Ithaca Energy (UK) Limited

Causeway-Fionn Decommissioning
Pipelines and Umbilical
Comparative Assessment

Prepared by Ithaca Energy (UK) Limited

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GLOSSARY AND ABBREVIATIONS

Term	Explanation
BEIS	Department for Business, Energy and Industrial Strategy, formerly the Department of Energy and Climate Change (DECC)
Bullhead	To forcibly pump fluids into a formation
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
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)
EA	Environmental Appraisal
EHC	Electric, hydraulic, control – describing the umbilical function
EUNIS	European Nature Information System, a habitat classification system for habitat identification
Gj	Gigajoule. 1 gigajoule is equal to 1 billion (10^9) joules
HS&E	Health, Safety and Environment
JNCC	Joint Nature Conservation Committee
km	Kilometre: 1,000m, equivalent to 0.54 nautical miles
MAT	Master Application Template, a central application in the BEIS PETS, linked to a particular activity type (e.g. drilling, pipeline installation, production), under which subsidiary applications (SATs) can be submitted to enable the activity to be carried out
NCMPA	Nature Conservation Marine Protected Areas: established under the Marine (Scotland) Act 2010
NCP	North Cormorant Platform
OGA	Oil and Gas Authority
OSPAR	The Convention for the Protection of the Marine Environment of the North East Atlantic 1992
PETS	Portal Environmental Tracking System
SAC	Special Area of Conservation: established under the Habitats Directive.
SFF	Scottish Fishermen's Federation
SOSI	Seabird Oil Sensitivity Index
SPA	Special Protection Area: established under the Birds Directive.
VMS	Vessel monitoring system
WI	Water injection

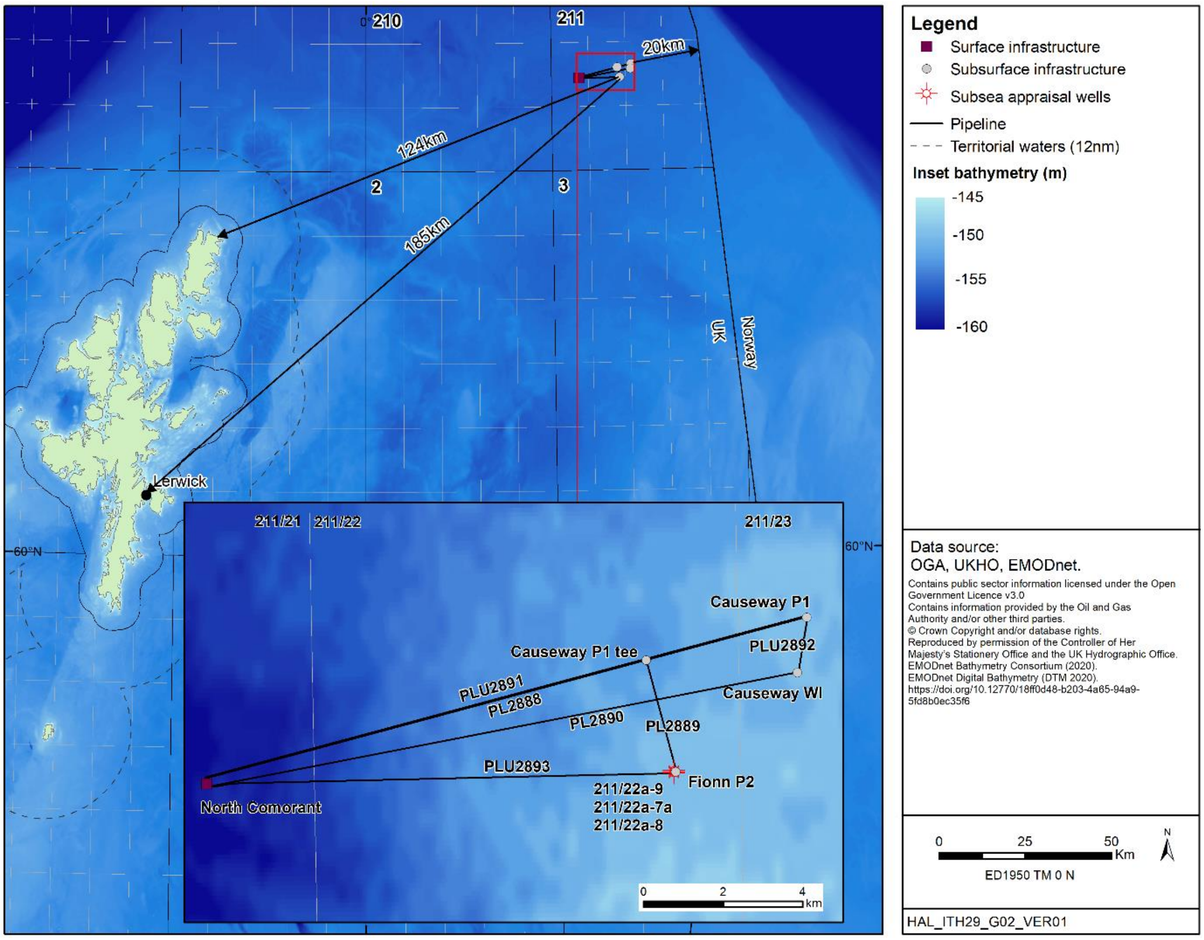
1 INTRODUCTION AND BACKGROUND

Ithaca Energy (UK) Limited (Ithaca Energy) is planning for the decommissioning of the Causeway and Fionn Fields, (hereafter Causeway-Fionn).

The Causeway field is located in the UKCS northern North Sea within Block 211/23d (Figure 1.1). The field is approximately 500km NNE of Aberdeen and approximately 185km from Lerwick in a water depth of 161m. The field was first discovered by well 211/22-3 drilled in 1983. The facilities comprise an 8” Production Pipeline, Control Umbilical and an 8” Water Injection Pipeline connected to one producing (P1) and one water injecting (W1) well which are tied back to TAQA Bratani Limited’s (TAQA) North Cormorant Platform (NCP).

The Fionn field is located within Block 211/22a. Fionn was discovered in 2007 as part of the Causeway field appraisal programme. Discovery well, 211/22a-6, established that the Central fault panel of the Causeway area on the Osprey ridge was a separate oil accumulation to Causeway and it was agreed with the Department of Energy and Climate Change (DECC), now the Department for Business, Energy and Industrial Strategy (BEIS), that it should be developed as a separate field, subsequently re-named as Fionn. Fionn facilities comprise one 8” production pipeline tied into the Causeway pipeline via a “Tee” and one Control Umbilical both supporting a single production well (P2). The Control Umbilical is also tied into NCP.

Figure 1.1 – Causeway and Fionn location



Separate Cessation of Production (CoP) notifications for both Causeway and Fionn were submitted on 21st December 2018 and approved on the 15th January 2019, by the Oil & Gas Authority (OGA).

Ithaca Energy and the other Section 29 holders for the assets, have decommissioning liability for the facilities associated with Causeway-Fionn and in consultation with BEIS, a combined Causeway-Fionn decommissioning programme (DP) is being submitted for these. Following public, stakeholder and regulatory consultation, the DP will be submitted, in full compliance with the Offshore Petroleum Regulator for Environment & Decommissioning (OPRED) guidelines.

The facilities subject to decommissioning are:

- The Causeway production and water injection wells
- The Fionn production well
- Three appraisal subsea wells
- The Causeway-Fionn pipeline system:
    - 2 x steel production pipelines PL2888 and PL2889, both trenched and mechanically backfilled
    - 3 x umbilicals PLU2891, PLU2892 and PLU2893, all three trenched to below seabed level, but not mechanically backfilled, left open to self-cover
    - 1 x water injection pipeline PL2890, trenched to below seabed level, but not mechanically backfilled, left open to self-cover
- Protective material (mattresses, sand bags and rock) – rock is present, in various quantities on all lines except the umbilical PLU2892
- Subsea infrastructure: valve skid/integrated protection structure (gravity based), purge spool (gravity based) and well structures (wellhead/protection structures)

To fulfil Ithaca Energy's HS&E policy, and in line with regulator (BEIS 2018) and industry guidance (OGUK 2015), the following comparative assessment covers the Causeway-Fionn pipeline system (pipelines, umbilicals, protective material) and supports the DP. Infrastructure associated with the pipeline system (valve skid/integrated protective structure and purge spool) is to be completely removed and, therefore, is not subject to comparative assessment.

The TAQA operated NCP infrastructure is not part of the Causeway-Fionn DP.

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), BEIS decommissioning 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 guidance (OGUK 2015) expanded on that initially provided in DECC (2011), with the aim of encouraging a consistent approach to the comparative assessment process in the UK. The comparative assessment for the Causeway-Fionn pipeline system has been drafted taking account of these guidance documents.

The pipeline system subsea infrastructure (valve skid/integrated protective structure and purge spool) are pipeline structures which must be completely removed and, as they are to be removed, these do not require further consideration in this comparative assessment.

The decommissioning options considered in the comparative assessment for the Causeway-Fionn pipeline system primarily relate to whether it is fully retrieved or wholly or partially to be left *in situ*, with different remedial approaches to exposed areas of pipeline and umbilicals, the methods used and their potential effects. Consistent with the OGUK (2015) and BEIS (2018) guidance, the comparative assessment considers these options, based on the following five 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 Causeway-Fionn pipeline system.

1.2 Consultation and Stakeholder Engagement

To identify potential environmental issues associated with the decommissioning of Causeway-Fionn, Ithaca Energy engaged with a number of stakeholders during the planning stage. In particular, Ithaca Energy wanted to ensure:

- awareness of all relevant environmental information for the area
- identification of stakeholder issues and concerns to be considered in the environmental impact assessment process, and which are relevant to the comparative assessment

Ithaca Energy had virtual meetings with consultees, at which a summary of the proposed decommissioning activities, the environment of the area and the key issues were presented, with consultees invited to discuss the proposals and raise any questions. Consultees were also given the opportunity to subsequently raise any further issues or concerns and provide details of new relevant information.

The consultees were the Department for Business, Energy and Industrial Strategy – Offshore Petroleum Regulator for Environment & Decommissioning (OPRED) (environmental section), the Joint Nature Conservation Committee (JNCC) and the Scottish Fishermen's Federation (SFF). OPRED had no comment at that time, JNCC noted that sea pens and burrows were identified from the pre-decommissioning survey and welcomed confirmation this would be included in the Environmental Assessment. SFF advised that UK and non-UK vessels utilise the area; this has been taken into consideration in assessing fishing effort. The presence of existing hard substrate throughout the area was also confirmed, and the main vessels operating there are the larger boats, with larger gear designed to account for this.

2 ENVIRONMENTAL DESCRIPTION

A summary of the Causeway-Fionn and wider environment along with seasonal sensitivities is given in Table 2.1. A full description of the environment is provided in the Causeway-Fionn Decommissioning Environmental Appraisal report (Ithaca Energy Document Reference CFI-LLA-IT-DE-RE-0002 Causeway-Fionn Decommissioning Environmental Appraisal)

Table 2.1 – Environmental summary and seasonal sensitivities

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Location	The Causeway and Fionn facilities are located in the East Shetland Basin area of the northern North Sea, in Blocks 211/23, 211/22 and 211/21, where they tie into the TAQA operated NCP. At their closest, the facilities are approximately 124km from the Shetland coastline and 20km from the UK/Norway transboundary line.											
Water column, climate and hydrography	Winds are variable, although predominately from the south and southwest. In winter, winds of Beaufort force 5 (~9-11m/s) or greater may be experienced at a frequency of approximately 60-65%. Annual mean significant wave height is approximately 2.7m, varying seasonally. Tidal currents in the northern North Sea area are generally weak and are readily influenced by other factors (e.g. winds and density driven circulation). Tidal currents are relatively weak for neap and spring tides (0.3 and 0.6m/s respectively). The water column stratifies thermally in summer and this is broken down in winter with increased wind and convective mixing. Annual mean sea surface temperatures are ~9.6°C, and bottom temperatures ~7.7°C. Surface and bottom salinities are approximately 35ppt and 35.2ppt respectively, with very little seasonal variation.											
Seabed, sediments	Relatively flat seabed though shoals slightly to the west; water depths across the area range from a minimum of 148m at the Fionn well location (P2) and maximum of 160m at the tie in at NCP. Depressions are noted on the seabed across the area which are generally minor, isolated features with a low surface expression (most <0.5m), which are sometimes associated with higher reflectivity (i.e. indicating areas of coarser sediment) and boulders; no evidence of shallow gas or gas release that would attribute these to pockmark features. The EUNIS habitat classification records the seabed sediments predominantly deep circalittoral sand across the majority of the area, the decommissioning baseline survey identifies transitional zone of muddy, slightly gravelly sand, with varying densities of cobbles present, either side of the rock placement used at initial installation.											
Plankton	The plankton community in the waters around Causeway-Fionn is similar to that found over a wide area of the northern North Sea. The phytoplankton community is dominated by the dinoflagellate genus *Tripos* (*Tripos fusus, Tripos furca, Tripos lineatum*), with diatoms such as *Thalassiosira* spp. and *Chaetoceros* spp. also abundant. Dinoflagellates typically comprise a greater proportion of the phytoplankton community than diatoms from June to October, when waters will be most stratified. The spring bloom in this region is stronger, relative to the autumn bloom, than elsewhere. Zooplankton species richness is higher in the northern North Sea than in the southern North Sea and the community displays greater seasonal variability. The zooplankton community is dominated by calanoid copepods, although other groups such as *Paracalanus* and *Pseudocalanus* are also abundant. There is also a high biomass of *Calanus* larval stages present in the region.											
	Key: Period of increased plankton abundance shown in darker blue											

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Benthos	Sensitivity similar throughout the year. The wider area has been described as a region of transition in the epibenthic community with species typical of water >100m deep such as *Astropecten irregularis* (echinoderm), *Hyalinoecia tubicola* (polychaete), *Echinus* spp. (echinoderm), *Anapagurus laevis* and *Pagurus pubescens* (crustaceans), and the anemone *Hormathia digitata*, as well as species more characteristic of shallower water, including crabs *Hyas coarctatus* and *Pagurus bernhardus*, the whelks *Neptunea antiqua* and *Colus gracilis*, starfish *Asterias rubens* and the hydroid *Hydractinia echinata*. The pre-decommissioning survey found that fauna was sparse across all biotopes, but primarily included sea pens (*Pennatula phosphorea* and *Virgularia* sp.), urchins (Echinidae), starfish (Asteroidea), hermit crabs (Paguridae) and cushion stars (Goniasteridae, including *Hippasteria phrygiana*) and polychaete worms (Hyalinoeciinae and Sabellidae) with faunal tracks, mounds and burrows identified. Taxa also included squat lobsters (Galatheoidea), redfish (Sebastidae), anemones (Actiniaria, including *Bolocera tuediae*), gadoid fish (Gadiformes) and faunal turf (Hydrozoa/Bryozoa), which were primarily associated with the rock placement for infrastructure protection. Sea pens and faunal burrows were present across all stations and most transects within the survey area. There was no survey evidence of the presence of *Arctica islandica* and no other sensitive habitat or species were observed.											
Fish	The area overlaps reported spawning grounds of Norway pout, saithe, haddock, cod and whiting (see below for timing) and also supports known nursery grounds for blue whiting, spurdog, European hake, haddock, Norway pout, herring, ling, mackerel, anglerfish and whiting.											
	3	5	5	5	2	1	0	0	0	0	0	0
	Key: 1 = 1 species spawning, 2 = 2 species spawning etc											
Birds	The area may be considered to be of low importance for seabirds in the context of the North Sea as a whole – this is related to the distance from breeding colonies (Causeway-Fionn is >124km from shore) and the availability of prey species (e.g. inshore areas around Shetland are of much greater importance, with only a few species breeding at colonies in Shetland with mean maximum foraging ranges exceeding 100km, e.g. northern gannet, northern fulmar, black-legged kittiwake). Species present vary seasonally and being far offshore, the birds present in the area are likely to be (predominately) those transiting through the area during migration, post breeding dispersion from colonies. The Seabird Oil Sensitivity Index (SOSI) has been developed based on previous indices and with method refining. Where there is no data coverage the JNCC guidance is used to reduce the extent of coverage gaps (these are shown in red). Where these could not be reduced, these are shown with N and highlighted Yellow. For the Blocks of interest, seabird sensitivity is low, for those months with data, with the exception of Dec for Block 211/23 where sensitivity is high and Sept and Dec for Block 211/22 which is moderate.											
Block 211/21	5	5	5	5	N	5	5	5	5	5	5	5
Block 211/22	5	5	5	5	N	5	5	5	4	4	4	4
Block 211/23	5	5	5	5	N	5	5	5	5	5	3	3
	1=extremely high		2=Very high		3 =High		4=Moderate		5=Low		N=no coverage	
Marine mammals	Harbour porpoise are frequently sighted throughout the central North Sea area and are likely to be the most abundant species in this area; while present throughout the year, peak numbers are generally recorded from June to October. White-beaked dolphins, are encountered regularly in coastal and offshore waters of the central and northern North Sea, although sightings are less common at latitudes above that of Shetland; while they can be sighted throughout the year, most frequent sightings are from July to October. Minke whales are also present, appearing to move south into the North Sea at the beginning of May and remaining until October. Several other species have been sighted in offshore waters of the northern North Sea, such as killer whale, bottlenose dolphin and beaked whales, but infrequently and/or in small numbers only. The area is distant from seal breeding colonies and haul-out sites; models based on tagging data suggest very low densities of both grey and harbour seal in the area.											
	Key: Darker colours reflect months when marine mammals are most frequently observed											

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conservation sites	The Shetland and wider region's coast have a variety of important habitats and species protected under international, national and local designations; however, these are at least 124km from the Causeway-Fionn area. The closest offshore Special Area of Conservation (SAC) is the Pobie Bank Reef, approximately 77km to the southwest, the closest Nature Conservation Marine Protected Area (NCMPA) is the North-east Faroe-Shetland Channel, approximately 104km to the northwest; these sites are designated for either habitat (reef, offshore deep-sea muds, offshore subtidal sand and gravels) and low or limited mobility species (deep-sea sponge aggregations). The pre-decommissioning survey identified sea pens *Pennatula phosphonea* and *Virgularia* sp, mounds and burrows and that the presence of the OSPAR listed threatened and/or declining habitat "sea pens and burrowing megafauna communities" was considered likely to occur within the survey area. However, based on sediment type and surface features, the consideration is that the habitat is not present, but Ithaca Energy have adopted a precautionary approach i.e. following JNCC (2014), and the lack of a definitive conclusion on the matter in the survey report, and have assumed it is present.											
Other Users	Blocks 211/23, 211/22 and 211/21 are all located in ICES rectangle 51F1 and fishing effort in the area is focused on demersal species; 2019 saw an increase in landings of pelagic species compared to that seen in 2018 and 2017, both of which had low or mainly disclosive catches. The area is within a wider mature oil and gas province, with considerable infrastructure in adjacent Blocks and the wider area. Shipping density is low, with these predominantly associated with vessels servicing the oil and gas industry. There are no Ministry of Defence exercise areas, dredging areas, or marine disposal sites in the vicinity and there are no telecommunication cables within the Blocks. There are no designated protected wrecks in the Causeway-Fionn area.											

Sources: Aires et al. (2014), Beaugrand (2003), Berx & Hughes (2009), Callaway et al (2002), Certain et al. (2015), Coull et al. (1998), DECC (2016), Ellis et al. (2012), Fugro (2020a,b), GEMS (2012a, b, c), Hammond et al. (2013, 2017), Jones & Russell (2016), JNCC (2014), McQuatters-Gollop et al (2007), OGA (2016), Reid et al. (2003), Reiss et al. (2010), Russell et al. (2017), Skov et al. (1995), Tasker & Pienkowskiw (1987), Thaxter et al. (2012), Turrell et al. (1992), Webb et al. (2016), Woodward et al. (2019), UKHO (2012, 2013)

3 CAUSEWAY AND FIONN PIPELINE FACILITIES FOR DECOMMISSIONING

At commencement of the comparative assessment process, Ithaca Energy 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 Causeway-Fionn DP covered by the comparative assessment, (Figure 3.1) and the feasible options under consideration for their decommissioning.

- **Causeway oil production pipeline (PL2888)**: the 15.554km (plus 440m riser and spool), 8" diameter steel export pipeline connects the Causeway production well (P1) to the NCP. The pipeline crosses the Magnus to Ninian 24" export pipeline (PL139).
- **Fionn oil production pipeline (PL2889)**: the 2.847km, 8" diameter steel pipeline connects the Fionn production well (P2) to the Causeway production pipeline (PL2888), via a valve skid assembly and Causeway Tee connection. The pipeline crosses the Causeway water injection pipeline (PL2890).
- **Causeway water injection pipeline (PL2890):** the 14.95km (plus 440m riser and spool), 8" diameter steel pipeline connects the Causeway water injection well to the NCP and crosses the Magnus to Ninian export pipeline and the Fionn production pipeline (PL2889).
- **Causeway electric/hydraulic/control (EHC) umbilical (PLU2891)**: the 15.83km service umbilical connects well P1 to the NCP and runs parallel (but separate from) the Causeway production pipeline. The umbilical crosses the Magnus to Ninian export pipeline.
- **Causeway infield EHC umbilical (PLU2892)**: the 1.49km service umbilical connects the Causeway water injection well to the Causeway production well P1. This umbilical does not cross any other pipelines
- **Fionn EHC umbilical (PLU2893)**: the 11.85km service umbilical connects the Fionn production well P2 to the NCP. The umbilical does not cross any other pipelines outside of the NCP 500m zone.

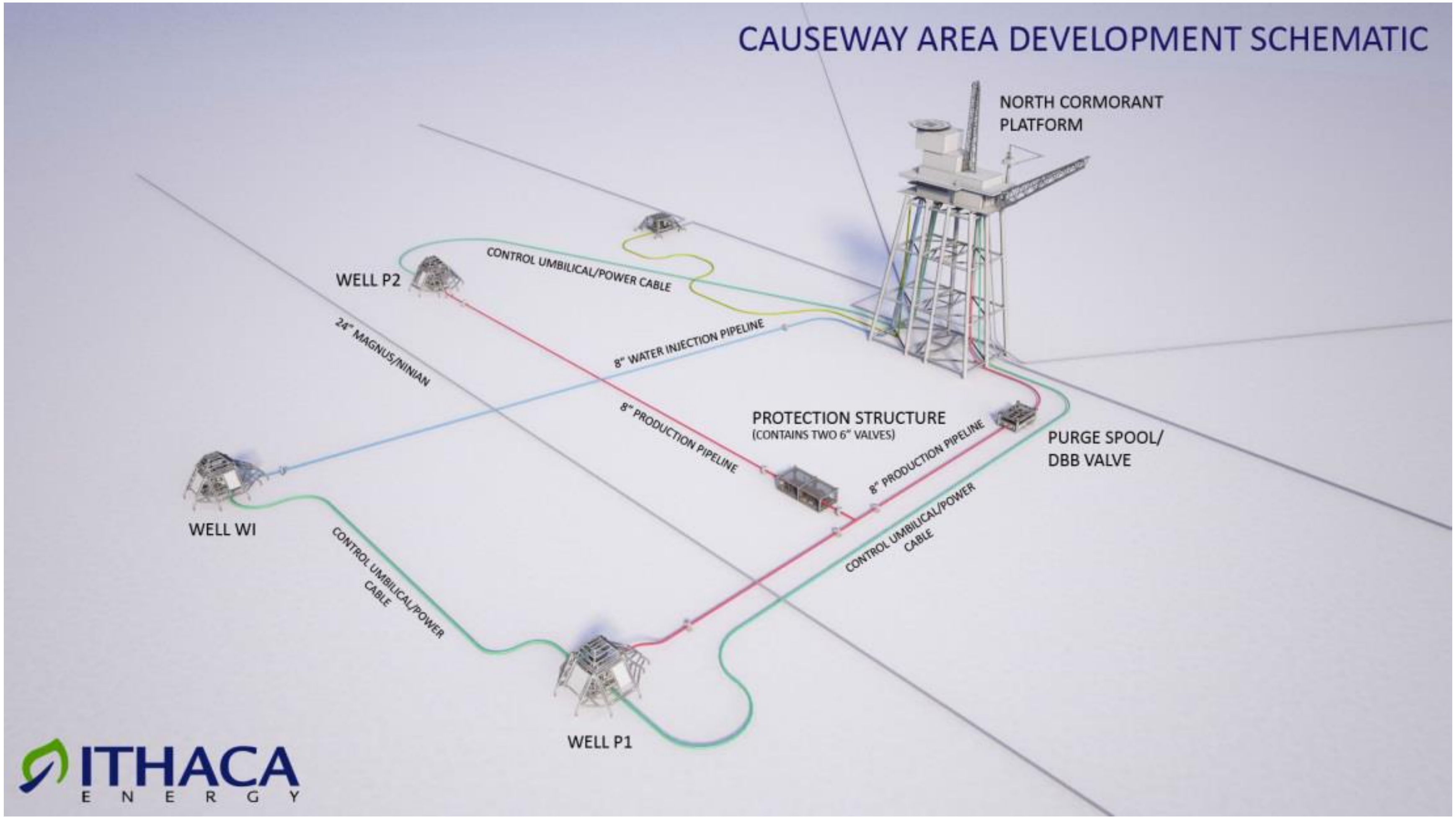
At installation, all lines were trenched to a minimum depth of 1m. Only pipelines PL2888 and PL2889 were then mechanically backfilled with sediment and buried to at least 1m (exceptions being at trench transitions, including at crossings, and approach to NCP (PL2888), where the lines are covered in protective material). The remaining lines (WI line PL2890 and the umbilicals PLU2891, PLU2892 and PLU2893), while also trenched to a minimum depth of 1m, were not mechanically backfilled but left open below seabed level to backfill naturally. These lines are also covered with protective material at trench transitions and approaches to infrastructure.

A study of potential fisheries interactions (Genesis 2012), was based on the production pipelines being trenched and mechanically backfilled and the WI pipeline trenched, but left open. The report recommended that protection of exposed WI pipeline (not in the vicinity of the NCP) was not required for hooking[1] and pull-over loads but was against impact loads, and that trenching of the pipeline was considered to be adequate in this respect. The umbilicals were considered too small a diameter to be analysed using the applied methodology of Det Norske Veritas (DNV) (Genesis 2012).

At time of submitting this comparative assessment, the production pipelines are still to be cleaned and flushed, with all wells being shut in. Options for this cleaning and flushing programme are being discussed with TAQA, the NCP operator, prior to decommissioning, including the potential to bullhead down the wells or discharge via the platform.

[1] Hooking is where the trawl equipment is "stuck" under the pipeline, a seldom occurring accidental situation, pull-over is where the trawl board, beam trawl or clump weight is pulled over the pipeline, after the initial impact (Genesis 2012)

Figure 3.1 – Causeway-Fionn infrastructure



Note: Although shown here the TAQA operated NCP is not part of Ithaca Energy's decommissioning programme. The three appraisal wells also being decommissioning (211/22a-7a, 211/22a-8 and 211/2a-9) are not shown on this field schematic, see Figure 1.1

The current contents of the lines are: production fluid (reservoir hydrocarbons/produced water) in the production pipelines (PL2888 and PL2889); water in the water injection pipeline (PL28890) and hydraulic fluid/methanol in the umbilicals (PLU2891, PLU2892 and PLU2893). Prior to any decommissioning activities, including any preparatory work being carried out, Ithaca Energy will ensure the production pipelines have been cleaned and flushed and left "hydrocarbon free", (with only residual hydrocarbon present) with the contents left being either inhibited (typically biocide, oxygen scavenger, corrosion inhibitor) seawater or potable water.

There is protection material located at trench transitions, crossings, and other “spot” locations. Protective material includes:

- **Concrete mattresses and sand bags**: these are located at a number of strategic locations along the production and water injection pipelines and umbilicals, including trench transitions (where the lines exit the seabed), approaches to infrastructure, at spool tie-in/riser locations and in the approaches to and at, crossing locations. The mattresses used for Causeway-Fionn are flexible, consisting of hexagonal concrete elements linked together with high strength non-biodegradable polypropylene rope, allowing the mattresses to follow the contours of the seabed and the pipeline.
- **Rock**: rock cover overlays the production and water injection pipelines and umbilicals (with the exception of PLU2892) at strategic locations including crossings, at approaches to well P1 and various spot locations, principally along the Causeway production pipeline PL2888 (See Appendix A).

In line with current guidance (BEIS 2018), the plan is to recover those mattresses 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. Where rock has been used to protect a pipeline/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. Where mattresses have been used in conjunction with the rock and are completely covered by it, then these mattresses will also be decommissioned *in situ*. Where mattresses are used at trench transitions and may be partially buried, these will be assessed at time of decommissioning for leaving *in situ* or recovery; this will be discussed with OPRED at time of decommissioning. From information at installation of the development, the estimated number of mattresses (total, buried and estimated to be recoverable) is shown in Table 3.1

Table 3.1 – Estimated mattresses present at Causeway and Fionn

Location	Total number of mattresses	Mattresses buried[1]	Mattresses at trench transitions[1]	Mattresses laid on seabed for recovery
Causeway	261	21	24	216
Fionn	179	2	22	155

Note: [1]Mattresses buried under rock will be decommissioned in situ and mattresses at trench transitions (where these may be partially buried) to be assessed at time of decommissioning for leaving in situ, or recovery.

If the pipeline is to be removed, partially or entirely, the expectation is that this should be done with minimum disturbance of the rock, i.e. that necessary to allow safe access to a pipeline/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 Causeway-Fionn pipeline 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.

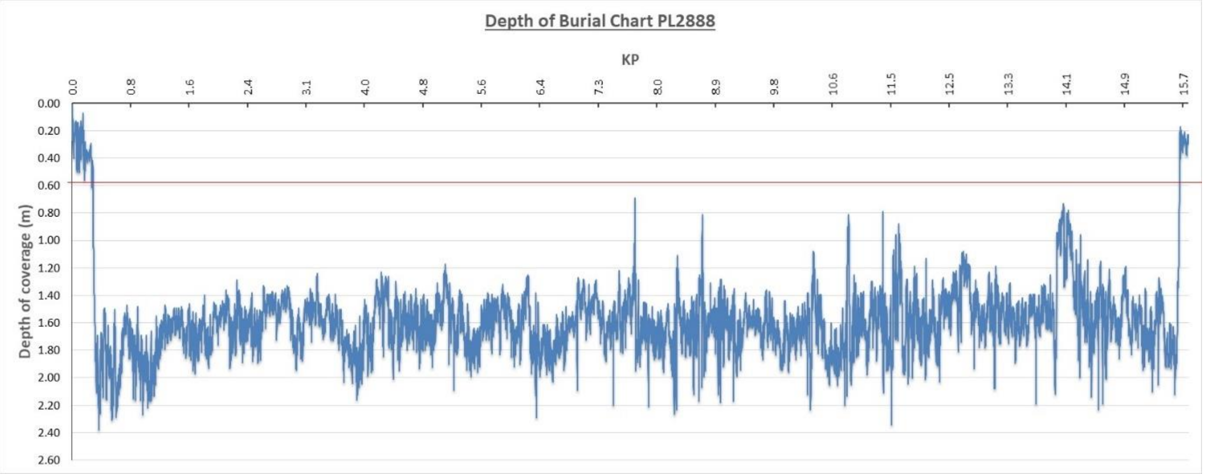
Freespans and exposed sections – adequately buried/trenched lines

After installation, currents and wave action at the seabed may lead to scour and pipeline exposure. A freespan occurs where the seabed sediments have been scoured from under a pipeline resulting in an unsupported section of pipe no longer in contact with the seabed. Pipeline inspection reports (i.e. iSurvey 2015, DeepOcean 2018) have not identified any freespans along any of the Causeway-Fionn pipeline infrastructure (this is as expected, given this area is not subject to vigorous currents and the sediment type, deep circalittoral sand). 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.

The BEIS (2018) guidance states that some pipelines/umbilicals can be considered for *in situ* decommissioning. A candidate type is described as *those which are adequately buried and trenched and which are not subject to development of spans and are expected to remain so*. The guidance continues, *it is expected that burial or to a minimum depth of 0.6 metres above the top of the pipeline will be necessary in most cases, trenching without burial will require more detailed information on backfill, and fishing activity. Note: Those which are trenched but not adequately buried will require more information on possible backfill and snagging risks*.

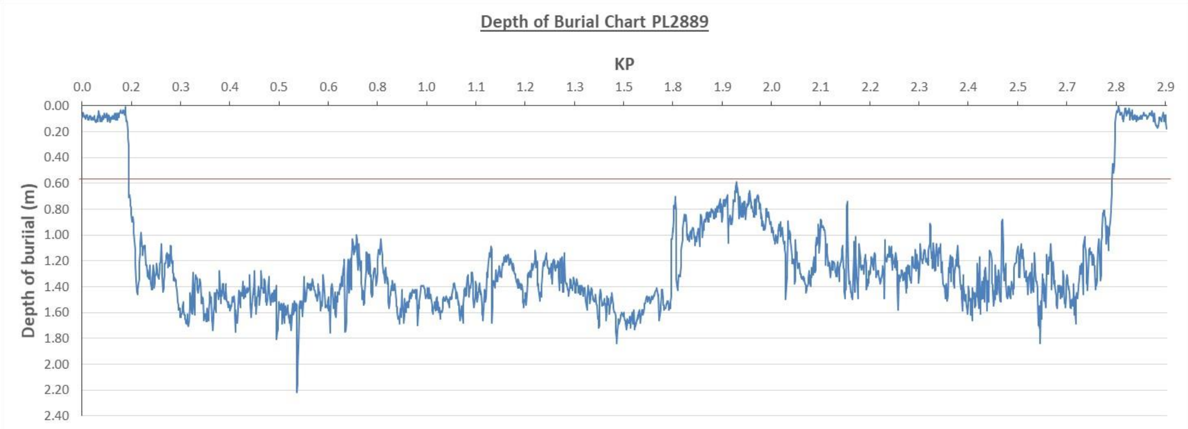
The 2018 inspection survey confirmed the production pipelines (PL2888 and PL2889) remain buried to a depth of at least 0.6m for the length where they were mechanically backfilled at installation (see Figures 3.2a and b, DeepOcean 2018) and remain covered where protective material has been used.

Figure 3.2a – Depth of burial of production line PL2888



Note: horizontal line is the BEIS (2018) minimum depth of burial (0.6m) KP = Kilometre Post

Figure 3.2b – Depth of burial of production line PL2889



Note: horizontal line is the BEIS (2018) minimum depth of burial (0.6m), KP = Kilometre Post

Exposed sections were identified from the 2018 survey (DeepOcean 2018) along the remaining lines (WI pipeline PL2890, umbilicals PLU2891, PLU2892 and PLU2893) which were installed in pre-cut trenches but not mechanically backfilled, but instead left open to backfill naturally. The term "exposed" from the survey is not used here to describe "a section of the pipeline which can be seen on the surface of the seabed", but instead sections of line which have not yet been covered through natural backfill (although not buried, these still meet the BEIS (2018) 0.6m criteria, as these are trenched to at least 0.6m below seabed level). The depth of lowering PL2890, PLU2891, PLU2892 and PLU2893 at installation are shown in Appendix B; this shows the lines are lowered to at least a minimum of 1m along the majority of their lengths (except, for example, at crossing and well/NCP approaches, these sections are covered by protective material); depth of lowering for the production pipelines PL2888 and PL2889 are not included here as these were mechanically backfilled at installation and depth of burial of these are shown in the figures above.

The 2018 survey completed an entire survey along the full lengths of all the lines (DeepOcean 2018).

Fishing effort in the area is low to moderate with demersal gear the predominant type used. There have been no reported fisheries interactions since the infrastructure was installed; the 2015 inspection survey of the production pipeline PL2888 did identify a lost fishing net to the west of the Causeway Tee/Valve skid location, but no incident was reported and this net was not recorded as an anomaly on the 2018 survey (DeepOcean 2018). Ithaca Energy develop risk based inspection and monitoring programmes for their assets 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.

Based on current guidance, the depth of burial/trenching maintained by the lines, and level of fishing effort, Ithaca Energy have identified all lines as being candidates for *in situ* decommissioning.

4 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 Energy 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 Energy initially identified a comprehensive list of potential decommissioning options for the Causeway-Fionn pipeline system 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 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 at the Causeway and Fionn wells and NCP is required; disconnection at NCP is also required for the future decommissioning of this installation by TAQA. Another option that was initially identified but not taken forward was the removal of the umbilical lines (PLU2891, PLU2892 and PLU2893) by cut and lift. Following discussions with the Causeway-Fionn pipeline technical authority, this option was discounted as there was confidence in the reverse reel method of recovery for the umbilicals, without the need for cut and lift.

The options taken forward for assessment are described below.

4.1 Options Taken Forward for Comparative Assessment

Elements common to all options

The following elements are common to all options:

- The cutting and removal of risers, tie-in spools and jumpers at well locations, subsea infrastructure (purge spool and valve skid) and tie-ins at the NCP and removal of the associated mattress/sand bag protection
- The removal of exposed mattresses and sand bags where feasible to do so (see below), removal of rock at P1 well location to access pipeline infrastructure
- The release of pipeline and umbilical contents to sea[2] (also applicable to options where the pipelines and umbilical are to be removed as ends will be cut at tie-in locations)

The following effects are, therefore, also common to all options. In all cases, moving and removing protective material and cutting tie-in spools/jumpers will result in an operational safety risk to personnel; the base case is not to use divers, with ROV/hydraulic equipment (grabs/cutters) being the preferred option, however, where this is not possible, divers may have to be used. While this area of

[2] Prior to any decommissioning or preparatory works being carried out, the pipelines will be cleaned and flushed, with the discharge from this scope of work either bullheaded down the well, or discharged via the NCP, with the pipelines left filled with inhibited seawater or potable water and residual (<30mg/l) reservoir hydrocarbons. At the time of cutting/disconnection, some of the inhibited water will discharge direct to sea, with the remainder staying within the pipeline due to hydrostatic pressure. The relevant environmental permits will be applied for at the time for this discharge.

the North Sea is not subject to vigorous currents, such as those in the southern North Sea, the divers would be working at depth (water depth across the area range from 148m to 160m).

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 umbilicals. Common to all options is the cuttings of pipeline/umbilical ends. This is applicable in full removal options, but also for *in-situ* decommissioning as disconnection is required for well and subsea infrastructure removal and also disconnection at NCP.

Where mattresses are suitably buried, (i.e. completely buried under rock) these will be decommissioned *in situ*; those at trench transition which are partially buried will be assessed at time of decommissioning and either decommissioned *in situ*, or recovered, this to be discussed with OPRED at time of decommissioning. Materials were installed in 2012 and inspection reports thus far have indicated no integrity issues with the mattresses. However, decommissioning activities may not commence until 2026/2027, by which time the mattresses will have been *in situ* for 15 years 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 Energy will look to identify options to reuse these, using licensed specialist contractors. If alternative, feasible options cannot be identified, the material will be disposed of to landfill; this worst case has been assumed for the purposes of assessment.

Historic cuttings are present at the NCP, however, the riser and J-tubes for the Causeway-Fionn system lie atop these and their disturbance is not anticipated at disconnection of the pipeline system from the NCP. There are historic cuttings piles at the well locations. Drill cuttings piles are not considered to be a significant consideration for the decommissioning of the Causeway and Fionn fields for the reasons provided below:

The definition of a cuttings pile used in the OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles is “an accumulation of cuttings on the sea bed which has been derived from more than one well”. The development of the Causeway fields involved one production well and one water injector well, the surface hole locations of which are separated by nearly 1.5km. There is a single well in the Fionn field at about 4km from the closest Causeway well.

The drilling of the Causeway and Fionn development wells was between 2006 and 2008 and thus, under PARCOM Decision 92/2 on the Use of Oil-Based Muds, the discharge of OBM cuttings was not permitted. OBM cuttings from the Causeway and Fionn development wells were retained on the rig and returned to shore for treatment and disposal. As a consequence, only water based mud cuttings were discharged to sea, and under OSPAR 2006/5 Stage 1 screening “Where water-based drilling fluids were used and no other discharges have contaminated the cuttings pile, no further investigation is necessary.” The surface hole sections (36", 26" and 17½" diameter) of these wells were drilled using water based muds and riserless with the cuttings discharged at the seabed. The total volumes of surface hole cuttings discharged from the Causeway and Fionn development wells (including sidetracks) were P1: 278m^3, W1:122m^3, and P2: 203m^3. There was no evidence from the pre-decommissioning survey results (Fugro 2020) of significant changes in sediment particle composition, total hydrocarbon content (THC), heavy and trace metals or macrofaunal at any of the stations sampled close to the Causeway and Fionn wells.

The evidence indicates that such drill cuttings accumulations as may be present immediately around the Causeway and Fionn wells are small and below the OSPAR Recommendation 2006/5 threshold for cuttings piles to be investigated further.

Diamond wire, hydraulic or oxy-acetylene cutting equipment will be used to cut tie-ins, and this will be common to all options. 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 and represent a minor increment to wider vessel traffic. This would be of relatively short duration, and at levels such that significant effects on noise sensitive species are unlikely.

The production/WI pipelines and umbilicals will have contained some chemicals used during production, the majority of which are in the OCNS group E (those considered to have the least potential environmental hazard). These lines will be cleaned and flushed and displaced with inhibited seawater/potable water (contents yet to be finalised) prior to decommissioning and removal. Some or all of this water will be lost to sea (including any residual hydrocarbon remaining in the production pipelines), when they are disconnected and/or cut. The water-based hydraulic fluid will remain in the umbilicals and some of this will also be lost to sea when they are disconnected and/or cut. Although tidal currents in the area are relatively weak, these chemicals and small quantities of residual oil are expected to rapidly disperse. Prior to the commencement of any offshore decommissioning work, the relevant environmental permits (e.g. MATs and associated SATs) will be applied for, including a chemical permit and an oil discharge permit for the residual hydrocarbons estimated to be discharged.

As the above effects are associated with elements common to all options, and must be undertaken as part of the decommissioning programme irrespective of the selected option, these will not be option distinguishers and they have not been further assessed as part of the individual option considerations. The potential effects of the common elements will be considered further as part of the Environmental Appraisal process for Causeway-Fionn.

Options considered for production (PL2888, PL2889) and water injection pipelines (PL2890)

Five options and one sub option were considered for these pipelines (Table 4.1).

Table 4.1 – Options and Sub-Options for the production and water injection pipelines

Complete removal
Option A: Complete removal by reverse reel, including sections under rock. Rock cover also removed.
Sub-Option A1: Complete removal by cut and lift, including sections under rock. Rock cover also removed.
Partial removal
Option B: Partial removal of by reverse reel - sections currently under rock, along with the rock cover, decommissioned *in situ*
Option C: Partial removal by cut and lift - sections currently under rock, along with the rock cover, decommissioned *in situ*
Leave *in situ*
Option D: Leave *in situ* of all sections, including sections under existing rock and the existing rock cover, cut ends lowered to below 0.6m with remedial mechanical backfill where required. **Option E**: Leave *in situ* of all sections, including sections under existing rock and the existing rock cover, cut ends covered with new rock cover.[1]

Notes: [1]Estimated new rock cover under this option would be a worst case total of 900 tonnes, across 6 different locations (150 tonnes at each location)

Options considered for service umbilicals (PLU2891, PLU2892 and PLU2893)

Four options were considered for the service umbilicals, the first two of which were applicable to PLU2891 and PLU2893 due to the presence of rock on these two umbilicals only; a sub-option was also considered for PLU2892 only due to the relatively short length of this line and the absence of rock protection (Table 4.2).

Table 4.2 – Options and Sub-Options for the umbilicals

Complete removal
Umbilical Option A: Complete removal by reverse reel, including sections under rock. Rock cover also removed.
Umbilical Sub-Option A1: Complete removal by reverse reel – applicable to PLU2892 only (no rock present on line)
Partial removal
Umbilical Option B: Partial removal by reverse reel, sections currently under rock and existing rock cover decommissioned *in situ*
Leave *in situ*
Umbilical Option C: Leave *in situ* of all sections, including sections under existing rock, and the existing rock cover. Cut ends lowered to below 0.6m with remedial mechanical backfill where required **Umbilical Option D**: Leave *in situ* of all sections, including sections under existing rock, and the existing rock cover. Cut ends covered with new rock cover[1].

Notes: [1]Estimated new rock cover under this option would be a worst case total of 900 tonnes across 6 different locations (150 tonnes at each location)

For those options where *in situ* decommissioning is proposed, some form of future monitoring may 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 (see Section 7.3).

While previously buried material can become exposed this is considered unlikely in the Causeway-Fionn area due to the weak currents and sediment type/mobility and has also been considered in the context of the extent the area is used by 3rd parties. Vessel Monitoring System (VMS) data shows levels of fishing effort in the area to be at low to moderate (moderate in 2019 compared to levels seen in 2018 and 2017) 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.

5 COMPARATIVE ASSESSMENT PROCESS

Ithaca Energy 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. The framework was further reviewed in light of updated regulator guidance (BEIS 2018), prior to undertaking the comparative assessment for the Anglia pipeline infrastructure and was considered suitable for that assessment. The framework remains robust and suitable for assessing the Causeway-Fionn 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 and umbilicals. Results are presented in Appendix C and are discussed in Section 6.

Ithaca Energy 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 Energy'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 Energy'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 C) 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 pipeline inspection reports, and other reference material including similar decommissioning documentation (i.e. pipeline comparative assessments and environmental appraisals) from projects in the wider North Sea.

Table 5.1 – Relative Risk and Impact Criteria and Scoring

		1	2	3	4	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	up to 10,000tCO_2 eq	10-15,000tCO_2 eq	15-30,000tCO_2 eq	30-50,000tCO_2 eq	>50,000tCO_2 eq
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 (criteria for pipelines only)	<£10m	£10-25m	£25-40m	£40-55m	>£55m
Economic	Total cost (criteria for umbilicals only)	<£5m	£5-6m	£6-7m	£7-8m	>£8m
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)	5	7.5	10
4 (High)	4	6	8
3 (Medium)	3	4.5	6
2 (Low)	2	3	4
1 (Very Low)	1	1.5	2

Options

Low **Medium** **High**

Best → **Worst**

5.2 Comparative Assessment Workshop

Ithaca Energy held an initial pre-workshop meeting with members of the Causeway-Fionn Decommissioning Team (the team) (see below), to:

- Review scoring criteria and methodology to ensure no modifications were required
- Agree the current status of all pipelines and umbilicals 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 Causeway-Fionn pipeline infrastructure. The workshop involved a multi-disciplinary team including:

- Malcolm Macleod (Senior Project Engineer – Ithaca Energy)
- Kevin Grant (Decommissioning Engineer – Ithaca Energy)
- Shaun Harnden (Pipeline Lead/Technical Authority – Ithaca Energy)
- Keith Stewart (Senior HSEQ Advisor – Ithaca Energy)
- Shaun Finch (Pipeline Technical Authority – Petrex)
- Steve Dempster (Pipeline Lead – Petrex)
- John Hartley (Director – Hartley Anderson)
- Suzanne Lumsden (Principal Consultant – 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. Information from the original development assessment and installation, (Valiant 2011 GEMS 2012a, b, c), along with pipeline inspection reports (iSurvey 2015, DeepOcean 2018), commissioned engineering reports (Petrex 2019), the pre-decommissioning surveys (Fugro 2020a, b) and a review of other comparative assessments for decommissioning projects in the wider North Sea, were used to inform the comparative 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 umbilicals is described in Section 6 below.

6 COMPARATIVE ASSESSMENT CONSIDERATIONS

The decommissioning options considered in the comparative assessment included complete removal (Option A, Sub-Option A1 and Umbilical Option A, Umbilical Sub-Option A1), partial removal (Option B and C and Umbilical Option B) and leave *in situ* (Option D and E and Umbilical Option C and D) (see Section 4, Tables 4.1 and 4.2). The criteria and sub-criteria considerations, and how the options have scored under these, are outlined below.

6.1 Safety

Safety risks are of high importance in the consideration of the decommissioning options, particularly where experience in some operations is relatively limited to date and where the work could involve high levels of activity with multiple vessels on location for long durations. Operations which take long periods of time may also be subject to extension through weather (see Appendix C).

The highest cumulative number of days is predicted for the complete removal options (Sub-Option A1 = 530 days, Option A/Umbilical Option A = 375 days (286 for production/WI pipelines and 89 for umbilicals), Option B/Umbilical Option B = 265 days (202 for production/WI pipelines and 63 for umbilicals). Some activities are likely to take place in parallel, shortening overall durations. The shortest durations are for the leave *in situ* options at between 119 and 168 days (these represent combined days for the pipeline/WI lines and umbilicals work scope for these options).

There is the ability to influence the safety risk associated with the operations for each option, including through the adherence to Ithaca Energy's Operational Excellence Management System and Operational Excellence Policy which must demonstrate that risks have been reduced to As Low As is Reasonably Practicable (ALARP), and through standard risk reduction procedures including (but not limited to) contractor selection and audit, and training. Additionally, risks are also posed to third parties during offshore works both in the short-term (through physical presence) and longer-term depending on the degree of removal and remediation proposed (see Appendix C).

Divers have only been proposed for the complete (Option A, and Sub-Option A1, Umbilical Option A and Umbilical Sub-Option A1) and partial (Option B and Umbilical Option B) removal options, as these options require a higher level of intervention and, therefore, generate additional risk; the exception being Umbilical Sub-Option A, for umbilical PLU2892, where no divers are proposed. Divers have not been proposed for the leave *in situ* options, therefore, higher diving activities and associated diver saturation days and vessel times are eliminated from these options. In addition to the consideration of risk relative to the duration of activities, all offshore activities would be subject to Ithaca Energy's operational risk assessment procedure, applicable to all activities, including decommissioning activities Ithaca Energy undertake.

The highest risk to offshore personnel is associated with the full and partial removal options, which will require the excavation/deburial of the production pipelines, WI line and umbilicals where either natural burial or backfill has occurred, the removal and disposal of the lines (and in the options (Option A, Sub-Option A1 and Umbilical Option A) where rock is also removed, the removal and disposal of the rock) and the reinstatement of the trenches. While this is routine construction work, relative to the *in situ* options, there is a higher risk to personnel offshore.

The risk to onshore personnel is relative to the quantity of material to be returned to shore for processing, which results in the complete removal options having the highest (i.e. worst) safety scores under this criteria. For the leave *in situ* options where any cut end section is not below 0.6m and these are remediated through either lowering or burial under mechanically backfilled natural sediment or rock (i.e. Options D, E and Umbilical Options C and D) the equivalent removals of material will be made, (i.e. spools/jumpers) and there is no difference in the onshore safety scores for these options.

Safety risks to 3rd parties during decommissioning decline with reduced time in the field (e.g. due to less potential interaction with other users). There will be some exclusion from the area of works for other users including fisheries and shipping during decommissioning activities, however this will be temporary.

Risks from vessel presence can be mitigated through the use of Notices to Mariners and appropriate vessel markings and lighting. Any works within existing fisheries exclusion zones (i.e. around wells, the tie-in valve skid and the NCP platform) will already be subject to exclusion from other users, and all disconnection works would take place within these zones.

The residual risk to 3rd parties is contingent on a number of factors, the primary one being the potential hazard to fishermen or other users of the marine environment, of material remaining on, or in the seabed, if this is not adequately buried or trenched. Risk is also proportional to the level (effort) and type of fishing carried out in the area; the Causeway-Fionn area experiences low to moderate fishing effort and effort is focused on demersal species, using demersal trawls. Risk to 3rd parties is eliminated under the complete and partial removal options; although the partial removal options leaves *in situ* pipeline/umbilical sections under rock, fishing has not been excluded from these areas for the duration of field life (*ca*. 8 years at time of comparative assessment submission), with no fishing interaction reported and the profile of rock berms are such that they are over trawlable, For those options where the lines will be decommissioned *in situ*, there remains a potential risk to fisheries in the long-term, if sections become exposed or do not remain adequately buried or trenched (see Appendix B), as those which are buried by sediments and rock cover, would not interact with other users, and their degradation rates are significantly less than those of surface laid pipelines (OGUK 2013).

Generally, carbon steel pipelines degrade at very low rates once cathodic protection has expired, at between 0.05-0.1mm/year when exposed directly to seawater or 0.01-0.02mm/year when buried (OGUK 2013), such that corrosion and collapse of the Causeway-Fionn pipelines would likely take centuries.

The 2018 pipeline inspection survey did not identify any freespans on any of the Causeway-Fionn lines. There have been no fishing related incidents associated with the Causeway-Fionn pipeline system and, with the exception of the safety zones around the three well locations and the valve skid at the Fionn export line tie-in, the area has been fished since the system was installed.

6.2 Environment

Seabed disturbance will be generated by any of the decommissioning options, the level of which is proportionate to the level of intervention, such that complete and partial removal achieve the highest scores (representing the worst case in this criteria). The interventions required to expose relevant pipeline and umbilical sections under each of the these options to facilitate removal would involve mass flow excavation to remove/move rock cover to expose pipelines/umbilicals, or excavation to uncover those pipelines which are buried beneath seabed sediments. The footprint of disturbance under all of the complete/partial removal options (Option A, and Sub-Option A1, Umbilical Option A and Umbilical Sub-Option A1, Option B and Umbilical Option B) will be greater than the existing footprint of the pipeline or umbilical and therefore are likely to represent the greatest source of impact. Displacing/removing the rock cover, seabed sediment and protective mattresses/sand bags will result in sediment re-suspension and disturbance, and disturbance to biological communities.

For Umbilical Sub-Option A1, the complete removal of PLU2892 only, the seabed disturbance for this option is not comparable to the complete removal options for the other umbilicals; this line is only ~1.5km length, it is trenched, with only natural backfill accumulated since installation and it has no rock associated with it. Reverse reel of this line, with little intervention, is estimated to result in minimal disturbance.

Options where it is proposed to leave *in situ* (Options D and E and Umbilical Options C and D) have the lowest level of seabed disturbance, due to more localised seabed interaction at pipeline/umbilical ends and sections where 0.6m burial needs to be achieved, e.g. flexible spools, and jumpers and transitions (the majority of the lines being adequately trenched and buried, or trenched) (see Section 3, Figures 3.2a and b, and Appendix B). Under these options, i.e. where mass flow excavation techniques and pipeline excavation would not take place, the footprint of effect is reduced. Where there are cut end sections on the seabed that require remediation (i.e. lowering, mechanical backfilling, or rock cover), then these will be very localised and small in area, with the result, these options scored the same for seabed disturbance (<10% of existing footprint). Some seabed disturbance will still occur at the removal point of the mattress protection and cutting and removal of spool pieces and jumpers for all options.

Emissions of carbon dioxide (CO_2) and total energy consumption (Gj) for each of the options (see Appendix C) reflect the number of vessels involved and duration in the field and the level of material recovered and recycled. In both cases, the greatest number of vessel days and the largest of quantities of material which would be recovered are associated with the full and partial removal options; energy consumption for replacing the material for those options to leave *in situ* (as these materials do not reach the recycling supply chain) was also taken into consideration but still scored lower than complete/partial removal options overall. Materials which could be recovered during the decommissioning process are dominated by steel with smaller quantities of aluminium from anodes, and copper and polypropylene from umbilicals.

None of the Causeway-Fionn infrastructure lies within a Natura 2000 site (i.e. Special Areas of Conservation (SAC) or Special Protection Areas (SPAs)), these sites designated under *The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended)* and *The Conservation of Habitats and Species Regulations 2017 (as amended)*. The closest of these is the Pobie Bank Reef SAC (86km away) although the qualifying interests of certain sites (e.g. seals and seabirds) may be present across the Causeway-Fionn area, at some distance from site boundaries. The Causeway-Fionn area is also far from the closest Nature Conservation Marine Protected Areas (NCMPAs) these designated under the *Marine (Scotland) Act 2010 (as amended)* in Scottish territorial waters and by the *Marine and Coastal Access Act 2009 (as amended)* in offshore waters. The closest site being the North-East Faroe-Shetland Channel, 108km to the north.

Additionally, protected species may also be present and include all cetaceans (e.g. harbour porpoise). No explosive cutting or other high energy noise producing activities are proposed to be undertaken as part of the pipeline/umbilical decommissioning options. Noise from vessel activity associated with the decommissioning activities has the potential to contribute to existing noise levels in the area, and longer campaigns (i.e. complete and partial removal) results in longer vessel time and related noise. Though this is not expected to be a source of likely significant effect for protected marine species (e.g. all cetaceans), this will be considered as part of the environmental appraisal process.

The pre-decommissioning survey (Fugro 2020a, b) is consistent in reporting no indication of sensitive species or habitats which would be subject to protection under the EU Habitats Directive (92/43/EEC) i.e. Annex I habitats (GEMS 2012a, b, c). The 2020 survey did observe the presence of sea pens (*Pennatula phosphorea* and *Virgularia* sp), mounds and burrows in varying densities across the survey stations. As such, burrows, and to a lesser extent mounds, met the descriptive criterion for the OSPAR listed ‘sea pen and burrowing megafauna communities’ habitat, therefore, the OSPAR listed ‘sea pen and burrowing megafauna communities’ habitat may be present (Fugro 2020a, b). Taking into consideration the sediment type and surface features present in the area, it could also be considered that the habitat is not present. However, a precautionary approach was adopted and a higher scoring for conservation sites and species was applied to the complete/partial removal given the level of intervention and seabed disturbance associated with these. The exception to this is the Umbilical Sub-Option A1, with the complete removal of PLU2892; this trenched line will be removed by reverse reel, with minimum seabed disturbance.

Any implications for protected sites and species from the selected options will be considered as part of the environmental assessment process.

6.3 Technical Feasibility

Technical risks are higher for the full/partial removal options than for those which propose to leave pipelines and umbilicals *in situ*. The removal options are generally considered of moderate complexity, involving techniques considered standard offshore operations such as the displacement of rock cover, removal of mattress protection, deburial and removal of the lines. However, the proposed scale of some of these operations such as for the removal of the production and WI pipelines makes their overall success of greater risk than standard procedure.

Similarly, whilst the removal of umbilicals by reverse reeling is feasible, uncertainties exist which could compromise the removal operation. These considerations are reflected in the uncertainty and risk scoring for this criteria (see Appendix C), for which those options using the above activities over more limited extents (i.e. the options to leave *in situ*) achieve lower scores.

6.4 Weather Sensitivity

Removal options tend to be more weather sensitive than the leave *in situ* options given the increased complexity of the operations and in general longer vessel times in the field and the leave *in situ* options having relatively shorter durations and therefore are less affected by weather. Remedial work associated with the leave *in situ* options (i.e. mechanical backfill with natural sediment or rock cover) are considered routine activities, relatively unaffected by weather.

6.5 Society

Societal effects associated with the decommissioning options reflect the potential for residual effects on fishing, navigation or other access associated with what remains on the seabed following decommissioning, as well as potential effects on coastal communities. The residual effects refer to the long-term implications of the options considered, although there will be some temporary societal effects relating to loss of access, particularly for fisheries. The scale of this impact is relative to the duration and scale of the activity and therefore interference would be greatest for the complete/partial removal options, and least for those options where the infrastructure is decommissioned *in situ*.

The Causeway-Fionn area is of relatively low to moderate use and importance to commercial fisheries, and the potential disruption of fishing activity would be restricted to temporary spatial interaction with vessels operating and in transit. This will represent a short-term increment to existing vessel presence in the area associated with field operations and wider commercial shipping. Following decommissioning, those areas of seabed subject to existing exclusion zones (e.g. around the wells and the valve skid) would be removed and open to fisheries under all of the options considered here. It is not regarded that any chosen option will lead to the long-term exclusion of other user activities including fishing, shipping, tourism and recreation and potential future use for marine renewable energy or carbon capture and storage (CCS).

With respect to coastal communities, a range of effects could be generated from the return to shore of component parts of the pipelines and umbilicals, with the greatest quantity of such materials recovered and retuned to shore associated with the complete/partial removal options. These effects could include visual intrusion (e.g. from the transit of vessels to shore), and noise, dust, fumes and odour associated with onshore material processing (though note that only licenced yards would be used). The level of work to be undertaken onshore, and related employment continuity assuming the use of established yards, will in part depend on the selected decommissioning option, e.g. substantially fewer materials will be returned to shore should the pipelines and umbilicals be decommissioned *in situ*.

6.6 Economic

Economic risks are primarily associated with the estimated cost of each decommissioning option and these are closely linked with the number of vessel days required to complete operations; complete and partial removal options (ranging from an estimated £10 to £82 million), are significantly more expensive than the other options (ranging from £5 to £8.5 million), although it should be noted that these are highly driven by market conditions at the time of vessel contracting.

With respect to the residual liability associated with the decommissioning options in terms of future monitoring and remediation, the least favoured option is to decommission the Causeway-Fionn pipeline system *in situ*. However, while these options leave pipeline and umbilical material in the field, if adequate burial or trenching is not evident (to at least 0.6m depth), remedial work will be undertaken where required, to achieve the required coverage (either back mechanical backfilling with natural sediment or from additional rock placement).

For the complete/partial removal options, there would either be nothing left on the seabed, or sections under existing rock would remain with all other sections removed. For these options, no residual liability is foreseen given appropriate remediation as part of the decommissioning operations.

7 SUMMARY AND RECOMMENDED OPTIONS FOR CAUSEWAY AND FIONN PIPELINES AND UMBILICALS DECOMMISSIONING

7.1 Summary

The cutting of spool pieces/jumpers, and riser connections and the removal of exposed protective material (mattresses and sand bags) where safe to do so, is common to all the decommissioning options considered and will, therefore, be carried out. In all cases, this will result in seabed disturbance where there is intervention, and discharge of pipeline/umbilical contents at disconnect; relevant applications will be made to OPRED (e.g. chemical permits) prior to activities being carried out.

Highest (worst) scoring options

The complete and partial removal options scored the highest across all categories with the exception of residual risk and residual liability. The complete and partial removal options represented the highest safety risk to personnel off- and onshore (i.e. related to quantity of material being handled off- and onshore). The environmental scores for these options were high as full/partial removal would generate an area of seabed disturbance greater than that occupied by the pipeline and umbilicals, and at least as great as that which would have been associated with installation, particularly the full removal option which also included the removal of those sections of lines currently protected with rock (the exception to this is the removal of umbilical PLU2892 – see below and also Section 6).

There would also be greater volumes of CO_2 emissions from longer vessel times in the field. Though complete/partial removal provides substantial returns to shore of recyclable material which could offset future emissions by displacing primary materials from the supply chain, this was largely counteracted by emissions from vessels involved in removal.

The costs of complete and partial removal options were significantly greater than options to leave *in situ*, including the options (e.g. pipeline Option E) where rock is proposed for remediation if any cut section not buried or trenched to 0.6m.

Lowest (best) scoring options

Overall, the lowest total scores were achieved for the options to decommission the production, water injection and service umbilicals *in situ*, with remediation, where required, to ensure adequate burial/trenching (to minimum 0.6m) of the cut ends, noting that the pipelines and umbilicals are all presently buried and/or trenched to a depth greater than 0.6m.

The low values were achieved by a combination of safety (divers not used), risk to personnel off and onshore (e.g. related to quantity of material being handled), limited interaction with the seabed, lower technical risk and costs.

While there was a higher score assigned to these options for residual effects on fishing/other users and residual liability, the production pipelines decommissioned *in situ*, are buried-and the WI pipeline and umbilicals are trenched to a depth of at least 0.6m. Leaving the pipeline system *in situ*, will lead to a requirement, at least for a period of time, of future surveys of these and those liabilities associated with keeping the infrastructure *in situ* will be appropriately addressed.

7.2 Recommended Proposed Options

A summary of the preferred options and the rationale for these is shown in Table 7.1 below.

Table 7.1 – Options proposed

Infrastructure	Preferred Option[1]	Rationale for selection
PL2888 (15.5km, 8" production pipeline) PL2889 (2.8km, 8" production pipeline) PL2890 (14.9km 8" water injection pipeline)	**Option D**: Leave *in situ* of all sections, including sections under existing rock and the existing rock cover, cut end lowered to below 0.6m with remedial mechanical backfill where required.	Leaving the infrastructure *in situ* clearly indicates significantly lower risks in terms of: • Safety of personnel • Seabed disturbance (taking into consideration new rock use) • Greenhouse gas emissions • Technical feasibility • Cost Although residual risk and residual liability for these options are higher, these are reduced further by the lines being covered (PL2888 and PL2889) or trenched (PL2890) to at least 0.6m for the majority of their lengths, with those sections not buried or trenched either covered in existing rock (approaches to crossings) or removed (i.e. spool pieces, jumpers), with cut ends lowered and mechanically backfilled, along with the level of fishing effort in the area and that fishing has occurred throughout the area, without incident for the life of the development.
PL2888 (15.5km, 8" production pipeline) PL2889 (2.8km, 8" production pipeline) PL2890 (14.9km 8" water injection pipeline)	**Option E** Leave *in situ* of all sections, including sections under existing rock and the existing rock cover, cut ends covered with new rock cover.	Leaving the infrastructure *in situ* clearly indicates significantly lower risks in terms of: • Safety of personnel • Seabed disturbance (taking into consideration new rock use) • Greenhouse gas emissions • Technical feasibility • Cost Although residual risk and residual liability for these options are higher, these are reduced further by the lines being covered (PL2888 and PL2889) or trenched (PL2890) to at least 0.6m for the majority of their lengths, with those sections not buried or trenched either covered in existing rock (approaches to crossings) or removed (i.e. spool pieces, jumpers), with cut ends lowered and mechanically backfilled, along with the level of fishing effort in the area and that fishing has occurred throughout the area, without incident for the life of the development.
PLU2891 (16.2km umbilical) PLU2893 (12.2km umbilical)	**Umbilical Option C** Leave *in situ* of all sections, including sections under existing rock, and the existing rock cover. Cut ends lowered to below 0.6m with remedial mechanical backfilled where required	Leaving the infrastructure *in situ* clearly indicates significantly lower risks in terms of: • Safety of personnel • Seabed disturbance • Greenhouse gas emissions • Technical feasibility

Infrastructure	Preferred Option[1]	Rationale for selection
		• Cost Although residual risk and residual liability for these are higher, these are reduced further by the lines being trenched to at least 0.6m for the majority of their lengths, with those sections not buried or trenched either covered in existing rock (approaches to crossings) or removed (i.e. spool pieces, jumpers), with cut ends lowered and mechanically backfilled, along with the level of fishing effort in the area and that fishing has occurred throughout the area, without incident for the life of the development.
PLU2892 (1.7km umbilical)	**Umbilical Sub-Option A1**: Complete removal by reverse reel – applicable to PLU2892 only (no rock present on line)	Short line (~1.5km), trenched at installation, not mechanically backfilled, no rock protection applied. Complete removal by reverse reel results in a higher risk to personnel off and onshore due to vessel time and quantity of material being handled, however, low technical feasibility score (routine activity, high confidence), seabed disturbance anticipated to be low/moderate (no or very little deburial expected). Low cost, removal of residual risk to fishing/other users and lower residual liability make this the preferred option.

Notes: [1]Two options (Options D and E) resulted in equivalent scores for PL2888, PL2889 and PL2890 and these have been included as separate line entries.

7.3 Legacy and Liability Management

A post decommissioning survey will be carried out. The approach for Causeway-Fionn will be to carry out the survey following a similar in scope to a pipeline inspection survey, using non-intrusive methods (e.g. ROV, drop-down camera) to identify any significant material remaining on the seabed that could be deemed a snagging hazard. There will be no intervention along the majority of the lines, including at those sections already covered in rock (with intervention only at line ends), therefore the rock will remain overtrawlable.

The post decommissioning survey will include not only the pipeline/umbilical routes, but also the areas covered by the existing 500m safety zones around the Causeway and Fionn wells, the valve skid and the approaches to the NCP; Ithaca Energy will continue to liaise with TAQA on the extent and scope of planned Ithaca Energy surveys within the NCP 500m safety zone.

In terms of future surveys, a risk based programme of monitoring, commensurate with the material decommissioned *in situ*, taking into consideration that no freespans are present, or have previously developed along the infrastructure, the lines are adequately buried or trenched to at least 0.6m and where this has not been the case, (i.e. at cut ends) remediation has been carried out, and the fishing effort in the area is low to moderate. The monitoring programme will be developed in discussion with the regulator and liaison with the relevant fishing bodies.

8 CONCLUSIONS AND KEY POINTS

The Causeway-Fionn Decommissioning Team identified all available decommissioning options for the Causeway-Fionn pipeline system and these were considered against a set of criteria and scoring system developed to allow their inter-comparison. The assessment was undertaken by a team with a good knowledge and experience of the development, including its current status and the environment within which it is located.

The overarching conclusion of the comparative assessment process is that complete (Option A, and Sub-Option A1, Umbilical Option A and Umbilical Sub-Option A1) or partial removal options (Option B and C and Umbilical Option B) have the highest (i.e. worst) scores for the production pipelines (PL2888 and PL2889) water injection pipeline (PL2890) and the service umbilicals (PLU2891 and PLU2893) and are therefore the least preferable options for these lines.

Given its length (*ca*. 1.5km), that it has no rock cover associated with it and reverse reel should require minimum intervention (i.e. not full deburial), complete removal of PLU2892 (Umbilical Sub-Option A1) is the most preferable for that line.

The preferred options for the production pipelines (PL2888 and PL2889) and water injection pipeline (PL2890) as concluded by the comparative assessment are *in situ* decommissioning Options D and E and the preferred option for PLU2891 and PLU2893 is the *in-situ* decommissioning Umbilical Option C.

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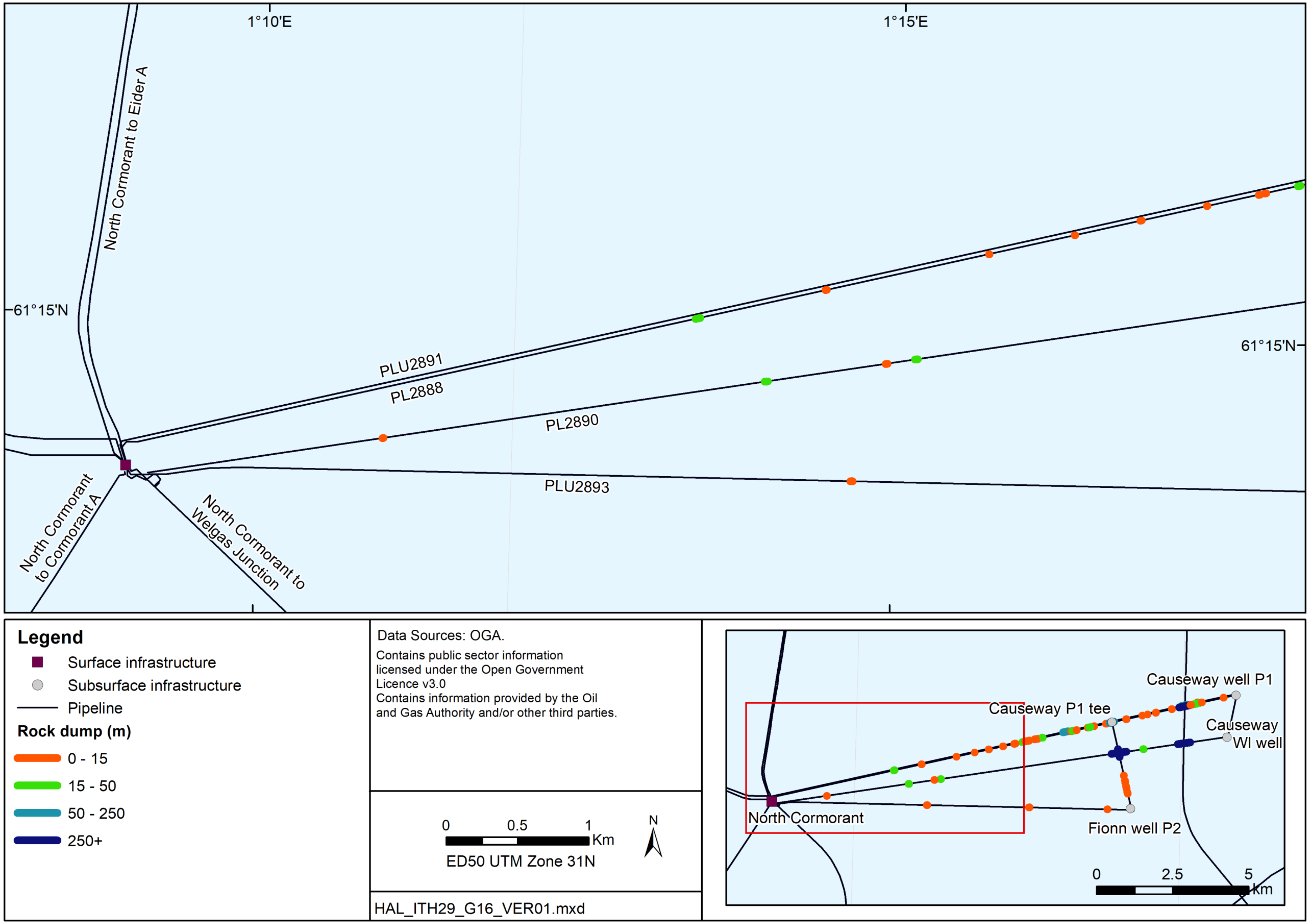
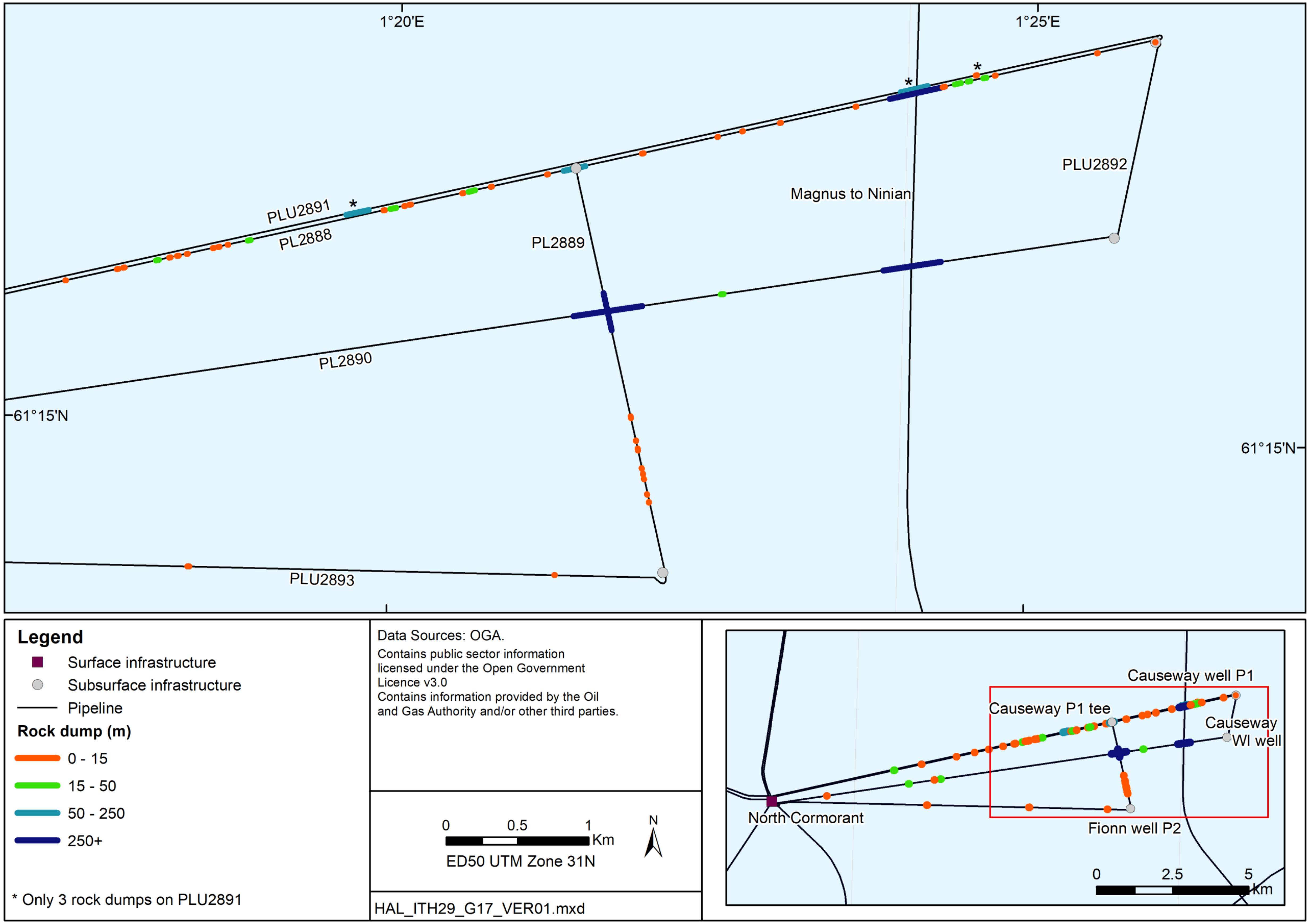
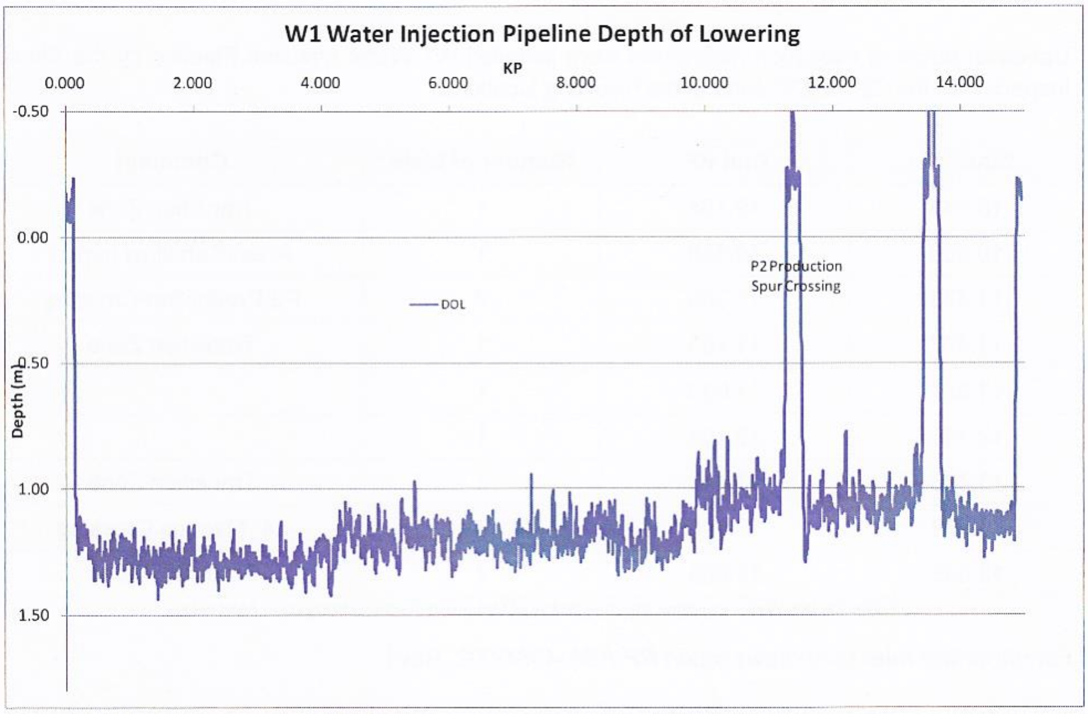
APPENDIX A – CAUSEWAY-FIONN PIPELINE AND UMBILICAL ROCK PROTECTION LOCATIONS




1°20'E
1°25'E
61°15'N
61°15'N
PLU2891
PL2888
PL2889
PL2890
PLU2892
PLU2893
Magnus to Ninian
*
Legend
Surface infrastructure
Subsurface infrastructure
Pipeline
Rock dump (m)
0 - 15
15 - 50
50 - 250
250+
* Only 3 rock dumps on PLU2891
Data Sources: OGA.
Contains public sector information licensed under the Open Government Licence v3.0
Contains information provided by the Oil and Gas Authority and/or other third parties.
0
0.5
1
Km
N
ED50 UTM Zone 31N
HAL_ITH29_G17_VER01.mxd
Causeway well P1
Causeway P1 tee
Causeway WI well
North Cormorant
Fionn well P2
0
2.5
5
Km

APPENDIX B – DEPTH OF LOWERING FOR PL2890, PLU2891, PLU2892 AND PLU2893

Figure B1 – WI pipeline PL2890 Depth of Lowering (DOL)



Note: KP = Kilometre Post

Figure B2 – Umbilical PLU2891 Depth of Lowering (DOL)

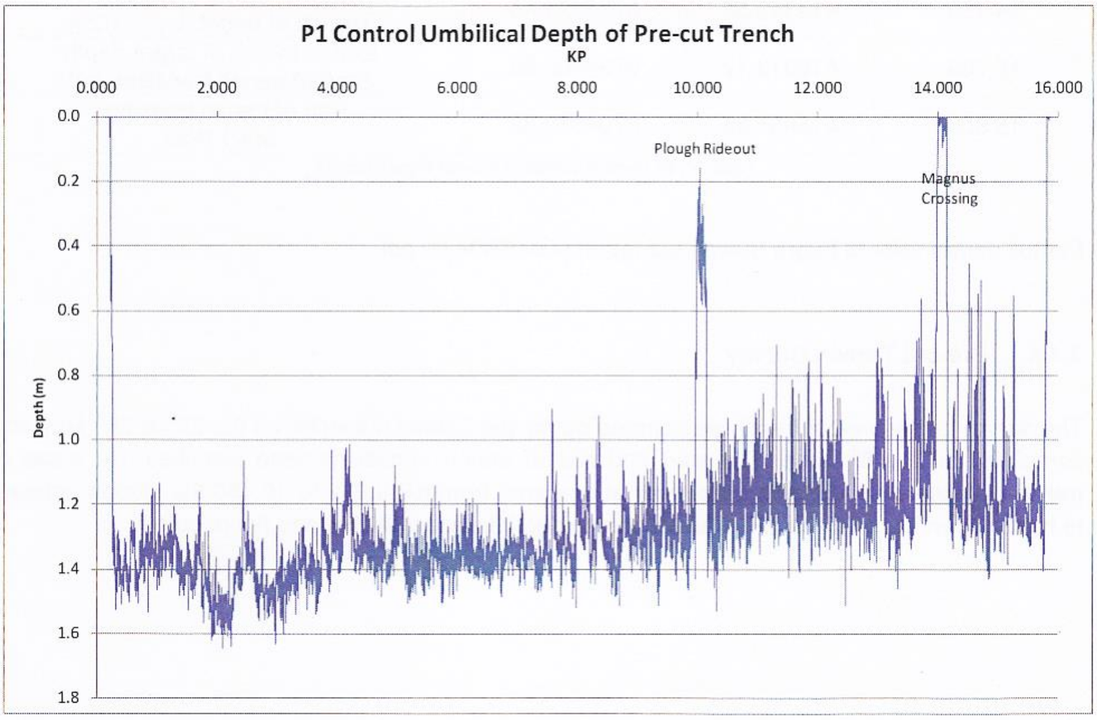


Figure B3 – Umbilical PLU2892 Depth of Lowering (DOL)

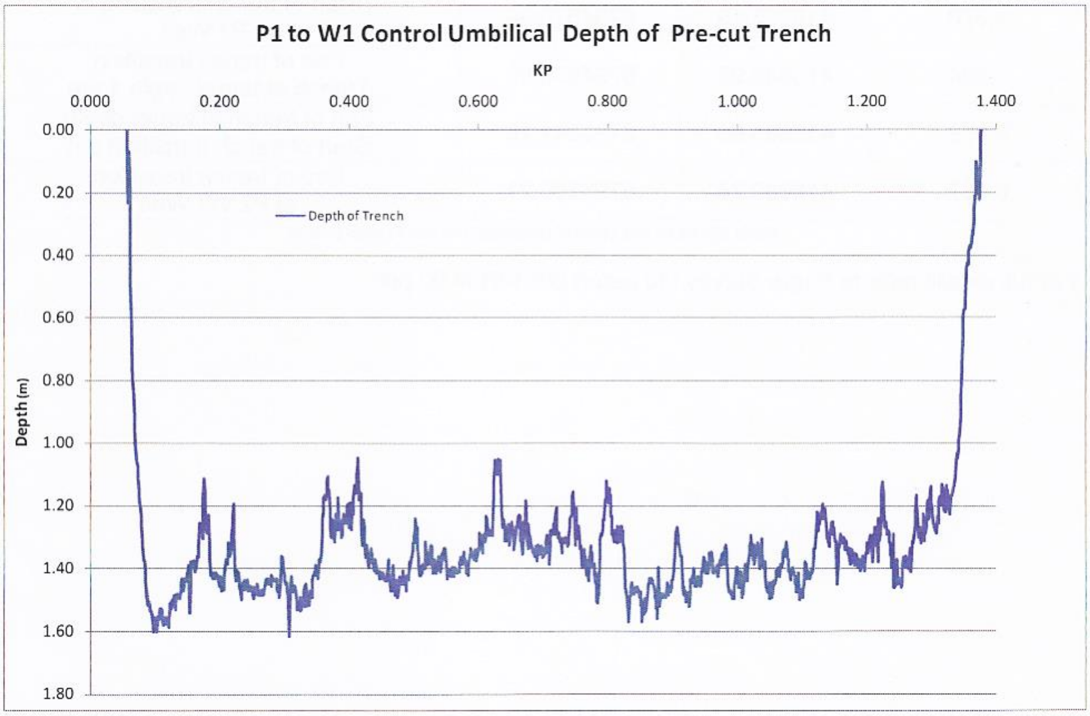
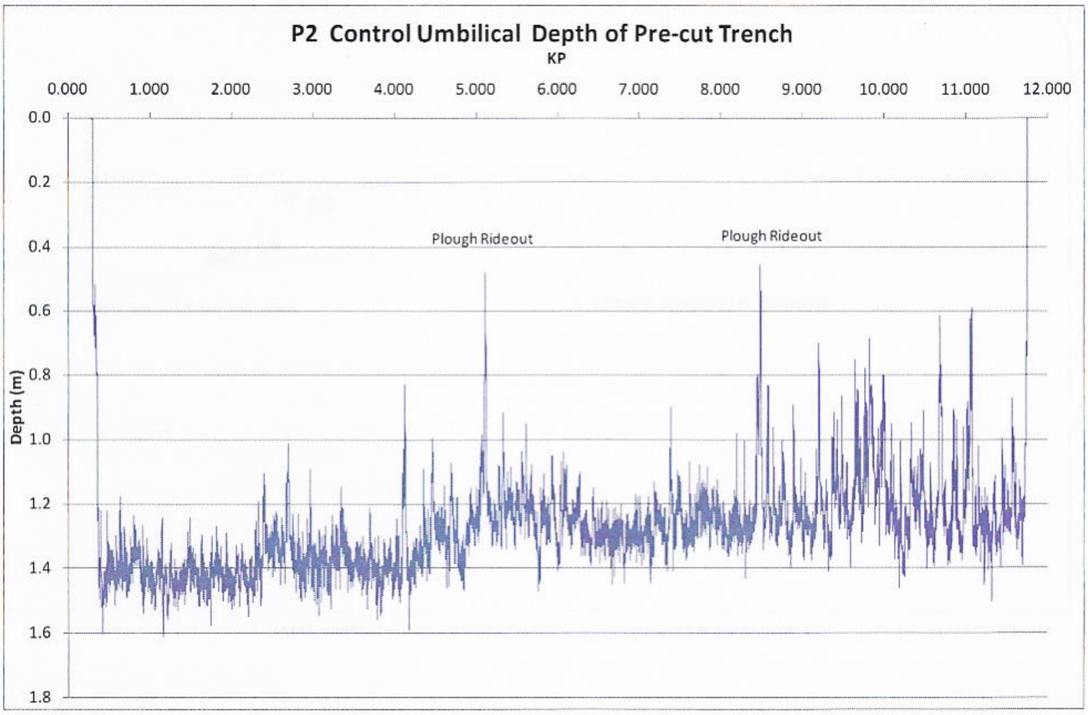


Figure B4 – Umbilical PLU2893 Depth of Lowering (DOL)



APPENDIX C – PIPELINES AND UMBILICALS COMPARATIVE ASSESSMENT SCORED OPTIONS MATRIX

		Option A - PL2888, PL2889 and PL2890 Complete recovery by reverse reel, including sections under rock. Rock cover also removed			Option B - PL2888, PL2889 and PL2890 Partial recovery by reverse reel, sections currently under rock, along with rock cover, decommissioned *in situ*			Option C - PL2888, PL2889 and PL2890 Partial recovery by cut and lift, sections currently under rock, along with rock cover, decommissioned *in situ*			Option D - PL2888, PL2889 and PL2890 Leave in situ, all sections, including sections under existing rock cover, cut ends lowered to below 0.6m with remedial mechanical backfill where required			Option E - PL2888, PL2889 and PL2890 Leave in situ of all sections, including sections under existing rock and the existing rock cover, cut ends covered with new rock cover		
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	2	1	2	2	1	2
Safety	Risk to divers during decommissioning operations	4	1	4	5	1	5	1	1.5	1.5	1	1	1	1	1	1
Safety	Risk to 3rd parties and assets during decommissioning operations	3	1	3	3	1	3	3	1	3	3	1	3	3	1	3
Safety	Residual risk to 3rd parties	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
			Total Average	22 4.4		Total Average	23 4.6		Total Average	17.5 3.5		Total Average	10 2.0		Total Average	10 2.0
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	7.5	5	1.5	7.5	5	1.5	7.5	2	1.5	3	2	1.5	3
Environment	CO_2 emissions (tCO_2 eq.)	2	1	2	2	1	2	3	1	3	1	1	1	1	1	1
Environment	Total energy consumption	3	1	3	3	1	3	4	1	4	2	1	2	2	1	2
Environment	Proportion of material reused/recycled	1	1	1	2	1	2	2	1	2	1	1	1	1	1	1
Environment	Proportion of material landfilled	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2
Environment	Conservation sites and species (including noise effects)	3	1	3	3	1	3	3	1	3	2	1	2	2	1	2
			Total Average	23.5 2.9		Total Average	24.5 3.1		Total Average	26.5 3.3		Total Average	16 2.0		Total Average	16 2.0
Technical	Technical feasibility	4	2	8	5	2	10	3	1.5	4.5	2	1	2	2	1	2
Technical	Weather sensitivity	5	2	10	5	2	10	5	2	10	3	1.5	4.5	3	1.5	4.5
			Total Average	18 9.0		Total Average	20 10.0		Total Average	14.5 7.3		Total Average	6.5 3.3		Total Average	6.5 3.3
Societal	Residual effect on fishing, navigation or other access (including cumulative)	1	1	1	2	1	2	2	1	2	3	1	3	3	1	3
Societal	Coastal communities	2	1	2	2	1	2	2	1	2	1	1	1	1	1	1
			Total Average	3 1.5		Total Average	4 2.0		Total Average	4 2.0		Total Average	4 2.0		Total Average	4 2.0
Economic	Total cost	4	2	8	4	2	8	5	2	10	1	2	2	1	2	2
Economic	Residual liability including monitoring and remediation if necessary	1	1	1	2	1	2	2	1	2	2	1	2	2	1	2
			Total Average	9 4.5		Total Average	10 5.0		Total Average	12 6.0		Total Average	4 2.0		Total Average	4 2.0
				22.3 4.5			29.7 5.9			22.1 4.4			11.3 2.3			11.3 2.3

Criteria	Sub criteria	Option A1 - PL2888, PL2889 & PL2890 Complete removal by cut and lift, including sections under rock, rock cover also removed		
		Risk/ Impact	Relative Uncertainty	Weighted Score
Safety	Risk to personnel offshore during decommissioning operations	4	1.5	6
Safety	Risk to personnel onshore during decommissioning operations	4	1.5	6
Safety	Risk to divers during decommissioning operations	1	1.5	1.5
Safety	Risk to 3rd parties and assets during decommissioning operations	3	1	3
Safety	Residual risk to 3rd parties	1	1	1
			Total	17.5
			Average	3.5
Environment	Chemical discharge	3	1	3
Environment	Hydrocarbon release from pipelines	2	1	2
Environment	Seabed disturbance and/or habitat alteration including cumulative impact	5	1.5	7.5
Environment	CO_2 emissions (tCO_2 eq.)	3	1	3
Environment	Total energy consumption	4	1	4
Environment	Proportion of material reused/recycled	1	1	1
Environment	Proportion of material landfilled	2	1	2
Environment	Conservation sites and species (including noise effects)	3	1	3
			Total	25.5
			Average	3.2
Technical	Technical feasibility	3	1.5	4.5
Technical	Weather sensitivity	5	2	10
			Total	14.5
			Average	7.3
Societal	Residual effect on fishing, navigation or other access (including cumulative)	1	1	1
Societal	Coastal communities	2	1	2
			Total	3
			Average	1.5
Economic	Total cost	5	2	10
Economic	Residual liability including monitoring and remediation if necessary	1	1	1
			Total	11
			Average	5.5
				20.9
				4.2

Criteria	Sub criteria	**Umbilical Option A - PLU2891 and PLU2893** Complete removal by reverse reel, including sections under rock, rock cover also removed			**Umbilical Option B - PLU2891 and PLU2893** Partial removal by reverse reel, sections currently under rock and existing rock cover decommissioned *in situ*			**Umbilical Option C - PLU2891, PLU2893 and PLU2892** Leave in situ of all sections, including sections under existing rock and the existing rock cover. Cut ends lowered to below 0.6m with remedial mechanical backfill where required			**Umbilical Option D - PLU2891, PLU2893 and PLU2892** Leave in situ of all sections, including sections under existing rock, and the existing rock cover. Cut ends covered with new rock cover		
		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	3	1.5	4.5	3	1	3	3	1	3
Safety	Risk to personnel onshore during decommissioning operations	4	1.5	6	4	1.5	6	2	1	2	2	1	2
Safety	Risk to divers during decommissioning operations	1	1.5	1.5	4	1.5	6	1	1	1	1	1	1
Safety	Risk to 3rd parties and assets during decommissioning operations	3	1	3	3	1	3	3	1	3	3	1	3
Safety	Residual risk to 3rd parties	1	1	1	1	1	1	1	1	1	1	1	1
			Total Average	16 3.2		Total Average	20.5 4.1		Total Average	10 2.0		Total Average	10 2.0
Environment	Chemical discharge	3	1	3	3	1	3	3	1	3	3	1	3
Environment	Hydrocarbon release from pipelines	1	1	1	1	1	1	1	1	1	1	1	1
Environment	Seabed disturbance and/or habitat alteration including cumulative impact	5	1.5	7.5	5	1.5	7.5	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	2	1	2	2	1	2	2	1	2	2	1	2
Environment	Proportion of material reused/recycled	1	1	1	2	1	2	3	1	3	3	1	3
Environment	Proportion of material landfilled	2	1	2	2	1	2	3	1	3	3	1	3
Environment	Conservation sites and species (including noise effects)	3	1	3	3	1	3	2	1	2	2	1	2
			Total Average	20.5 2.6		Total Average	21.5 2.7		Total Average	17 2.1		Total Average	17 2.1
Technical	Technical feasibility	3	1.5	4.5	3	1.5	4.5	2	1	2	2	1	2
Technical	Weather sensitivity	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
			Total Average	9 4.5		Total Average	9 4.5		Total Average	6.5 3.3		Total Average	6.5 3.3
Societal	Residual effect on fishing, navigation or other access (including cumulative)	1	1	1	1	1	1	2	1	2	3	1	3
Societal	Coastal communities	2	1	2	2	1	2	1	1	1	1	1	1
			Total Average	3 1.5		Total Average	3 1.5		Total Average	3 1.5		Total Average	4 2.0
Economic	Total cost	5	2	10	4	2	8	2	2	4	3	2	6
Economic	Residual liability including monitoring and remediation if necessary	1	1	1	2	1	2	2	1	2	2	1	2
			Total Average	11 5.5		Total Average	10 5.0		Total Average	6 3.0		Total Average	8 4.0
				17.3 3.5			17.8 3.6			11.9 2.4			13.4 2.7

Criteria	Sub criteria	Umbilical Option A1 - PLU2892 ONLY Complete removal by reverse reel (no rock present on line) Risk/ Impact	Relative Uncertainty	Weighted Score
Safety	Risk to personnel offshore during decommissioning operations	3	1	3
Safety	Risk to personnel onshore during decommissioning operations	3	1	3
Safety	Risk to divers during decommissioning operations	1	1	1
Safety	Risk to 3rd parties and assets during decommissioning operations	1	1	1
Safety	Residual risk to 3rd parties	1	1	1
			Total	9
			Average	1.8
Environment	Chemical discharge	3	1	3
Environment	Hydrocarbon release from pipelines	1	1	1
Environment	Seabed disturbance and/or habitat alteration including cumulative impact	2	1	2
Environment	CO_2 emissions (tCO_2 eq.)	1	1	1
Environment	Total energy consumption	2	1	2
Environment	Proportion of material reused/recycled	2	1	2
Environment	Proportion of material landfilled	2	1	2
Environment	Conservation sites and species (including noise effects)	2	1	2
			Total	15
			Average	1.9
Technical	Technical feasibility	2	1	2
Technical	Weather sensitivity	3	1	3
			Total	5
			Average	2.5
Societal	Residual effect on fishing, navigation or other access (including cumulative)	1	1	1
Societal	Coastal communities	1	1	1
			Total	2
			Average	1.0
Economic	Total cost	1	2	2
Economic	Residual liability including monitoring and remediation if necessary	1	1	1
			Total	3
			Average	1.5
				8.7
				1.7