerable risks are considered as 'significant'. Risks categorised as 'tolerable if ALARP' would generally require further approval of the details of proposed mitigation by an appropriate regulatory body such as the Health and Safety Executive or Environment Agency.

Scope of the Assessment

Study Area

22.3.16 The study area for individual identified hazards and threats has been considered based on the likely impact pathways, distances to receptors, the scale of potential worst-case impact from case-study incidents, or on professional judgement if no information on previous events is available.

Scenarios

22.3.17 The assessment for the Proposed Development considers two scenarios:

- Construction phase, including construction of the Power, Capture and Compression site (PCC) facilities, and the connections within the identified connection corridors; and
- Operation phase of the Proposed Development.

22.3.18 Decommissioning of the Proposed Development is not specifically included as the hazards are anticipated to be encompassed by those assessed for the construction and operation phase, and no additional decommissioning hazards have been identified.

Consultation

22.3.19 An EIA Scoping Opinion was received from the Planning Inspectorate in April 2019 (Appendix 2A: Scoping Report and Appendix 2B: Scoping Opinion, PEI Report, Volume II).

22.3.20 Table 22-1 provides an account of how comments raised by stakeholders in the Scoping Opinion in relation to Major Accidents and Natural Disaster have been considered and actioned where appropriate.

Table 22-1: Key Issues Raised in Relation to Major Accidents and Natural Disaster During EIA Scoping

Key issue raised (by whom, ID/page no., theme)	Response to issue raised and action taken where appropriate
Secretary of State Scoping Opinion, 4.10.8: Health and Safety. The Scoping Report identifies the potential for health and safety impacts to arise but does not provide further detail regarding the proposed assessment of these impacts. The ES should set out the proposed methodological approach for assessing these matters.	Health and safety impacts related to Major Accidents and Natural Disaster are covered within this chapter.
The Scoping Report proposes to scope out a specific assessment for major accidents or disaster vulnerability on the basis that risks of major accidents would be suitably assessed, regulated and controlled by other legislative framework (including through an application of an Environmental Permit and through accordance with the Control of Major Accident Hazards Regulations 2015). The Scoping Report confirms that accidental events such as fuel spillages and abnormal air emissions would be discussed in relevant chapters of the ES and a risk assessment for accidental events would be provided. With regard to major accidents, the Inspectorate is content that provision of the assessments within other relevant ES aspect chapters should not impede the ability of the ES to adhere with the EIA Regulations and welcomes the intention to include a risk assessment. The Applicant should ensure that the introductory sections of the ES contain clear cross referencing to where the assessment of major accidents or disasters is located. There should be sufficient information in the ES regarding Major Accidents and Natural Disaster where likely significant effects could occur. Paragraphs 8.4-8.10 of the Scoping Report do not specifically address the issues of disaster vulnerability; therefore, the Inspectorate does not agree that this aspect can be scoped out of the ES.	As a result of the Inspectorate's comments a Major Accidents and Natural Disaster chapter has been produced in line with available guidance. This assessment includes fires/explosions, noxious substances, storms, climate change, terrorism/arson, earthquakes, lightning, aeroplane/drone impacts, and domino effects from neighbouring facilities. Embedded mitigation and design impact avoidance measures will be in place for the operational Proposed Development to minimise major accidents and hazards arising from it, including a HAZID, a HAZOP, a COMAH licence, and an Environmental Permit. The engineering design shall accommodate all necessary mitigation measures. Emergency plans will be produced in accordance with the Environmental Permit.

Assumptions & Limitations

22.3.21 This assessment is based on the preliminary design of the Proposed Development and early appraisal of potential hazards that will be refined and reappraised as the project develops.

22.4 Baseline Environment

22.4.1 This section presents a description of the baseline environmental characteristics within the study area. The baseline relevant to this topic comprises:

- A description of potential natural hazards which may impact the Site, including meteorological hazards, geological hazards and other types of hazards;
- Existing major accident hazard sources that may impact the Site;
- Other hazards and threats identified within the UK National Risk Register (HM Government, 2017);
- Sensitive environmental receptors within the study area at risk of MA&ND hazards associated with the Proposed Development.

Natural Hazards

Meteorological Hazards

22.4.2 Hazards resulting from severe weather events which could impact the Proposed Development include:

- flooding, comprising:
  - flooding following heavy rainfall events (including fluvial, surface water, groundwater and sewer flooding);
  - coastal flooding following storm surge (relevant to main development site only);
- storms and gales;
- drought;
- heatwave;
- cold and snow;
- lightning and electrical storms (thunderstorms);
- events of reduced visibility (e.g. due to volcanic ash, dust sand or fog); and
- extreme humidity (high and low).

Geological Hazards

22.4.3 As outlined in Chapter 10: Geology and Hydrogeology (PEI Report, Volume I) the geology underlying the Site is of no risk or very low to low risk of hazards associated with ground stability, such as landslides, ground collapse, ground compression, sinkholes, running sand and shrinking or swelling of clay.

Seismic Hazards

22.4.4 Based on the information provided in Chapter 10: Geology and Hydrogeology (PEI Report, Volume I) the geology underlying the Site is of no risk or very low risk of seismic hazards.

Existing Major Accident Hazards

22.4.5 Existing major accident hazard sources include industrial sites (such as those operated under COMAH and Hazardous Substances Consents (HSC)), waste management sites, electricity, gas and fuel infrastructure which may pose a risk of fire, explosion or an industrial accident, such as chemical release, airfields, as well as residual risk from unexploded ordnance (UXO).

22.4.6 Onsite UXO risks will be managed in accordance with the Construction Industry Research and Information Association (CIRIA): guidance document: Assessment and management of unexploded ordnance risk in the marine environment (C754) (CIRIA, 2016). Firstly, by conducting a detailed desk-based risk assessment and then, if required, by on-site risk management, including a geophysical survey.

22.4.7 Industrial sites that could be the source of, or increase the risk or consequences of, a major accident and/or domino effect have been identified and assessed in Section 22.8 of this chapter. The sites considered include:

- Bran Sands Wastewater Treatment Plant;
- Teesport;
- Seal Sands and North Tees and Billingham Industrial Areas; and
- Teesside Renewable Energy Power Station (Tees REP)

Sensitive Environmental Receptors

22.4.8 Chapter 3: Description of the Existing Environment (PEI Report, Volume I) sets out the closest environmental receptors to the Site. These include residential receptors, ecological receptors, controlled waters and Public Rights of Way and permissive paths.

22.5 Development Design and Impact Avoidance

22.5.1 The following impact avoidance measures will either be incorporated into the design or are standard construction or operational measures. These measures have therefore been taken into account during the impact assessment process described in this chapter:

Design

22.5.2 The design engineers will prepare a number of philosophies with regard to process safety and safeguarding, isolation, emergency shutdown and if required, depressurisation. The design engineers will also review the layout and give due consideration both to the on-Site location of facilities as well as the off-Site receptors.

22.5.3 A design hazard management plan will be prepared and a number of hazard identification and evaluation assessments (HAZID and HAZOP reviews) have been and will continue to be carried out on the Proposed Development during the design process, which is a standard approach to preventing or

otherwise minimising hazardous scenarios through appropriate design during the Front End Engineering Design (FEED) studies to be progressed.

22.5.4 Major accident assessments and studies will be prepared over the course of the design development and a Major Accident Prevention Plan (MAPP) will be prepared to inform the application for COMAH Licence for the operational facility. CDM regulations will be followed as required.

Construction

22.5.5 The use of suitably experienced contractors, risk assessments, working method statements, operating procedures and personnel training will minimise the risk of accidental scenarios occurring during construction of the Proposed Development.

22.5.6 A Construction Environmental Management Plan (CEMP) will be prepared to set out how construction activities would be managed and controlled in compliance with accredited health and safety and environmental management systems, relevant legislation and environmental permits, consents and licences. A framework CEMP is included as Appendix 5A (PEI Report, Volume III).

Operation

22.5.7 As outlined previously, a COMAH Licence from the HSE and an Environmental Permit from the Environment Agency will be required for the operation of the Proposed Development. Both permissions require a number of stipulations and requirements to be fulfilled to the satisfaction of the regulators including use of appropriate control and monitoring procedures, risk assessments, management systems and control measures to minimise the risk of accidents occurring and to minimise the effects of any such accidents on offs-site receptors as well as the operational workforce. The permit requires the approach to managing accidents and emergencies to be in accordance with the use of Best Available Techniques (BAT).

22.6 Assessment

Construction

22.6.1 A number of potential accident scenarios could occur during construction of the Proposed Development including:

- Fire or explosion including through disturbance of UXO;
- Ground instability including collapse of excavations;
- Leaks and spillages of chemicals or fuels resulting in contamination or release of hazardous substances to the environment.

22.6.2 A summary of the construction phase assessment is provided within Table 22-1.

Operation

22.6.3 The assessment of Major Accidents and Natural Disaster considers operations on the PCC, the high pressure CO_2 Export Pipeline to Mean Low Water Springs and along the associated medium pressure CO_2 Gathering

Network and Natural Gas Connection Corridor plus the Electrical Connection Corridor.

22.6.4 There will be hazardous and potentially harmful substances present on the PCC, the CO_2 Export Pipeline, the Natural Gas Connection and in the CO_2 Gathering Network in quantities which, if released, have the potential to cause a major accident.

22.6.5 The hazardous substances on the operational PCC will include:

- Low, medium and high pressure CO_2 – an asphyxiant which is potentially toxic in high doses;
- Natural gas, a highly flammable gas comprising mainly of methane supplied via a dedicated pipeline and to be used as primary fuel in the CCGT;
- Hydrogen, a highly flammable gas, to be used as a coolant in the electrical generator and as a reagent in the oxygen removal system. Hydrogen will be stored on-site in compressed gas cylinders;
- Diesel fuel oil, a flammable and environmentally harmful liquid, to be used to provide fuel for emergency standby plant;
- Aqueous amine solutions (a proprietary blend of substances most likely including monoethanolamine (MEA)), which are harmful liquids to be used in the carbon capture CO_2 absorption and regeneration system;
- Reclaimer sludge from the absorber which is classed as hazardous waste;
- Potentially aqueous ammonia, a toxic liquid, which may be used in the treatment of exhaust gas emissions from the CCGT and in the treatment of water within the Heat Recovery Steam Generator (HRSG); and
- Other treatment chemicals as may be required for water treatment, wastewater treatment, solvent reclamation or other on-site processes.

22.6.6 Diesel fuel, aqueous ammonia and amine solutions will be stored in dedicated above ground bulk tanks mounted within secondary containment bunds, so as to contain spillages.

22.6.7 Smaller quantities of other hazardous materials will also be present on site. These substances would not be expected to initiate or exacerbate major accidents or disasters but could be harmful in the event of a major accident, that causes loss of containment. For example, if hazardous substances were released during a fire event, due to the failure of storage vessels, which resulted in the hazardous substances being present in the firewater runoff. These hazardous materials, present in small quantities, include nitrosamines and nitramines, which are present within the CO_2 absorption/regeneration system. Water and effluent treatment chemicals used on-site in smaller quantities will include sodium hydroxide and hydrochloric acid. Smaller inventories of synthetic oils will be present in transformers and rotating equipment.

22.6.8 Design and operational controls will be in place to manage the risks associated with the smaller inventories of the above hazardous substances including use of dedicated bunded above ground storage areas, segregation of incompatible materials, dedicated filling points and management procedures for the handling, storage and use of the materials.

22.6.9 Table 22-2 lists the potential Major Accidents and Natural Disaster relevant to the operation of the Proposed Development and the storage and handling of hazardous substances present on site.

22.6.10 The information summarised in Table 22-2 has been based on the Preliminary Hazard and Environmental Assessments (PHEA) undertaken for the Proposed Development.

22.6.11 Additional information is presented in Section 22.7 on the risks associated with a release of CO_2, and a description of the potential for large scale “knock-on” accidents, referred to as Domino Effects, is presented in Section 22.722.8.

Table 22-2: Summary of Major Accidents and Natural Disasters

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
1	Fire/explosion	Natural gas – loss of containment from supply pipeline and/or power plant equipment. Hydrogen – loss of containment from storage cylinders, pipework and/or process equipment (cooling equipment and oxygen removal equipment) Whilst the volume of hydrogen stored on the site will be low, a release of flammable gas could be caused by mechanical failure or impact damage resulting in a loss of containment. Immediate ignition of the gas would lead to a localised flash or jet fire depending on gas volume and pressure. Delayed ignition could lead to an explosion and/or fire.	Fire and/or explosion could result in significant harm to people on Site, with the potential for fatal injuries. There is also the potential for harm to people and businesses off-site, such as radiant heat burns and impact injuries from explosions. The environmental impact of a major fire could affect the Teesmouth and Cleveland Coast SPA/Ramsar site and the Teesmouth and Cleveland Coast SSSI, as a result of thermal radiation and run-off of firewater. It is unlikely that this type of accident could impact listed buildings or other heritage sites based on distance. Firewater run-off reaching areas of unmade ground could contain contaminants which would be potentially harmful to groundwater.	Design of the natural gas systems to industry codes and standards. Compliance with the Pressure Equipment (Safety) Regulations 2016 and the Pipelines Safety Regulations (PSR) (HSE, 1996). Selection of pipeline routes, depth of cover in areas of higher risk, use of existing established pipe racks and the construction of safety systems to prevent pipeline damage, such as the installation of barriers. Pipeline safety systems and gas/liquid pressure regulation to be installed along with operational controls and monitoring. Gas Detection systems at the Site and in the vicinity of high hazard areas. Minimising the storage volumes of high hazard	Tolerable (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
				materials (e.g. small volumes of hydrogen) Fire detection and fire protection systems will be installed on the site, including passive and active fire suppression systems. The PCC would be designed to contain firewater runoff and prevent material reaching unmade ground or other environmental receptors. Detailed emergency plans will be produced for the installation in accordance with the Environmental Permit and all applicable Regulations.	
2	Fire	Diesel fuel oil – release of flammable liquid from storage, pipework or operating equipment Whilst the volume of diesel stored on the site will be low, the ignition of diesel, released due to failure of primary containment, could result in a localised pool fire if the vapour found a source of ignition.	A local diesel pool fire could result in harm to people on-site and damage to assets but would be unlikely to escalate to a major accident affecting areas off-site as diesel fuel would only be used in small quantities as start-up fuel or for back-up generators located in close proximity to the main generating station or compression equipment, some	Design of the storage tanks to industry codes and standards. Installation of the storage tank(s) within a secondary containment system (bund) designed in accordance with CIRIA C736 guidance (CIRIA, 2014). Instrumentation and control systems will be installed to	Tolerable (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
			distance from the Site boundary.	monitor tank contents and prevent overfill. Minimising the storage volumes of high hazard materials. Depending on the inventory of diesel and other dangerous substances, the PCC may be regulated through the Control of Major Accident Hazards (COMAH) Regulations (HSE, 2015). It will also be regulated though an Environmental Permit.	
3	Toxic/asphyxiant gas release	Accidental release of CO_2 at high pressure on the PCC or from a medium or high pressure pipeline.	CO_2 is toxic and an asphyxiant, depending on the concentration in air. It is also odourless and heavier than air. A leak or rupture of a system containing high pressure (dense phase) CO_2 will be noisy and will be observed with the naked eye due to the transition between the phases. There will be an associated large reduction in temperature from a high pressure release	Detailed standards and codes of practice written specifically for the design and operation of dense phase or supercritical CO_2 plant and pipelines are still being developed, therefore industry codes and standards for gas and chemical pipelines will be applied where appropriate. According to the HSE, "*ongoing work suggests that the hazards involved with the bulk transport of CO_2 are similar to the hazards transporting natural gas*".	Tolerable if ALARP (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
			A release of CO_2 could be caused by mechanical failure or impact damage resulting in a loss of containment. The impact of the release on people and the environment depends on the pressure, temperature and mass of material that is lost, however there is the potential for a major accident resulting in significant harm and potential fatalities, both on-site and off-site. Further details of the hazards associated with a CO_2 release are contained in Section 22.7.	The PCC has been deliberately sited close to the shoreline to maximise distance from sensitive receptors so as to prevent the harmful consequences of any major accidents. In particular, the siting of the high-pressure CO_2 system close to the shoreline minimises the risk of any high-pressure CO_2 release from impacting off-site receptors, particularly given the prevailing wind direction. Compliance with Pipeline Safety Regulations (1996) and additional specific safety measures for CO_2 pipelines will apply, including the monitoring of fluid composition and the prevention of water ingress, which could accelerate corrosion and premature failure. Pressure monitoring and pressure relief systems to prevent overpressurisation situations. Use of containment measures and barriers to prevent damage to pipelines.	

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
				Detailed emergency plans will be produced for the installation in accordance with the Environmental Permit and all applicable Regulations.	
4	Toxic/asphyxiant gas release	Release of medium pressure CO_2.	CO_2 is toxic and an asphyxiant, depending on the concentration in air. It is also odourless and heavier than air. A leak or rupture from a system containing low or medium pressure (gas phase) CO_2 from the CO_2 Gathering Network is unlikely to be seen as it is an odourless and transparent gas. Depending on the energy of the gas there will be limited dispersion. The risk is that medium pressure CO_2 is not dispersed and not seen. A release of low-pressure gaseous CO_2 would be caused by mechanical failure or impact damage resulting in a loss of containment. The impact of the release on people and the environment depends on the pressure, temperature and mass of gas that is lost, however there is the potential for a major accident resulting in significant	Compliance with Pipeline Safety Regulations (HSE,1996) and additional specific safety measures for CO_2 pipelines will apply, including the monitoring of gas composition and pressure and the prevention of water ingress, which could accelerate corrosion and premature failure. Leak detection systems. Isolation valves in the pipeline system to minimise inventory release to the atmosphere. Use of containment measures and barriers to prevent damage to pipelines.	Tolerable (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
			harm and potential fatalities, both on-site and off-site.		
5	Toxic release (liquid or gaseous amine solvent)	Release of abnormal levels of amine from CO_2 absorption/regeneration system.	Amines used in the CO_2 absorption/regeneration system are non-flammable, toxic solvents which are harmful to people and hazardous to the environment. An abnormal release of amines could occur from failure in process equipment, pipework, the offloading (road tanker import) system and storage vessels and could be caused by mechanical failure or impact damage. Loss of this material into surface water drains could reach local watercourses including the River Tees or the adjacent Teesmouth SPA. Therefore, this would be a major accident with the potential to harm the local environment as a result of the toxicity of amines, and by an increase in the pH of the environment and by the reduction in the dissolved	Amine storage tank(s), process equipment and pipework design and construction to industry standards. Site process water to be segregated from surface water drains and routed to holding tanks or wastewater treatment plant for treatment and testing prior to discharge. Surface water drains and attenuation system to have isolation valves installed to be closed in the event of accidental spillage into the uncontaminated surface water drainage system. Design of site containment facilities and drainage systems to industry standards (e.g. CIRIA C736) and operated in accordance with the Environmental Permit. Gas sensors and emissions and process monitoring systems to monitor release	Tolerable if ALARP (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
			oxygen concentration within the river.	concentrations with alarms to inform operatives of elevated release levels and interlocks to automatically isolate or shut down systems in the event of an abnormal release.	
6	Toxic release (N-amine degradation products)	Release of abnormal levels of N-amine from CO_2 absorption/regeneration system.	N-amines formed as by-products within the capture plant are non-flammable, toxic solvents which are harmful to people and hazardous to the environment. An abnormal release of N-amines could occur from process abnormalities could giving rise to elevated release concentrations from the emissions stacks.	Process equipment and pipework design and construction to industry standards. Gas sensors and emissions and process monitoring systems to monitor plant performance and amine degradation with alarms to inform operatives of elevated release levels and interlocks to automatically isolate or shut down systems in the event of an abnormal plant performance. Wastes from the CO_2 capture system to be collected for off-site disposal via a licensed hazardous waste management contractor.	Tolerable if ALARP (**not significant)**
7	Toxic and/or environmentally harmful release (including aqueous ammonia solution and diesel)	Release of aqueous ammonia or diesel through loss of containment.	Aqueous ammonia solution which may be used in the emissions abatement system, is harmful to people, causing burns, eye damage and	Ammonia and diesel storage tank(s), process equipment and pipework design and construction to industry standards.	Tolerable (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
		Associated with the aqueous liquid loss would be ammonia vapours from the liquid. Diesel may be stored in bulk tanks, to be used as fuel in back-up emergency power generators and/or firewater pumps.	respiratory irritation. It is toxic to aquatic life in the environment. A release of these substances could occur from failure in process equipment, pipework, the offloading (road tanker import) system and storage vessels and could be caused by mechanical failure or impact damage. Loss of these material into storm drains could reach local water courses including the River Tees or Teesmouth SPA. Therefore, this would be a major accident with the potential to harm the local environment as a result of the toxicity of the chemicals.	Minimising the storage volumes of high hazard materials Site process water to be segregated from surface water drains and routed to holding tanks or wastewater treatment plant for treatment and testing prior to discharge. Surface water drains and attenuation system to have isolation valves installed to be closed in the event of accidental spillage into the uncontaminated surface water drainage system. Design of site containment facilities and drainage systems to industry standards (e.g. CIRIA C736) and operated in accordance with the Environmental Permit.	
8	Domino effects from incidents at neighbouring facilities	Fire and/or explosion, toxic release, discharges to air and water.	The location of the PCC is on a former industrial site with no active industrial operations in the immediate vicinity with the exception of buried gas pipelines.	Further details of the potential hazards associated with domino effects to and from neighbouring industrial sites are contained in Section 22.8.	Tolerable (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
			The PCC lies within the consultation distances for these pipelines. There are no COMAH installations or high hazard installations in the vicinity of the PCC. The CO_2 Gathering Network and Natural Gas Connection Corridor do pass through the Seal Sands complex which includes COMAH installations and close to Bran Sands WWTW and pipelines along Dabholme Gut. These installations have the potential for major accident hazards such as fires, explosions and toxic releases. The proximity of these sites to the Proposed Development is such that they could have an impact on the Proposed Development pipelines.	Based on current operations in the vicinity of the PCC the risk of domino effect is considered acceptable and this position will be agreed with the operators of the respective pipelines.. Should new developments take place near to the PCC in the future these would need to be sited to prevent domino effects from occurring by following the HSE standard land use planning methodology (PADHI assessment). Similarly, the proposed CO_2 Gathering Network and Natural Gas Connection Corridor routes lie outside the consultation distances for the existing COMAH facilities and lie within existing pipeline corridors.	
9	Domino effects to neighbouring facilities	Fire and/or explosion, toxic release, discharges to air and water.	Neighbouring facilities include a wastewater treatment plant, port facilities and logistics centres. A major accident such as a fire, explosion or toxic	The PCC has been deliberately sited so as to maximise distance from sensitive receptors and other industrial operations so as to prevent the	Tolerable if ALARP (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
			release from the Proposed Development could potentially impact the operation of these facilities depending on plant locations.	harmful consequences of any major accidents. In particular, the siting of the high-pressure CO_2 Compressor close to the shoreline minimises the risk of any high-pressure CO_2 release from impacting off-site receptors, particularly given the prevailing wind direction. Further details of the potential hazards associated with domino effects to and from neighbouring industrial sites is contained in Section 22.8.	
10	Natural disaster - severe weather	Rainfall and storm surges could cause flooding from the River Tees.	The PCC is located in a Flood Zone 1 therefore there is a low risk of flooding which could be caused by storms increasing the height of the River Tees. The consequences of water flooding the PCC could include contamination with polluting substances, destabilising assets and compromising the integrity of plant and equipment.	A flood risk assessment is contained in an appendix to Chapter 9: Surface Water, Flood Risk and Water Resources (PEI Report, Volume I). This will be used to inform the detailed design of the Proposed Development in terms of surface water management and selection of finished floor levels. Electrical equipment such as transformers and switchgear are to be located above predicted flood levels.	Tolerable (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
				Flooding guidance is provided by the Environment Agency for sites regulated under the Environmental Permitting Regulations.	
11	Natural disaster - climate change	Ambient temperature extremes, high windspeeds. Flooding extremes associated with rising water levels and climate change covered under Scenario Ref. 9 above.	The impact of climate change causing extremes of temperature and winds may affect process operation of the PCC such as the cooling systems and structural stability. This could potentially impact the operation and efficiency of the Proposed Development.	The engineering design will take into account the predicted ambient temperatures and wind speeds over the operational lifecycle of the Proposed Development. This includes consideration of suitable materials of construction and the design of utility systems such as cooling water.	Tolerable (**not significant)**
12	Terrorism/arson	Fires, explosions.	Fires and explosions at the Proposed Development could be caused by acts of vandalism, arson and/or terrorism. The worst-case risks and effects are as described in Scenario Ref. 1.	Security measures will be installed at the PCC and along pipeline routes, including site security, CCTV and fencing to prevent intruders and cyber security measures to prevent hacking. Security advice for high hazard sites is provided within a document published by the National Counter Terrorism Security Office and Association of Chief Police Officers (NaCTSO, 2014).	Tolerable (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
13	Earthquake / seismic event	Asset damage, potential subsequent fires, explosions.	The impact of an earthquake of significant magnitude could cause a major accident and damage to site infrastructure and harm to people both on-site and off-site.	Although minor earthquakes have occurred in the area of the Proposed Development site (including a magnitude 3.1 earthquake on 23 January 2020), it is not located within an area which has a high risk of earthquakes and/or seismic activity. However, the risk of earthquakes will be taken into consideration during the civil and structural engineering design, which will utilise the appropriate design codes and standards.	Tolerable (**not significant)**
14	Lightning	Asset damage, potential subsequent fires, explosions.	A lightning strike could cause a major accident, harm to people on-site and damage to site infrastructure. Lightning could also present a source of ignition to flammable materials. A subsequent major fire could harm people both on-site and off-site.	The engineering design of the Proposed Development will include appropriate electrical earthing and bonding systems. The design and maintenance of these systems will reduce the likelihood of a major accident being initiated by a lightning strike to a very low level. Guidance is provided by the HSE on the management of potential ignition caused by lightning (HSE, 2014).	Tolerable (**not significant)**

Scenario Ref.	Major Accident/ Natural Disaster	Substance/System Hazard	Risks and Consequence before Mitigation	Embedded Mitigation Measures and References	Tolerability
15	Aircraft/drone impact	Asset damage, potential subsequent fires, explosions	The nearest airport to the Proposed Development is Durham Tees Valley, located approximately 20 miles in a south-westerly direction. This is a relatively small airport; however, expansion is planned to follow the recent change of ownership in 2019 with a number of new routes recently announced. A military airport base is located at RAF Leeming, approximately 50 miles from the Proposed Development in a south-westerly direction. The impact of an aircraft crash on the Proposed Development would be a major accident with the potential for significant injuries to people and damage to assets, both on-site and off-site.	The Proposed Development is located in an area which does not have a high density of air traffic and facilities are not designed to withstand such an impact. Consequently, vigilance and security systems are the key mitigation measures, with automated shutdown and interlocks installed as part of the plant operating philosophy to safely shut down the plant in the event of an abnormal incident. Use of bunding and impermeable surfacing will minimise the risk of chemical releases to ground or controlled waters in the event of any incident.	Tolerable (**not significant)**

22.7 Potential for Major Accidents Associated with Carbon Dioxide Releases

22.7.1 The HSE publication on the major hazards associated with CO_2 (HSE, 2011) states that this gas is an asphyxiant which displaces oxygen in air at a concentration of 50%v/v. However, even at lower concentrations, CO_2 creates an immediate threat to life at a concentration of only 15% in air due to the toxicological impact it has on the body when inhaled at this concentration.

22.7.2 The HSE has undertaken a Dangerous Toxic Load assessment for CO_2 which concludes a significant danger to humans through asphyxiation and loss of consciousness if they inhale CO_2 at concentrations above around 7% in air (i.e. > 70,000 ppm). The HSE has derived and published Specified Level of Toxicity (SLOT) and Significant Likelihood of Death (SLOD) Levels for hazardous substances and concluded that CO2 data indicates it does not meet the criteria for classification as a dangerous substance.

22.7.3 However, in addition to the hazard posed by CO_2 if inhaled, there are additional hazards associated with dense phase CO_2 that are likely to occur when CO_2 is handled in large quantities and at high pressure (dense phase). These can arise when a release occurs, and the pressure suddenly falls or is lost completely and result in cryogenic burns to living creatures and damage to assets such as embrittlement of metallic structures and pipework.

22.7.4 HSE (2011) describes historical accidents involving CO_2, including a release of 15 tonnes of CO_2 from a facility in Germany which resulted in the hospitalisation of 107 people in the local area. The inventory involved in this accident provides an indicative estimate of the potential harm caused by a CO_2 release from a pipeline fitted with isolation valves.

22.7.5 Modelling of CO_2 releases using industry standard software has been undertaken by the HSE, which is presented in HSE (2011). For example, page 16 of HSE (2011) states that the hazardous distance associated with the rupture of a dense phase CO_2 pipeline would be of the order 100 m to 200 m. The hazardous distance is defined as the distance which would cause severe distress to people and may result in fatalities if vulnerable persons or living creatures are exposed.

22.7.6 A number of research projects have been undertaken to refine and validate the software used for modelling dense phase CO_2 releases and to further understand the potential hazards of a major release. NZT Power and NZNS Storage are using industry standard tools to model CO_2 releases. The outcomes of this modelling will be reviewed by the project team and incorporated into the design of the Proposed Development.

22.7.7 The Proposed Development has been deliberately sited so as to maximise distance from sensitive receptors and other industrial operations, to prevent the harmful consequences of any CO_2 releases. In particular, the siting of the high-pressure CO_2 Compressor on the steelworks site towards the shoreline

minimises the risk of any high-pressure CO_2 release from impacting off-site receptors, particularly given the prevailing wind direction. The hazardous distances outlined above have been used as part of the plant layout concept design to keep the hazardous distances within the Site boundary and therefore not impact on off-site receptors.

22.7.8 Where the CO_2 Gathering Network is located close to potential receptors, the design of the pipeline will incorporate embedded mitigation such as thickened pipe walls, pipe within a pipe arrangements or additional protection to minimise the impacts on receptors in the event of a failure.

22.8 Domino Effects

22.8.1 As outlined in Table 22-2, no neighbouring installations have been identified that could be the source of, or increase the risk or consequences of, a major accident and/or domino effect. Similarly, while there are several nearby facilities that could be affected by a major accident associated with the Proposed Development, it has been deliberately sited to minimise such an effect.

22.8.2 Where the CO_2 Export pipeline or other connections run close to the existing gas pipelines coming on shore at Coatham Sands, additional measures such as thickened pipe walls and pipe within a pipe arrangements would be used where appropriate to minimise the risk of any domino effect with existing infrastructure in the event of a failure.

22.8.3 Neighbouring facilities that have been considered in more detail include:

- Bran Sands Wastewater Treatment Plant located approximately 500 m from the PCC and close to the CO_2 Gathering Network:
  - the Bran Sands works processes domestic and industrial effluent and sludge for the Teesside area and the wider north-east region;
  - operation of the Proposed Development will have sufficient design and operational safeguards so as not to impact on the operation of the Bran Sands facility, including that if any effluent is sent to Bran Sands it will be within agreed specifications so as not to disrupt Bran Sands operations; and
  - an accident, such as a major fire at the Proposed Development, may restrict Bran Sands operations, such as preventing operators working outside, however recovery from the impact should have a negligible long-term impact on the Bran Sands site. The plant is located sufficiently far from the PCC so as to minimise the risk of fire spreading from one facility to the other. In the event of a major accident at Bran Sands, precautionary measures would be applied such as closing valves on the CO_2 Gathering Network to isolate the inventory.
- Teesport:
  - Teesport is located on the south bank of the River Tees approximately 2.8 km from the PCC. It is a significant deep-water

port complex, supporting the movement of international imports and exports throughout the north of the UK. An accident, such as a major fire at the Proposed Development, may temporarily restrict dock operations, such as preventing vessels from berthing. This would be expected to result in a temporary impact for the duration of the incident but would be unlikely to result in a long term effect on the Teesport Dock operations due to distance. The port is located sufficiently far from the PCC so as to minimise the risk of fire spreading from one facility to the other.

- Billingham, Seal Sands and North Tees Industrial Area:
  - the Billingham and Seal Sands industrial areas on the north bank of the River Tees approximately 2.2 km from the PCC. They contain a number of major industrial installations, including chemical manufacturing and oil storage facilities. Many of these facilities are regulated under the COMAH legislation. Consequently, they will have assessed their impact upon neighbours, in the event of a major accident and domino effects. The Proposed Development pipelines (including the CO_2 Gathering Network and Natural Gas Connection) will be designed and routed so as to minimise the potential for domino effects in the event of a major incident; and
  - an accident, such as a major fire at the Proposed Development, could restrict operations at Seal Sands and North Tees, such as preventing operators working outside, however recovery from the impact should have a negligible long-term impact on the sites. The plants are located sufficiently far from the PCC so as to minimise the risk of fire spreading from one facility to the other.
- Teesside Renewable Energy Power Station (Tees REP):
  - this facility is currently under construction on the south bank of the River Tees approximately 3 km from the PCC. When operational will generate electrical power from the combustion of biomass, formed by compressed wood pellets and wood chip. The site is located within the CO_2 Gathering Network. In the event of a major accident at a nearby facility such as the Tees REP, precautionary measures would be applied such as closing valves on the CO_2 Gathering Network to isolate the inventory. The REP plant is located sufficiently far from the PCC so as to minimise the risk of fire spreading from one facility to the other.

22.8.4 The high concentration of industrial facilities in the local area provides a wealth of experience in the management of major accidents. The Cleveland Emergency Planning Unit (CEPU) provides an emergency planning service to ensure the local authorities are prepared to respond to emergencies and to support the emergency services and the community. This organisation provides information to businesses and has many years' experience working with COMAH sites and operators of major pipelines in Hartlepool, Middlesbrough, Stockton on Tees and Redcar and Cleveland.

22.8.5 It is a requirement of the COMAH Regulations that neighbouring upper tier sites should review and update their off-site emergency plans and Safety

Reports to take into consideration potential impact of domino sites, which could potentially include this Proposed Development. This ensures that domino effects are assessed in detail by major accident installations.

22.9 Mitigation and Monitoring

Assessment Conclusions

22.9.1 The assessment has identified the potential Major Accidents and Natural Disaster which could be applicable to the Proposed Development, associated with the substances present and operations to be undertaken. Principally, these could include fires, explosions and the release of CO_2 gas. These incidents have an extremely low probability of occurrence but could have significant impacts on people and the environment without mitigation.

22.9.2 The Proposed Development will be within an area of Teesside where similar facilities such as power plants and chemical works have been in operation for decades. Consequently, these hazards are well understood by plant operators and controlled by the Regulatory Authorities and the Applicant will draw on this expertise plus that of its own heritage of designing, building and operating potentially hazardous installations globally to reduce the risk of major accidents occurring to as low as reasonably practicable.

22.9.3 The engineering design of the Proposed Development will incorporate appropriate standards, proven design methods and control measures necessary to reduce the risks of such accidents to an acceptable level, i.e. ALARP, which is the standard expected by the Regulatory Authorities (HSE and Environment Agency).

22.9.4 The Proposed Development will require appropriate permissions to be in place for its operation including COMAH Licence and Environmental Permit, and these regulatory controls will stipulate a number of requirements that must be demonstrated to prevent or minimise the effects of major accidents.

22.9.5 With the implementation of these measures in addition to those described in Table 22-2 above, the MA&ND risks are considered to have been mitigated to ‘tolerable’ or ‘tolerable if ALARP’ and therefore the effects are considered as ‘not significant’ for both plant construction and operation.

Secondary Mitigation

22.9.6 At this stage no secondary mitigation measures (i.e. additional to the embedded mitigation within the Proposed Development) have been identified as being required to further mitigate any significant effects for Major Accidents and Hazards. Detailed emergency plans will be produced for the installation in accordance with the Environmental Permit and all applicable Regulations.

22.10 Residual Effects

22.10.1 No residual effects have been identified.

22.11 References

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