Department for
Business, Energy
& Industrial Strategy

NEP / NZT Environmental Management

Key Knowledge Document

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Acknowledgements

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1.0 Project Summary

1.1 Net Zero Teesside Onshore Generation & Capture

NZT Onshore Generation & Capture (G&C) is led by bp and leverages world class expertise from ENI, Equinor, and Total. The project is anchored by one of the first flexible gas power plant with CCUS which will compliment rather than compete with renewables. It aims to capture ~2 million tonnes of CO2 annually from 2026, decarbonising 750MW of flexible power and delivering on the Chancellor's pledge in the 2020 Budget to "support the construction of the UK's first CCUS power plant." The project consists of a newbuild Combined Cycle Gas Turbine (CCGT) and Capture Plant, with associated dehydration and compression for entry to the Transportation & Storage (T&S) system.

1.2 Northern Endurance Partnership Onshore/Offshore Transportation & Storage

The NEP brings together world-class organisations with the shared goal of decarbonising two of the UK's largest industrial clusters: the Humber (through the Zero Carbon Humber (ZCH) project), and Teesside (through the NZT project). NEP T&S includes the G&C partners plus Shell, along with National Grid, who provide valuable expertise on the gathering network as the current UK onshore pipeline transmission system operator. The Onshore element of NEP will enable a reduction of Teesside's emissions by one third through partnership with industrial stakeholders, showcasing a broad range of decarbonisation technologies which underpin the UK's Clean Growth strategy and kickstarting a new market for CCUS. This includes a new gathering pipeline network across Teesside to collect CO2 from industrial stakeholders towards an industrial booster compression system, to condition and compress the CO2 to offshore pipeline entry specification.

Offshore, the NEP project objective is to deliver technical and commercial solutions required to implement innovative First-of-a-Kind (FOAK) offshore low-carbon CCUS infrastructure in the UK, connecting the Humber and Teesside Industrial Clusters to the Endurance CO2 Store in the Southern North Sea (SNS). This includes CO2 pipelines connecting from Humber and Teesside compression/pumping systems to a common subsea manifold and well injection site at Endurance, allowing CO2 emissions from both clusters to be transported and stored. The NEP project meets the CCC's recommendation and HM Government's Ten Point Plan for at least two clusters storing up to 10 million tonnes per annum (Mtpa) of CO2 by 2030.

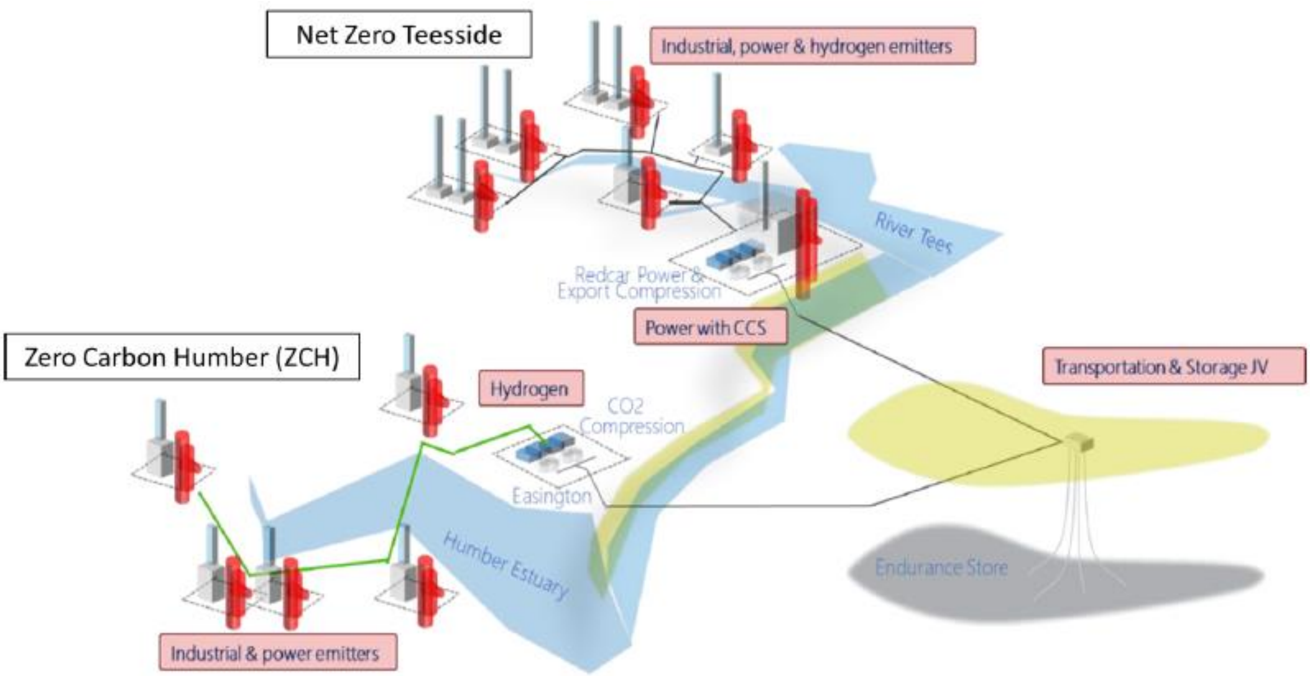

Figure 1: Overview of Net Zero Teesside and Zero Carbon Humber projects.

2.0 Environmental Capability

bp is an integrated and well-established operator in the United Kingdom Continental Shelf (UKCS) where it has operated for over 30 years and holds numerous license interests, some of which it operates on behalf of itself and its partners.

The Northern Endurance Partnership (NEP) carbon storage project will be led by BP as the operator.

The NEP project where applicable will adopt the same bp common practices as the North Sea business, including the bp Major Projects common process (MPcp) and the bp Operating Management System (OMS). The MPcp is the practice for bp operated Major Projects and describes how projects are optimised and executed. Whereas, the OMS provides a framework for managing health, safety, security and environment (HSSE) and operational risks in bp operating activities. The MPcp will ensure projects conform with all relevant OMS requirements.

The NEP project is early in project development, and hence, presently may not have implemented the practices required for the operate phase or established a lengthy performance history. Therefore, the environmental issues submission may refer to existing North Sea business practice and environmental performance to demonstrate bp's competence in relation to environmental protection.

bp is committed to attaining the highest standards of HSSE performance. bp's goals are simply stated:

- No accidents
- No harm to people
- No damage to the environment

bp's HSSE goals are enshrined in the bp Code of Conduct and the bp OMS. The Code of conduct is a public statement that bp is committed to doing the right thing. It serves as a valuable resource to help employees and others make informed, ethical decisions.

3.0 Environmental Management System

bp's environment management system (EMS) is embedded in OMS which integrates all bp's operating standards into one consistent set of expectations, defining the requirements for how bp operating entities deliver safe and reliable operations.

The OMS framework (Figure 2 below) comprises three key components which together provide a roadmap to safe and reliable operations:

- The elements of operating, which informs:
- The Performance Improvement Cycle, which applies to the local business processes; and,
- Which deliver the Elements of Operating.

Figure 2: bp's OMS Framework

bp OMS, requires bp entities to identify and systematically manage the impact of their activities on the environment and integrate environmental requirements into the local business OMS ("OMS EIE Management Requirements"). bp group procedures implement and drive continuous improvement in E&S performance of projects and operations.

The Production & Operations business OMS is well aligned with ISO 14001:2015, a globally recognized international standard which sets specific requirements for an effective EMS. An EMS Manual describes the arrangements in place to conform with the requirements of ISO 14001:2015 and with OMS EIE Management Requirements. OMS EIE Management Requirements require bp Major Operating Sites to maintain external certification or attestation to ISO 14001.

The NEP project, through the project stages and associated HSE management activities, will build the foundations of its EMS in preparation for OMS implementation in the operate phase.

4.0 Organisation, Roles & Responsibilities

The NEP project will be delivered by the bp Projects team. During the NEP project phase and prior to the operations phase, the Vice President (VP) for Global Concept Development, Projects is accountable for HSE on the project. The NEP project Senior Health, Safety, Environment & Carbon (HSE&C) Manager is accountable for implementing and maintaining the HSE systems and processes on the project that are used by the line organisation to manage HSE performance.

The purpose of the NEP project HSE&C resource is to advise and support line management in the delivery of HSE&C performance, including:

- Providing assurance that the project complies with all applicable UK and international environmental legislation and bp environmental policies and standards e.g. the environmental requirements within bp's MPcp, OMS and the Management of Environment and Social Performance Group Defined Practice
- Supporting the project team in development and implementation of E&S procedures to manage project-specific E&S risks.
- Supporting the Project team in development and implementation of E&S self-verification and contractor oversight programmes.
- Add in bullet on assessing and managing env impacts?

Engineering, Procurement, Construction, and Installation contractors are expected to have their own HSSE Management System to help them deliver safe, reliable, and compliant operations. This will include specific E&S management and monitoring plans, tailored for their scope and work locations. Contractors will be responsible for their own performance and for self-verifying conformance in accordance with the contract work scope. bp will perform oversight of the implementation and self-verification of contractor arrangements.

5.0 Legal & Other Regulatory Requirements

5.1 bp's Compliance Management System

bp OMS also, provides the framework for developing an appropriate system to monitor and evaluate continuing compliance with all relevant legal requirements. The NEP project Health, Safety and Environment (HSE) Compliance Management System (CMS) will be aligned with the five-step compliance management process, as shown in Figure 3.

The Energy Act 2008 makes provisions under Part 1, Chapter 3 for the regulation of the storage

Figure 3: bp's Compliance Management Process

of carbon dioxide. Subsequently, The Storage of Carbon Dioxide (Licencing etc.) Regulations 2010, made under Part 1 of The Energy Act 2008, makes provisions for the licencing and enforcement regime for the storage of carbon dioxide, in relation to permeant disposal. In addition, The Energy Act 2008 (Consequential Modifications) (Offshore Environmental Protection) Order 2010 makes provisions to ensure existing regulations apply to carbon dioxide storage as they do for oil and gas activities. Key regulations include, but are not limited to, The

Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended), The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended), The Offshore Installations (Emergency Pollution Control) Regulations 2002 (as amended) and The Offshore Chemical Regulations 2002 (as amended).

The Oil & Gas Authority (OGA) regulates offshore carbon dioxide storage, and as the licensing authority approves and issues storage permits and maintains the carbon storage public register. In addition, to seeking the storage permit from the OGA, the NEP project will obtain a grant of the appropriate rights from The Crown Estate.

During FEED the NEP project will prepare and implement a plan to verify and document compliance with applicable legal and regulatory requirements, and to obtain appropriate and timely HSE regulatory and permitting approvals. This will include an Applicability Register and Compliance Matrix that will be maintained up to date for new or amended HSE legal requirements. The regular review of new or amended legislation will include, but not be limited to, all formal changes to the relevant UK Acts of Parliament, Statutory Instruments, Health and Safety Executive bulletins and Safety and Operations Notices, UK Government consultations and Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) Environmental Alerts. It is be supported by a third-party specialist compliance contractor.

5.2 NEP Regulatory Compliance Assurance Register

A full chain Regulatory Compliance Assurance Register (RCAR) has been issued for NZT and NEP. The RCAR has been developed to ensure that the Basis of Design (BoD) for the codes and standards to be issued to the NZT and NEP Tier 1 Contractors contains a list of applicable regulations to the project design phase.

The full RCAR provides a list of regulations and clauses applicable by project phase, scope and discipline and a short narrative on how to demonstrate compliance. This includes documents, records or design barriers, that demonstrate compliance with the applicable legal and regulatory HSSE requirements.

The RCAR references all UK HSE legislation that may be relevant to the activities for the facilities for NZT and NEP Phase 1. It identifies accountability by discipline to each of the UKCS HSE regulation clauses. Legislation has been tagged with a high-level topic heading and detail level topic heading.

6.0 Environmental Management

6.1 Environmental Baseline Survey Activity

6.1.1 2020 Survey and Output

During October and November 2020, NEP conducted an environmental baseline survey in conjunction with a geophysical survey and a geotechnical survey. The survey took place across the UKCS quads 42 and 43 on-board the MV Ocean Reliance from 7th October to 9th November 2020. The environmental survey was to profile the characterisation of the current state of marine environment and a baseline against which future change can be assessed. The objectives of the environmental baseline as defined by the scope of work (bp, 2020) were to:

- Determine the characteristics of seabed sediments
- Determine water column characteristics through the collection of hydrographic profiling data and water samples.
- Characterise benthic communities
- To provide an assessment of likely habitats and biotopes and the presence of environmentally sensitive species and habitats.

Environmental stations were targeted at the Endurance store and the Bunter outcrop. Data acquisition included drop-down camera digital imagery, grab samples for sediment characterisation and macrofauna analysis and water samples to assess baseline water quality. In addition, samples were also collected from the water column and sediment for eDNA analysis.

6.1.2 2021 Survey and Output

Prior to the end of June 2021 NEP had successfully deployed Autonomous Surface Vessels (ASVs) for the acquisition of Multi-Beam Echo Sounder (MBES), Side-scan Sonar (SSS) and Sub-Bottom Profiler (SBP) data along the proposed Teesside and Humber CO2 export pipeline routing corridors. This data acquisition will be utilised for geotechnical assessments, but also for the identification of potentially sensitive seabed habitats, such as Sabellaria spinulosa and rocky reefs, which are both Annex I listed habitats under the EU Habitats Directive. Where potentially sensitive features are identified these will be targeted for additional drop-down camera surveys and habitat assessment. Prior to the end of June 39% of the MBES and SSS data has been acquired over the pipeline routes and Endurance area.

6.2 ENVIID Report and Output

An Environmental Impact Identification (ENVIID) workshop and subsequent report have been completed for NEP. The objectives of the ENVIID workshop were to:

- Identify environmental and social negative and positive impacts (planned) and risks (unplanned) that could arise and;
  - For planned activities, assess the significance of the impacts.
  - For potential unplanned events, prioritise such that they can be further evaluated through the risk process.
- Identify and validate safeguards that are in place at the time of the ENVIID workshop.
- Identify areas of design, processes and/or activities that can be changed or modified to eliminate or further mitigate environmental and social impacts.
- Recommend actions (that include actions to undertake further assessment) to eliminate or further mitigate impacts.

Activities included in the ENVIID:

- Installation, hook-up and commissioning (HUC) (including pipe laying activities), and operation of subsea infrastructure, pipelines, well manifolds, umbilical's, etc.;
- Drilling, well clean-up and operations of 5 disposal wells and 1 spare/monitoring well; and
- Installation of export pipeline landfall at Teesside and Humber

Base case activities included for review by the ENVIID are shown in Table 1.

Table 1 : Base Case Scope of the ENVIID

Base Case Scope	
Pipeline landfall	Horizontal Directional Drilling (HDD) and open cut trenching
Umbilical routing	From Teesside

Later project phases (i.e. decommissioning) were not considered given current lack of available information. Their inclusion will be considered as part of subsequent ENVIID's in future stages of the project (i.e. Define and Execute).

The following project components and activities were considered outside the scope of the ENVIID:

- Survey activity (i.e. seismic, environmental and geotechnical);
- Geological stores beyond Endurance identified for future project phases

The ENVIID methodology followed the sequence of five stages, as detailed below:

Stage 1

The project was broken down into systems and project phases. The following systems were considered during the workshop:

- Export pipelines landfall;
- Export pipelines;
- Subsea infrastructure; and
- Wells.
- For each system the following project phases were considered:
- Site preparation and construction, including installation of pipelines and subsea infrastructure
- Drilling operations (offshore);
- Commissioning and start-up; and
- Operations
- For each system both planned operational modes and unplanned events (including emergency conditions) were considered.

Stage 2

Applicable environmental and social aspects were then identified, and the potential impacts of these aspects were detailed.

Stage 3

Any existing safeguards or controls that can be used to mitigate the impacts of the aspects identified in Stage 2 were identified and listed in the ENVIID register.

Stage 4

For planned activities:

- Severity of impacts were assessed, considering the identified and validated safeguards listed in the ENVIID register.
- Assessment of the duration and/or frequency was performed
- Impact significance was determined
- Impact significance level determines the need for further impact management

For unplanned events, risks were assessed and prioritised.

Stage 5

Based on the results of the ENVIID, recommended actions were then formulated to better understand the aspect or impact, to eliminate, prevent or reduce the potential impacts if practicable and feasible. The results of all five stages were captured in the ENVIID register.

A summary of potential key aspects associated with planned events that were identified are listed in Table 2.

Table 2: Summary of key aspects identified for Planned Events

Phase	System	Activity & Aspect
Installation & Drilling	Wells	Jack-up rig temporary exclusion zone – Restriction of fishing
Installation & Drilling	Export pipelines, Wells & Subsea infrastructure	Temporary exclusion of fishing / fishing lanes
Installation	Export pipelines	Trenching and dredging activity – Wildlife disturbance and water quality impact
Installation	Export pipelines	Pipeline protection - Loss of natural habitat with rock cover
Installation	Subsea Infrastructure	Piling activities – Underwater sound
Installation	Export pipeline landfall	Land take, trenching and cofferdam, large quantities of soil / sand removal – Wildlife disturbance
Operations	Wells	Installation of fishing activity compliant subsea infrastructure
Operations	Wells	Bunter outcrop formation water displacement – Aqueous discharges
Operations	Export pipelines	Pigging – line-controlled depressurisation at surface

A summary of potential key aspects associated with unplanned events that were identified are listed in Table 3.

Table 3: Summary of key aspects identified for Unplanned Events

Phase	System	Activity & Aspect
Drilling	Wells	Bunkering of SBM, potable water and diesel – Chemical release
Drilling	Wells	Transfer of chemical IBCs – Chemical release
Drilling	Wells	Spills of chemicals associated with cementing, brines, SBM, WBM, hydraulic oils, lubricating oils, rainwater runoff, tank overflow, etc.
Installation & Drilling	Export pipelines, Wells & Subsea infrastructure	Minor operational leaks of oil and chemicals
Commissioning & Start-up	Export pipelines	Release of chemically inhibited water
Operations	Wells	Well blow out during operations due to shallow hazards
Operations	Wells	Cement fatigue resulting in leak – CO2 in water column
Operations	Wells	On-structure legacy wells – CO2 / formation water displacement
Operations	Wells	Off-structure legacy wells – CO2 / formation water displacement
Operations	Export pipelines	Offshore CO2 pipeline leak / rupture due to corrosion, fatigue, and damage
Operations	Export pipelines	Damage to third party pipeline and umbilical crossings – oil and gas leaks
Operations	CO2 Gathering Network (including export pipeline landfall)	CO2 pipeline leak / rupture due to corrosion, fatigue, and damage

6.3 Greenhouse Gas Emission Forecasts

A GHG Life of Operation (LoO) forecast was developed by bp to calculate the carbon dioxide and methane emissions for Phase 1 of NZT and NEP. Traditionally bp GHG emission forecasts for Oil and Gas facilities report only Scope 1 and Scope 2 emissions. However, this project is bp's first "Low Carbon" project which means it has unique emissions reporting and accounting requirements. Therefore, the scope of the forecast was detailed as per the following definitions:

- **Steady state exhaust GHG emissions:** emissions due to imperfect capture during steady state operation, dependent on the capture efficiency of the carbon capture plant.
- **Dispatchability exhaust GHG emissions:** emissions due to start-up of the Power and Capture (P&C) plant from hot, warm and cold starts e.g. when the power station is running but the carbon capture plant hasn't warmed up yet. This includes the LP compressor blowdown.
- **T&S unavailability GHG emissions**: emissions caused by a failure in the Transport and Storage (T&S) system (e.g. offshore power cable), leading to unplanned T&S down-time, forcing venting of carbon dioxide captured from the Teesside and Humberside 3rd party industrial emitters (including P&C) until the issue is resolved.
- **Non-routine venting GHG emissions**: emissions from cold start-ups after planned maintenance and TARs.
- **Fugitive GHG emissions:** leaks and seeps from the PCC site (CO2 and Natural Gas), carbon dioxide gathering network (assumed that the compressor seal CO2 leak is greatest contributor from GEN CAT report) and natural gas supply line
- **Power GHG emissions:** emissions due to the carbon intensity of the National Grid which will supply power when power station is not operating. The power will be used for P&C (CCGT and utility) requirements and to run the T&S network (HP compressors are the dominant power draw).
- **Diesel GHG emissions:** emissions from a diesel jack-up rig used to drill the 6 wells, perform well wash water activities (GEN CAT report) and well interventions (assuming a day per well per year).

Key scope exclusions were:

- All onshore Humberside emissions including their onshore T&S (HP compressors) and 3rd party industrial emitters, excluding emissions due to T&S unavailability.
- Emissions from Teesside 3rd party industrial emitters, excluding emissions due to T&S unavailability.
- Further phases of development
- Decommissioning (covered in Life Cycle Assessment (LCA) report)
- Construction/Commissioning (covered in LCA report)

Key assumptions used in the forecast were:

- The Baringa Model (Heat Retention and Fast Heating Exchanger case – case 39) was chosen as the reference case for the power station's power profile. The availability of P&C is built into this model.
- Power generation efficiency = 49%
- CO2 Capture rate = 95%
- Teesside T&S availability = 94.4%
- Humberside T&S availability = 94.7%
- UK Carbon grid intensity was taken from BEIS 2018 EEP report. This only extends to 2035 so this value (41.2 gCO2/kWh) was extrapolated with a straight line to a grid intensity value of 0 gCO2/kWh at 2050.

The key metrics from the full chain NZT/NEP forecast are shown in figure 4 and the yearly GHG forecast and break-down of the emissions by source type are shown in figures 5 and 6 respectively.

- The schematic shows 0.08 tonnes of CO2 are released for every tonne of CO2 stored for the full chain NZT/NEP system.
- For this forecast the GHG intensity of P&C exceeds the predicted National Grid intensity by 2039.
- The largest proportion of the emissions is due to the T&S unavailability causing the forced venting of captured carbon dioxide from the 3rd parties. The split of these emissions between P&C, Teesside 3rd parties and Humberside 3rd parties is roughly equal in Phase 1, however the proportions are expected to change as further phases of development are completed.
- The next largest contributor is the steady state exhaust emissions from P&C due to imperfect capture by the carbon capture plant.
- These two emissions sources make up 89% of the total emissions. Hence the greatest opportunities for emissions reduction come from maximising the carbon capture efficiency and the availability of the T&S system.

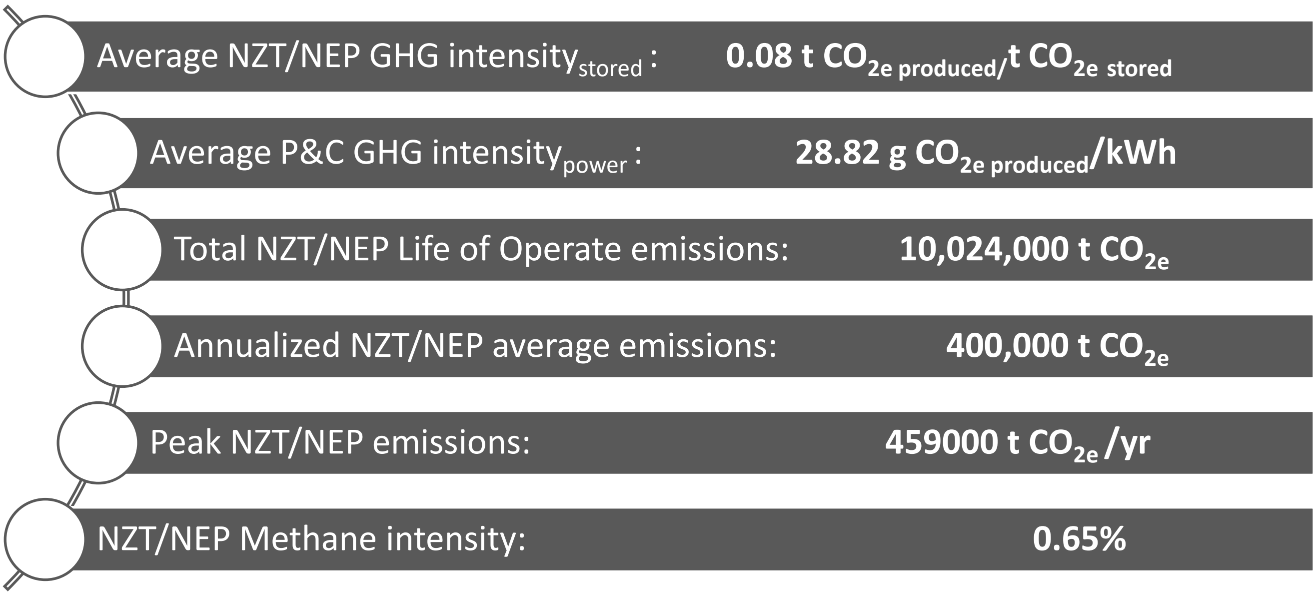

Figure 4: Schematic showing the key metrics for the NZT/NEP Full chain GHG forecast.

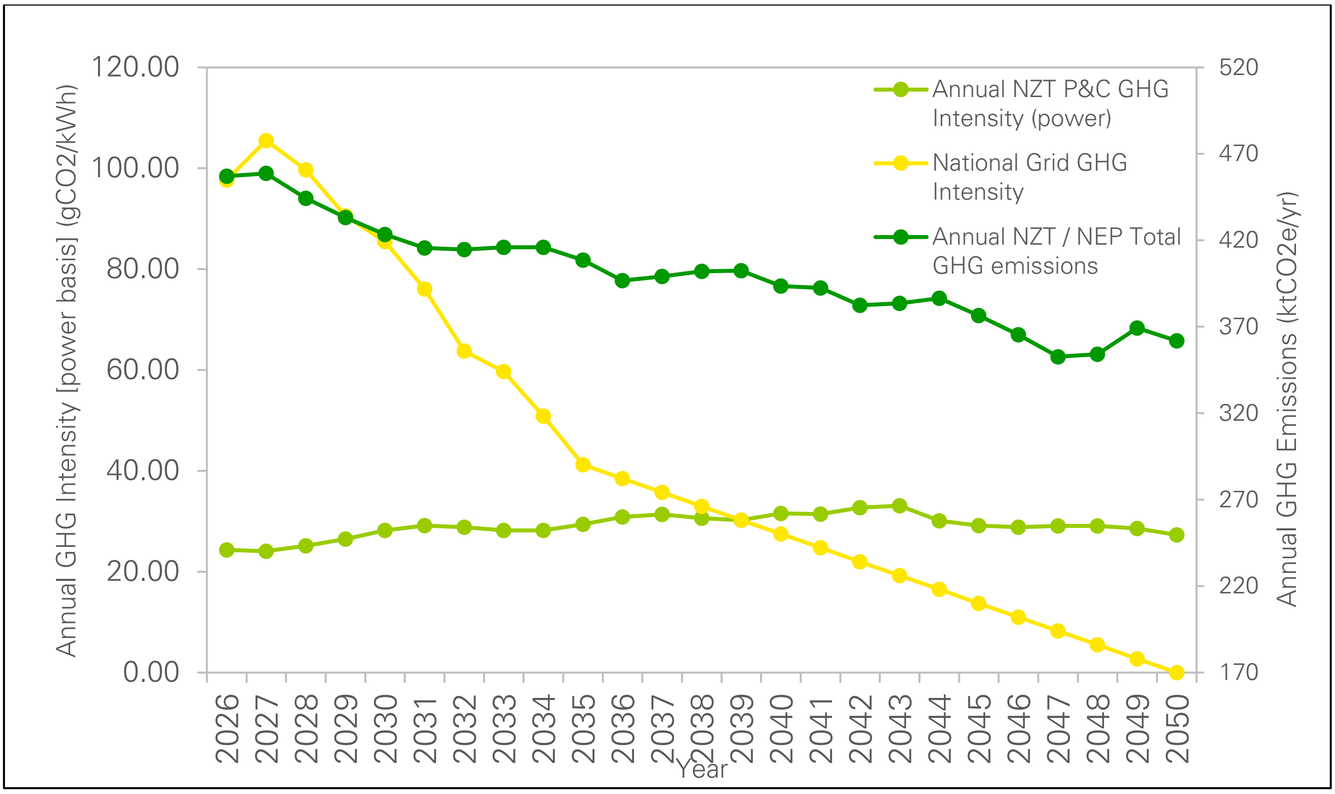

Figure 5: NZT/NEP Teesside Full Chain GHG forecast

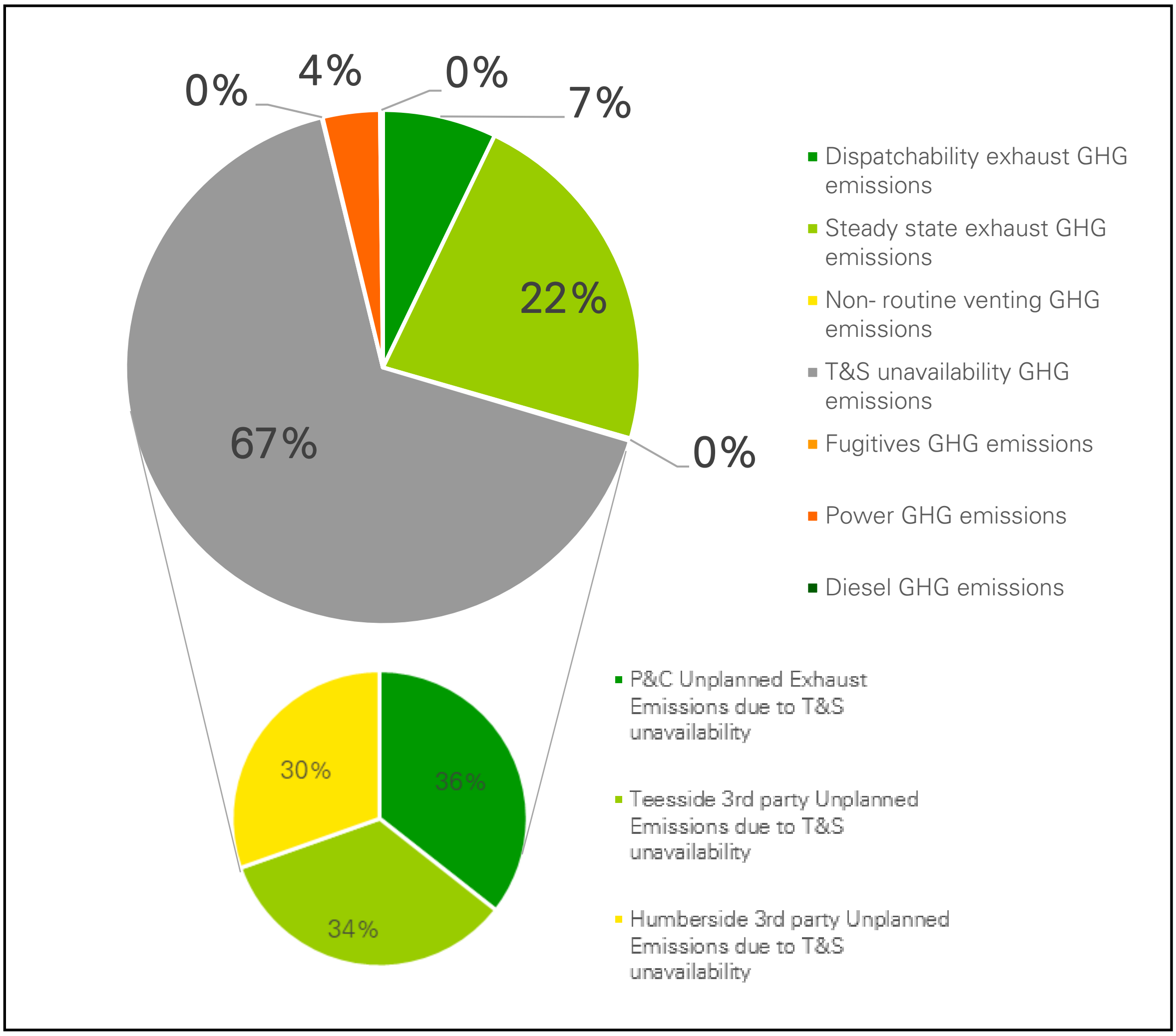

Figure 6: NZT/NEP Full Chain GHG emissions by source type

6.4 Life Cycle Assessment

- A GHG life cycle study was undertaken with the key findings below: during Phase 1 Procurement & Construction emissions are equivalent to 7% of the total operational emissions.
- Phase 1 total operational emissions are equivalent to 7% of the total sequestered CO2.
- The equivalent total Procurement & Construction emissions will be sequestered within 50 days based upon the year 1 injection rate, with equivalent total Phase 1 operational emissions being sequestered in just under 3 years based upon the annual average injection rates.
- Based upon a Teesside Power Plant capture efficiency of 90% and the current availability estimates along with BEIS predicted National Grid emissions intensity, the BEIS estimate of 64 gCO2e/kWh in 2032 will better the Teesside Power Plant's emissions intensity of 72 gCO2e/kWh in the same year

6.5 Waste Management eVIP and Output

The waste minimisation environmental Value Improvement Practice (eVIP) aims to reduce project life cycle costs and achieve sustainable conservation of resources through application of the waste hierarchy (Figure 7). The waste minimisation eVIP is applied to projects where significant waste volumes could be generated or where there are wastes requiring special treatment during the construction and / or operation phases.

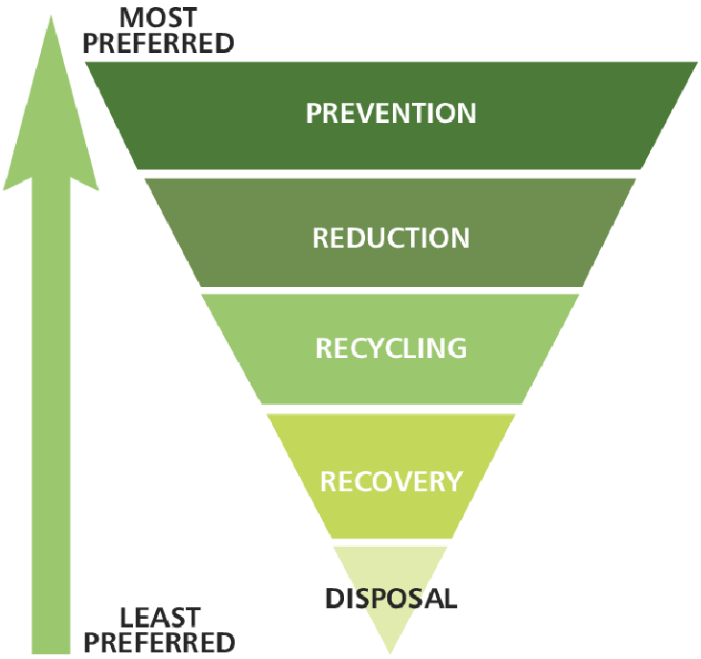

Figure 7: Waste Hierarchy

The purpose of the Waste Minimisation eVIP is to identify likely waste streams that will be produced during the project's construction and operation phases and to actively consider achievable source reduction or waste product recycling and recovery opportunities rather than traditional 'end of pipe' disposal options.

The outcomes of the waste minimisation eVIP feed into:

- Project action tracking database as part of the Project Management Control System (PMCS);
- Engineering studies;
- Environmental Impact Identification (ENVIID) process;
- Project basis of design updates; and
- Inform future BPEO/BAT Assessments

According to the Waste Management Licencing definition a material is considered to be waste when the producer or holder discards it, intends to discard it, or is required to discard it. By "discard" it is made clear that disposal as well as recycling and recovery is meant. In practice, only waste streams that will be treated off-site were registered.

Minimising waste streams as part of design requires all elements, including life of field requirements to be considered. The workshop assessed risks arising through additional process complexity and integration (e.g. process safety, reliability, start-up, operability, turndown, maintenance constraints, transportation risks etc.) and considered risks and constraints to operations. The workshop also considered existing waste minimisation options already identified by the project.

The project scope includes:

- Gas Power and Carbon Capture Plant
- Construction and commissioning
- Offshore scope: drilling wastes

For construction and commissioning the following waste streams were considered:

- Dredging and excavation (associated with pipelay activities)
- Non-hazardous waste construction materials (concrete, scrap metal, wood, cable, insulation, plastics, blasting grit etc.)
- Hazardous solid wastes (used filters, oil-contaminated rags, used chemical containers and batteries, blasting grit, paints, solvents etc.)
- Hazardous liquid wastes (used lubricating oil and hydraulic fluids etc.)
- Domestic wastes
- Hydrotest water (chemically inhibited water and commissioning fluids)

Offshore drilling activities included the following waste streams:

- Use of oil based (OBM), water based (WBM) and synthetic based (SBM) muds
- Drill cuttings (water based and oily)
- Oily fines from centrifuges
- Well clean-up (solids)
- Cement
- Hazardous solid wastes (used filters, oily rags, batteries, chemical containers, paints etc.)
- Hazardous liquid wastes (lubricating oil, hydraulic fluid, chemicals etc.)
- Non-hazardous waste (scrap metal, wood, carboard, plastics etc.)
- Domestic wastes

During the workshop, the waste streams were reviewed and discussed in order to identify those which should provide the main focus for the eVIP discussion.

The Potential Impact / Manageability matrix shown in Figure 8 and Figure 9 gives the waste stream ranking in terms of potential impacts on the natural and / or socio-economic environment against manageability; the number in brackets gives the number of waste streams identified. The ranking helps focus attention on those with higher potential impacts and lower manageability.

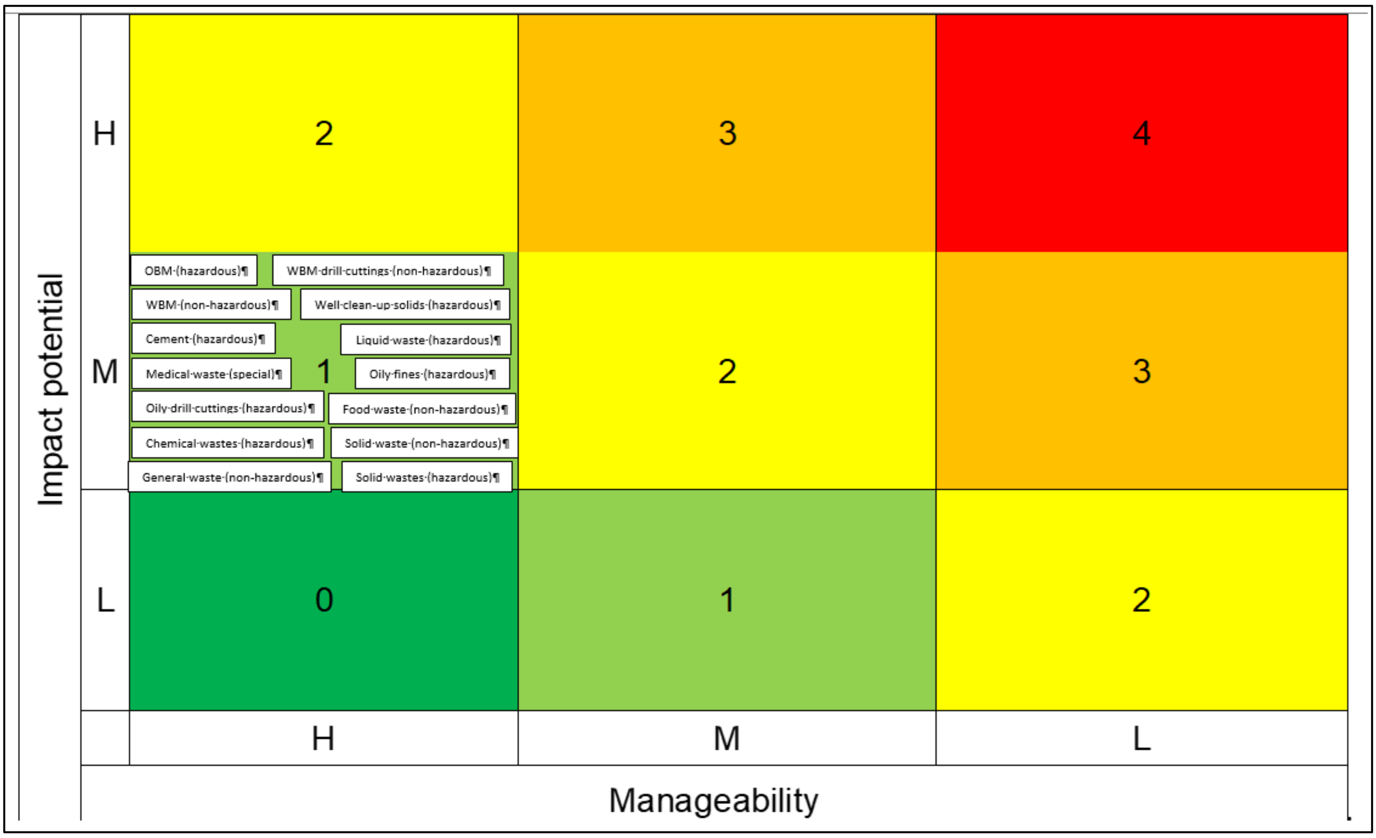

Figure 8: Offshore Drilling Waste Streams Potential Impact / Manageability Matrix

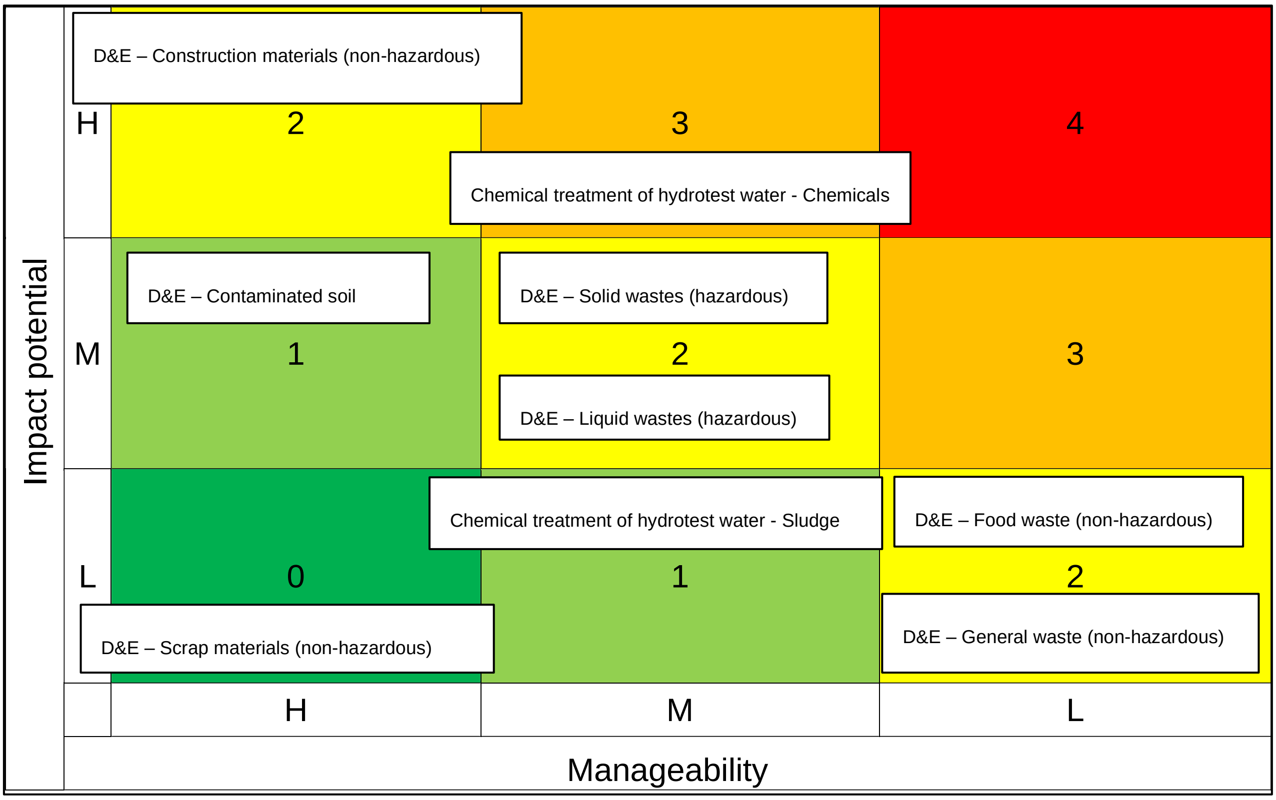

Figure 9: Construction and Commissioning Waste Streams Potential Impact / Manageability Matrix. D&E – Dredging and Excavation

The project waste management strategy is based on the waste hierarchy of minimisation, reuse / recycling and disposal following treatment. Multiple waste minimisation opportunities were identified during the workshop. All of which have been assigned actions to pursue the minimisation opportunity further.

6.6 Pipeline Constraints Studies

6.6.1 Teesside

A Pipeline Constraints and Engineering Geological Ground Model desk study for the proposed Teesside Pipeline routing has been issued for the NEP project. This report has been developed independently by a third part consultant. The report presents the pipeline engineering geological ground model and constraints model for the proposed pipeline routes from the Teesside (landfall) to Endurance.

A number of potential environmental and social constraints were identified including Annex I Habitats, marine mammals and marine and coastal nature conservation areas. In addition, the constraints study considered critical fish habitat, fishing activity, marine activity data, protected wrecks, offshore wind farm developments and oil & gas infrastructure. These features will be considered during final route planning and construction to ensure the necessary mitigation measures are identified and implemented. The location of infrastructure or the routing of pipelines was assessed to become more favourable with less constraints further offshore from Teesside to the Endurance blocks.

6.6.2 Humber

A review was carried to identify the physical, environmental and socio-economic constraints and their relative influence on pipeline routing, between the Endurance storage site and the Yorkshire, Humber and Lincolnshire coasts. This study has been developed independently by a third part consultant. The study identified three main route corridors with multiple offshore and nearshore corridor options, matched to seven potential landfall areas on the Holderness coast and to the south of the Humber Estuary.

Criteria were defined related to environmental and social aspects to be managed, considering the activity set associated with the landfall and nearshore pipeline project. The landfall options have been assessed against these criteria and ranked from an environmental, socioeconomic, and constructability risk management perspective. Identified key uncertainties and assumptions were also presented; and a prioritised list of required actions to support subsequent decision making was also developed.

6.7 Hypersaline Formation Water Discharge Studies

The development plan for NEP includes the option to produce water from the Endurance structure (Bunter sandstone formation) as part of the pressure management process. This water production will occur relatively late on in project life but plans for its discharge or treatment and disposal need to be in place early to ensure regulatory compliance.

NEP has completed a number of modelling and experimental studies that consider the following:

- Assessing the impacts of large-scale disposal of formation water into the marine environment;
- Understanding the dilution of the formation water following displacement into the water column; and
- Assessing the dispersion and dilution of hypersaline formation water at the seabed as a result of displacement of store formation water in the upper 300m of the Bunter outcrop formation

6.7.1 Modelling Report

Work undertaken by an independent institute used a very high-resolution hydrodynamic model system, utilising the Unstructured Grid, Finite-Volume Coastal Ocean Model (FVCOM) to assess the environmental impact potential arising from the possible disposal of hypersaline formation waters into the water column.

The scenarios modelled included surface release from one location, at a release rate of 25,400 m3/d, and a seafloor release from one location of 6,300 m3/d. The study also modelled 10 x 320 m3/d and 1 x 3,200 m3/d discharges for displaced formation water scenarios at the Bunter outcrop.

Key findings from the study were:

- Disposal at the sea surface led to far quicker dispersion and smaller seafloor footprints due to dilution in the vertical drop
- The affected area for the surface release scenario was 400 times lower than the seabed release
- Sand waves on the seafloor may reduce dispersal and increase retention of formation waters over small areas
- Dispersion in a hydrodynamically active region like the North Sea acts to dilute disposed formation waters rapidly, such that the potential impact footprint (area exposed to environmentally damaging salinity or temperature) is small, generally measured in 10's of meters depending on scenario and in-situ conditions.
- The footprint of heavy metals was the largest impact prediction, suggesting that heavy metal concentrations may be the controlling factor from an ecosystem point of view

Table 4: Impacted Regions

Site	Release Rate m3/d)	Release mode	Predicted Impact Area (km2)	Max Salinity (PSU)	Max Temp (°C)
Endurance	-	Baseline	-	-	-
	6,300	Sea floor	0.3 - 1.57	48.32	11.8
	25,400	Sea surface	9.3 × 10-4 - 4.25 × 10-3	48.02	12.2
Outcrop	-	Baseline	-	-	-
	10 x 320	Sea floor	0.045 - 2.3	44.44	11.0
	3200	Sea floor	0 - 0.027	36.46	9.44

6.7.2 DREAM Modelling Report

The scenarios modelled were a surface release from a single location, at a release rate of 25,400 m3/d, and at the seafloor with the same combined release rate from 4 separate well locations (4 x 6,300 m3/d).

Key findings from the study were:

- The Environmental Impact Factors (EIFs)[1] for all scenarios ranged from 950 to 3,548 for the maximum EIF and 494 to 2,529 for the mean EIFs
- Lowest EIFs were associated with the surface release scenarios and that factored in air entrainment, which appear to prevent the formation water plume from sinking rapidly
- The breakdown in contaminant contribution to EIF was almost identical for all six of the scenarios modelled with 87% of the EIF risk attributable to arsenic (34%), zinc (22%), copper (12%), chromium (10%) and lead (9%). The contribution of oxygen depletion was 8%
- Rapid dilution and mixing of discharged formation water plumes meant salinity and temperature were minimal contributors to the calculated EIFs for all modelled scenarios

6.7.3 CFD Modelling Report

transient single-phase Computational Fluid Dynamics (CFD) simulations were performed for flow field, turbulence and transport of formation water-seawater mixture to predict the extent of elevated salinity region on seabed arising from the possible displacement of store formation water in the upper 300m of the Bunter outcrop formation, ~20km east of the Endurance store.

Seabed bathymetry was built from a point cloud data file consisting of 15 million points. These data were processed to create smooth seabed surfaces, a three-dimensional CFD domain was created assuming flat interface for water surface. CFD domain covers the seabed area of 3km x 5km. CFD domain was aligned in the direction of tidal wave current, North-West to South-East.

Two different scenarios were modelled:

1. Displacement from the exposed outcrop (~700,000 m3); and
2. Discharge from a single point (circular region of 0.5m radius).

A worst-case discharge scenario was modelled – discharge rate of 3,200m3/d and salinity of 250,000ppm. The CFD results confirms that the increase in salinity is much smaller on the seabed and well below the 5% increase criteria for the case of discharge from the exposed outcrop zone. For the single point discharge scenario, increased salinity is only observed in the proximity of discharge location (less than 250m of radius zone) (Figure10).

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[1]One Environmental Impact Factor (EIF) unit represents a volume of water (defined as 105 m^3) which has the potential to harm ≥ 5% of the marine species in the receiving environment

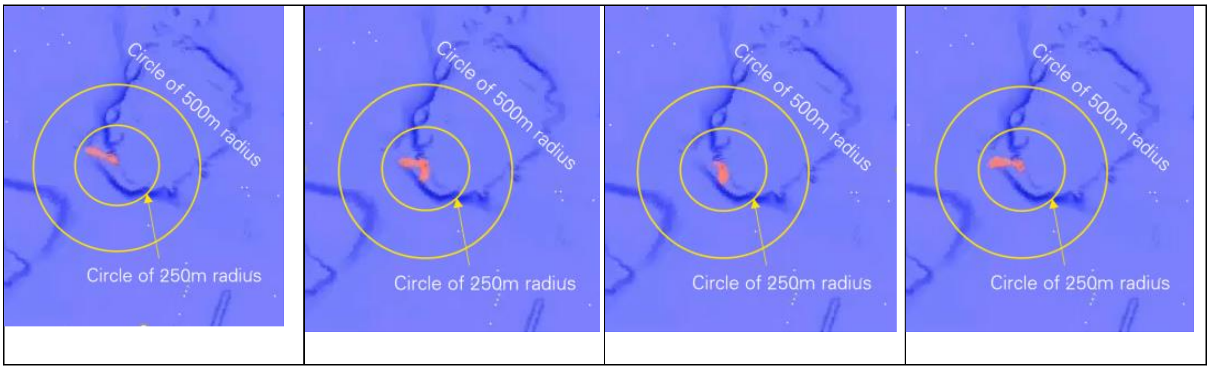

Figure 10: Closeup View of Salinity Profile for Point Discharge Case highlighting the seabed region with salinity increased by 5% of seawater salinity

6.7.4 Fluid Dynamics Study

This study explored the dilution of the formation water following release into the water column. Independent experiments considered the flow and mixing for a variety of formation water discharge source conditions (Figure 11). The experiments used a tank of depth 60cm, width 60 cm and lateral extent 2.5m, and moving source to model the background current. The typical flow rates used in the experiments were 5-10 cc/s from a nozzle of diameter 0.5 cm. In each case, the resulting dilution and potential dispersal of the plume of formation water is described and quantified in terms of time-averaged models of the flow.

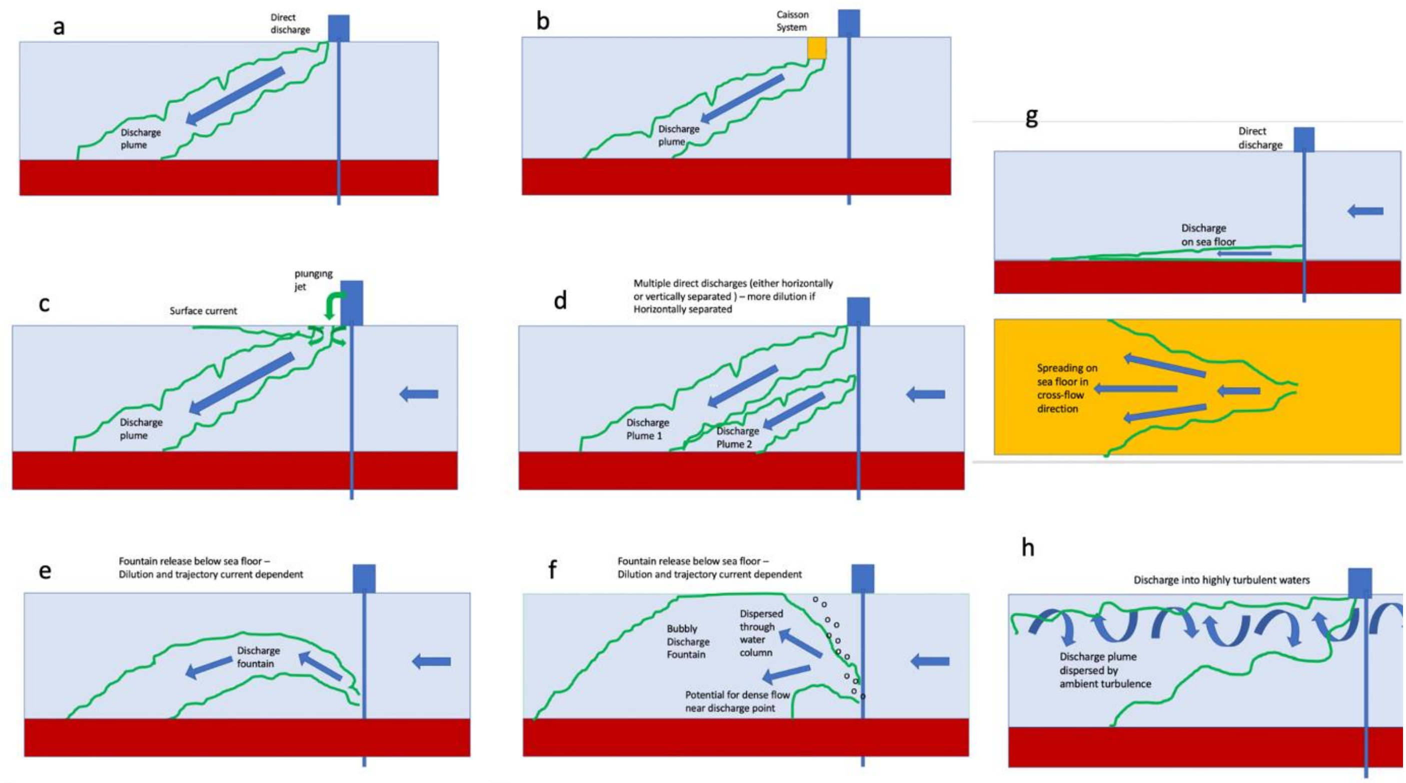

Figure 11: Range of experiments, including (a) simple discharge; (b) a caisson source; (c) a plunging jet; multiple discharge ports; (e) a fountaining source; (f) a bubble fountain; (g) a sea-floor release; and (h) release into highly turbulent surface waters.

The key findings from the study were:

- Near surface discharge appears to provide a good means of diluting the formation water release, such that for typical release rates the concentration drops off rapidly in the first 100-200m from the release point, prior to reaching the seabed.
- The degree of dilution is largely controlled by the mixing in the buoyancy driven descending plume, but additional engineered discharge techniques can enhance this a small amount.
- The use of multiple discharge points just below the surface, separated in the cross-current direction may be the most effective means of enhancing the dilution of the discharge, since this will produce multiple plumes, each of which undergoes dilution.

7.0 Community & Stakeholder Engagement

7.1 Completed and Ongoing Engagement

NEP has undertaken early engagement during pre-FEED with regulators, statutory nature conservation bodies (SNCBs) and other interested parties (e.g., fisheries, offshore wind farm developers, oil & gas operators, local authorities and local wildlife trusts). This has included discussions regarding the planned 2020 and 2021 survey activity scopes as well as sharing output from the 2020 survey results. Furthermore, the NEP project has undertaken early engagement with regulators and SNCBs regarding the management of formation water displacement of store formation water in the upper 300m of the Bunter outcrop formation (see Section 0).

7.2 Planned Future Engagement

The NEP project has commenced preparation of the environmental statement for Phase 1 of the proposed development. Following the requirements of The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 the NEP project will be submitting a proposed scoping document to OPRED requesting comments on the proposed content of the environmental statement from the Regulator, SNCBs and other interested parties. Once prepared the environmental statement will be submitted to OPRED and follow the required public notice and consultation processes.

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