Ithaca Energy (UK) Limited

Anglia Decommissioning
Pipelines and Umbilical
Comparative Assessment

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GLOSSARY AND ABBREVIATIONS

Term	Explanation
BEIS	Department for Business, Energy and Industrial Strategy
CA	Comparative Assessment
Concrete mattress	A series of concrete blocks usually connected together by polypropylene ropes which resembles a rectangular mattress. These are used for the weighting and/or protection of seabed structures including pipelines
CSV	Construction Support Vessel
DECC	Department of Energy and Climate Change
DSV	Dive Support Vessel
DP	Decommissioning Programme. Costed programmes submitted to BEIS, detailing the measures the Licensee proposes to take in connection with the decommissioning of oil and gas infrastructure (installations and pipelines)
EIA	Environmental Impact Assessment
Gj	Gigajoule. 1 gigajoule is equal to 1 billion (10^9) joules
HS&E	Health, Safety and Environment
JNCC	Joint Nature Conservation Committee
LOGGS	Lincolnshire Offshore Gas Gathering System
MCZ	Marine Conservation Zone
NNSSR SAC	North Norfolk Sandbanks and Saturn Reef Special Area of Conservation
NUI	Normally Unattended Installation: an installation with minimal facilities which is not permanently crewed and is controlled from a remote location (e.g. other platform or shore)
OSPAR	Oslo and Paris Convention
Phytoplankton	Free-floating microscopic plants
SAC	Special Area of Conservation: established under the Habitats Directive. Sites that have been adopted by the European Commission and formally designated by the government of each country in whose territory the site lies.
SPA	Special Protection Area: established under the Birds Directive.
Spalling	Defects or breakdown of concrete, in this case the breaking and falling off during handling of the concrete coating originally applied to the pipelines.
UKCS	United Kingdom Continental Shelf

1 INTRODUCTION AND BACKGROUND

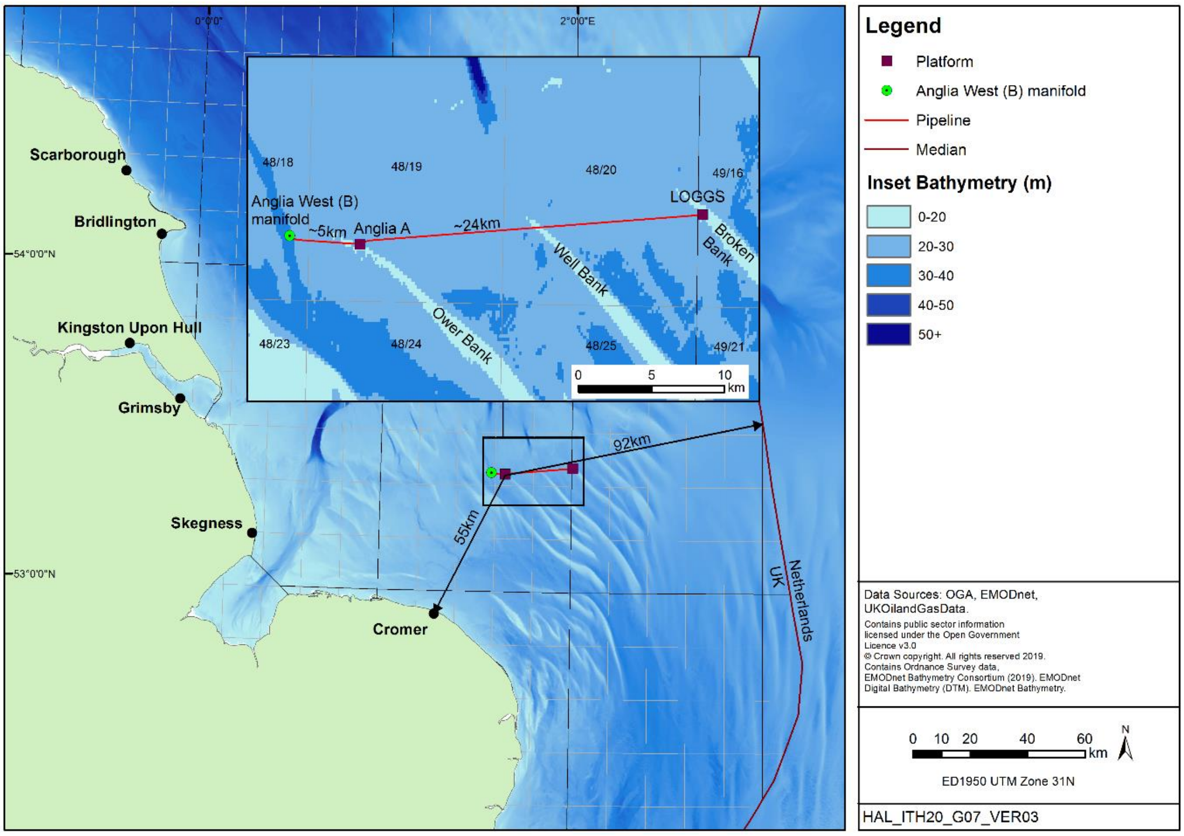
Ithaca Energy (UK) Limited (Ithaca) is planning for the decommissioning of the Anglia Field, a gas/condensate field located in the southern North Sea (infrastructure straddles Blocks 48/18, 48/19 and 48/20) approximately 55km from the UK mainland and 95 km from the UK/Dutch median line (Figure 1.1). Ithaca acquired an operated interest in the Field from GDF SUEZ E&P Ltd (now ENGIE) in December 2010 and a Cessation of Production (CoP) notification was submitted on 26th November 2015 and approved on the 16th of May 2016 by the Oil and Gas Authority.

Ithaca has decommissioning liability for the facilities associated with Anglia, and has therefore drafted their Decommissioning Programmes (DPs) for these. The facilities are:

1. The Anglia A normally unattended installation (NUI) (Anglia A NUI) (topsides, jacket and securing piles)
2. The Anglia West (B) manifold (gravity based) and integrated protective structure (piled)
3. Eleven wells (6 x production wells (Anglia A NUI), 2 x subsea production wells (Anglia West (B)) and 3 subsea appraisal wells)
4. The Anglia pipeline system; Anglia A NUI to Anglia West (B) infield concrete coated pipeline and control umbilical (~5km in length, trenched and buried separately) and Anglia A NUI to the Lincolnshire Offshore Gas Gathering System (LOGGS) PP platform export concrete coated pipeline with piggybacked methanol line (~24km in length, trenched and buried)
5. Protective material (mattresses, concrete protective structures, frond mattresses, grout bags and rock)

The ConocoPhillips LOGGS infrastructure is not part of the Anglia Decommissioning Programmes.

Figure 1.1 – Anglia location



The Anglia A NUI, export pipeline (and piggybacked methanol line) and approximately 2.5km of the infield pipeline and umbilical are located within the western boundary of the North Norfolk Sandbanks and Saturn Reef Special Area of Conservation (NNSSR SAC); the remainder of the infield lines and the Anglia West (B) manifold lie outwith the boundary of the site. Approximately 18km of the export pipeline/methanol line also lies within the boundary of the Southern North Sea Special Area of Conservation (SNS SAC) (see Section 2 and Figure 2.4). Both the infield pipeline/umbilical and the export/methanol pipeline cross 3rd party pipelines and cables.

To fulfil Ithaca's HS&E policy and in line with regulator (BEIS 2018) and industry guidance (OGUK 2015), the DPs are supported by a Comparative Assessment of the feasible options for the decommissioning of the Anglia pipelines, umbilical and protective material (the Anglia Pipeline System). The Comparative Assessment is a systematic process by which various options are examined, leading to the identification of a preferred option for decommissioning of this infrastructure.

1.1 Purpose, Regulatory Context and Approach

The OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations sets out OSPAR Contracting Parties obligations on the decommissioning of offshore installations. Pipelines do not fall within the definition of offshore installations and are not covered by this OSPAR Decision, and there are currently no international guidelines on the decommissioning of disused pipelines.

In the UK, the principal legislation for the decommissioning of disused offshore installations and pipelines is the *Petroleum Act 1998* (as amended) ("the 1998 Act"). Under Part IV of the 1998 Act and amendments to it through the *Energy Act 2008*, operators proposing to decommission an offshore installation or submarine pipeline must submit a Decommissioning Programme. Where the programme includes the decommissioning of pipelines (and umbilicals), the Department for Business, Energy and Industrial Strategy (BEIS), (previously the Department of Energy and Climate Change (DECC)) guidance (BEIS 2018) indicates a Comparative Assessment must be carried out to examine all feasible options for decommissioning to inform decisions relating to the decommissioning of those pipelines. Oil and Gas UK published further guidance (OGUK 2015) expanding on that initially provided by DECC (2011), with the aim of encouraging a consistent approach to the Comparative Assessment process in the UK. The Comparative Assessment for the Anglia Pipeline System has been drafted taking account of this guidance.

The decommissioning options considered in the Comparative Assessment for the Anglia pipelines, umbilical and protective material (described above), primarily relate to whether these are wholly or partially to be left *in situ* or fully retrieved, the methods used and their potential effects, and any proposed remediation. Consistent with the OGUK and BEIS guidance (OGUK 2015, BEIS 2018), the Comparative Assessment considers these options for the Anglia Pipeline System, based on the following 5 criteria: Safety, Environmental, Technical, Societal and Economic (see Section 5).

This document describes the Comparative Assessment process, the outcomes and the recommended options for the decommissioning of the Anglia Pipeline System.

2 SUMMARY OF ENVIRONMENTAL CONDITIONS

Physical environment

The Anglia facilities are located in a shallow area of the southern North Sea, an area with an extensive network of large sand banks and smaller scale sandwaves and ripples. The Anglia A NUI lies on the north-west end of the Ower Bank at a depth of ~20m and the ~24km export/methanol lines traverse the north west end of the Well Bank (Figure 1.1). Depths range between 20m and 28m along the pipeline, with sandwave amplitudes of several metres recorded. Similarly, large sandwaves and megaripples are recorded along the ~5km pipeline route to the Anglia West (B) manifold (Fugro 2018a) where the depth is ~30m.

There are uncertainties about the rate of migration of these banks, but observations suggest that this could be in the order of 0.4m/yr to 1m/year (Cooper *et al.* 2008, also see Jenkins *et al.* 2015). Smaller sandwaves (up to ~5m) present around Anglia, unlike the sandbanks, are more active, flow-transverse features (Cameron *et al.* 1992). The strong currents and large coastal sediment supplies contribute to the Anglian sediment plume (Dyer & Moffat 1998) which extends eastwards across the Southern Bight and also the North Norfolk sandbanks (HR Wallingford 2002), with highest average sediment concentrations in winter months to the south of the Anglia facilities at more than 30mg/l, with averages of 10-15mg/l around Anglia (CEFAS 2016). Summer concentrations tend to be less than 10mg/l.

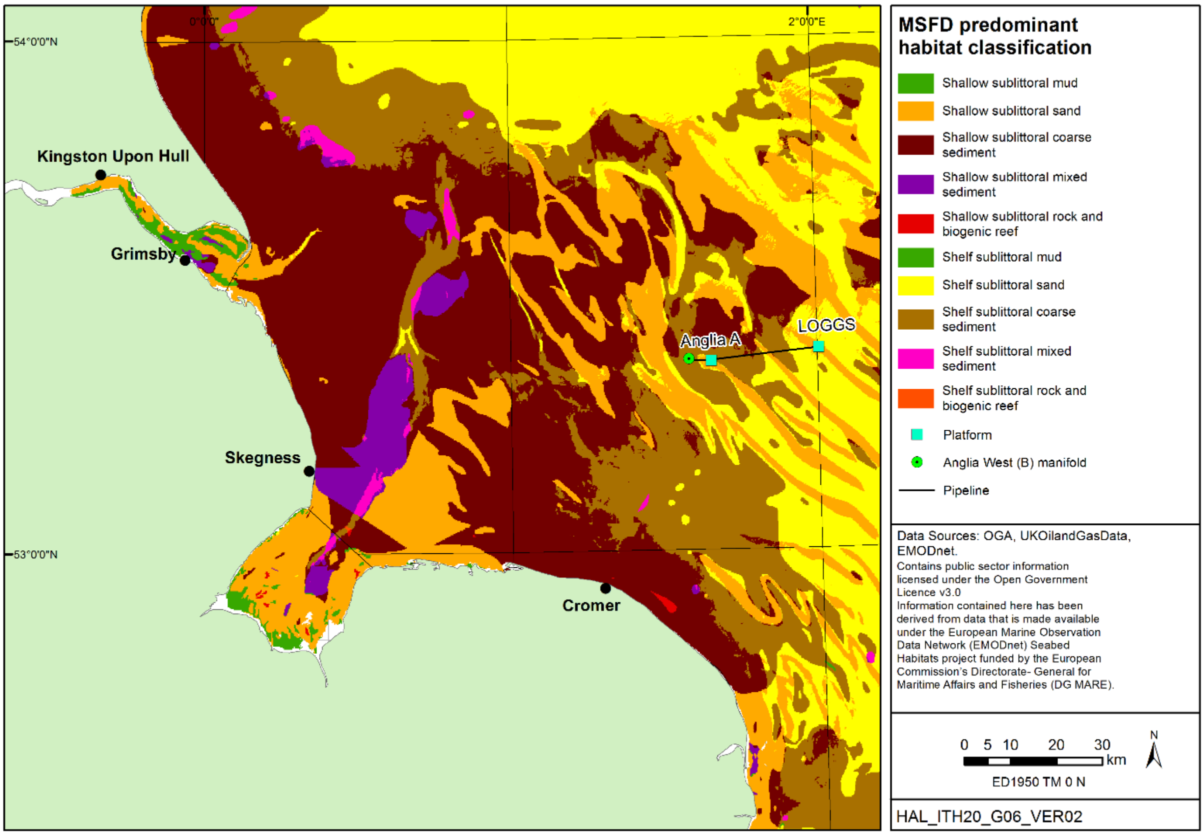
The Anglia facilities are located in an area of circalittoral sand and coarse sediment (see Figure 2.1 and also Cameron *et al.* 1992), with isolated boulders and cobbles observed (Fugro 2018a). The area around the Anglia A NUI and Anglia West (B) is characterised by moderately to well sorted medium to coarse sand with thicknesses varying between 1 and 9m, underlain by Late Weichselian glacial material of the Botney Cut and Bolders Bank Formations (Gardline 2003).

Southwesterly winds dominate in autumn and winter months, with winds from the north-northeast marginally more common in spring and summer (UKHO 2013). The frequency of gales (≥ Beaufort force 7) is <15% in winter and 2-4% in summer (UKHO 2013). The average sea surface and bottom temperature for this region of the southern North Sea ranges from 15-17°C in summer to 6->6°C in winter. Where stratification occurs, this is weak compared with the central North Sea, with a difference between surface and bottom waters of generally <2ºC. Sea surface salinity is in the range 34.5-34.75ppt (parts per thousand) throughout the year (UKHO 2013, ICES data). Spring tidal current flow rates vary from 0.1-1.7 knots and 0-0.8 knots at neaps (UKHO 2008). The residual currents in the area have a predominant bottom flow direction of southeast, with a broad shaped tidal ellipse (where total current speed is approximately constant, or decreases only slightly between ebb and flood, but with a change in direction).

Biological environment

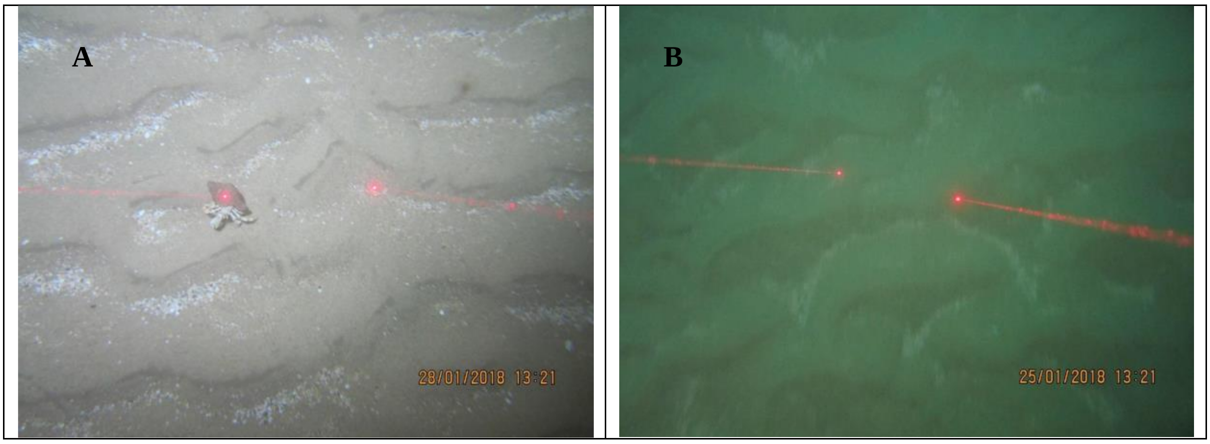
The infauna assemblage of the mixed coarse/find sand seabed around the Anglia A NUI, represents a combination of three southern North Sea groupings as defined by Reiss *et al*. (2010), and characterised by the polychaetes *Nephtys cirrosa* and *Magelona johnstoni*, the shrimp *Gastrosaccus spinifer* and the small amphipod *Urothoe brevicornis*. The mobile epifauna of this region is characterised by crabs (*Liocarcinus holsatus* and *Pagurus bernhardus*) and brittlestars (*Ophiura* and *Ophiura albida*) (Reiss *et al*. 2010); and the encrusting epifauna characterised by *Hydrallmania falcata*, *Alcyonidium diaphanum*, *Vesicularia spinosa* and *Flustra foliacea* (Rees *et al*. 1999).

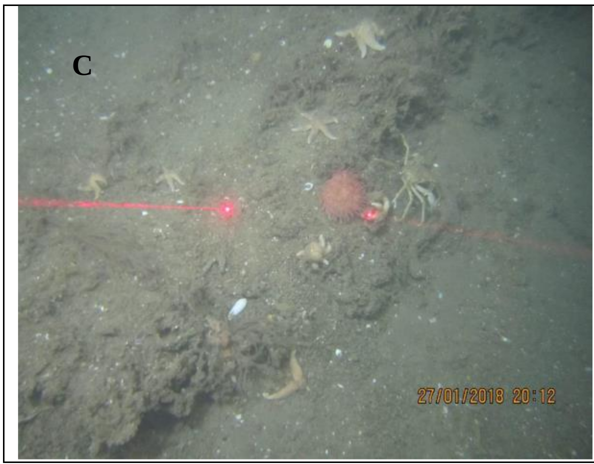
Figure 2.1 – Predicted seabed habitats



Survey work was carried out in 2017/early 2018 by Fugro to support the Anglia decommissioning assessment (Fugro 2018a, b). The epifauna was generally sparse and uniform, with starfish, hermit crabs and hydroid/bryozoan turf present throughout, but with anemones (*Urticina* sp. and *Metridium dianthus*) and soft coral (*Alcyonium digitatum)* seen in the deeper sediments (Figure 2.2). *Sabellaria spinulosa* aggregations (not defined as biogenic reef) were recorded along one of the 18 video transects.

Figure 2.2 – Seabed images from the Anglia area (pre-decommissioning survey)

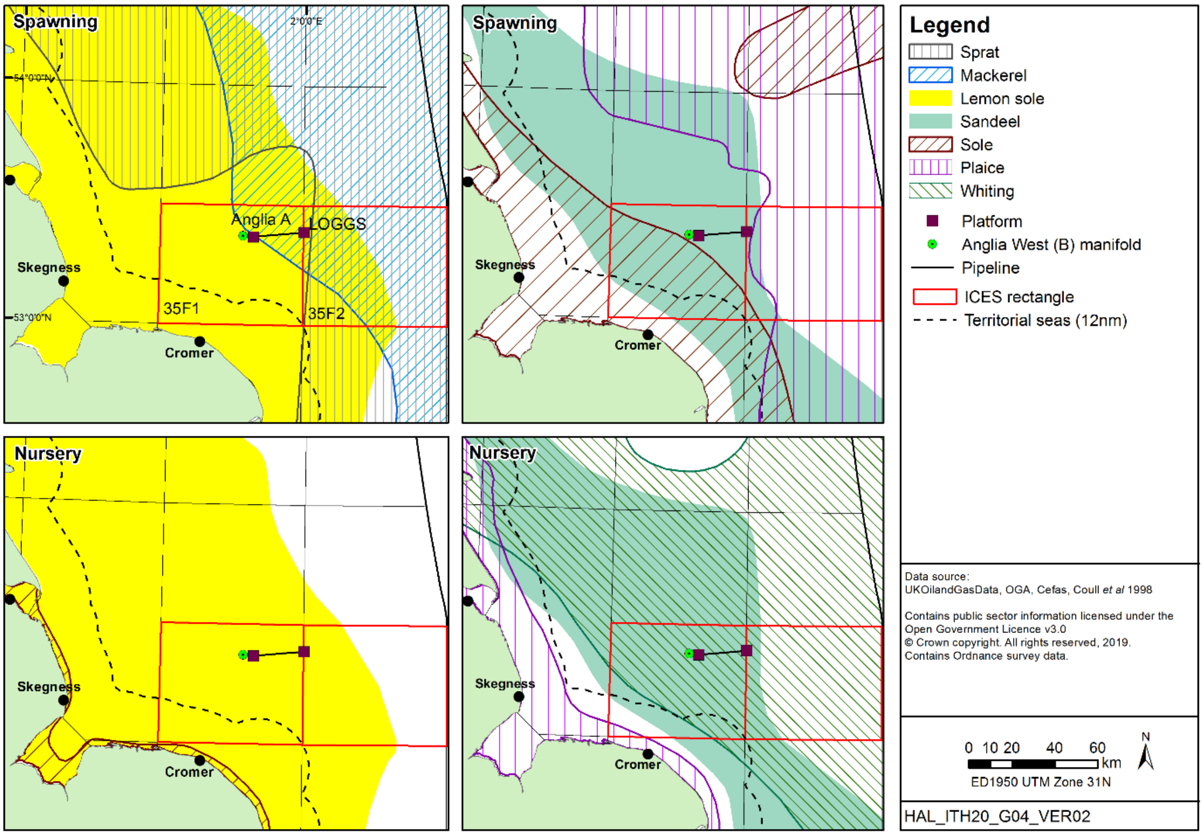




Source: Fugro 2018a
A: ST01 (midway along pipeline route from Anglia West (B) manifold to Anglia A NUI), showing rippled sand with shell fragments and a hermit crab (Paguridae)
B: ST08 (200m SE of Anglia A NUI), showing rippled sand with shell fragments
C: TR17 (transect running along Anglia A NUI to LOGGS pipeline) showing coarse mixed sediment with *S. spinulosa* crusts, starfish (*A. rubens*), anemone (*Urticina sp.*), crab (*Hyas araneus*) and areas of hydroid/bryozoan turf

The Anglia area lies in ICES Rectangle 35F1, which overlaps with known spawning grounds of herring (*Clupea harengus*) (August-October), mackerel (*Scomber scombrus*) (May-August), sole (*Solea solea*) (March-May), lemon sole (*Microstomus kitt*) (April-September) and sandeel (*Ammodytes marinus*) (November-February), (Figure 2.3), as well as nursery grounds of whiting (*Merlangus merlangus*), plaice (*Pleuronectes platessa*), lemon sole and sandeel (Coull *et al*. 1998). Additional surveys suggest spawning grounds for whiting as well as herring, mackerel, cod and sole nursery grounds are also present (Ellis *et al*. 2012). The area supports commercially important populations of whelk (*Buccinum undatum*), lobster (*Homarus gammarus*) and various crab species.

Figure 2.3 – Fish spawning areas



The shingle beaches and coastal marshes of the North Norfolk Coast are important for a number of breeding tern species and these areas along with the wetlands of Breydon Waters and Berney Marshes, are amongst some of the most important areas in the UK for wintering birds, regularly supporting in excess of 120,000 and 90,000 individuals respectively (Frost *et al*. 2016). Inshore and offshore areas are also important, providing feeding grounds to breeding, migratory and on-passage birds.

The importance of the east coast of England to breeding seabirds and wintering/passage waterbirds is reflected in the designation of a number of international and national conservation sites on land and at sea. The two most significant sites, in terms of wintering bird numbers are The Wash and the North Norfolk Coast Special Protection Areas (SPAs).

There is a general trend of decreasing diversity and abundance of cetaceans with decreasing latitude across the North Sea. In contrast to the high species diversity and abundance off Scotland, only a handful of species are sighted with regularity in the southern North Sea. The most abundant cetacean by far in the southern North Sea is the harbour porpoise (*Phocoena phocoena*).

Within the southern North Sea, survey effort has markedly increased in the last 15years on account of baseline surveys related to the offshore wind energy development schemes. These and other data, including the 1994 and 2005 SCANS surveys, have allowed recent modelling efforts to identify areas of persistent relatively high harbour porpoise density (Heinänen & Skov 2015), resulting in the designation of the Southern North Sea SAC. Seasonal differences in the relative use of this large (36,951km^2), primarily offshore site by harbour porpoise have been identified; in the summer, elevated densities are expected only within the northern two thirds of the site, while the southern third is the preferred area in the winter, together with two small patches in the north[1]. From the work of Heinänen & Skov (2015), model-predicted densities of harbour porpoise suggest > 2.7 animals per km^2 are common within the summer and winter areas of the SNS SAC.

The Anglia Field lies on the western edge of the SNS SAC, with the closest boundary to the site (summer area) lying 4.7km to the northwest of the Anglia A NUI. The export pipeline/methanol line to the LOGGS PP facilities lies largely within the SNS SAC summer area (approximately 18km of the ~24km line). Model-predicted density in the Anglia area for summer 2009 was *ca*. 1.2-1.8 harbour porpoise per km^2 (Heinänen & Skov 2015). Winter densities in the Anglia area are subject to greater uncertainty due to limited survey coverage; model predictions suggest that they may be similar or greater than summer densities, although it is noted that the identified area of persistent high winter density lies some 35km to the south. The latest SCANS-III survey provided abundance and density estimates for large areas across the North Sea; the Anglia facilities lie in ‘block O’ (total area = 60,198km^2) with an estimated density of 0.89 harbour porpoise per km^2 (Hammond *et al.* 2017).

Other cetaceans that can be present in the southern North Sea, including the Anglia area, albeit in low numbers or sighted with occasional to rare frequency include: minke whale (*Balaenoptera acutorostrata)*, white-beaked dolphin (*Lagenorhynchus albirostris*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), bottlenose dolphin (*Tursiops truncatus*), and short-beaked common dolphin (*Delphinus delphis*) (Reid *et al*. 2003).

Two species of seal occur in the southern North Sea, harbour (*Phoca vitulina*) and grey (*Halichoerus grypus*) seals; both are listed on Annex II of the Habitats Directive. Colonies and hauls-out sites of harbour and grey seals are present on the east coast of England, several of which are designated as Special Areas of Conservation (SACs) under the Habitats Directive. Anglia facilities are within the foraging range of both species and while both could be present in the Anglia area, numbers are expected to be low, based on models of marine usage (see for example Brasseur *et al.* 2015, Jones *et al*. 2015; Jones & Russell 2016; Russell *et al*. 2017).

[1] Draft Conservation Objectives and Advice on Activities for the Southern North Sea SCI were accessed from the JNCC website (Aug 2017) at: http://jncc.defra.gov.uk/pdf/SouthernNorthSeaConservationObjectivesAndAdviceOnActivities.pdf

Conservation designations

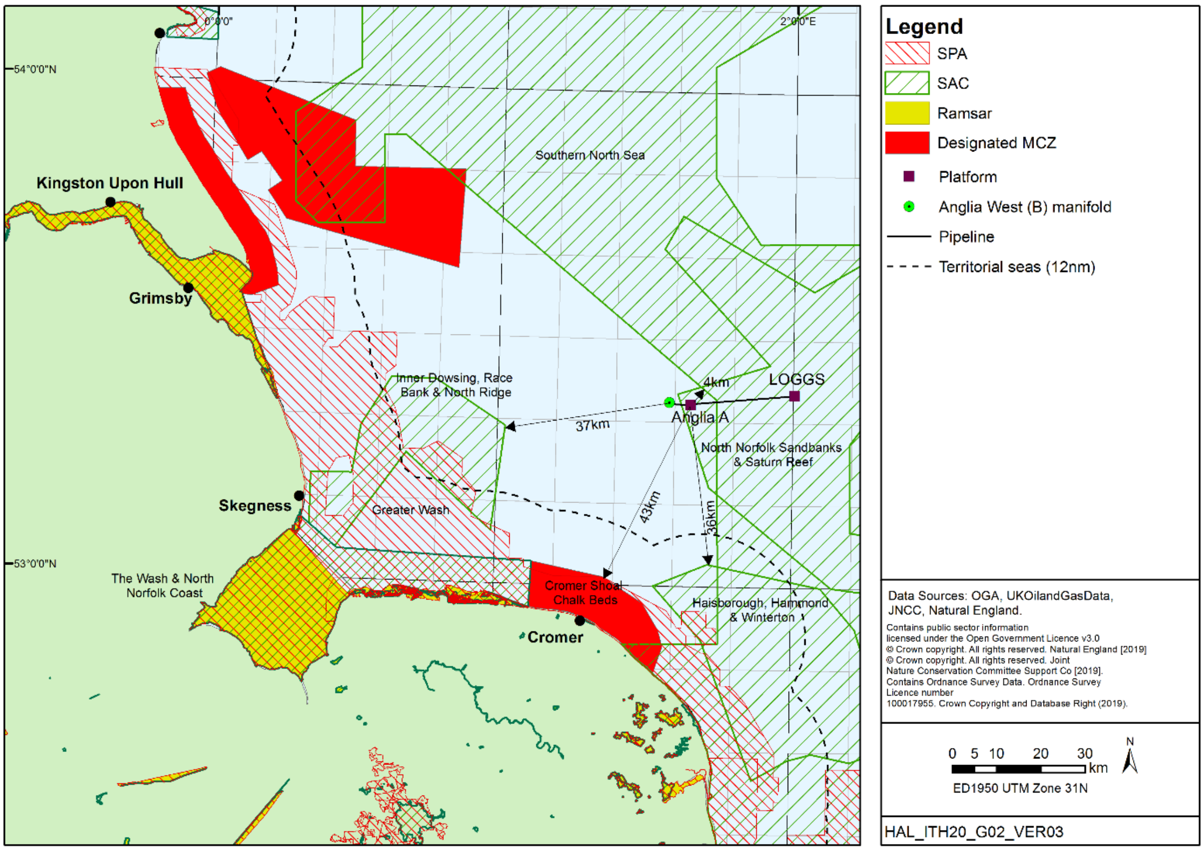
The importance of the region is reflected in the designation of a number of international and national inshore and offshore conservation sites (Figure 2.4). The majority of the Anglia infrastructure to be decommissioned, with the exception of approximately half of the infield line and the Anglia West (B) manifold, is within the boundary of the NNSSR SAC, while approximately 18km of the ~24km export line between Anglia A NUI and LOGGS PP is within the SNS SAC.

The NNSSR SAC contains the most extensive example of offshore linear ridge sandbanks in UK waters, and encompasses an area where previous seabed surveys identified an extensive biogenic reef created by the ross worm *Sabellaria spinulosa*, called Saturn reef (Jenkins *et al.* 2015). The sandbanks are subject to a range of current strengths which are strongest on the banks closest to shore, and are dominated by sandy sediments (see Parry *et al.* 2015).

Data from the baseline survey of the Anglia area carried out in 2002 (Gardline 2003) and the pre-decommissioning survey, while finding individuals, did not identify any occurrence of *S. spinulosa* reef (Fugro 2108a, b).

The SNS SAC was selected primarily on the basis of preferential and prolonged use by harbour porpoises, but variability in numbers within the site and across the North Sea (seasonally and between years) is known to be high.

Figure 2.4 – Conservation designations



Other designated sites are 10s of km away from Anglia and the proposed decommissioning activities.

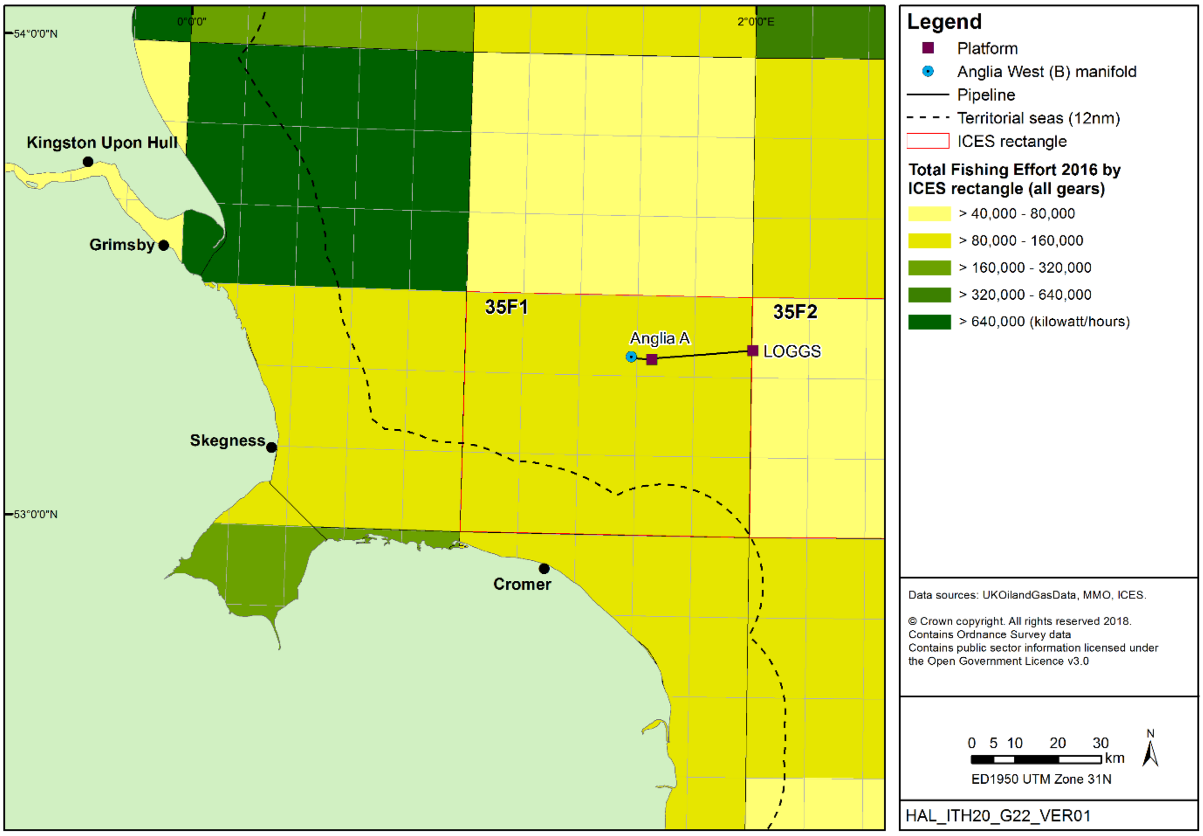
Other users of the marine environment

Hydrocarbon production in the southern North Sea is predominantly gas with some condensate. There is an extensive network of offshore production installations along with interfield and export pipelines serving terminals including at Bacton, Theddlethorpe and Easington/Dimlington. There are a number of pipelines and a cable that cross the Anglia lines, all of which have protective material associated with them. The 24" Esmond to Bacton gas pipeline crosses the Anglia West (B) infield pipeline and umbilical, and the 24" Clipper to Bacton gas pipeline and separate 3.5" chemical line cross the Anglia export pipeline/methanol line – these are two separate lines, although shown as one line in Figure 3.1 below.

The southern North Sea is a mature basin, and many of the field developments are therefore at a mature stage of production and are either subject to their own Decommissioning Plans (e.g. Ann and Alison fields, parts of the Viking and LOGGS fields, the Saturn, Annabel and Audrey fields) or are likely to be subject to decommissioning planning in the coming years. There are a number of operational, under construction and consented wind farm developments in the southern North Sea, the closest of which is the Dudgeon operational wind farm, ~15km south west of the Anglia West (B) manifold.

ICES rectangles are used for fisheries data recording and management. The Anglia facilities are in ICES rectangle 35F1. Vessel Monitoring System (VMS) data shows levels of fishing effort in the Anglia area, to be at low levels (Figure 2.5). Inshore fisheries are of importance around the Lincolnshire and Norfolk coasts, and particularly in the Wash, although this activity will not tend to extend out to sea as far as Anglia. Most fishing effort in the rectangles is carried out by traps which will predominantly target crabs, lobsters and whelks. There is a significant local fishery for brown crab (*Cancer pagurus*).

Figure 2.5 – Fishing effort by all vessels in and around 35F1 in 2016



Shipping density data (OGA website[2]) provided as part of the 29th Licensing Round, shows Blocks 48/18 as having low levels of shipping traffic, and Blocks 48/19 and 48/20 having high levels of shipping traffic. A vessel traffic survey will be carried out to support the decommissioning permits.

3 ANGLIA PIPELINE FACILITIES FOR DECOMMISSIONING

At commencement of the Comparative Assessment process, Ithaca identified the pipeline and umbilical infrastructure and their boundaries, including protective material, to be considered in the assessment.

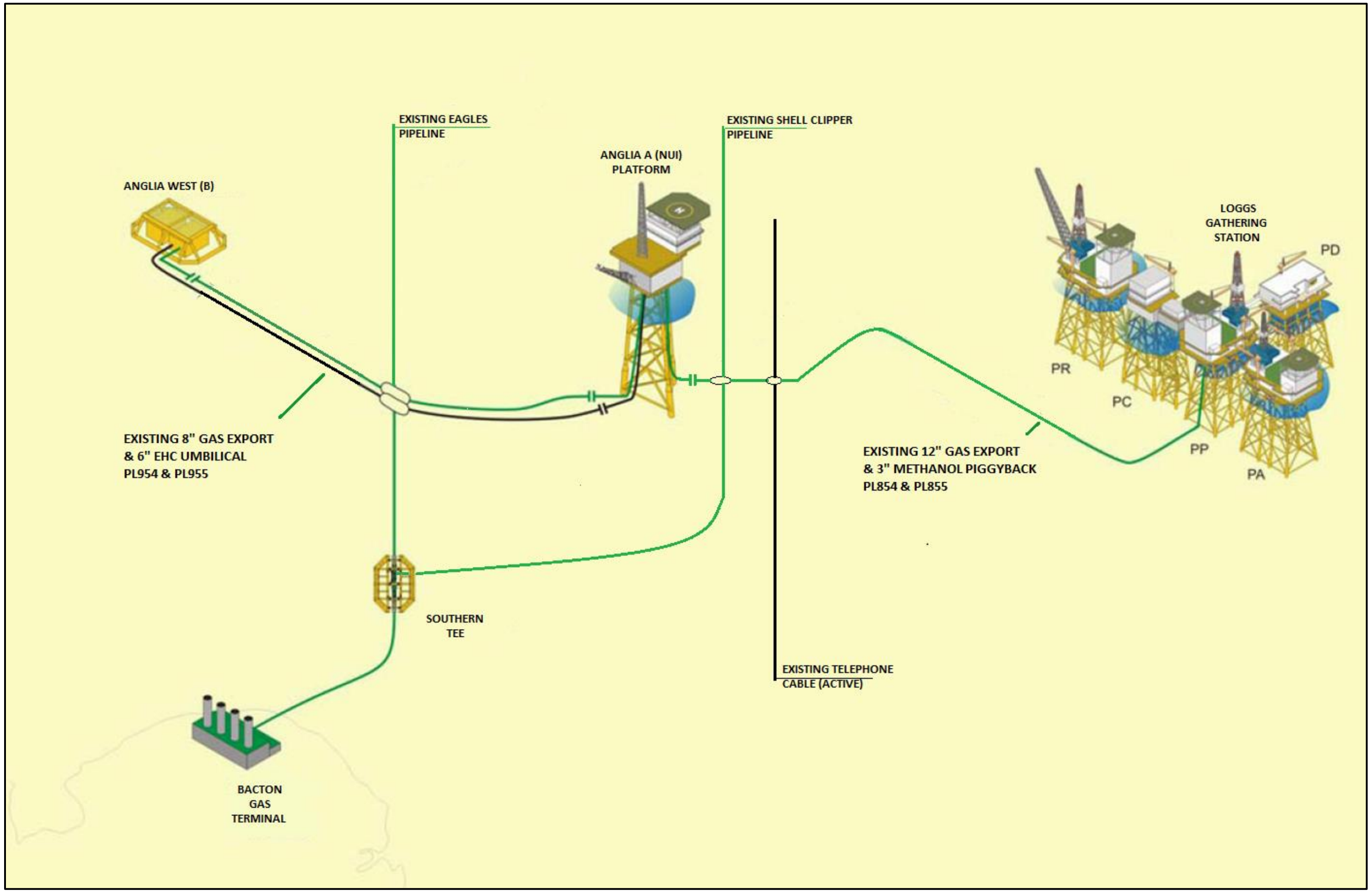
The following section provides an overview of the infrastructure relevant to the Anglia Decommissioning Programmes covered by the Comparative Assessment, (Figure 3.1) and the feasible options under consideration for their decommissioning.

A summary of the pipeline and umbilical system included in the Comparative Assessment is described below:

- **Anglia gas export pipeline and associated methanol line (PL854 and PL855)**: the ~24km, 12″ diameter concrete coated export pipeline (PL854) and the 3" diameter piggybacked methanol line (PL855), connects the Anglia A NUI to the PP platform at LOGGS. Both the production and methanol lines and all tie-in spools are of carbon steel. The depth of burial of the lines is ~1m along the majority of their length and both are no longer in use. They have been cleaned and are currently filled with untreated seawater. These pipelines have three crossings: the Shell Clipper to Bacton pipeline and glycol line and a telephone cable (Stratos 1), which is now out of service
- **Anglia infield gas pipeline (PL954)**: the ~5km, 8″ diameter concrete coated infield pipeline (PL954) connects the Anglia A NUI to Anglia West (B). The pipeline and tie-in spools are of carbon steel. The depth of burial of the line is ~1.3m along the majority of its length and is no longer in use. The line has been cleaned and currently contains inhibited seawater with residual condensate. There is one crossing along this line, the Esmond to Bacton pipeline.
- **Anglia infield service umbilical (PL955)**: the ~5km electrical, hydraulic and methanol/chemical umbilical was separately trenched and buried from the infield gas pipeline and is buried to ~ 0.8m for the majority of its length. This also crosses the Esmond to Bacton pipeline.

[2] OGA website, information on levels of shipping activity (29th Seaward Licensing Round) – accessed June 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/540506/29R_Shipping_Density_Table.pdf

Figure 3.1 – Anglia infrastructure



Note: Although shown here as one green line, the existing Shell Clipper pipeline comprises two lines, the Clipper to Bacton 24" gas line (PL632) and the 3.5" glycol line (PL996), which are trenched separately (~80m between then). This, along with the out of service cable, are the three crossings along the Anglia export line. There is one crossing along the infield line (PL253).

The gas export line and associated methanol line have been positively isolated at both ends and depressurised. At Anglia West (B), the jumpers connecting the wells to the production manifold were also disconnected with the ends blanked off with blind flanges (i.e. positively isolated) (permit applications PLA/261, SATS CP/797 and CP/815, 2015).

All lines were trenched and buried on installation, and there are a number of protection structures located at transitions at riser connections and other key areas (e.g. crossings) which include:

- **Concrete mattresses, frond mats (anti-scour mattresses), concrete protective structures and grout bags**: these are located at a number of strategic locations along the export and infield production pipelines and umbilical, including trench transitions (where the lines exit the seabed prior to connection at the installations/manifold) and approaches to the infrastructure, at spool tie-in/riser locations and in the approaches to and at, crossing locations.
- **Rock**: there is a quantity of rock cover overlaying the production lines and umbilical at strategic locations including trench transitions and crossings, at approaches to LOGGS PP and Anglia West (B) (within the 500m zones).

The mattresses/protective covers used for the Anglia infrastructure are a mixture of flexible concrete mattresses, frond mats and concrete protective structures (dog houses/kennels). The flexible concrete mattresses which typically consist of articulated concrete blocks linked by latticed polypropylene rope, allow the mattresses to follow the (3D) contours of the seabed and the pipeline; these can also be constructed using concrete segments which can accommodate a 2D profile and these are also present at the Anglia location.

Frond mattress (anti-scour mattresses) uses polypropylene "fronds" which act like artificial seaweed and trap sediment. These are typically deployed in areas with mobile seabed which is prone to scouring; the fronds promote sediment deposition after deployment, gathering silt and sediment and building up natural banks to reduce scouring. These can become buried over time.

In line with current guidance (BEIS 2018), the plan is to recover those mattresses/frond mats/concrete protective structures which are exposed and where the condition of the protective material makes it viable to do so, using a subsea grab, thus minimising exposure of and safety risk to divers. In the case of rock, where this has been used to protect a pipelines/umbilical, following current guidance (BEIS 2018), the assumption is if the pipeline is to remain *in situ*, then the rock will remain in place, undisturbed. If the pipeline is to be removed, partially or entirely, then the assumption is minimum disturbance of the rock is expected, i.e. that necessary to allow safe access to the pipelines/umbilical, and the elimination of any seabed obstruction that may result from the presence of the rock (BEIS 2018). This has been taken into account when assessing the different decommissioning options for the Anglia pipeline and umbilical system.

Prior to decommissioning work commencing offshore, relevant Master Application Template (MAT) and associated Subsidiary Application Template (SAT) applications, for decommissioning the lines, will be applied for at a suitable future date.

Freespans and exposed sections

After installation, currents and wave action at the seabed may lead to scour and a buried pipeline becoming exposed. A freespan occurs where the seabed sediments have been scoured from under a pipeline (see Figure 3.2) resulting in an unsupported section of pipeline no longer in contact with the seabed. An exposed pipeline is where a section of the pipeline can be seen on the surface of the seabed but is not free-spanning and the pipeline remains in contact with the seabed.

Freespans can present a danger to other users of the marine environment, particularly fishing activity using towed gear which can become trapped under the pipeline. Freespans in excess of 0.8m in height and 10m in length (BEIS 2018) should be reported and marked on relevant Kingfisher bulletins (FishSAFE website).

Figure 3.2 – Illustration of a pipeline freespan

Source: FishSAFE website

From previous pipeline inspection surveys (2012 and 2014), both freespans and exposed sections have been identified along the Anglia pipelines and umbilical; the 2014 inspection report refers to remediation of a freespan section carried out in 1995, using rock placement, but there has been no requirement for remediation since (ConocoPhillips 2014).

The pre-decommissioning survey of 2018 confirmed the majority of the pipelines and umbilical lengths remain buried to a depth of at least 0.6m. Current guidance (BEIS 2018) indicates that decommissioned pipelines, mattresses and related items left *in situ* to should be covered by such a depth. However, the survey did identify a number of small freespans and exposed sections (Table 3.1 and 3.2).

None of the freespans identified were more than 0.8m in height from the top of the pipeline and 10m in length. The locations of freespan sections from the 2012, 2014 and 2018 pre-decommissioning survey are detailed in tables B.1, B.2 and B.3 and shown in figures B.1, B.2 and B.3 in Appendix B, with a summary description provided below.

From the 2012 survey, two freespans were identified, both of which were on the export/methanol line PL854/PL855. One was within the 500m zone of the Anglia A NUI, and the second was approximately 300m east of the Stratos cable crossing; freespans identified from the 2018 survey were also present at these two locations.

Nine freespans were found in the 2014 survey, seven of which were on the PL854/PL855 line and two located on the infield gas line PL954; none were recorded on the umbilical PL955. The 2014 survey mapped the Anglia West (B), Anglia A NUI and LOGGS areas, the full pipeline routes were not covered. Of the seven freespans found in 2014 on PL854/PL855, five were within the Anglia A 500m safety zone (three adjacent to the platform) and the remaining two were adjacent to the platform within the LOGGS platform 500m safety zone. Three of the freespans found in 2014 within the Anglia A NUI 500m safety zone were also identified in the 2018 survey. A freespan in the north east of the Anglia A NUI 500m safety zone, was identified in all three surveys, although this changed in length, height and from one span to two spans – see Appendix B. The two freespans found in 2014 on line PL954, located adjacent to the Anglia A NUI, were also observed in the 2018 survey. Three of the freespans identified in 2014 (one adjacent to Anglia A NUI and two adjacent LOGGS) did not correspond to freespan locations in the 2018 survey.

Twenty-three freespans were identified from the 2018 survey (see Table 3.1 and Appendix B), some of which corresponded with freespans also identified from the 2012 and 2014 surveys, see above.

Ithaca develop inspection and monitoring programmes for their assets based on a risk based approach, and such an approach will be taken to identify and develop an appropriate monitoring programme for any pipeline material decommissioned *in situ*, and in discussion with the regulator.

Table 3.1 – Freespans identified from 2018 survey

Pipeline	Pipeline length (m)	Number of freespans identified	Total length of pipeline freespanning (m) (% of total line)	Max. height of freespan (m)	Max. length of freespan (m)
PL854/PL855 Gas export / methanol line	24,000	8	97 (<1%)	0.4	23.2
PL954 infield gas line	5,000	5	34 (<1%)	0.6	8.2
PL955 infield umbilical	5,000	10	34 (<1%)	0.5	6.6

Notes: All figures rounded. The majority of freespan sections are located in and around the Anglia A NUI (within the 500m safety zone), the Anglia West (B) manifold and at LOGGS PP (see also Appendix B)

Table 3.2 – Exposed sections identified from 2018 survey

Pipeline	Pipeline length (m)	Number of exposed sections identified	Total length of line exposed (m) (% of total line)	Length of longest exposed section (m)
PL854/PL855 export / methanol line	24,000	19	519 (2%)	87
PL954 infield gas line	5,000	9	97 (2%)	25
PL955 infield umbilical	5,000	40	145 (3%)	12

Notes: All figures rounded

4 ANGLIA PIPELINE DECOMMISSIONING OPTIONS

This Comparative Assessment has been undertaken to inform decisions on the decommissioning of the pipelines and umbilical described in Section 3 above and shown in Figure 3.1.

The possibility for reuse of all or part of the pipeline system was considered by Ithaca prior to commencing the decommissioning process. No viable reuse options were identified and these were therefore not considered in the Comparative Assessment.

Initial screening of options

Ithaca initially identified a comprehensive list of potential decommissioning options for the Anglia Pipeline System (as described in Section 3) which were informed by engineering input on technical feasibility and the environmental characteristics of the area (as summarised in Section 2). All identified options were reviewed in order to identify those options that could be taken forward to the Comparative Assessment (see Section 4.1).

From this initial review, the option to "Leave *in situ*" with no additional work was not considered feasible since the disconnection of the Anglia pipelines and umbilical, where these are connected to the relevant Anglia A NUI and Anglia West (B) infrastructure, is required to allow the removal of these installations. Disconnection is also required at LOGGS PP in preparation for its future decommissioning.

Leaving *in situ* with no additional work, including removal of tie-in spools, was the only option not taken forward for assessment. Those options that were taken forward for assessment are described below.

4.1 Options Taken Forward for Comparative Assessment

In all cases, irrespective of the option, the activities common to all are to: use divers to facilitate moving and recovery of protective material (mattresses, concrete structures etc), where feasible to do so; use divers to cut and recover tie-in spools; leave *in situ* any rock and any section of pipeline/umbilical under rock, and decommission *in situ* any buried protective material (buried to at least 0.6m depth, in alignment with BEIS 2018 guidance for buried pipelines) where these are not likely to be a future hazard. For those options where the pipelines and umbilical are to remain *in situ*, the ends will be cut (for the tie-ins to be removed) and left open to seawater, these cut ends will then be reburied with natural backfilled sediment.

Options considered for export production pipeline with piggybacked methanol line (PL854 and PL855) and infield production pipeline (PL954)

- P(a) = Complete recovery, reverse S-lay
- P(b) = Complete recovery, cut and lift
- P(c) = Leave *in situ*, with remediation of freespan sections by cut and lift
- P(d) = Leave *in situ*, with remediation of freespan sections by rock placement
- P(e) = Leave *in situ*, with no remediation of freespan sections

Options considered for umbilical line (PL955)

- U(a) = Complete recovery, reverse reel
- U(b) = Leave *in situ*, with remediation of freespan sections by cut and lift
- U(c) = Leave *in situ*, with remediation of freespan sections by rock placement
- U(d) = Leave *in situ*, with no remediation of freespan sections

Pipelines (PL854/PL855 and PL954)

Options P(a) and P(b) are similar and would involve the complete removal of the pipelines and piggybacked methanol line, the difference being the method of removal, either by reverse S-lay or cut and lift, types and duration of vessel used, and estimated diver time.

Both options would require sediment to be excavated, using a subsea excavator or jet prop machine, to access the lines, as well as seabed remediation once all infrastructure has been removed. Initial de-burial of the line is required so as not to overburden the line as it is being recovered. For reverse S-lay, a pipelay barge would move along the line, picking the line up as it goes, with the line being cut on deck. These cut sections would be offloaded to a smaller barge, which would be towed to shore for offloading. Option P(b) does not require a pipelay barge but instead uses a Dive Support Vessel (DSV) to deploy divers and cutting equipment to the lines once these are de-buried. As sections of the line are cut into manageable sections (*ca*. 12m lengths), these are recovered to small support barges, which are then towed to shore for offloading. For both Options, any remaining trenches would be rectified using a Construction Support Vessel (CSV) infilling these with the natural sediment initially excavated.

Common to all options, including to P(a) and P(b), would be the decommissioning *in situ* of the sections of pipeline at the crossing locations. Therefore, for Options P(a) and P(b), the pipelines would also be cut at the approaches to the crossings with the cut ends reburied with natural backfill. Option P(b) has the highest estimated diver days[3], of all Options considered at 318, with Option P(a) diver days estimated at 52. Total vessel days for Options P(a) and P(b) have been estimated at 249 and 328 respectively, representing the second highest and highest of all Options considered.

Options P(c) and P(d) both leave the pipelines *in situ*, with differences in remediation of the freespan sections measuring >5m in length, while P(e) also leaves the pipeline *in situ*, but has no remediation of the freespan sections.

Option P(c) uses a DSV or CSV to deploy divers to cut and remove the required sections, these being recovered to a small support barge, which is then towed to shore for offloading. The vessels under these Options use dynamic positioning (DP) to maintain station. Divers progress along the line, cutting and recovered the required sections. All cut ends are lowed into the seabed, using localised excavation and re-buried by backfilling with the excavated sediment. Option P(d) utilises a rock placement vessel and the deployment of a fall pipe that track along the pipelines, covering those freespan sections with rock. Option P(e) proposes to decommission the pipelines *in situ*, with no remediation of the freespan sections (by either cut and lift, or rock placement), but would still include the removal of the tie-ins and associated protective material at Anglia West (B) and Anglia A NUI.

Options P(c) has the second highest estimated number of diver days of all pipeline Options considered at 110 with total vessel days estimated at 44. Total vessel days are 44 for Option P(c) and 14 for both P(d) and P(e).

Umbilical (PL955)

Option U(a) involves the complete removal of the umbilical by reverse reel. As for the pipelines, the section of umbilical under the crossing would be decommissioned *in situ*, with the ends at the approaches cut and then reburied. A CSV under DP would be used, initially picking up the umbilical then recovering by reeling it onto a reel, backing along the umbilical as it goes. Recovery of the umbilical through reverse reeling is not expected to require the initial excavation of the umbilical or trench infilling once removed. Total diver and vessel days for Option U(a) have been estimated at 13 and 9 respectively.

Options U(b), U(c) and U(d) are the same as P(c), P(d) and P(e) respectively and would be as described above, the difference being in diver and vessel time, associated with the shorter (~5km) length of line.

Total estimated diver time for Option U(b) is 33 days, the highest for the umbilical Options and 14 days for Options U(c) and U(d), with vessel days estimated at 17 days, 9 and 7 respectively.

[3] Diver days are calculated using the formula Diver Days = DSV days x 3 / 1.5 where 3 divers are operational i.e. in the water. The 1.5 factor removes the 30% non-working time due to currents and other non-operational time including transits and port calls.

Where all, or any part of the Anglia Pipeline System is proposed to be decommissioned *in situ*, consideration will be given to the effects of continued degradation of the pipeline and umbilical material and whether this could result in possible future environmental effects, particularly in relation to other users of the sea.

5 COMPARATIVE ASSESSMENT PROCESS

Ithaca developed a framework for conducting a Comparative Assessment in preparation for decommissioning their Athena (Block 14/18b) and Jacky (Blocks 12/21c and 11/30) assets, that used qualitative and quantitative data to evaluate alternative decommissioning options.

In preparation for the Anglia Comparative Assessment, Ithaca reviewed this framework in light of updated Regulator guidance (BEIS 2018) and concluded it remained suitable for assessing the Anglia Pipeline System.

This framework draws from OSPAR 98/3 and Regulator and industry guidance (OGUK 2015, BEIS 2018) and uses a methodology and scoring system to assess the relative performance of each of the potential decommissioning options for the pipelines/methanol line and umbilical. Results are presented in Appendix A and are discussed in Section 6.

Ithaca has a risk management process as part of their verified management system. This provides a consistent and systematic approach to (not exhaustive):

- Identifying hazards associated with specific operations including all environmental aspects
- Assessing and understanding the risks associated with these hazards and
- Identifying where further risk controls may be required

Following a review, it was felt the Comparative Assessment process was consistent with Ithaca's approach to risk assessment and that an additional risk assessment on the recommended decommissioning option would not be required.

5.1 Comparative Assessment Criteria and Scoring

Criteria for evaluating the relative potential impact/risk of the options were developed with reference to the OSPAR Decision 98/3, Regulator (BEIS 2018) and industry guidance (OGUK 2015), and Ithaca's HS&E policy and Mission Statement. covering the following areas:

1. Safety
2. Environmental
3. Technical
4. Societal
5. Economic

Sub-criteria were also derived (see Table 5.1) to cover:

- The potential risk to life of offshore and onshore personnel of each option considered
- All potential impacts (including cumulative effects) on the marine environment, including exposure of biota to contaminants, other biological impacts arising from physical effects, impacts on, and interference with other legitimate uses of the sea
- The potential impact on the conservation sites and species
- All potential impacts on other environmental receptors, including from emissions to the atmosphere, and onshore impacts
- Consumption of natural resources and energy associated with reuse and recycling
- Potential risk of project failure and technical challenge
- Potential impacts on amenities, the activities of communities and on future uses of the environment
- Costs of each option

The sub-criteria were scored on a five point scale ranging from 1 (Very Low) through to 5 (Very High), where 1 represents best performance/least significant impact/lowest risk and 5 worst performance/largest significant impact/highest risk. Scores for the sub-criteria were then weighted on a three point scale (see Table 5.2) according to the level of definition and understanding of methods, equipment and hazards ("uncertainty"), ranging from Low Uncertainty – high definition and understanding of methods, equipment and hazards (weighting x 1), to High Uncertainty – low level of definition and understanding of methods, equipment and hazards (weighting x 2). Final scores for each criterion were recorded in matrix format (see Appendix A) with relative ranking for each option derived from the weighted scores using the matrix in Table 5.3.

Where quantitative data are used, these have been based on measurable data i.e. CO_2 emissions (tonnes) and cost estimates (£). Qualitative assessment is based on a range of sources including regional and site specific data, supporting documents including previous Anglia pipeline inspection reports, and other reference material including similar decommissioning documentation (i.e. pipeline comparative assessments and EIAs) from projects in the wider Anglia area/southern North Sea.

Table 5.1 – Relative Risk and Impact Criteria and Scoring

Criteria	Sub criteria	Very Low 1	Low 2	Medium 3	High 4	Very High 5
Safety	Risk to personnel offshore during decommissioning operations	No risk	Minor/first aid	Medical aid/lost time injury	Permanent disability/fatality	Multiple fatalities
Safety	Risk to personnel onshore during decommissioning operations	No risk	Minor/first aid	Medical aid/lost time injury	Permanent disability/fatality	Multiple fatalities
Safety	Risk to divers during decommissioning operations	No risk	Minor/first aid	Medical aid/lost time injury	Permanent disability/fatality	Multiple fatalities
Safety	Risk to 3rd parties and assets during decommissioning operations	No risk	Loss of access to operational area	Interference with 3rd party operations altering safety risk	Damage to 3rd party asset/damage to vessel	Damage to 3rd party asset requiring remediation/loss of vessel
Safety	Residual risk to 3rd parties	No risk	Potential snagging risk	Damage/loss of fishing gear	Damage to vessel	Loss of vessel
Environment	Chemical discharge	None	PLONOR chemicals only	No warnings or substitution labels RQ<1	Warning labels RQ>1	Warnings and substitution labels RQ>1
Environment	Hydrocarbon release from pipelines	None	<50 litres	50 litres - 500 litres	501 litres - 1000 litres	>1000 litres
Environment	Seabed disturbance and/or habitat alteration including cumulative impact	None	<10% of existing footprint	10% - 50% of existing footprint	>50% - 100% of existing footprint	>100% of existing footprint
Environment	Atmospheric (CO_2) emissions	2000tCO_2eq	10,000tCO_2eq	50,000tCO_2eq	100,000tCO_2eq	>250,000tCO_2eq
Environment	Total energy consumption and GHG emissions	<10,000Gj	10,000-100,000Gj	>100,000-200,000Gj	>200,000-400,000Gj	>400,000Gj
Environment	Proportion of material recycled	>80%	50% - 80%	30% - <50%	10% - <30%	<10%
Environment	Proportion of material landfilled	0%	<10%	10% - 30%	>30% - 50%	>50%
Environment	Conservation sites and species (including noise effects)	No impact	Potential effects but unlikely to be detectable as within normal variability	Minor detectable effects with rapid recovery	Effects detectable, not affecting site integrity or species population	Significant effects on site integrity or population
Technical	Technical feasibility	Routine operations with high confidence of outcomes Very low risk of failure	Routine operations with good confidence of outcomes Low risk of failure	Non-routine operations but with good experience base Low risk of failure	Non-routine operations with limited experience base Moderate risk of failure	Untried technique Higher risk of failure
Technical	Weather sensitivity	Operations not weather sensitive	Operations are little affected by weather	Requires good weather window	Requires typical summer good weather window	Requires long good weather window
Societal	Residual effect on fishing, navigation or other access (including cumulative)	No effect	Access to area unrestricted	Access to area with charted obstructions	Access to area with uncharted debris and obstructions	Closed access to area
Societal	Coastal communities	No impact	Impacts within normal variability of onshore operations	Short term nuisance during onshore operations	Medium term nuisance during onshore operations	Long term nuisance during onshore operations
Economic	Total cost	<£2m	£2-5m	£5-10m	£10-15m	>£15m
Economic	Residual liability including monitoring and remediation if necessary	No residual liability	Surveys and remediation unlikely to be required	Surveys and remediation requirement anticipated but at declining frequency	Surveys and remediation likely to be required in each 5 year period	Annual survey and potential for remedial work

Table 5.2 – Levels of uncertainty weighting

Increasing uncertainty →		
x 1 (Low)	x 1.5 (Medium)	x 2 (High)
High level of definition and understanding of methods, equipment and hazards	Moderate level of definition and understanding of methods, equipment and hazards	Low level of definition and understanding of methods, equipment and hazards

Table 5.3 – Ranking of weighted scores

	Uncertainty		
Impact/ Consequence	1 (Low)	1.5 (Medium)	2 (High)
5 (Very High)	High 5	High 7.5	High 10
4 (High)	Medium 4	High 6	High 8
3 (Medium)	Medium 3	Medium 4.5	High 6
2 (Low)	Low 2	Medium 3	Medium 4
1 (Very Low)	Low 1	Low 1.5	Low 2

Options

Low **Medium** **High**

Best → **Worst**

5.2 Comparative Assessment Workshop

Ithaca held an initial pre-workshop meeting with members of the Comparative Assessment team (see below), to:

- Review scoring criteria and methodology to ensure no modifications were required
- Agree the current status of all pipelines, methanol line and umbilical, including protective material
- Identify all potential options for their decommissioning and agree feasible options to take forward to Comparative Assessment (initial screening)
- Identify potential equipment and vessels needed to achieve decommissioning
- Estimate duration of operations for each option

While considering each option in turn, the adequacy of the information base was also reviewed, and any key gaps identified (see further studies/technical notes).

A workshop was subsequently held to assess those options taken forward for decommissioning the Anglia Pipeline System. The workshop involved a multi-disciplinary team (the team) including:

- Janet Ogilvie (HSE Manager – Ithaca Energy)
- Angus Bertram (Project Manager – Ithaca Energy)
- Jim Gordon (Decommissioning Operations – Ithaca Energy)
- Mike Cornish (Principal Subsea Engineer – Petrex)
- John Hartley (Director – Hartley Anderson)
- Suzanne Lumsden (Environmental Advisor – Hartley Anderson)

The workshop included an around table discussion with the team focusing on several key areas:

- Identify potential fate of materials recovered and taken to shore
- Examine comparative safety of the different options
- Examine comparative costs of the different options
- Examine comparative environmental implications of the different options (for the natural environment and other users of the area)
- Examine comparative ongoing liability implications

The workshop commenced with brief presentations re-affirming the requirement for a Comparative Assessment to be carried out and the Regulator’s expectations that all feasible options for pipeline decommissioning must be considered on their merit. This must be supported by a robust evidence base, an environmental overview of the area, including a description of the designated sites within which the infrastructure is located and their designated features, and an overview of the options from an engineering perspective.

A pipeline inspection survey was carried out in 2014 by ConocoPhillips and a survey was carried out along the Anglia pipeline infrastructure in December 2017/January 2018 by Ithaca (see Section 3). Information from these surveys along with original information from the installation of the export and infield pipeline systems was used to compile a table of pipeline/methanol line and umbilical information; this was circulated to the team prior to the workshop for review and agreement that the information was accurate. Information on freespan sections from a 2012 report of the pipeline system, the 2014 inspection report and the pre-decommissioning survey was used to collate information on current and historic freespan sections (see Appendix B). A review of other Comparative Assessments for decommissioning projects in the wider southern North Sea was also undertaken and information from this used to inform the Anglia assessment.

Using the agreed criteria and methodology, and the supporting information available, the team then considered each option in turn, within their area of expertise, assigning impact values and level of uncertainty values to generate an overall assessment of the option.

The outcome of the Comparative Assessment process and the resulting recommended decommissioning option for the pipelines and umbilical is described in Section 6 below.

6 RESULTS AND RECOMMENDED OPTIONS FOR ANGLIA PIPELINES/METHANOL AND UMBILICAL DECOMMISSIONING

The Options considered for the decommissioning of the Anglia Pipeline System are described in Section 4.1 with Option scores shown in Appendix A. A summary of each Option and final recommendations is described below. Where there are common elements within Options and the consideration of these have been the same, this is summarised below and not included further in the individual Option descriptions

6.1 Considerations Common to all Options

The following elements are common to all options:

- The removal of tie-in spools at Anglia West (B), Anglia A NUI and LOGGS PP
- The removal of exposed mattresses and concrete protective structures where safe to do so
- The decommissioning *in situ* of infrastructure at crossing locations and covered with rock
- The full release of pipeline and umbilical contents to sea (also applicable to options where the pipelines and umbilical are to be removed as ends will be cut at tie-in locations and approaches to crossings)

The following effects from these elements are common to all options. Individual options assessment only considers the incremental effects generated from those option specific interventions (in Sections 6.2 and 6.3, where assessment has identified low, medium or high, with regards to specific criteria and sub-criteria, refer to Appendix A, for overall assessment of the option see Table 5.3).

In all cases, moving and removing protective material and tie-in spools will result in an operational safety risk to personnel. Divers will be required to move and retrieve protective material (where grabs are not used) and cut line ends. The area experiences strong currents making conditions more hazardous for divers. The moving/removal of protective materials will also result in some disturbance to seabed sediments and communities. This disturbance would be localised and limited to benthic communities colonising the hard surfaces of the protective material and those immediately adjacent to the pipelines and umbilical.

Where pipeline and umbilical ends are cut, the exposed ends are then lowered into the seabed following sediment excavation using mass flow excavation and then back filled with the natural sediment. Mass flow excavation is where a flow of water is directed at the seabed to displace the sediment. This equipment can be deployed from a DSV using proven technology and methods, with time on site expected to be of short duration. If any tie-in infrastructure (e.g. spool pieces/flanges) being removed is covered by rock, the rock will first be moved (by grab) to enable access to the infrastructure, then replaced once the spools/flanges are removed to protect the pipeline/umbilical ends.

Where protective material is suitably buried, or where it is not feasible to recover protective material, these will be decommissioned *in situ*. The mattresses are more than 25 years old and there is the potential for them to break up while attempting to recover them by grab. The fragmented material would be in the form of single or several concrete segments linked by short sections of polypropylene rope. Most of such material is expected to remain over-trawlable (and analogous to the occasional naturally occurring cobbles and small boulders in the area). If mattress fragments are picked up by fishing nets there is the potential for some damage to the catch although again this can be considered analogous to naturally occurring rock on the area. For protective material that is recovered, and following the waste hierarchy, Ithaca will look to identify options to reuse these, using specialist contractors. If alternative, feasible options cannot be identified, these will be disposed of to landfill and the worst case of landfill has been assumed for the purposes of assessment.

Historic cuttings piles are not present at the Anglia A NUI or Anglia West (B). The hydrographic regime in the southern North Sea is such that cuttings are typically redistributed and degraded by natural physical and biological processes. Seabed contamination from historical cuttings as a result of removing infrastructure is therefore not anticipated.

Diamond wire, hydraulic or oxy-acetylene cutting equipment will be used to cut tie-ins, and this will be common to all options. A proportion of the Anglia infrastructure is located within the SNS SAC for harbour porpoise. Noise from cutting equipment, along with vessel noise, will be generated as a result of decommissioning activities. The noise generated by vessels would be localised, represent a minor increment to wider vessel traffic, would be present for a relatively short duration, and are not considered to be at a level for which significant effects on noise sensitive species is considered unlikely.

For all options, the discharge to sea of chemicals and any residual hydrocarbons (condensate) from the open lines, has been assessed as medium and low respectively (see Section 5.1, Tables 5.1, 5.2 and 5.3 and Appendix A); relevant applications will be made to OPRED (e.g. chemical permits) prior to activities being carried out. All lines have been cleaned and flushed and left with either inhibited seawater (containing for example corrosion inhibitor and biocide) or untreated seawater. Given the tidal currents in the area, these chemicals and small quantities of condensate are expected to rapidly disperse.

In all cases, a post-decommissioning survey will be carried out, the scope of which will be agreed with the Regulator; an over-trawlability survey may not be the most appropriate approach in this case, and alternative methods will be discussed.

In all cases, future monitoring will be required primarily to ensure the area remains safe for other users of the marine environment.

The extent and frequency of this monitoring will be determined on a risk basis and agreed after discussions with the Regulator. While previously buried material can become exposed, or freespans form, or where previous freespan sections can become reburied, this has been considered in the context of the extent the area is used by 3rd parties where there could be a snagging risk. Vessel Monitoring System (VMS) data shows levels of fishing effort in the Anglia area, to be at low levels and this, along with the extent of material decommissioned *in situ*, will support the formulation of a future monitoring programme which will be discussed with the Regulator.

6.2 Production Pipelines/Methanol Lines (PL854, PL855 and PL954)

Option P(a) – complete recovery, reverse S-lay

This option on this length of pipeline, has not, to date, been executed in the North Sea, with limited experience for this type of operation (e.g. limited to small sections of line at installation).

Safety

Safety risk to personnel (offshore, onshore and divers) would be very high. Divers would be required to remove tie-ins/protective material at Anglia West (B) and Anglia A NUI, common to all options. However, divers would also be required to expose and cut ends of lines in approaches to crossings, increasing their time on the seabed. For Options P(a-d), where there is increased diver intervention required and a resulting increased time on the seabed, risk to diver safety has consequently been categorised as having a high risk/impact score, and a medium risk of uncertainty. Operational risk for personnel offshore, is increased for retrieving and cutting the material onboard; the reverse S-lay method pulls the lines onto the vessel where the line is then cut into sections and stored on deck. There is a large amount of material to handle, including the attached methanol line, along with uncertainty around the integrity of the pipeline; due to the high forces the pipelines will be subjected to during recovery and the level of pipeline and material coating degradation, for example the concrete coating could spall during recovery and handling.

Operational risk is also increased for personnel onshore, with this categorised as having a high risk/impact. Multiple cut sections will be received by the yard and processed, and uncertainty remains regarding the integrity of the concrete coating. Handling and processing steel pipe for recycling may be standard operations for the yard, however, the concrete coating would first have to be removed, increasing the risk to personnel.

There is a good understanding of the locations of work to be carried out (at tie-in locations and along the pipeline lengths), with notifications of vessel movements and presence on site being made through notices to mariners, reducing the potential risk to 3rd parties during decommissioning operations. The assessment for this remains medium due to the number of days vessels will be on location ~249 days (Appendix A).

Residual risk to 3rd parties was considered low for this Option. The majority of pipeline and protective material would be recovered, with only that already under rock (i.e. at crossing locations) remaining. In the event of concrete coating and concrete mattress breakage during recovery, the post-decommissioning survey would identify any pieces of debris with the potential for snagging, for subsequent uplift.

Environmental

Seabed disturbance and disturbance to seabed communities will occur along the pipeline lengths. The concrete weight coating and the steel pipe wall will be subject to high forces during recovery, and given its age, and to reduce these forces, the pipelines and associated methanol line would first be unburied to allow the these to be recovered without overburdening the lines. Localised seabed disturbance will also occur at crossing approaches where sediment/protective material is removed and lines cut.

Under this option, vessels used for the recovery of the pipeline can be under DP or be anchored (e.g. pipelay barge), depending on vessel used, requiring multiple anchor deployments along the pipeline.

The entire gas export pipeline/methanol line and approximately half of the infield line are located within the western area of the NNSSR SAC, designated for the presence of sandbanks and biogenic reefs of the polychaete *Sabellaria spinulosa*; the Anglia infrastructure is located sufficiently close to the western boundary of the SAC that the remainder of the infield line and the Anglia West (B) manifold are located outside the SAC boundary. Disturbance of the seabed and rock placement has the potential to impact the habitats and species within the NNSSR SAC. The survey conducted in 2002 (Gardline 2003) and 2017/early 2018 (Fugro 2018a, b) only found individual occurrences of *Sabellaria spinulosa* and did not identify any occurrence of *Sabellaria spinulosa* reef in the Anglia area. The Anglia facilities lie at the northernmost ends of the Ower, Well and Broken Banks, which form part of the Annex I sandbank features of the NNSSR SAC.

Removing the pipeline will result in physical disturbance of the seabed and may result in a trench forming. Given the seabed sediment types and the current regime, any trench resulting from the removal of the pipelines is expected to quickly infill, such that the seabed would be expected to rapidly recover, with limited impact on the sandbank features.

The majority of the gas export line between the Anglia A NUI and LOGGS PP is also located within the SNS SAC, designated for harbour porpoise, with the remainder and all of the infield line, located outside the SAC boundary. Noise generated from cutting equipment will be localised at the crossing locations and of short duration; some cutting will take place within the SNS SAC boundary under this option. Vessel noise will occur along the length of the pipeline as the pipeline is retrieved.

Option P(a) has the highest energy use and associated emissions, along with Option P(b), using specialised vessels in the case of reverse S-lay, the time vessels are on location and taking into consideration material being brought onshore.

Technical

The vessels and techniques involved in Option P(a) are not considered proven in the North Sea and there is a high level of uncertainty and low confidence in the expected outcomes.

Vessel availability is an issue; specialist vessels are required and currently no vessels have been adapted for reverse S-lay of a complete pipeline[4]. The concept is also unproven in the North Sea for an entire line that has been in operation in excess of twenty years.

Additional vessel time is required; Option P(a) has the second highest number of vessel days of all options considered, estimated at 249 days, with a large quantity of material brought back on board, with initial processing (cutting into sections) and then taken to shore for final processing (recycling/disposal). This, along with diver time required on the seabed, requires a good weather window for operations.

Societal

Access to the area for other users of the marine environment, particularly commercial fisheries, will be unrestricted upon completion of works; there is currently unrestricted access along the pipeline routes, which will be temporarily curtailed during decommissioning operations.

Under Option P(a), the majority of pipeline material will be recovered to shore. However, at crossing locations, material will remain *in situ*, including the protective material. There is also uncertainty as to the condition and integrity of the protective material, and, if some material is likely to break up while trying to be retrieved, or, if this material is suitably buried, then this will be decommissioned *in situ*. The material remaining on the seabed will be marked on charts and remediated as appropriate.

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[4] While no suitable vessels are currently available, this option is included in the anticipation that as decommissioning projects become more common, suitable vessels could be adapted for this operation in the future, and potentially by the time the Anglia Pipeline System is decommissioned.

A post-decommissioning survey will be carried out along the pipeline corridors and within the 500m safety zones, and if appropriate, an over-trawlability survey would be conducted upon completion of decommissioning works to identify any potential snagging hazard remaining on the seabed. A programme of monitoring, will be agreed with the Regulator.

This option results in a large amount of pipeline material being taken to shore for processing, including the tie-in spools, (tie-ins being returned under all options considered), and the majority of the pipelines (except those sections under crossings). However, in terms of volume of material, Anglia, by comparison to infrastructure in the deeper North Sea, is relatively small and the material being returned is not expected to represent a significant increment to that already processed at a receiving yard. There may be a slight increase in traffic and road use and noise from processing material, but this is expected to be of short duration, and considered as normal operations for the yard.

Economic

The cost of Option P(a) is the second highest of the options considered (>£15 million) and substantially greater than those for Options P(c) (£5-£10 million), P(d) (£2-£5 million) and P(e) (£2-£5 million). There also remains very high uncertainty around this cost given the status of vessel availability and that it is currently an unproven concept in the North Sea.

The majority of the pipeline material is being returned to shore, and residual liability is considered low. A post decommissioning survey will be carried out and a programme of monitoring agreed. From this, any future remediation would be agreed with the Regulator and carried out, although the requirement for this is anticipated to be low.

The overall assessment for Option P(a) was Medium.

Option P(b) – complete recovery, cut and lift

Safety

Safety risk to personnel remains very high for Option P(b). This requires the longest time offshore for vessels (estimated at 328 days) and offshore personnel and the longest diver time of all options considered (318 days). Divers are required to cut pipelines at crossing approaches and execute multiple cuts and prepare pipeline sections for removal, increasing their exposure time to potential harm. An estimated 2000 cuts would be required for the export pipeline/methanol line and 416 for the infield pipeline under this option (based on the lines being cut into 12m sections). Divers could also be exposed to concrete debris if this breaks from the pipeline during manipulation.

Operational risk for offshore personnel is slightly greater than that for Option P(a); a similar amount of material is being returned to the vessel, but this is initially received as cut sections, although the risk was still categorised as High (carries a risk of permanent disability/fatality).

Operational risk is also comparable to Option P(a), for similar reasons. Multiple cut sections will be received by the yard and processed, which may be normal yard work for the steel pipeline, but processing of the concrete coating increases risk and uncertainty remains regarding the integrity of the concrete coating.

Risks to 3rd parties during decommissioning operations and residual risk post decommissioning, are comparable with Option P(a).

Environmental

Seabed disturbance for Option P(b) is comparable to Option P(a); the entire pipelines would require de-burial to enable access. Energy use and associated emissions are also comparable to P(a), the vessels for recovery being on site for a similar duration and the material being returned to shore being the same.

Technical

The vessels and techniques involved in Option P(b) are considered proven. However, there remains uncertainty regarding the integrity of the pipeline and the potential for the concrete coating to break away under manipulation. Confidence in the expected outcome therefore remains relatively low and uncertainty remains high.

This Option has the longest estimated diver time and along with Option P(a), requires a good weather window for operations.

Societal

Residual effects on other users of the marine environment is comparable to Option P(a); there will be unfettered access across the whole site following decommissioning, and the majority of the pipeline material would be removed. However, there is uncertainty over the integrity/condition of the material during handling, which may result in some remaining *in situ*.

The anticipated impact on coastal communities would be as for Option P(a), i.e. overall considered low, as the same volume of material would be returned to shore for processing and is not considered outside normal operations for the yard.

Economic

The cost for Option P(b) is the highest of all options considered (>£15 million), and substantially more than Options P(c)-P(e), although there still remains a medium level of uncertainty around costs.

Residual liability is comparable with Option P(a), the majority of pipeline material is being recovered and there will be in place post decommissioning monitoring, commensurate with that material left *in situ*.

The overall assessment for Option P(b) was Medium.

Option P(c) – leave *in situ*, with remediation of freespan sections by cut and lift

Safety

The safety risk for this Option remains very high for offshore and onshore. Although the majority of the pipelines would be left *in situ*, divers are required to prepare, cut and remove freespan sections of the pipeline to the vessel. Their exposure time (estimated at 101 days) would be less than that for Option P(b), (~333 days) but still higher for those options (Options P(d) and P(e)) where diver intervention is kept to a minimum and estimated to be 47 days for both.

The >5m length freespan sections of pipelines cut and recovered to the vessel, is significantly less than that for full recovery Options P(a) and P(b). However, as for Option P(b), the risk remains high due to handling multiple cut pipeline sections and the uncertainty over the behaviour of the concrete coating during recovery.

There is a good understanding of operations, locations of infrastructure to be recovered and vessel movements. Vessel movements and locations on site will be notified through notices to mariners, reducing the risk to 3rd parties during decommissioning operations.

Residual risk to third parties has been assessed as medium for this option. Where sections have been cut away, there is the potential for the remaining cut ends to become exposed, increasing future snagging risk. To minimise this cut ends would be re-buried using natural backfill.

Environmental

Disturbance of the seabed is considered to be low to medium and less than that for Options P(a) and P(b). Disturbance will result from the removal of the protective material and tie in spools (common to all) and there will be disturbance as a result of preparing, cutting and removing the freespan sections. Cut ends will be reburied using natural backfill.

Options P(c), P(d) and P(e), all have similar energy use and associated emissions. Option P(c) does involve the return to shore of pipeline material, but the additional energy use/emissions for this were not significantly higher to make the overall assessment different.

Technical

Vessel and equipment availability, techniques and type of operations has been considered the same as that for Option P(b); there is availability of vessels, equipment and expertise within the industry. Although the method for recovery is proven for short sections, there remains a level of uncertainty around the integrity of the pipeline and if it could be removed for e.g. without concrete spalling, leading to lower confidence in the expected outcome.

Societal

Residual effect on other users of the marine environment upon completion of Option P(c) has been assessed as medium. The majority of pipeline is expected to remain *in situ*, with relatively few sections cut away. Access to the area will be unrestricted and if remaining pipeline material were to become exposed, the potential risk of snagging would increase. The remaining material will be charted.

The assessment of impact on coastal communities remains low; a smaller volume of material will be returned to shore compared to full removal options, and while there may be a slight increase in traffic, road use, noise and odour, operations are considered typical for a receiving yard.

Economic

The cost for Option P(c) (£5-10 million) is considerably less than that for either P(a) and P(b), (both estimated to be in the >£15 million category, with P(b) the higher of the two) although the overall assessment remains as medium, again reflecting a level of uncertainty over elements of the costing.

The movement of sediment in the area, as shown by the presence of large sandwaves and exposed and freespan pipeline sections, is such that a more comprehensive post decommissioning programme, is likely to be required in order to identify any future remediation. As such, the residual liability is considered to be high, and this also applies to Options P(d), and P(e), where the pipelines are to remain *in situ*. A programme of monitoring, which reflects the extent of pipeline and associated protective material left *in situ*,-will be agreed with the Regulator and any future remediation requirement will be determined through this monitoring programme.

The overall assessment for Option P(c) was Medium.

Option P(d) – leave *in situ*, with remediation of freespan sections by rock placement

Safety

For this option, risk to divers remains high as they are required for the cutting and removal of tie-in spools and exposed protective material (common to all options), and may be involved in rock placement; for this option it has therefore been assumed diver time required is less than that for Options P(a-c), but slightly greater than for Option P(e).

A small amount of pipeline material will be recovered to the vessel, with the majority of the pipelines remaining *in situ*. Material recovered will comprise the tie-in spools and protective material and while handling this material still represents a safety risk to personnel, it uses standard equipment, methods and there is existing experience of this in the industry. Overall operational risk is also reduced for personnel onshore as minimum quantities of pipeline and protective material are being returned for processing.

The risk to 3rd parties is similar to Option Pc), however, for Option P(d) it is slightly reduced, reflecting the reduced time vessels are estimated to be on location (~14 days compared to ~44 days).

Residual risk to 3rd parties has been assessed as medium. The majority of pipeline lengths are buried, with rock used to remediate the freespan sections. However, it remains medium as the potential for future freespan sections to occur cannot be discounted. The long term monitoring programme, to be agreed with the Regulator, will identify any future potential issues to be remediated as required.

Environmental

Sediment disturbance will occur from rock used for remediation of freespan sections; almost all of the freespans present on the infield pipeline and export pipeline/methanol line are located within the boundary of the NNSSR SAC, as a consequence, remediating these with rock will result in the introduction of a considerable amount of new hard substrate to the site. Based on ten freespans to be remediated, (i.e. freespans of >5m length present on the infield pipeline and export pipeline/methanol line), and assuming 6.6 tonnes of rock per metre, the rock required for this is estimated at 800tonnes.

Technical

The vessels and techniques involved in Option P(d) are considered well proven and there is high confidence in the expected outcomes. These operations are considered routine and as the majority of the pipeline is to remain *in situ* and no additional manipulation or handling of the pipeline is required, uncertainty around pipeline integrity no longer applies.

Societal

As for all options considered, access to the area for other users of the marine environment, particularly for commercial fisheries, will not be restricted and all material remaining on the seabed will be marked on charts. Berm profiles of the rock used to remedy freespan sections will be over-trawlable; rock by its nature will adopt a sloped profile and is not considered to represent an increase in risk to 3rd parties.

Impact on coastal communities is considered low; relatively low volumes of material is being returned, with no significant increase in traffic, road use, noise or odour anticipated.

Economic

Overall costing for this option is the second lowest at <£5 million, although there does remain a level of uncertainty on costing some elements, keeping the assessment for this as medium.

The majority of pipeline material will be left *in situ*, but sections currently with freespans of >5m length will be remediated by rock, thereby reducing the potential snagging hazard from these sections. There will be no additional cut and reburied ends that could become exposed in the future that could increase the risk of snagging. All remaining material will be charted and a post decommissioning survey will be carried out. However, the assessment for residual liability remains high for this Option as a more comprehensive monitoring programme is expected, given the majority of material is being left *in situ*, that freespans have occurred on the pipelines over the life of the field, and the requirement for future remediation cannot be discounted.

The overall assessment for Option P(d) was Medium.

Option P(e) – leave *in situ*, no remediation of freespan sections

Safety

Option P(e) has the minimum amount of diver intervention, vessel days on site and material returned onshore for processing than any other option assessed. However, a safety risk remains (medium) for offshore personnel; divers are still required to cut and remove tie-in spools and recoverable protective material in an area with strong currents and offshore personnel are still required to recover the material to the vessel, so is assessed as comparable to Option P(d).

The risk to onshore personnel is very low, as only tie-in and protective material is to be received at the yard, which would be considered normal operations.

Risk to 3rd parties during decommissioning operations is comparable to Option P(d).

Residual risk to 3rd parties has been assessed as medium for this Option. Given that the majority of the pipeline will remain *in situ*, there will be no remediation of existing freespan sections, and the potential for sediment movement to rebury and expose sections in the future, the potential risk to 3rd parties cannot be discounted. However, the area experiences a low fishing effort, predominately using static gear (see Section 2), and this risk is reduced through monitoring and future remediation if required, in discussion with fisheries organisations and the Regulator.

Environmental

Seabed disturbance will be localised to tie-in locations and to those benthic communities colonising exposed protective material. As the pipeline would be left *in situ*, there will be no requirement to cut and remove sections of pipeline in the approaches to crossings.

No intervention/remediation will be carried out on freespans identified in the 2018 survey, resulting in no additional seabed disturbance and rock placement along the pipeline lengths.

Technical

Vessels and techniques for this option are well proven and there is high confidence and low uncertainty in the expected outcomes.

Societal

Residual effect on other marine users is considered not too dissimilar to Option P(d); although rock is not being used to remedy freespan sections under Option P(e). As no intervention is being carried out on these sections, the potential for these to become a future snagging risk cannot be wholly discounted and this is reflected in a more comprehensive future monitoring programme being anticipated.

Impact on coastal communities is as for Option P(d).

Economic

The cost of Option P(e) (£2-£5 million) is the lowest, but not significantly different to the cost of Option P(d), which is also in this cost bracket, but estimated as higher than P(e).

The assessment for residual liability is high for this Option as a more comprehensive monitoring programme is expected, given the majority of material is being left *in situ*, that freespans have occurred on the pipelines over the life of the field, and the requirement for future remediation cannot be discounted.

The overall assessment for Option P(e) was Low.

6.3 Umbilical (PL955)

Option U(a) – complete recovery, reverse reel

Safety

Safety risk to offshore and onshore personnel is medium for this option; diver time is required for the cutting and removing of tie-ins and exposed protective material and also at the crossing approaches, enabling the section of umbilical under the crossing to be decommissioned *in situ*. The majority of the umbilical line material will be brought onshore for processing. The assessment is medium as there remains uncertainty over the integrity of the umbilical and how it will behave during manipulation.

Risk to 3rd parties during decommissioning operations and residual risk have been assessed as low for this Option. The umbilical is some distance from 3rd party infrastructure and decommissioning vessel presence along the ~5km line will be notified to mariners, reducing the overall risk. The majority of the umbilical and protective material will be removed, leaving little *in situ* with the potential to pose a future risk.

Environmental

It has been assumed no excavation will be required to facilitate the release of the umbilical. Seabed disturbance will occur along the extent of the umbilical as this is reeled back onto the vessel, although this will be localised to sediment lying on the umbilical, which is expected to fall back as the umbilical is removed. Vessels used to complete Option U(a) will use DP, avoiding seabed disturbance from anchoring.

There will be the seabed disturbance at the approaches to the crossing, where the umbilical is cut and ends reburied.

All options for umbilical decommissioning had comparable estimated energy use and associated emissions, with no option being significantly different to the other; all options require the moving/removal of protective material and tie-in infrastructure, with the same vessels, and material returned to shore.

Technical

Although not commonly undertaken, reverse reeling is a proven technology in the UKCS. However, the technical feasibility was assessed as medium for the level of uncertainty around umbilical integrity and the likely behaviour of the line during manipulation.

Societal

All material will be removed, with the exception of the section of umbilical under the Esmond to Bacton (PL253) pipeline crossing, removing the future potential for freespans to form, essentially eliminating future snagging risk.

At the approaches to the crossing, the umbilical will be cut, with the ends reburied using natural backfill. Access for other users will be unrestricted and snagging hazard potential is considered low.

The material will be returned to shore for processing. While this represents the majority of the umbilical material, in terms of volume received at the yard this is considered within the scale of normal operations. While there is the potential for a slight increase in traffic and noise, it is unlikely to represent a significant increase in that already carried out at the yard and will be of short duration. Therefore, this has scored low.

Economic

The cost of Option U(a) (<£2 million) is the second lowest of the Options assessed for the umbilical. It should be noted, with the exception of Option U(c), which has been estimated at £2-5 million, all Options considered for decommissioning the Anglia umbilical have an estimated cost of <£2 million. All costings have the same uncertainty level assigned.

A post decommissioning survey will be conducted and a monitoring programme agreed with the Regulator. While not anticipated, if any remedial work is identified through the post decommissioning monitoring, this will be discussed with the Regulator and carried out as deemed necessary.

The overall assessment for Option U(a) was Low.

Options U(b), U(c) and U(d)

Options U(b), U(c) and U(d) are the same as Options P(c), P(d) and P(e) respectively, but on a smaller scale (i.e. applicable to the 5km long infield umbilical compared to the 5km and 24km pipeline). Where considerations of the options are essentially the same for both the umbilical and the pipelines, (safety, environmental, technical and societal, including residual effects on other users of the marine environment and residual liability, monitoring and future remediation if necessary), these have not been repeated here.

Approximately half of the umbilical length is located within the NNSSR SAC boundary, and the majority of the freespans along the umbilical are located with the Anglia West (B) 500m safety zone and not within the NNSSR SAC boundary and this has been taken into consideration when assessing seabed disturbance, conservation sites and species.

Although not reflected in the matrix scores, there are differences in diver time, vessel days on location and cost for the umbilical options compared to their pipeline counterparts, reflecting the shorter length involved (~5km for the umbilical).

Option U(b) (leave *in situ*, remediation of freespan sections by cut and lift) requires the greatest diver intervention, resulting in the highest number of diver and vessel days on site and the highest cost of all umbilical options. Options U(c) (leave *in situ*, remediation of freespans by rock placement) and U(d) (leave *in situ* with no remediation of freespan sections), vessel days on site and cost, with no significant difference between these. As for the pipelines, it has been assumed diver time may be required for rock placement for Option U(c) and as such, risk for this has been categorised as high.

The overall assessments for Option U(b) and U(c) was Medium, and Low for Option U(d).

Recommendation for the decommissioning of the Anglia Pipeline System

Options P(a-d) and U(b) have increased risk to diver safety with the time and work required to prepare the pipelines and umbilical for complete or partial removal, or remediation, and also has an increased operational risk through the handling of material returned to the vessels. Although sections of the pipelines and umbilical under crossings would remain, residual risk to third parties is essentially eliminated in any of these options.

All remaining pipeline (P(e)) and umbilical (U(a), U(d) and U(e)) options also have a risk to diver safety, as all options involve the moving/removing of protective material and cutting and removing tie-in infrastructure. However, these options have reduced diver time compared to those with high levels of intervention, particularly those using cut and lift for partial or full removal of the pipelines (P(b), P(c)) and umbilical (U(b)). Options P(e) and U(d) require the least amount of diver time of all options.

Residual risk to third parties also remains with those options to decommission the pipelines and umbilical *in situ*, retaining the risk of snagging from freespans. However, none of the freespans identified from the pre-decommissioning survey are of the size that are reportable and a risk-based monitoring programme will be developed and any future remediation requirements identified will be addressed.

Option P(a) relies on specialist vessels and unproven reverse S-Lay technology and methodology. The remaining pipeline and umbilical options do not rely on such specialised vessels, increasing potential vessel availability, and use proven technology and methods.

The entire export pipeline/methanol line and approximately half of the infield pipeline and umbilical are located within the NNSSR SAC. In addition to the disturbance associated with the removal of protective material/tie-in infrastructure the highest additional seabed disturbance was estimated from Options P(a), P(b), P(c) and U(b); Option U(a) also had a high seabed disturbance associated with it, but this would be temporary, no pre-excavation is expected, no additional rock is used, and only half of the umbilical is located within the SAC boundary. Option P(e) has the lowest level of estimated seabed disturbance associated with it, both along the export pipeline/piggybacked methanol line located entirely within the NNSSR SAC and the infield gas pipeline.

Options P(d) and U(c) use rock placement to remediate freespans identified from the pre-decommissioning survey. However, the sediments are mobile, covering and uncovering freespans over time, and remediating a current freespan by rock is no guarantee another freespan will not develop elsewhere along the pipeline system. These options also introduce additional hard substrate to the area. The majority of the freespans on the umbilical line are within the Anglia West (B) 500m safety zone i.e. not within the SAC boundary. No additional hard substrate is introduced to the area by Options P(e), or U(d) and seabed disturbance from these is localised to the areas where protective material is moved/removed and tie-in infrastructure is removed (i.e. at LOGGS PP and Anglia A NUI within the SAC boundary, and at Anglia West (B), outside the boundary).

None of the options were considered to have a significant (negative) impact on communities, and commercial fishing in the area was not expected to be affected (i.e. through exclusion/lack of access to fishing grounds) following decommissioning.

In terms of residual liability, all options where the infield pipeline, export pipeline/piggybacked methanol line and umbilical would remain in *situ* P(c-e) and U(b-d) have been assessed as requiring a more comprehensive survey and monitoring programme, given that material is being decommissioned *in situ*, and that freespans occur on the lines. Although overall, Options U(a) and U(d) were comparable (both had an overall assessment of low), by progressing with Option U(a) and removing the umbilical, this removes the possibility of future freespans forming on this line (ten were identified from the 2018 survey) and future snagging potential and also reduces residual liability for this line.

Options P(e) for the pipelines/piggybacked methanol line (leave *in situ*, with no remediation of freespan sections) and U(a) for the umbilical (complete recovery, by reverse reel) were considered the most favourable and were recommended as the Options going forward for decommissioning.

6.4 Legacy and Liability Management

A post decommissioning survey will be carried out to identify any significant material remaining on the seabed that could be deemed a snagging hazard.

From the data available, freespans were identified from the 2012 and 2014 surveys and the 2018 decommissioning baseline survey. Over this period, and due to the mobility of the sediments and currents in the area, the freespans have been assessed as changing over time, in length, height and to some degree in location. The degree to which the physical presence of Anglia West (B) and the Anglia A NUI contribute to the development of freespans (e.g. through scour) is presently uncertain, and will be determined following decommissioning as monitoring data are acquired. The post decommissioning survey will include not only the pipeline/umbilical routes, but also the area covered by the current 500m safety zones around Anglia West (B) and Anglia A NUI, as well as the approaches to the LOGGS platform; Ithaca will continue to liaise closely with ConocoPhillips on the extent and scope of planned Ithaca surveys within the LOGGS platform 500m safety zone.

Other users of the offshore environment have been excluded from these safety zones since their application and although none of these freespans have been reportable, during the period for which data is available, an understanding of sediment movement within these areas, once the infrastructure is removed, is essential to inform a risk based approach for future monitoring. Potential risks to fishing from the small freespans currently identified are considered low as the predominant gear used in the area is static, targeting crab and lobster, and not mobile gear towed from vessels.

If agreed, an over-trawlability survey will be included to ensure any pre-existing rock cover decommissioned *in situ*, is over-trawlable and does not present a snagging hazard. If it is agreed that an over-trawlability survey is not suitable, alternative methods for post-decommissioning survey will be discussed with the Regulator to agree the survey methods and scope.

In terms of future surveys, a risk based programme of monitoring, commensurate with the material decommissioned *in situ*, will be developed in discussion with the Regulator, taking into consideration that freespans have previously developed along the lines to be left *in situ*, and that once the infrastructure has been removed, the influence, if any, these had on the creation of freespans, will be better understood. This will identify any future snagging hazard potential with remediation carried out as required and in conjunction with discussions with the Regulator and the relevant fishing bodies.

7 CONCLUSIONS AND KEY POINTS

The Anglia Decommissioning Team identified all available decommissioning options for the Anglia Pipeline System. Ithaca used the comparative assessment framework they have developed to assess the decommissioning options for the Anglia Pipeline System and from this, several key points were identified:

Pipeline/piggybacked methanol line

- One option for the complete removal of the infield pipeline and export pipeline/methanol line (reverse S-lay), involved unproven techniques and technology for the UKCS and pipelines of this length and age, required specialist vessels and increased operational safety risk, compared to the leave *in situ* options.
- Options for complete removal of the pipelines (reverse S-lay and cut and lift) and the option to leave the pipelines *in situ*, but to remediate the freespan sections by cut and lift, have a significant diver risk, as well as higher operational risks, handling recovered/cut material and the risk of concrete spalling from the concrete coated pipelines.
- All other options use proven technology and methods and are considered technically feasible.
- Complete removal of the infield pipeline and export pipeline/methanol line by cut and lift required significant equipment and personnel spread and also had a significant operational safety risk compared to the leave *in situ* options.
- Removal of exposed protective material will be carried out as part of the decommissioning offshore activities – final schedule to be determined
- Complete removal of the infield pipeline and export pipeline/methanol line, either by reverse S-lay or by cut and lift resulted in the highest estimated seabed disturbance, most of which would occur within the North Norfolk Sandbank and Saturn Reef SAC, although this disturbance would be temporary and with rapid recovery.
- Snagging risk for the leaving the pipelines/piggybacked methanol line *in situ* options was higher than removal. However, where there is existing rock covering these (crossings) and rock remediation of freespans, the rock profile is and would be over-trawlable, and an over-trawlability verification/or other agreed method of survey would be carried out where rock placement is required for remediation.
- The majority of current freespans on the pipeline/piggybacked methanol line are located within existing 500m safety zones, which will cease upon removal of the associated infrastructure. Other users of the marine environment (e.g. fisheries) have been excluded from these areas for the duration of field life. While none of the freespans are of reportable size and not considered a snagging hazard, the post-decommissioning survey will determine any potential snagging hazards within these zones, i.e. within the 500m safety zones, where users have been excluded for the duration of operations, and along the pipeline routes. A risk based monitoring programme, taking into consideration the material decommissioned in situ, and the current and historic survey data and agreed with the Regulator, will be established to identify future exposure/debris if the pipelines/piggybacked methanol line becomes exposed, degrades and breaks up and if future freespans develop which could be a snagging hazard.
- As the production lines and methanol line have been cleaned and flushed, and currently left filled with inhibited or untreated seawater, with only residual (condensate) hydrocarbon, the effects of discharges from open lines was considered medium to low.

Umbilical

- All options for the umbilical use proven technology and methods and are considered technically feasible. Reverse reeling (Option U(a)) is relatively uncommon and requires more specialist, modified vessels, but the technology for the removal of umbilicals of this length is available.
- Removal of the umbilical in its entirety would result in seabed disturbance along its ~5km length, however, this was considered a short-lived effect, with sediment movement expected to infill any resulting depression relatively quickly and this option did not require the introduction of new hard substrate (rock) for remediation.
- Snagging risk for leaving the umbilical *in situ* options was higher than removal and would result in high legacy liability.
- The majority of current freespans are located on the infield umbilical and complete removal of the umbilical, although generating some temporary seabed disturbance, will eliminate the potential for future freespans.

Assessment of all available options for the decommissioning of the Anglia Pipeline System indicates there is a significant increase in safety risk for complete removal of the infield pipeline and export pipeline/methanol line, and from remediation of freespans on both these lines and the umbilical by cut and lift.

Therefore, the recommended decommissioning options for the Anglia gas pipelines and umbilical are:

- Pipeline – Option P(e) – Leave *in situ*, with no remediation of freespan sections
- Umbilical – Option U(a) - Complete recovery, reverse reel

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APPENDIX A – PIPELINES, METHANOL LINE AND UMBILICAL COMPARATIVE ASSESSMENT SCORED OPTIONS MATRIX

Gas export pipeline and associated methanol line (PL854 and PL855) and infield gas pipeline (PL954)

		Option P(a) Complete recovery, reverse S-lay			Option P(b) Complete recover, cut and lift			Option P(c) Leave in situ, with remediation of freespan sections, cut and lift (where required)			Option P(d) Leave in situ, with remediation of freespan sections using rock (where required)			Option P(e) Leave in situ, no remediation of freespan sections		
Criteria	**Sub criteria**	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score
Safety	Risk to personnel offshore during decommissioning operations	4	2	8	4	2	8	4	1.5	6	3	1	3	3	1	3
Safety	Risk to personnel onshore during decommissioning operations	4	1.5	6	4	1.5	6	4	1.5	6	1	1	1	1	1	1
Safety	Risk to divers during decommissioning operations	4	1.5	6	4	2	8	4	1.5	6	4	1	4	3	1	3
Safety	Risk to 3rd parties and assets during decommissioning operations	3	1	3	3	1	3	3	1	3	2	1	2	2	1	2
Safety	Residual risk to 3rd parties	2	1	2	2	1	2	3	1.5	1	2	1.5	3	3	1.5	4.5
			Total	25		Total	27		Total	22		Total	13		Total	13.5
			Average	5.0		Average	5.4		Average	4.4		Average	2.6		Average	2.7
Environment	Chemical discharge	3	1	3	3	1	3	3	1	3	3	1	3	3	1	3
Environment	Hydrocarbon release from pipelines	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2
Environment	Seabed disturbance and/or habitat alteration including cumulative impact	5	1	5	5	1	5	2	1	2	2	1	2	2	1	2
Environment	CO_2 emissions (tCO_2 eq.)	3	1.5	4.5	3	1	3	2	1	2	2	1	2	2	1	2
Environment	Total energy consumption	4	1.5	6	4	1	4	2	1	2	2	1	2	2	1	2
Environment	Proportion of material reused/recycled	2	1.5	3	2	1.5	3	5	1	5	5	1	5	5	1	5
Environment	Proportion of material landfilled	3	1.5	4.5	3	1.5	4.5	2	1	2	2	1	2	2	1	2
Environment	Conservation sites and species (including noise effects)	4	1	4	4	1	4	3	1	3	4	1	4	1	1	1
			Total	32		Total	28.5		Total	21		Total	22		Total	19
			Average	4.0		Average	3.6		Average	2.6		Average	2.8		Average	2.4

		Option P(a) Complete recovery, reverse S-lay			Option P(b) Complete recover, cut and lift			Option P(c) Leave in situ, with remediation of freespan sections, cut and lift (where required)			Option P(d) Leave in situ, with remediation of freespan sections using rock (where required)			Option P(e) Leave in situ, no remediation of freespan sections		
Criteria	**Sub criteria**	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score
Technical	Technical feasibility	5	2	10	4	1.5	6	3	1.5	4.5	2	1	2	1	1	1
Technical	Weather sensitivity	4	1	4	4	1	4	4	1	4	3	1	3	2	1	2
			Total	14		Total	10		Total	8.5		Total	5		Total	3
			Average	7.0		Average	5.0		Average	4.3		Average	2.5		Average	1.5
Societal	Residual effect on fishing, navigation or other access (including cumulative)	2	1	2	2	1	2	3	1.5	4.5	3	1	3	3	1	3
Societal	Coastal communities	2	1	2	2	1	2	2	1	2	2	1	2	1	1	1
			Total	4		Total	4		Total	6.5		Total	5		Total	4
			Average	2.0		Average	2.0		Average	3.3		Average	2.5		Average	2.0
Economic	Total cost	5	2	10	5	1.5	7.5	3	1.5	4.5	2	1.5	3	2	1	2
Economic	Residual liability including monitoring and remediation if necessary	1	1	1	1	1	1	4	1.5	6	4	1.5	6	4	1.5	6
			Total	11		Total	8.5		Total	10.5		Total	9		Total	8
			Average	5.5		Average	4.3		Average	5.3		Average	4.5		Average	4.0
				23.5			24.5			19.8			14.9			12.6
				4.7			4.9			4.0			3.0			2.5

Infield service umbilical (PL955)

		Option U(a) Complete recovery, reverse reel			Option U(b) Leave in situ, with remediation of freespan sections, cut and lift (where required)			Option U(c) Leave in situ, with remediation of freespan sections using rock (where required)			Option U(d) Leave in situ, no remediation of freespan sections		
Criteria	**Sub criteria**	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score
Safety	Risk to personnel offshore during decommissioning operations	3	1.5	4.5	4	1.5	6	3	1	3	3	1	3
Safety	Risk to personnel onshore during decommissioning operations	3	1	3	4	1.5	6	1	1	1	1	1	1
Safety	Risk to divers during decommissioning operations	4	1	4	4	1.5	6	4	1	4	3	1	3
Safety	Risk to 3rd parties and assets during decommissioning operations	2	1	2	2	1	2	2	1	2	2	1	2
Safety	Residual risk to 3rd parties	2	1	2	3	1.5	1	2	1.5	3	3	1.5	4.5
			Total	15.5		Total	21		Total	13		Total	13.5
			Average	3.1		Average	4.2		Average	2.6		Average	2.7
Environment	Chemical discharge	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
Environment	Hydrocarbon release from umbilical	1	1	1	1	1	1	1	1	1	1	1	1
Environment	Seabed disturbance and/or habitat alteration including cumulative impact	4	1	4	2	1	2	2	1	2	2	1	2
Environment	CO_2 emissions (tCO_2 eq.)	1	1	1	1	1	1	1	1	1	1	1	1
Environment	Total energy consumption	1	1	1	2	1	2	1	1	1	1	1	1
Environment	Proportion of material reused/recycled	3	1	3	5	1	5	5	1	5	5	1	5
Environment	Proportion of material landfilled	4	1	4	2	1	2	2	1	2	2	1	2
Environment	Conservation sites and species (including noise effects)	2	1	2	2	1	2	3	1	3	2	1	2
			Total	20.5		Total	19.5		Total	19.5		Total	18.5
			Average	2.6		Average	2.4		Average	2.4		Average	2.3

		Option U(a) Complete recovery, reverse reel			Option U(b) Leave in situ, with remediation of freespan sections, cut and lift (where required)			Option U(c) Leave in situ, with remediation of freespan sections using rock (where required)			Option U(d) Leave in situ, no remediation of freespan sections		
Criteria	**Sub criteria**	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score
Technical	Technical feasibility	3	1.5	4.5	3	1.5	4.5	2	1	2	1	1	1
Technical	Weather sensitivity	3	1	3	3	1	3	3	1	3	2	1	2
			Total Average	**7.5 3.8**		**Total Average**	**7.5 3.8**		**Total Average**	**5 2.5**		**Total Average**	**3 1.5**
Societal	Residual effect on fishing, navigation or other access (including cumulative)	2	1	2	3	1.5	4.5	3	1	3	3	1	3
Societal	Coastal communities	2	1	2	2	1	2	2	1	2	1	1	1
			Total Average	**4 2.0**		**Total Average**	**6.5 3.3**		**Total Average**	**5 2.5**		**Total Average**	**4 2.0**
Economic	Total cost	1	1.5	1.5	2	1.5	3	2	1.5	3	2	1	2
Economic	Residual liability including monitoring and remediation if necessary	1	1	1	4	1.5	6	4	1.5	6	4	1.5	6
			Total Average	**2.5 1.3**		**Total Average**	**9 4.5**		**Total Average**	**9 4.5**		**Total Average**	**8 4.0**
				12.7 2.5			18.1 3.6			14.5 2.9			12.5 2.5

APPENDIX B – IDENTIFIED FREESPANS ALONG THE ANGLIA PIPELINE SYSTEM

Table B.1 – Pipeline PL854-PL855 export pipeline and piggybacked methanol line (pipeline length 24,000m)

2012 Survey[1]						2014 Survey[2]						2018 Survey[3]						
KP	Easting	Northing	Length (m)	Height (m)	Freespan	KP	Easting	Northing	Length (m)	Height (m)	Freespan	KP	Easting	Northing	Length (m)	Height (m)	Freespan	Comment
						-0.034	433821.75	5916248.18	10.02	0.88	Start							
						-0.024	433816.31	5916256.1	10.02	0.88	End							
						0.065	433728.07	5916249.53	7.98	0.24	Start							
						0.073	433720.11	5916248.85	7.98	0.24	End							
												0.655	433140.41	5916203.21	9.33	0.13	Start	Span identified from 2018 survey in area not surveyed in 2014.
												0.664	433131.07	5916202.38	9.33	0.13	End	
												11.643	422185.12	5915353.32	22.9	0.31	Start	Span identified from 2018 survey in area not surveyed in 2014.
												11.666	422162.25	5915351.85	22.9	0.31	End	
11.681	422146.75	5915351.73	8.5	0.2	Start													
11.69	422138.3	5915351.15	8.5	0.2	End													
												11.693	422135.4	5915350.09	10.79	0.1	Start	Span identified from 2018 survey in area not surveyed in 2014
												11.703	422124.61	5915349.15	10.79	0.1	End	
												23.107	410758.06	5914428.69	12.01	0.22	Start	
												23.119	410746.78	5914424.53	12.01	0.22	End	
						23.12	410745.73	5914423.87	6.09	0.1	Start							
23.126	410740.34	5914422.69	14.7	0.4	Start	23.126	410740.01	5914421.8	6.09	0.1	End							Same span 2012 and 2014
23.14	410726.49	5914417.76	14.7	0.4	End	23.132	410734.21	5914419.85	17.19	0.26	Start	23.14	410727.21	5914417.5	14.07	0.41	Start	Shift in KP 2.4m longer in 2014
						23.15	410718	5914414.07	17.19	0.26	End	23.154	410714.06	5914412.49	14.07	0.41	End	Shift in KP 3.12m shorter in 2018
						23.41	410475.85	5914313.35	15.02	0.21	Start	23.403	410483.74	5914315.81	23.16	0.3	Start	Same span 2014 and 2018
						23.425	410460.2	5914307.1	15.02	0.21	End	23.426	410459.34	5914306.18	23.16	0.3	End	Shift in KP 8.14 longer in 2018
						23.475	410408.12	5914285.63	4.15	0.43	Start	23.475	410408.71	5914285.38	4.95	0.29	Start	Same span, 0.8 longer in 2018
						23.479	410403.84	5914283.78	4.15	0.43	End	23.48	410403.69	5914283	4.95	0.29	End	
												23.489	410394.14	5914278.69	0.21	0.09	Start	
												23.489	410393.92	5914278.58	0.21	0.09	End	
						23.533	410382.73	5914250.88	7.78	0.57	Start							
						23.541	410386.05	5914243.67	7.78	0.57	End							

Notes: [1] The total length of pipeline freespaning (m) and % of total line in 2012 was 23m and <0.1%. [2] 68m and <0.3% for 2014 and [3] 97m and <0.5% in 2018

Table B.2 – Pipeline PL954 (pipeline length 5,000m) – Pipeline not included in the 2012 survey

2014 Survey[1]						2018 Survey[2]						
KP	Easting	Northing	Length (m)	Height (m)	Freespan	KP	Easting	Northing	Length (m)	Height (m)	Freespan	Comment
						0	410351.97	5914254.08	4.69	0.62	Start	
						0.005	410347.29	5914254.43	4.69	0.62	End	
0.017	410334.7	5914254.96	6.72	0.52	Start	0.018	410333.68	5914255.17	7.49	0.57	Start	Same span, 0.77m longer in 2018
0.024	410327.99	5914255.32	6.72	0.52	End	0.026	410326.17	5914255.18	7.49	0.57	End	
0.043	410309.01	5914255.95	8.74	0.21	Start	0.043	410309.02	5914255.24	6.54	0.29	Start	Same span, 2.2m shorter in 2018
0.052	410300.27	5914256.13	8.74	0.21	End	0.049	410302.48	5914255.54	6.54	0.29	End	
						0.114	410237.59	5914258.2	8.23	0.14	Start	
						0.123	410229.36	5914258.64	8.23	0.14	End	
						2.611	407746.79	5914421.8	6.74	0.15	Start	Span identified from 2018 survey in area not surveyed in 2014
						2.618	407740.06	5914422.23	6.74	0.15	End	

Notes: [1] The total length of pipeline freespaning (m) and % of total line in 2014 was 15m and <0.4% and [2] 34m and <0.7% for 2018

Table B.3 – Pipeline PL955 (pipeline length 5,000m) – pipeline not included in the 2012 and 2014 surveys

2018 Survey					
KP	Easting	Northing	Length (m)	Height (m)	Freespan
0.056	410295.02	5914228.12	0.64	0.03	Start
0.057	410294.4	5914227.94	0.64	0.03	End
1.13	409227.21	5914270.33	3.3	0.13	Start
1.133	409223.95	5914271	3.3	0.13	End
1.843	408515.82	5914320.24	4.93	0.22	Start
1.849	408510.19	5914319.69	4.93	0.22	End
2.769	407592.89	5914387	3.05	0.14	Start
2.772	407589.85	5914387.3	3.05	0.14	End
3.768	406595.07	5914446.91	4.31	0.38	Start
3.773	406590.76	5914446.85	4.31	0.38	End
4.492	405880.05	5914528.47	1.48	0.05	Start
4.493	405878.65	5914258.97	1.48	0.05	End
4.513	405860.23	5914536.09	2.48	0.17	Start
4.516	405857.88	5914536.91	2.48	0.17	End
4.607	405775.21	5914575.44	5.48	0.23	Start
4.612	405770.36	5914577.98	5.48	0.23	End
4.631	405754.65	5914587.1	6.55	0.53	Start
4.637	405749.08	5914590.56	6.55	0.53	End
4.655	405734.58	5914599.91	1.46	0.1	Start
4.656	405733.34	5914600.68	1.46	0.1	End

Notes: [1] The total length of pipeline freespaning (m) and % of total line in 2018 was 34m and <0.7%.

Figure B.1 – Freespans within Anglia West (B) safety zone and on PL954 and PL955

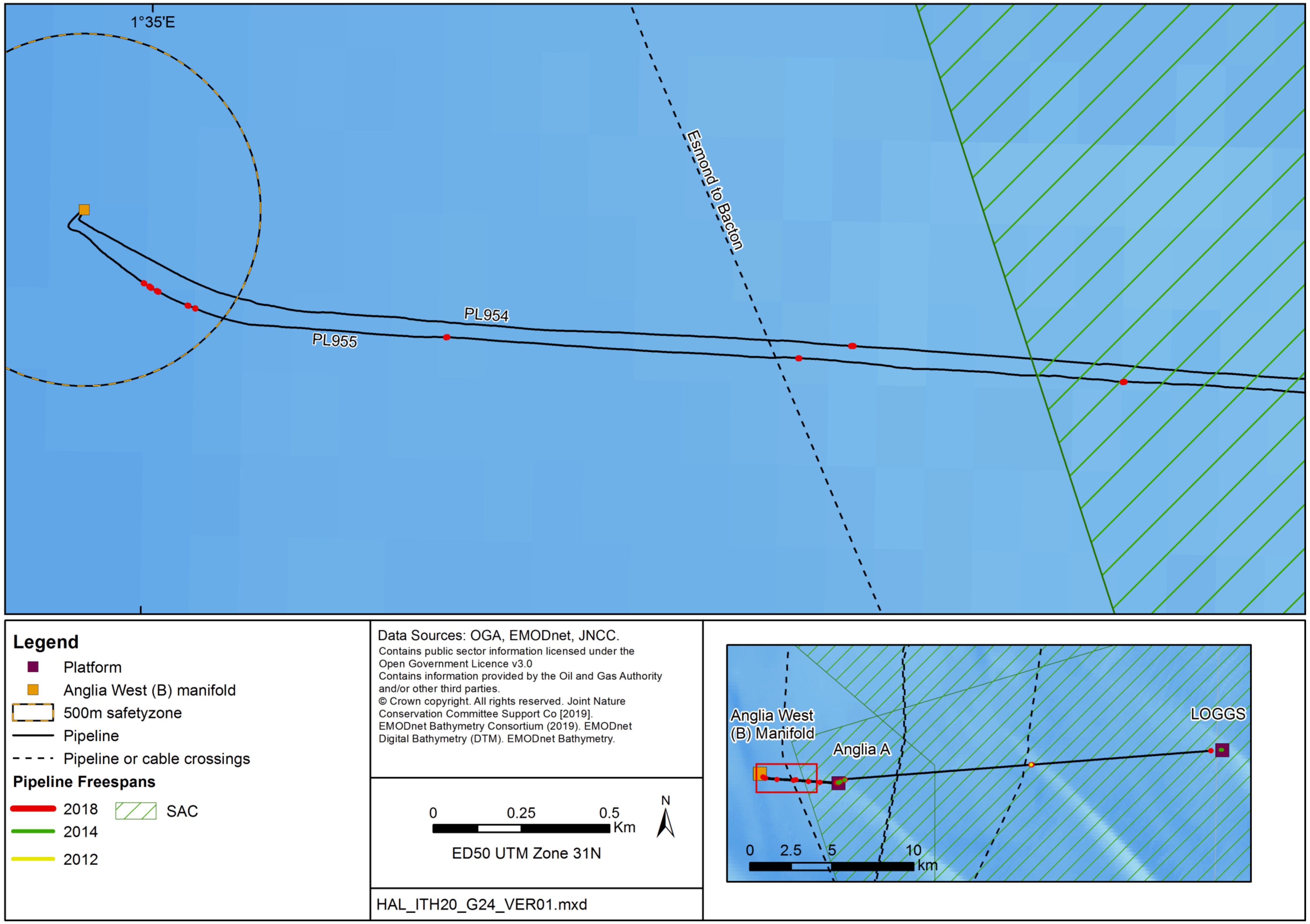

Figure B.2 – Freespans within Anglia A NUI safety zone and on PL954, PL955 and PL854/855

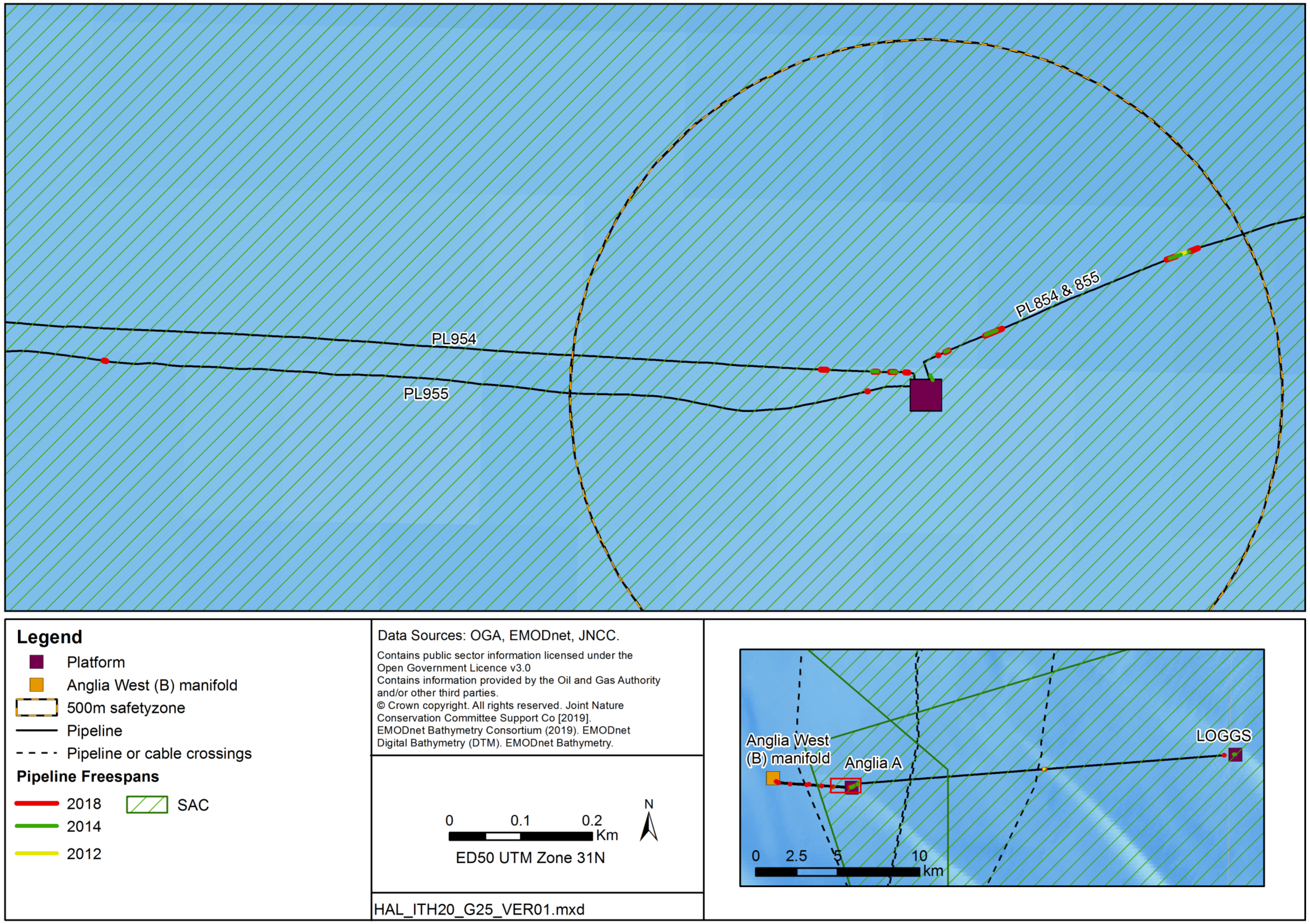

Figure B.3 – Freespans on PL854/855