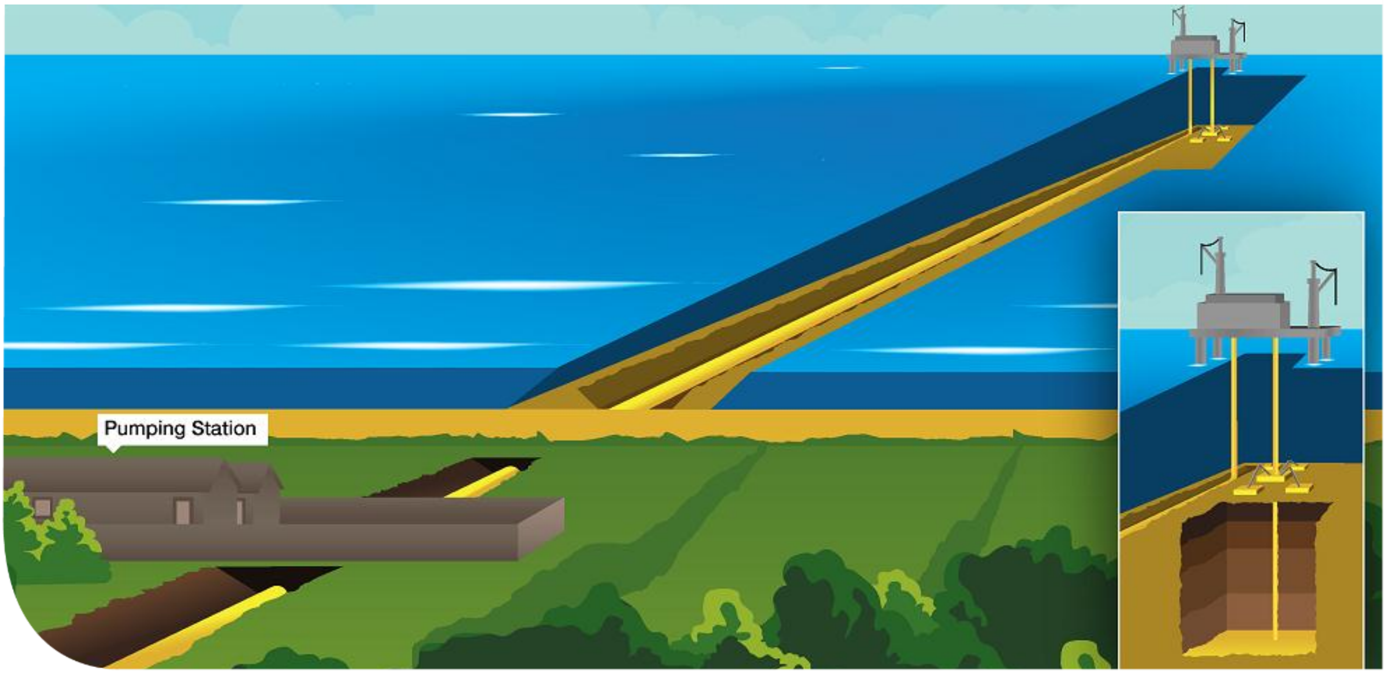
January 2016

K44: Provisional Closure - Post Closure Report

Category: Storage



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Contents

Key Words

Key Work	Meaning or Explanation
Carbon	An element, but used as shorthand for its gaseous oxide, $CO_{2.}$
Capture	Collection of CO_2 from power station combustion process or other facilities and its process ready for transportation.
Closure	Sealing the well following cessation of injection of CO_2.
Key knowledge	Information that may be useful if not vital to understanding how some enterprise may be successfully undertaken.
Storage	Containment in suitable pervious rock formations located under impervious rock formations usually under the sea bed.
Carbon Sentinel Limited (CSL)	This is a wholly owned subsidiary of NGCL, which holds CO_2 Storage Licence CS001.

Executive Summary

This report is one of a series of “key knowledge” reports which are issued here as public information. These reports were generated as part of the Front End Engineering Design (FEED) Contract agreed with the Department of Energy and Climate Change (DECC) as part of the White Rose Project.

The White Rose CCS Project plans to develop an integrated power and Carbon Capture and Storage (CCS) demonstration project with a gross output of 448MW of electricity where over 90% of the plant’s carbon dioxide (CO_2) emissions up to 2.68MTPA for a period of twenty years will be transported through a dedicated pipeline offshore for permanent underground storage in the UK Sector of the southern North Sea, specifically the Endurance Structure located in blocks 42/25 and 43/21.

Delivery of the full-chain project is be provided by National Grid Carbon Limited (NGCL), which is responsible for the Transport and Storage (T&S) network and Capture Power Limited (CPL), which is responsible for the Oxy Power Plant (OPP) and the Gas Processing Unit (GPU).

The Endurance structure is a four-way dip-closure within the Bunter Sandstone Formation of the Southern North Sea. It is a saline formation, approximately 22km long, 7m wide and over 200m thick. The crest of the reservoir is located at a depth of approximately 1020m below the sea bed. A layer of mudstone called the Röt Clay provides the primary seal. This in turn is overlain by more than 90m of a salt layer known as the Röt Halite at the base of the 900m thick Haisborough Group which provide the secondary sealing capability. None of the overburden faults visible on seismic penetrate the Röt Halite.

The proposed OPP will be connected by a short 12in diameter pipeline to a junction manifold, the Camblesforth Multi-Junction, which is provided to allow easy connection of other regional CO_2 emitters. From the Multi-Junction a 60km 24in diameter pipeline buried to at least 1.2m will be connected to the Barmston booster pumping station situated close to the proposed beach crossing. A 90km 24in diameter pipeline will be laid offshore to the platform location in Block 42/25d. The pipeline from Camblesforth to the platform will have a capacity of up to 17MTPA of CO_2 to allow for future expansion.

The injection wells, to be drilled by jack-up rig through the platform, will be moderately deviated to optimise the separation of their bottom hole locations within the Bunter Sandstone reservoir. The CO_2 will be injected into the Bunter Sandstone reservoir through perforation in the lower (deeper) half of the reservoir thickness in order to maximise the residual trapping of CO_2. The CO_2 plume will develop and migrate, initially vertically towards the top of the reservoir, and then laterally towards the crest of the structure in an east-south-easterly direction.

The Storage Complex comprises the Storage Site, its Triassic underburden down to the base of the Zechstein Halite and the overburden up to the top Jurassic Lias. Conformance of the observed and predicted response of the Storage Site to CO_2 injection will be monitored during the injection period under a comprehensive Measurement, Monitoring and Verification Plan (MMV Plan). If the operation of the Storage Site behaves as forecast and the dynamic capacity is confirmed, consideration may be given to increasing the quantity of CO_2 to be stored in the Endurance Structure. After injection ceases, the Storage Site and Storage Complex will be monitored for a number of years after which the platform and wells will be decommissioned before responsibility for the Storage Complex will be transferred to the designated Competent Authority.

The actions, which are designed to demonstrate that the Endurance Storage Site is evolving towards the safe and permanent storage of the injected CO_2, are described in this document.

1 Introduction

National Grid Carbon Limited (NGCL) is a wholly owned subsidiary of the National Grid group of companies. Capture Power Limited (CPL) is a special purpose vehicle company, which has been formed by a consortium consisting of General Electric (GE), Drax and BOC, to pursue the White Rose (WR) Carbon Capture and Storage (CCS) Project (the White Rose Project).

CPL have entered into an agreement (the FEED Contract) with the UK Government's Department of Energy and Climate Change (DECC) pursuant to which it will carry out, among other things, the engineering, cost estimation and risk assessment required to specify the budget required to develop and operate the WR Assets. The WR Assets comprise an end-to-end electricity generation and carbon capture and storage (CCS) system comprising, broadly: a coal fired power station utilising oxy-fuel technology, carbon dioxide capture, processing, compression and metering facilities; transportation pipeline and pressure boosting facilities; offshore carbon dioxide reception and processing facilities and injection wells into an offshore storage reservoir located in the North Sea blocks 42/25 and 43/21. Carbon Sentinel Limited (CSL) a wholly owned subsidiary of NGCL and holds CO_2 Storage Licence CS001.

CPL and NGC have entered into an agreement (the KSC) pursuant to which NGC will perform a project (the WR T&S FEED Project) which will meet that part of CPL's obligations under the FEED Contract which would be associated with the T&S Assets. The T&S Assets include, broadly: the transportation pipeline and pressure boosting facilities; offshore carbon dioxide reception and processing facilities and injection wells into the offshore storage reservoir, which was previously identified as "5/42" and is now known as "Endurance".

A key component of the WR T&S FEED Project is the Key Knowledge Transfer process. A major portion of this is the compilation and distribution of a set of documents termed Key Knowledge Deliverables (KKDs). This document is one of these KKDs and its specific purpose is summarised below.

The Endurance structure is a four-way dip-closure within the Bunter Sandstone Formation of the Southern North Sea. It is a saline formation, approximately 22km long, 7km wide and over 200m thick. The crest of the reservoir is located at a depth of approximately 1020m below the sea bed.

The Storage Complex is planned to be developed using a platform with six wells slots through which three injection wells slots are to be drilled. The CO_2 will be delivered to this platform in dense phase through a 24in pipeline from the shore.

This provisional Closure/Post Closure Plan describes the actions, monitoring, measurement and verification activities that are designed to demonstrate that the Endurance Storage Site is evolving towards the safe and permanent storage of the injected CO_2. The data acquisition and verification activities are a part of the on-going Monitoring, Measurement and Verification ("MMV") Plan (see KKD K42). Based on its results an interim decision will be made to abandon the injection wells, remove the platform, seal the pipeline and, subsequently, agreement will be made for the transfer of responsibility for the Storage Site from CSL (the Operator) to the Competent Authority, which is currently the Oil and Gas Authority (OGA), in fulfilment of the conditions under Article 18 of the EU CCS Directive for the transfer of Storage Sites (Ref.1).

2 Purpose

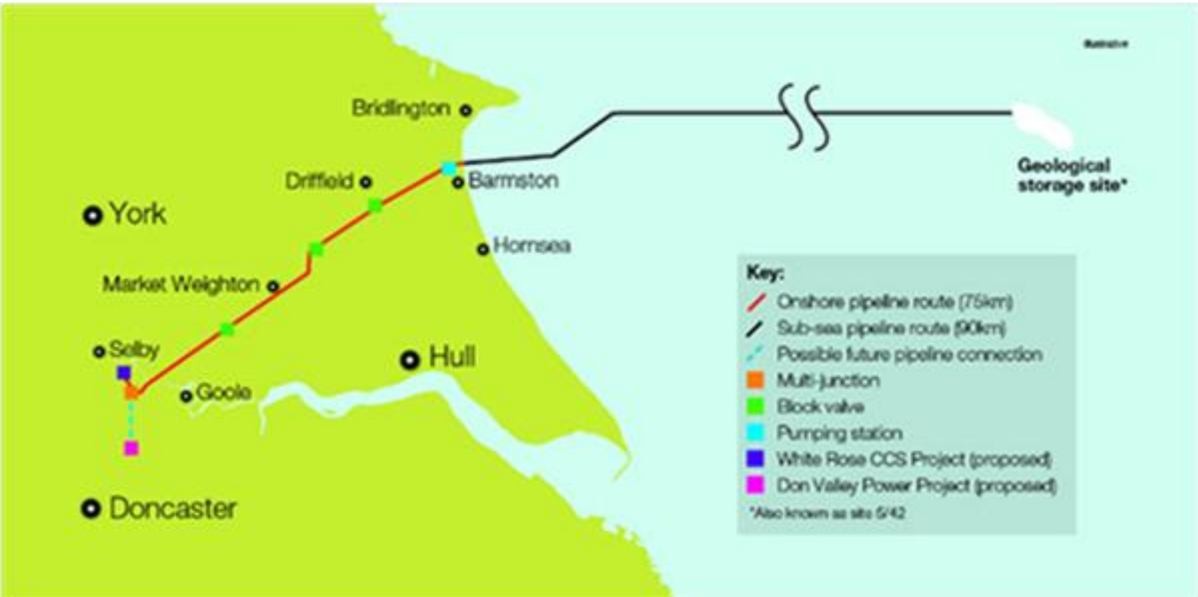
This report describes the framework for closure of the storage site in line with the existing regulatory guidelines (Ref.6). An overview is provided of the post closure monitoring plan and to potential criteria for the final closure of the site and transfer of responsibility to the regulatory authorities.

3 Project Overview

The White Rose Project would provide an example of a clean coal-fired power station of up to 448MW gross output, built and operated as a commercial enterprise.

The project comprises a state-of-the-art coal-fired power plant that is equipped with full CCS technology. The plant would also have the potential to co-fire biomass. The project is intended to prove CCS technology at a commercial scale and demonstrate it as a competitive form of low-carbon power generation and as an important technology in tackling climate change. It would also play an important role in establishing a CO_2 transportation and storage network in the Yorkshire and Humber area. Figure 3.1 below gives a geographical overview of the proposed CO_2 transportation system.

Figure 3.1: Geographical overview of the transportation facility

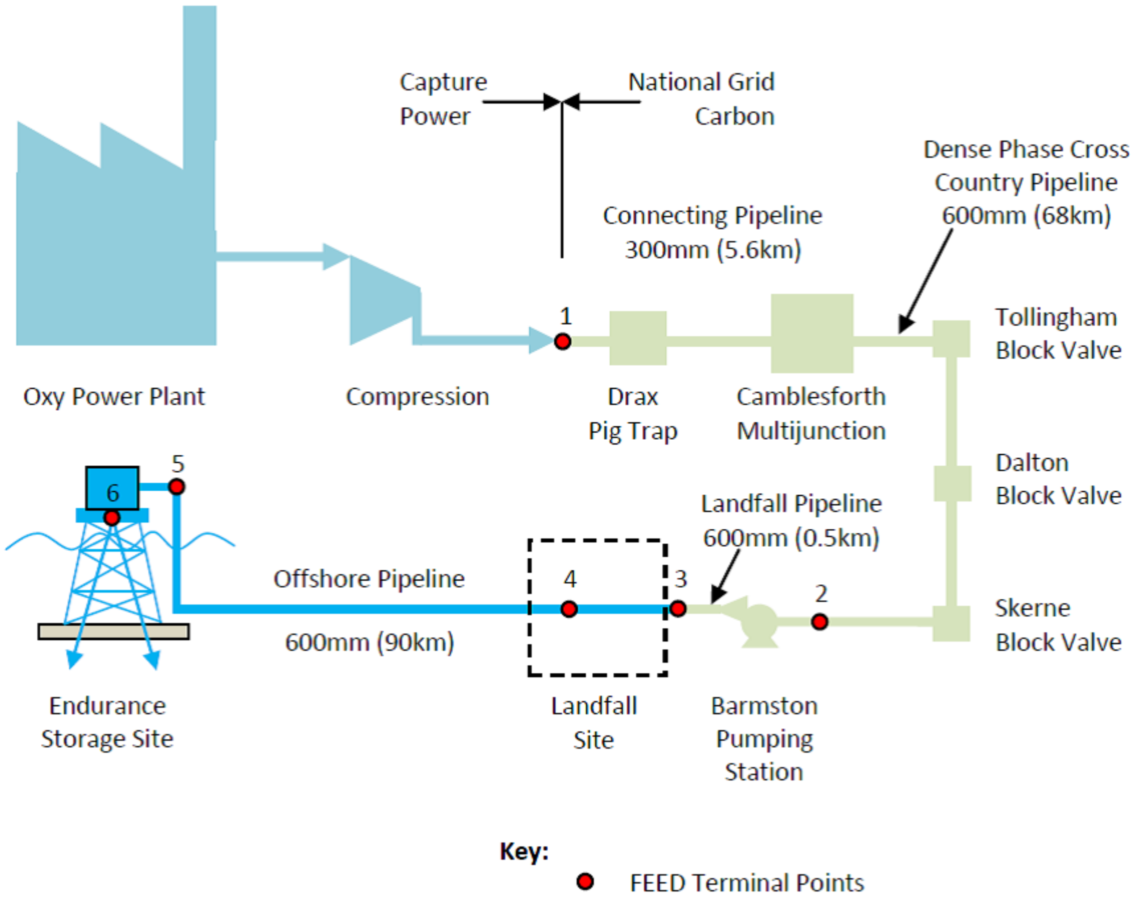


The standalone power plant would be located at the existing Drax Power Station site near Selby, North Yorkshire, generating electricity for export to the Electricity Transmission Network (the "Grid") as well as capturing approximately 2 million tonnes of CO_2 per year, some 90% of all CO_2 emissions produced by the plant. The by-product CO_2 from the Oxy Power Plant (OPP) would be compressed and transported via an export pipeline for injection into an offshore saline formation (the reservoir) for permanent storage.

The power plant technology, which is known as Oxyfuel combustion, burns fuel in a modified combustion environment with the resulting combustion gases being high in CO_2 concentration. This allows the CO_2 produced to be captured without the need for additional chemical separation, before being compressed into dense phase and transported for storage.

The overall integrated control of the End-to-End CCS chain would have similarities to that of the National Grid natural gas pipeline network. Operation of the Transport and Storage System would be undertaken by NGC. However, transportation of carbon dioxide presents differing concerns to those of natural gas; suitable specific operating procedures would be developed to cover all operational aspects including start-up, normal and abnormal operation, controlled and emergency shutdowns. These procedures would include a hierarchy of operation, responsibility, communication procedures and protocols. Figure 3.2 below provides a schematic diagram of the overall end-to-end chain for the White Rose CCS Project.

Figure 3.2: End To End Chain Overall Schematic Diagram



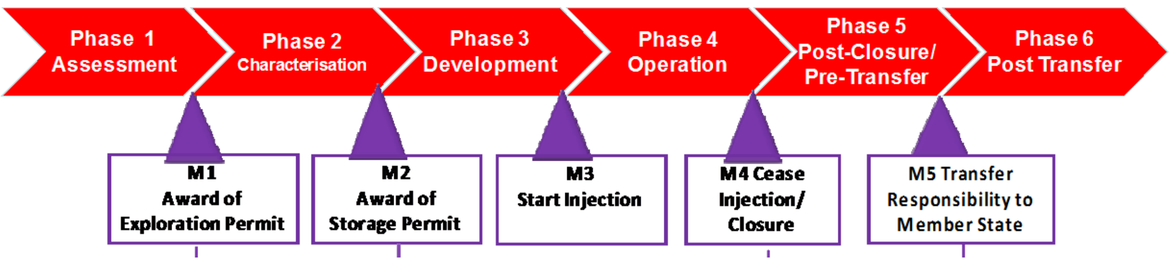
The 5/42 geological storage site and the offshore platform facility at point 6 on Figure 3.2 have been renamed “Endurance”.

4 Background

Under the general scheme as presented in the EU CCS Guidance Document 1 (GD1) (Ref. 2) the commencement of the 5th Project Phase, namely the Post-Closure/Pre-Transfer Project Phase is marked by the 4th Project Milestone (Figure 4.1), which is the cessation of injection or "Closure" of the Storage Complex at the end of the Operation Phase. This specifically means that no more CO_2 will be injected into the Storage Site and during this phase the principal activities for the WR Project are the sealing and abandonment of the wells, the removal of the platform and sealing of the pipeline and the decision of the Competent Authority to accept the transfer of responsibility.

These activities, and the information required to make the decision associated with them, are governed by the MMV Plan which will continue to remain in full force and effect and continues to be reported and updated annually.

Figure 4.1: CCS Project Phase and Milestones (from GD1)



Article 18 of the CCS Directive states that when a storage site has been closed (as per the conditions in the Article 17(a) and (b), i.e. that the conditions of the storage permit have been met or that the substantiated request for closure by the Operator has been authorised by the Competent Authority), the responsibility for all legal obligations can be transferred to the Competent Authority of the Member State subject to several conditions noted in Article 18(1):

- all available evidence indicates that the stored CO_2 will be completely and permanently contained;
- a minimum period after closure, to be determined by the Competent Authority has elapsed; this minimum period shall be no shorter than 20 years, unless the Competent Authority is convinced that the first condition above is fulfilled;
- the financial obligations under Article 20 have been fulfilled and
- the site has been sealed and the injection facilities have been removed.

In order to provide the evidence that the stored CO_2 will be completely and permanently contained, as mentioned above, the MMV Plan continues during the 5th Project Phase and the Operator is required to demonstrate that the stored CO_2 is permanently contained by meeting at least the three conditions noted in Article 18(2):

- observed behaviour of the injected CO_2 conforms to the modelled behaviour;
- no detectable leakage; and
- the storage site is evolving towards a situation of long-term stability.

The MMV Plan specifies the technologies, methodologies and frequency of the various measurements that are recommended for each of the phases of the project and is subject to annual updates in order that the latest technologies and methodologies are deployed in order to satisfy the conformance and containment objectives of the plan.

The Closure Plan is essentially an extension of the MMV Plan and because this plan evolves over the duration of the project, the precise activities to be undertaken for Closure can only be specified at the time of closure, building on the experience and data acquired during the operational (CO_2 injection) phase and using this to refine the models of the Endurance Storage Site.

Critical to these processes are the continuous consultation between the Operator and the Competent Authority on practical interpretation of the above criteria in the context of the WR Project and to establish objective metrics for evaluation of predictive accuracy of models and minimum thresholds for leakage detection and in particular, the timing of the sealing and abandonment of the injection wells and the removal of the injection facilities.

5 MMV Plan

The MMV Plan, which is provided by K42 (Storage risk assessment reports), contains important definitions, its legislative context (Ref. 6) and site specific definitions that are key to the operation of the plan. For the purpose of this report, the Post Closure / Pre-Transfer Phase is sub-divided into Post Injection prior to, and Post Closure after, well abandonment and platform removal. This sub-division reflects the necessary changes in monitoring methodologies depending on whether the platform and wells are available to host monitoring equipment. Although the platform and wells could be abandoned at the end of the Post Closure phase, maintaining a platform is costly and not completely without risk and the earliest reasonable abandonment is recommended. In regard to this aspect of the WR Project, the down-dip location of the injection wells means that as the plume migrates to the crest of the structure, the wells are no longer in contact with the free CO_2 cap, as they would be if the injectors were located at the crest of the structure.

5.1 Definitions; Endurance Site Specific Description

Under the current legislation the following definitions have been proposed. They are illustrated below in Figure 5.1:

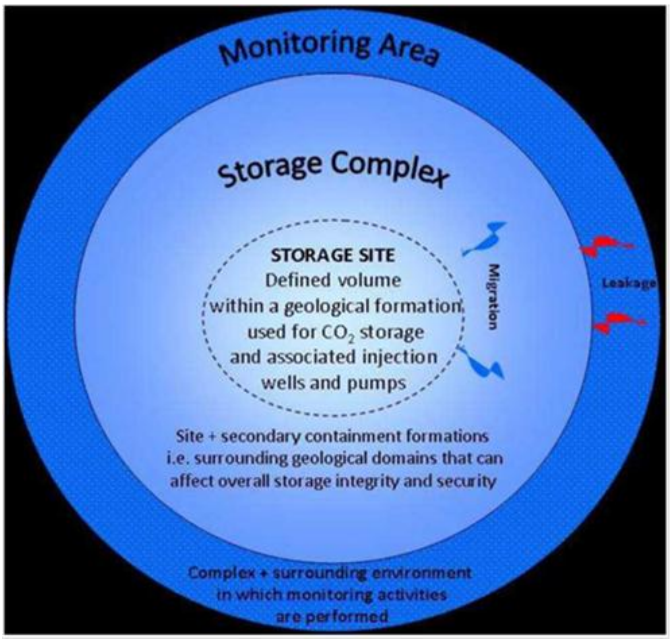
5.1.1 Storage site

A defined volume within a geological formation used for CO_2 storage and associated injection wells and infrastructure.

5.1.2 Storage complex

The Storage Complex consists of the storage site plus secondary formations i.e. surrounding geological domains that can affect overall storage integrity and security.

Figure 5.1: CO_2 Storage Definitions



The identification and definition of Storage Complex is critical as “leakage” is defined as the release of CO_2 from the Storage Complex whereas movement of CO_2 within the Storage Complex is defined as migration.

It is expected that stored CO_2 will be retained permanently within the storage site and that any migration outside the storage site may represent a significant irregularity in which case the operator would be required to institute corrective measures. Where migration does imply a risk of leakage outside the complex or an increase in environmental or public health risk then it will represent a significant irregularity.

5.1.3 Migration

The movement of CO_2 within the Storage Complex is defined as migration.

5.1.4 Leakage

Leakage means any release of CO_2 from the Storage Complex.

5.1.5 Storage Permit

The Storage Permit, issued by the Competent Authority, authorises the geological storage of CO_2 in a Storage Site by the Operator, and specifying the conditions under which it may take place.

5.1.6 Substantial Change

A Substantial Change refers to any change which is not provided for in the Storage Permit. In order to address the various changes, which may occur and for which accountability may be made in the Storage Permit, the Risk Assessment (Ref. 5) summarises the normal and alternative evolution scenarios that may arise from injecting CO_2 in the storage site.

5.1.7 CO_2 Plume

The CO_2 plume is the location and volume of the dispersing mass of CO_2 within the geological formations.

5.1.8 Significant Irregularity

A significant irregularity is one which occurs during the injection or storage operations or an irregularity in the condition of the Storage Complex itself, and which *implies the risk* of a leakage or risk to the environment or human health.

5.1.9 Significant Risk

This addresses the combination of a probability of occurrence of damage and a magnitude of damage that cannot be disregarded without calling into question the purpose of the Directive for the Storage Site concerned.

5.1.10 Corrective Measures

Corrective measures are any actions taken to correct significant irregularities or to close leakages in order to prevent or stop the release of CO_2 from the Storage Complex.

5.1.11 Closure

This is the definitive cessation of CO_2 injection into the Storage Site.

5.1.12 Post Closure

Post closure is the period after the closure of a Storage Site and includes the period after transfer back to the Competent Authority.

5.2 Endurance Site Specific Definitions

5.2.1 Endurance Storage Site

For the Endurance structure, the Storage Site is comprised of the three layers of the Bunter Sandstone Formation.

The vertical extent of the Storage Site is shown in Figure 5.2 and Figure 5.3.

The areal dimensions of the Storage Site are taken from the most likely Top Bunter depth map which closes at 1460mTVDSS

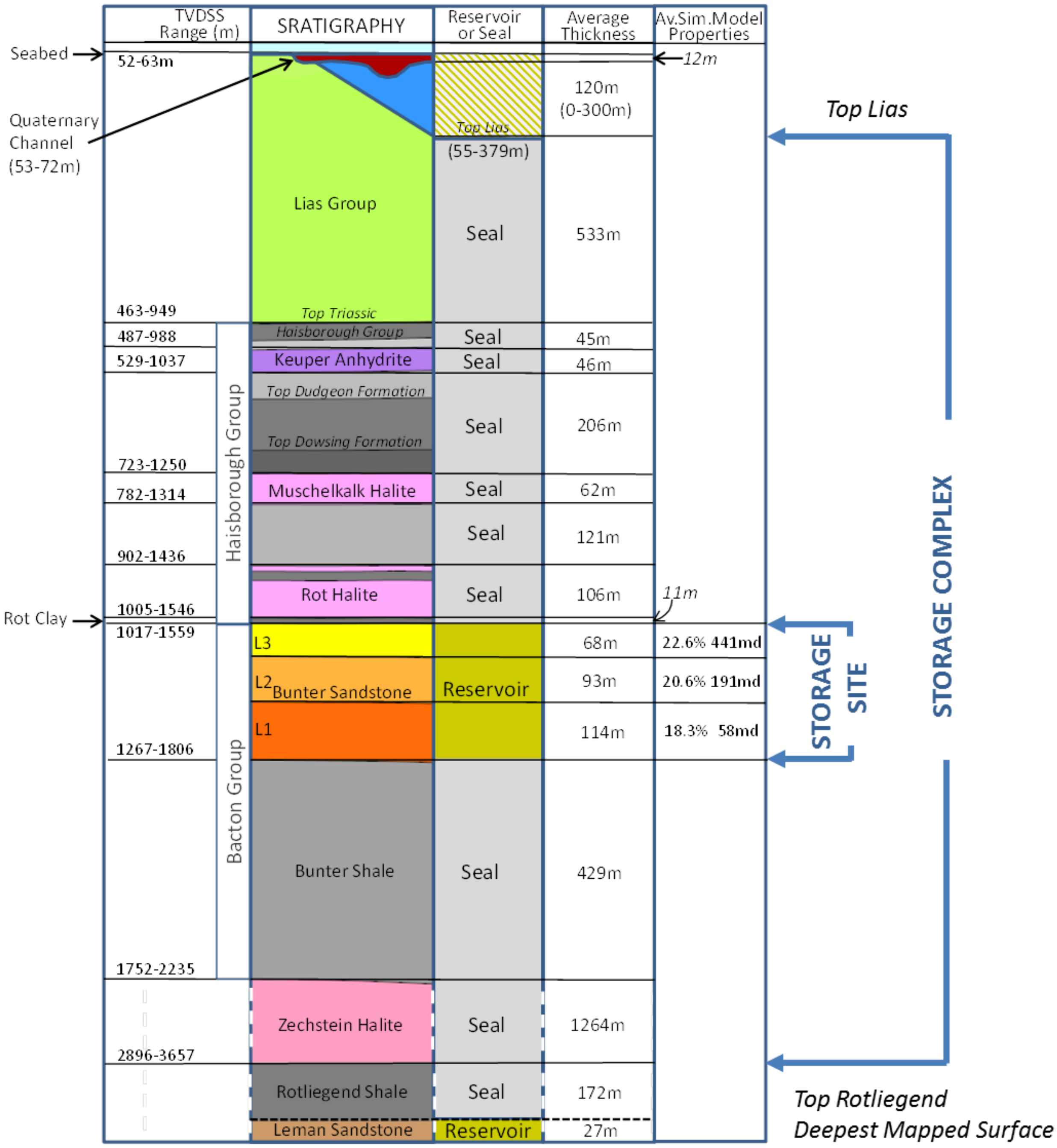
5.2.2 Endurance Storage Complex

The Storage Complex is defined from the Top Rotliegend (circa 2896m to 3657m) to the top of the Lias formation (circa 52m to 63m) and entirely encompasses the Storage Site.

The Upper Rotliegend is likely to provide a further seal. However, the base of the formation and the top of the underlying Leman Sandstone reservoir cannot be mapped seismically with any confidence and consequently the base of the storage complex has been placed at the deepest confident mapable horizon, namely the Top Rotliegend.

The areal definition for the Storage Complex for the Endurance structure is taken as the closure of the high case (deeper on flanks) top Bunter Sandstone depth map at -1554mTVDSS. It includes all the overburden geological formations directly above the Rot Clay seal up to the Top of the Lias, the shallowest formation that is anticipated to be a sealing interval.

Figure 5.2: Vertical Limits of the Storage Site and Complex



5.2.3 Endurance Monitoring Area

The Monitoring Area will extend beyond the Storage Site and Storage Complex – both vertically and areally. The areal extent also includes the seabed outcrop of the Bunter formation to the east and south of the main Endurance structure. This additional area is included as it is expected that formation brine will be expelled from the outcrop as a result of the increased pressure caused by CO_2 emplacement within the Endurance structure. Due to the structural configuration and particularly as the injection point is shallower than the structural closure, it is considered impossible that any CO_2 will be present at the outcrop.

Vertically the Monitoring Area includes stratigraphy outwith the Storage Complex. This includes the Middle Jurassic to Cretaceous strata, which outcrop the seabed on the margins of the Endurance anticline, and the Quaternary channels of unknown lithology which locally erode older stratigraphy.

The requirements for monitoring the outcrop are predominantly environmental and relate only to the quantities of dissolved solids in the formation brine at that location.

A cross-sectional representation is provided by Figure 5.3; refer to Figure 5.4 for the line of section A-A'.

Figure 5.3: Section Illustrating Key Wells & Limits of Storage Site, Complex & Monitoring Area

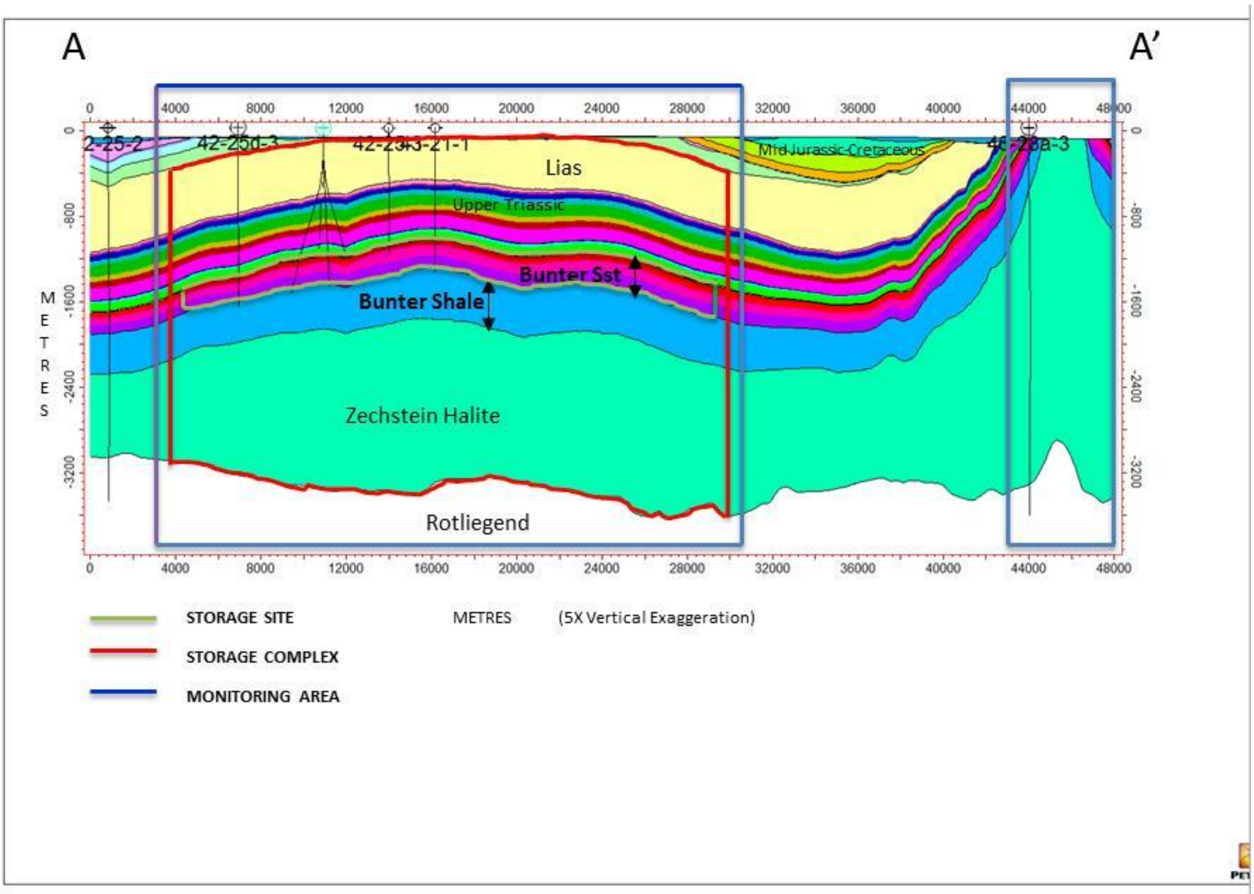
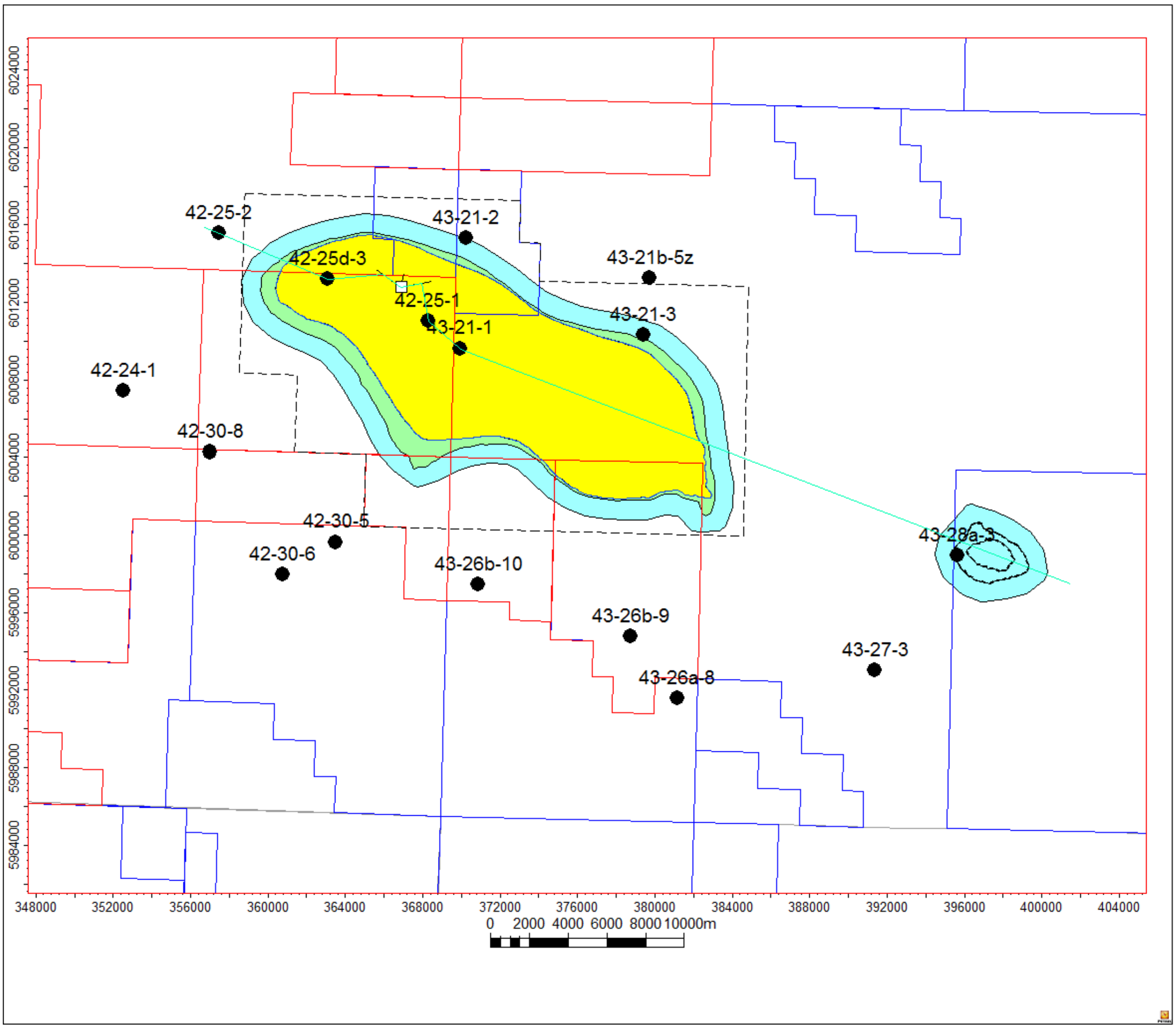


Figure 5.4: Areal View Illustrating the Storage Site, Complex and Monitoring Area showing the line of the cross-section taken for Figure 5.3



The extent of monitoring to be carried out is intended to balance the requirements laid out in legislation with economic considerations regarding type and frequency of monitoring with particular reference to plume migration.

As a result, the North West of the CCS license area, including appraisal and crestal wells (in addition to the injection wells) will be subject to more stringent and regular monitoring than the South and East of the structure and the Bunter Outcrop until such times as plume migration or other events occur such that the types, extent and frequency of monitoring needs to be modified.

6 Closure and Post Closure Activities

Once the decision to close the storage complex would be agreed with the Competent Authority, CO_2 injection would cease. At this time, the wells would be isolated from the other platform facilities and the isolation valves on the pipeline closed. All recording systems and other data acquisition required according to the MMV Plan would remain active.

Once the decision to abandon the wells was made and the platform removal was sanctioned, the first activities would be the well abandonments. For this work, a drilling rig would be mobilised. The wells would be abandoned one-by-one in according with the abandonment regulations in force at that time, but although the procedure may vary to suit the well construction details, generally it would accord with the following outline:

1. wells are killed and circulated to kill weight mud;
2. the perforated interval of each well is squeeze cemented using CO_2 inert cement;
3. the completions and Christmas tree are recovered;
4. the casing is milled out through the Rot Halite, the Rot Clay and Into the Bunter sandstone;
5. a pancake plug of CO_2 inert cement is set across the top of the Bunter Sandstone, through the Rot clay into the Rot Halite (it is recommended that a minimum of 50 m of Rot halite will be left without casing and uncommented so that salt creep can provide a secondary seal structure);
6. pancake plug is weight and pressure tested;
7. 2nd and third abandonment plugs are set as required; and then
8. final abandonment plug is placed near surface and the casing is cut and removed from below the mudline.

Once all wells were sealed, platform removal could be undertaken and the pipeline could be sealed.

7 Monitoring Technologies

As previously noted, monitoring technologies and the parameters, which are measured, would change depending on the availability of the platform and wells (Post Injection) or after well abandonment and platform removal (Post Abandonment). Details and descriptions of the equipment, data acquisition and rationale are contained in the MMV Plan and in the Offshore Environmental Statement (Ref. 5).

7.1 Post Injection Technologies

Technologies and techniques, which could be employed during the Post Injection period, are:

- wellhead pressure and temperature*;
- downhole pressure and temperature;
- inert and isotope tracers (only required if gas seeps are identified prior to injection);
- casing annulus pressures*;
- 3-D seismic;
- microseismic network* (Decommissioned approximately two years after Closure);
- tiltmeter network* (decommission with microseismic network);
- Global Positioning System* (GPS);
- sonar bubble stream detection;
- seawater chemistry;
- ground water monitoring;
- seabed sampling and gas analysis; and
- ecosystem monitoring.

* denotes technologies not available after well abandonment and platform removal.

At the time of closure, the dynamic reservoir, static geological and geomechanical models, which would have been continuously updated and calibrated throughout the operational phase, would be used to predict the behaviour of the Storage Complex and rate of decay of the pressure after injection ceases. Once injection had ceased, the average pressure of the Storage Site would start to decline as the pressure dissipates through the Greater Bunter aquifer and through brine discharge from the seabed outcrop. The plume will continue to migrate towards the crest of Storage Site and a 3-D time lapse seismic survey would be performed sometime after the cessation of injection to corroborate the pressure decline and reservoir modelling predictions. Within five years of the cessation of injection, the excess pressure that would have resulted from injection would be expected to have reduced by a third (according to current modelling forecasts) and this would be sufficient time to definitively establish the Storage Site pressure decline trend in the absence of the detection of any irregularities. Once the trajectory of the pressure response had been confirmed, the monitoring and measurement effort can be reduced and the optimum timing for the permanent sealing of the wells and the removal of the surface infrastructure could be decided.

7.2 Post Abandonment Technologies

Technologies and techniques, which could be employed Post Abandonment period, are:

- downhole pressure and temperature (available for five years after abandonment;
- 3-D seismic (only required if an irregularity is detected);
- sonar bubble stream detection;
- Seawater chemistry;
- ground water monitoring;

- seabed sampling and gas analysis; and
- ecosystem monitoring.

If no significant pressure deviations are experienced during the Post Injection period, it would be unlikely that any would be detected during the Post-Abandonment period as the pressure would continue to drop and the integrity of the Storage Site and Storage Complex would increase, not only from the decaying pressure, but also from the permanent abandonment of the injection wells removing the possibility of well seal failure as described in the Alternative Evolution Scenarios envisaged by the risk assessment. This reduction in pressure also would also reduce the stress on the crestal legacy wells and the risk of leakage continually reduces with the elapsed time after Closure.

During the Post Abandonment period, if no irregularities were detected, the Transfer Report would be prepared and submitted to the Competent Authority for consultation. The Transfer Report would reiterate the evidence for complete and permanent storage according to the following assessments:

1. conformity with models:
   a. no requirement to update models to match observed data over the previous (rolling) five years and in particular, reservoir pressure data and plume migration; and
   b. backcasting model results match monitored parameters throughout the entire project life from first injection; and
2. absence of any detectable leakage:
   a. well seal integrity is good with no leaks deterioration of damage;
   b. CO_2 plume migration is as expected and within the storage site; and
   c. geochemical analyses (on core samples) match geochemical modelling;
3. evolution to long term stability:
   a. model predictions indicate CO_2 to be stable and stored within the storage complex;
   b. the monitored parameters, particularly the average reservoir pressure, are converging to stable values as predicted by modelling; and
   c. the rates of change of monitored parameters are relatively small and declining.

The Transfer Report would also document the storage activities that had taken place throughout the project, including but not limited to:

- narrative history of the site, including site characterisation, operations, leakage events and anomalies, corrective measures, and summary of monitoring results; this history should cover the entire CCS lifecycle phases (as discussed in GD1);
- history of injection facility construction and what activities were undertaken in the closure and post-closure periods;
- a revised finalized complex characterisation report, including information from the final static and dynamic models;
- narrative history of modelling processes, results from modelling and simulation activities, changes made to the models as a result of new data and history matching, and the corresponding uncertainty analysis;
- description of how uncertainties have been analysed and managed, and review key decisions made under uncertainty in retrospect;
- an updated project risk assessment showing how all individual risks that were identified have evolved throughout the project life;
- explanations for upgrading or downgrading risks during the life of the project; and

- proof of site sealing and removal of injection facilities.

On a technical basis, the transfer of responsibility from the Operator (CSL) to the Competent Authority (the OGA) would take place once the Competent Authority is satisfied that there was sufficient evidence, as submitted in the Transfer Report, for complete and permanent containment of the stored CO_2 and adopts a final decision of approval.

7.3 After Transfer

Similarly, to Post-Abandonment period above, the continuation of the pressure decay would continue to improve the integrity of the Storage Site and Storage Complex. Monitoring of the Storage Complex would continue, but the emphasis would then be on leak detection using sonar bubble stream detection.

8 Conclusion

This document has set out a provisional closure and post-closure monitoring plan for the White Rose CCS project principally covering the period between the cessation of injection to the time of transfer of responsibility of the storage complex from the Operator to the Competent Authority. This monitoring plan, implemented as part of the wider MMV plan, would rely on pressure measurements for tracking trends in pressure decline and would rely on time-lapse seismic for tracking CO_2 plume migration and for leakage detection during the post-injection and post-closure stages of the project. Both are considered mature monitoring technologies and they would deliver necessary data for quantitative assessment of compliance with EU CCS Directive criteria for complete and permanent CO_2 storage.

9 References

Ref.	Source
Ref. 1	Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.
Ref. 2	Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Guidance Document 1, CO_2 Storage Life Cycle Risk Management Framework, European Communities, 2011, DOI: 10.2834/21150.
Ref. 3	Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Guidance Document 3, Criteria for Transfer of Responsibility to the Competent Authority, European Communities, 2011, DOI: 10.2834/21150.
Ref. 4	D5.4 Best Practice Guidelines, CO_2 CARE CO_2 Site Closure Assessment Research, FP7-ENERGY-2010-1, British Geological Survey, 2013.
Ref. 5	NGCL – CCS - Offshore Environmental Statement, Hartley Anderson Oct 2015.
Ref. 6	UK Statutory Instrument, 2010 No. 2221, Environmental Protection, The Storage of Carbon Dioxide (Licensing etc.) Regulations 2010

10 Glossary

Term	Explanation
%	Percentage
CCS	Carbon Capture and Storage
CO_2	Carbon dioxide
CPL	Capture Power Limited
CSL	Carbon Sentinel Limited
DECC	Department of Energy and Climate Change
EU	European Union
GD1	EU CCS Guidance Document 1
GE	General Electric
in	Inch
m	meter
MMV	Measurement, Monitoring and Verification
MW	Megawatts
mTVDSS	True Vertical Depth (in meters) of a point in a well, referenced to the seabed
MTPA	Million tonnes per annum
NGCL	National Grid Carbon Limited
OGA	Oil and Gas Authority
OPP	Oxy Power Plant
T&S	Transport and Storage
stratigraphy	The way in which rock strata are arranged, and the chronology of their formation