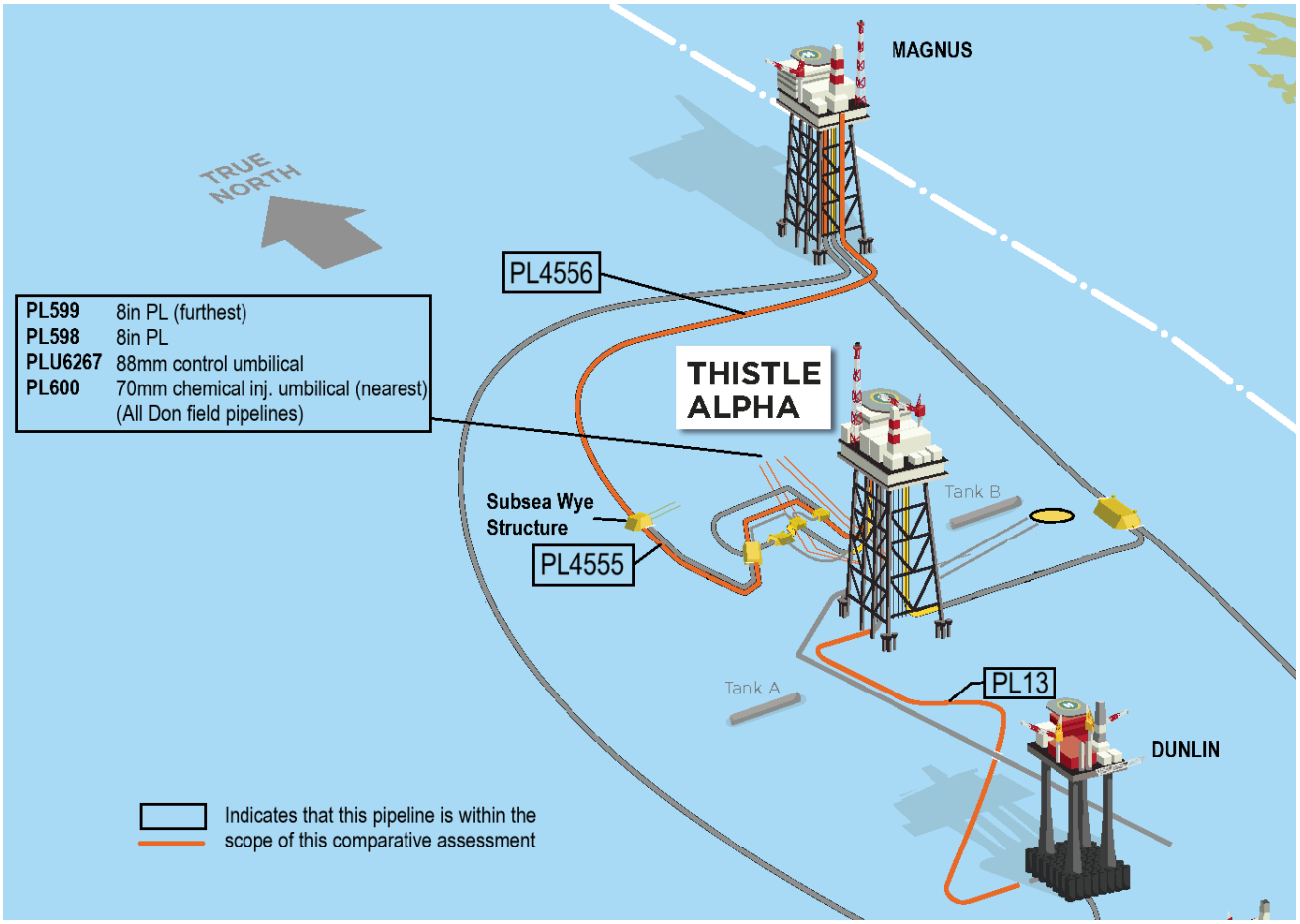
Combined Thistle & Don Pipeline Decommissioning Comparative Assessment



FINAL Version

DOCUMENT CONTROL

Document ID:		M3525-ENQ-THI-DN-0000-REP-0011	
Document Classification:		PUBLIC	
Document Ownership:		Decommissioning	
Date of Document:	11/05/23	Signature	Date
Prepared by:	S. Axon	S. Axon	28 April 2025
Reviewed by:	K. Langworthy	K. Langworthy	28 April 2025
Approved by:	M. Bean	M. Bean	28 April 2025

REVISION RECORD

Revision No.	Date of Revision	Reason for Issue
A1	27 June 2023	Issued for internal and partner review
A2	27 Nov 2023	Issued to OPRED for review
A3	24 April 2024	Updated and reissued to OPRED
A4	30 May 2024	Updated for Don pipelines and reissued to OPRED
A5	09 Oct 2024	Updated and reissued to OPRED
A6	12 Nov 2024	Issued for Public & Statutory Consultation
C1	28 April 2025	FINAL Version

DISTRIBUTION LIST

Company	No. of copies
Offshore Petroleum Regulator for Environment and Decommissioning	1 electronic
GMG, NFFO, NIFPO, SFF	1 electronic
Partners, etc.	1 electronic

TABLE OF CONTENTS

1. Executive Summary 10
1.1 Overview 10
1.2 Conclusions 11
1.3 Summary tables for the Thistle and Don pipelines 13
1.4 Recommendations 18
2. Introduction 19
2.1 Overview 19
2.2 Purpose 21
3. Environmental Setting 24
3.1 Bathymetry and seabed features 24
3.2 Habitat sensitivities 24
3.3 Commercial fishing 26
3.4 Other commercial activity 27
3.5 Pipeline stabilisation and protection features 27
3.6 Assumptions, limitations, and gaps in Knowledge 29
4. The pipelines 31
4.1 Overview 31
4.2 Thistle pipelines 31
4.3 Don pipelines 53
4.4 Pipeline crossings 55
4.5 Dealing with pipeline crossings 55
5. Decommissioning options 57
5.1 Pipeline decommissioning 57
6. Comparative Assessment 61
6.1 Method 61
6.2 Comparative Assessment for Thistle pipelines 65
6.3 Comparative Assessment for Don pipelines 74
7. Conclusions 79
7.1 Thistle pipelines 79
7.2 Don pipelines 82
8. References 86
Appendix A Exposure and spans detail sheets 87
Appendix A.1 PL13 exposures (>50m) and spans (>10m) 87
Appendix B PL13 Mattress locations 90
Appendix B.1 PL13 mattress locations (based on survey data) 90
Appendix C PL4556 As-Built Alignment Sheets 92
Appendix C.1 PL4556 legend for as-built alignment sheets 92
Appendix C.2 PL4556 As-built alignment sheet KP-0.000 to KP1.287 93
Appendix C.3 PL4556 As-built alignment sheet KP1.098 to KP2.608 93
Appendix C.4 PL4556 As-built alignment sheet KP2.508 to KP4.018 94
Appendix C.5 PL4556 As-built alignment sheet KP3.922 to KP5.432 94
Appendix C.6 PL4556 As-built alignment sheet KP5.351 to KP6.861 95
Appendix C.7 PL4556 As-built alignment sheet KP6.776 to KP8.286 95
Appendix C.8 PL4556 As-built alignment sheet KP8.188 to KP9.698 96
Appendix C.9 PL4556 As-built alignment sheet KP9.600 to KP11.110 96
Appendix C.10 PL4556 As-built alignment sheet KP11.010 to KP12.520 97
Appendix C.11 PL4556 As-built alignment sheet KP12.420 to KP13.930 97
Appendix C.12 PL4556 As-built alignment sheet KP13.830 to KP15.340 98
Appendix C.13 PL4556 As-built alignment sheet KP15.240 to KP16.750 98

Appendix C.14 PL4556 As-built alignment sheet KP16.650 to KP18.160 99
Appendix C.15 PL4556 As-built alignment sheet KP18.065 to KP19.575 99
Appendix C.16 PL4556 As-built alignment sheet KP19.493 to KP21.003 100
Appendix C.17 PL4556 Rock as-built alignment sheet KP20.903 to KP22.413 100
Appendix C.18 PL4556 As-built alignment sheet KP22.315 to KP23.302 101
Appendix D Umbilical construction 102
Appendix D.1 PL600 chemical injection umbilical 102
Appendix D.2 PLU6267 control umbilical details 102
Appendix E Field Layouts 103
Appendix E.1 Thistle approaches (PL13, PL74, PL75 & PL4555) 103
Appendix E.2 Don pipeline approaches at Thistle 104
Appendix E.3 Dunlin 'A' approaches (PL13) 105
Appendix E.4 Wye structure (PL4555, PL4556) 106
Appendix E.5 Magnus (PL4556) 107
Appendix F PL13 CA Summary tables 108
Appendix F.1 Technical assessment for PL13 108
Appendix F.2 Safety assessment for PL13 109
Appendix F.3 Environmental assessment for PL13 110
Appendix F.4 Societal assessment for PL13 111
Appendix F.5 Cost assessment for PL13 111
Appendix G PL4555 and PL4556 CA Summary tables 112
Appendix G.1 Technical assessment for PL4555 and PL4556 112
Appendix G.2 Safety assessment for PL4555 and PL4556 112
Appendix G.3 Environmental assessment for PL4555 and PL4556 113
Appendix G.4 Societal assessment for PL4555 and PL4556 113
Appendix G.5 Cost assessment for PL4555 and PL4556 114
Appendix H Don Pipeline CA Summary tables 115
Appendix H.1 Technical assessment for Don pipelines 115
Appendix H.2 Safety assessment for Don pipelines 115
Appendix H.3 Environmental assessment for Don pipelines 116
Appendix H.4 Societal assessment for Don pipelines 117
Appendix H.5 Cost assessment for Don pipelines 117
Appendix I Cost As A Differentiator 118
Appendix I.1 Overview 118
Appendix I.2 Thistle pipeline assumptions 119
Appendix I.3 Don pipeline assumptions 119
Appendix I.4 Thistle pipeline decommissioning cost by difference 120
Appendix I.5 Don pipeline decommissioning cost assessment 122

FIGURES AND TABLES

Figure 2.1.1: Thistle in relation to other assets and infrastructure 19
Figure 2.1.2: The Don field assets and infrastructure 20
Figure 2.2.1: Locality of Thistle and Don within wider North Sea area 22
Figure 2.2.2: Locality of Thistle & Don in relation to other assets and infrastructure 23
Figure 3.2.1: Features of conservation Interest in relation to Thistle 25
Figure 3.3.1: Value of fish landings from 51F1 as a percentage of UK fishing effort 26
Figure 3.3.2: Value of fish landings from 51F1 26
Figure 3.3.3: Value per km^2 for fish landed from ICES 51F1 27
Figure 3.5.1: Examples of grout mattresses used for remediation (2014) 28

Figure 4.2.1: PL13 examples of degraded CWC (2014) 32
Figure 4.2.2: PL13 snagged fishing nets (2014) 32
Figure 4.2.3: PL13 comparison of historical exposures (>50m long, 2010 to 2018) 35
Figure 4.2.4: PL13 comparison of historical spans (>10m long, 2010 to 2018) 36
Figure 4.2.5: PL13 pipeline depth of burial profile (2008) 37
Figure 4.2.6: PL13 pipeline route (2008) 38
Figure 4.2.7: PL13 pipeline depth of burial profile (2010) 39
Figure 4.2.8: PL13 pipeline route (2010) 40
Figure 4.2.9: PL13 pipeline depth of burial profile (2012) 41
Figure 4.2.10: PL13 pipeline route (2012) 42
Figure 4.2.11: PL13 pipeline depth of burial profile (2014) 43
Figure 4.2.12: PL13 pipeline route (2014) 44
Figure 4.2.13: PL13 pipeline depth of burial profile (2016) 45
Figure 4.2.14: PL13 pipeline route (2016) 46
Figure 4.2.15: PL13 seabed and pipeline profile (2018) 47
Figure 4.2.16: PL13 pipeline depth of burial profile (2018) 48
Figure 4.2.17: PL13 pipeline route (2018) 49
Figure 4.2.18: PL4555 (& PL2579) pipeline and seabed profile (2016) 50
Figure 4.2.19: PL4555 (& PL2579) pipeline depth of burial profile (2016) 51
Figure 4.2.20: PL4555 (& PL2579) pipeline route (2016) 51
Figure 4.2.21: PL4555 (& PL2579) seabed and pipeline profile (2019) 52
Figure 4.2.22: PL4555 (& PL2579) pipeline depth of burial profile (2019) 52
Figure 4.2.23: PL4555 (PL2579) pipeline route (2019) 53
Figure 4.4.1: Over/under convention for pipeline crossings 55
Figure 4.5.1: Pipeline underneath being removed 56
Figure 5.1.1: Exposures, spans & partial removal 57
Figure 6.2.1: PL13 new rock over existing cover inside trench 66
Figure 6.2.2: PL13 new rock over exposed pipeline inside trench 66
Figure C.1.1: PL4556 As-built alignment sheet legend 92
Figure C.2.2: PL4556 As-built alignment sheet KP-0.000 to KP1.287 93
Figure C.3.3: PL4556 As-built alignment sheet KP1.098 to KP2.608 93
Figure C.4.1: PL4556 As-built alignment sheet KP2.508 to KP4.018 94
Figure C.5.2: PL4556 As-built alignment sheet KP3.922 to KP5.432 94
Figure C.6.3: PL4556 As-built alignment sheet KP5.351 to KP6.861 95
Figure C.7.4: PL4556 As-built alignment sheet KP6.776 to KP8.286 95
Figure C.8.5: PL4556 As-built alignment sheet KP8.188 to KP9.698 96
Figure C.9.6: PL4556 As-built alignment sheet KP9.600 to KP11.110 96
Figure C.10.7: PL4556 As-built alignment sheet KP11.010 to KP12.520 97
Figure C.11.8: PL4556 As-built alignment sheet KP12.420 to KP13.930 97
Figure C.12.9: PL4556 As-built alignment sheet KP13.830 to KP15.340 98
Figure C.13.10: PL4556 As-built alignment sheet KP15.240 to KP16.750 98
Figure C.14.11: PL4556 As-built alignment sheet KP16.650 to KP18.160 99
Figure C.15.12: PL4556 As-built alignment sheet KP18.065 to KP19.575 99
Figure C.16.13: PL4556 As-built alignment sheet KP19.493 to KP21.003 100
Figure C.17.14: PL4556 As-built alignment sheet KP20.903 to KP22.413 100
Figure C.18.15: PL4556 As-built alignment sheet KP22.315 to KP23.302 101
Figure D.1.1: PL600 chemical injection umbilical construction 102
Figure D.2.1: PLU6267 hydraulic control umbilical construction 102
Figure E.1.1: Thistle platform approaches (PL13, PL74, PL75, PL4555 & PLU6221) 103
Figure E.2.1: Don pipelines at Thistle platform approaches (PL598, PPL599, PL600, PLU6267) 104
Figure E.3.1: Dunlin 'A' approaches (PL13) 105

Figure E.4.1: Wye structure approaches (PL4555 & PL4556) 106
Figure E.5.1: Magnus approaches (PL4556) 107

Table 4.1.1: Thistle pipeline summary 31
Table 4.1.2: Don pipeline summary 31
Table 4.2.1: PL13 historical exposure and span summary 34
Table 4.5.1: Impact of pipeline crossings on pipeline decommissioning options 56
Table 5.1.1: Thistle pipeline decommissioning options 58
Table 5.1.2: Don pipeline decommissioning options 58
Table 5.1.3: Decommissioning the Thistle pipelines 59
Table 5.1.4: Decommissioning the Don pipelines inside Thistle 500 m zone 60
Table 6.1.1: Comparative Assessment method – criteria & sub-criteria 64
Table 6.2.1: PL13 summary of temp. and permanent impacts on seabed 71
Table 6.2.2: PL4555, PL4556 summary of temp. and permanent impacts on seabed 72
Table 7.1.1: Summary of normalised cost assessment (incl. surveys) 81
Table A.1.1: PL13 historical exposures (>50m long) and spans (>10m long) 89
Table B.1.1: PL13 mattress locations as found in pipeline surveys 91
Table F.1.1: Technical assessment for PL13 108
Table F.2.1: Safety assessment for PL13 109
Table F.3.1: Environmental assessment for PL13 110
Table F.4.1: Societal assessment for PL13 111
Table F.5.1: Cost assessment for PL13 111
Table G.1.1: Technical assessment for PL4555 and PL4556 112
Table G.2.1: Safety assessment for PL4555 and PL4556 112
Table G.3.1: Environmental assessment for PL4555 and PL4556 113
Table G.4.1: Societal assessment for PL4555 and PL4556 113
Table G.5.1: Cost assessment for PL4555 and PL4556 114
Table H.1.1: Technical assessment for Don pipelines 115
Table H.2.1: Safety assessment for Don pipelines 115
Table H.3.1: Environmental assessment for Don pipelines 116
Table H.4.1: Societal assessment for Don pipelines 117
Table H.5.1: Cost assessment for Don pipelines 117
Table I.1.1: Categories of impact – cost assessment 118
Table I.4.1: Thistle PL decom – dims for normalised cost assessment (incl. surveys) 120
Table I.4.2: Thistle PL decom – dims for normalised cost assessment (excl. surveys) 121
Table I.5.1: Don PL decom – dims for normalised cost assessment (incl. surveys) 122
Table I.5.2: Don PL decom – dims for normalised cost assessment (excl. surveys) 123

TABLE OF ABBREVIATIONS

ABBREVIATION	EXPLANATION
~	Approximately
3LPP	3-Layer Polypropylene, coating used for carbon steel pipelines and pipework
ADJL	Adjacent seabed level
ALARP	As Low as Reasonably Practicable
approach	Initial or final stretch of pipeline (or umbilical) as it leaves its point of origin or reaches its destination
BNOC	British National Oil Corporation
CWC	Concrete Weight Coated (PL13)
CSV	Construction Support Vessel
CTEE	Coat Tar Epoxy Enamel
cut and lift	The 'cut and lift' method of removing trenched and buried pipelines would involve excavating the pipelines from within the seabed and thereafter cutting the pipeline into recoverable and transportable lengths. This method of removal can be very time-consuming for long pipelines and, would be problematic for concrete coated pipelines. The method is usually only viable for short pipelines
DAC	Deadman Anchor Cable.
decom	decommissioning (used in Appendix I)
DFGI	Dunlin Fuel Gas Import
dims	dimensions (used in Appendix I)
DNO	DNO ASA is a Norwegian oil and gas operator focused on the Middle East and the North Sea.
DOC	Depth of Cover (depth of sediment covering a pipeline)
DOL	Depth of Lowering (bottom of pipe in trench)
Don	Don field ~14km north of Thistle. Not to be confused with Don South-West and West Don fields operated by EQ. The Don Decommissioning Programmes were approved in 2011, and much of the associated infrastructure has been decommissioned, but the scope of the Decommissioning Programmes excluded the associated infrastructure inside the Thistle 500m safety zone.
DP	Decommissioning Programme(s)
DSW	Don South-West
EA	Environmental Appraisal
EBS	Environmental Baseline Survey
EnQuest	EnQuest Heather Limited
EPDM	Ethylene Propylene Diene Monomer
ES	Start of exposure, as indicated in the pipeline burial profiles in section 4
ESDV	Emergency Shutdown Valve
exposure	An exposure occurs when the 'crown' of a pipeline or umbilical can be seen. This does not generally mean it is a hazard
FishSAFE	The FishSAFE database contains a host of oil & gas structures, pipelines, and potential fishing hazards. This includes information and changes as the data are reported for pipelines and cables, suspended wellheads pipeline spans, surface & subsurface structures, safety zones & pipeline gates (www.fishsafe.eu).
FS	Span, as indicated in the pipeline burial profiles in Section 4
HSEQ	Health, Safety, Environment, Quality
GMS	Start of grout mattress(es) as indicated in the pipeline burial profiles in section 4. Grout mattresses were usually used to support the pipeline, being installed to reduce an individual span length of a pipeline
ICES	International Council for the Exploration of the Seas
ID	Identity (as in tabulated feature)
IRM	Inspection, Repair, Maintenance
", in	Inch; 25.4 millimetres

ABBREVIATION	EXPLANATION
J lay	A pipelay method whereby sections of pipe are welded together whilst the pipeline is supported on a vertical tower, their transition down to seabed taking the form of an "J"
km	Kilometre
KP	Kilo Point. Measured from the pipeline end flange – end pipespool interface. Usually this is measured from the point of pipeline origin to the end, but sometimes for convenience pipeline surveys are measured from the pipeline flange at the end.
LAT	Lowest Astronomical Tide
Lockheed Chamber	A diver accessible chamber at the base of a riser to allow the pipeline to riser weld to be executed
Lundin	Lundin Energy. An independent oil and gas exploration and production company based in Sweden
m	Metre(s)
MFE	Mass Flow Excavator
MPA	Marine Protected Area
MS	Start of mattress(es) as indicated in the pipeline burial profiles in Section 4
MSB	Mean Seabed
N, S, E, W	North, South, East, West
n/a	Not Applicable
N/A	(Data) Not Available
NFFO	National Federation of Fishermen's Organisations
NLGP	Northern Leg Gas Pipeline
NIFPO	Northern Ireland Fish Producers Organisation Ltd
NORM	Naturally Occurring Radioactive Material
NSTA	North Sea Transition Authority
OD	Outside Diameter (of pipe)
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
Order of Magnitude	Size difference by factor of 10: one (10^1) means 10-times, two (10^2) means 100-times difference
piggybacked	Clamped or connected to another pipeline along its length
pipeline	Generic term used for either a pipeline or an umbilical
PL, PLU	Pipeline, Umbilical Identification numbers (UK). PL also used as shorthand for "pipeline" in some table captions.
PL600	PL600, PL600.1 through PL600.6 as described on the relevant PWA (consent No. 17-V-25)
post-trenching	Post-trenching involves cutting, ploughing, or jetting a trench underneath the pipeline, such that it is lowered into the seabed
PWA	Pipeline Works Authorisation
Q1, Q2, Q3, Q4	Quarter 1, Quarter 2, Quarter 3, or Quarter 4 of any given year
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
Qualitative	Result determined using judgement and use of risk and impact matrices
Quantitative	Result determined using numerical data and by calculation
remediation	For the purposes of this document remediation can mean one of, or a combination of the following: removal of exposures and spans, deposition of additional rock. Post-trenching has been discounted for the pipelines assessed herein.
reportable span	A reportable span is a significant span which meets set criteria (FishSAFE criteria) of height above the seabed and span length (10m long x 0.8m high)
reel lay	Using the reel-lay method a flexible pipeline or small diameter rigid pipeline is installed from a large reel mounted on a pipelay barge. A pipe is spooled from a drum (reel) straightened with tension applied and laid over a ramp to the seabed
risk	Defined by the Institution of Civil Engineers as being either an 'opportunity' or 'threat'. in this report the word "risk" is used to describe a "threat".
ROV	Remotely Operated Vehicle

ABBREVIATION	EXPLANATION
ROVSV	Remotely Operated Vehicle Support Vessel
RS	Start of rock as indicated in the pipeline burial profiles in section 4
S lay	A pipelay method whereby sections of pipe are welded together on a horizontal deck, their transition down to seabed taking the form of an elongated "S"
SAC	Special Area of Conservation
SALB	Single Anchor Leg Base (used to be the Northern Producer export route)
SALM	Single Anchor Leg Mooring
SFF	Scottish Fishermen's Federation
span	Like an exposure except that the whole of the section of pipeline is visible above the seabed rather than just part of it. Once the height and length dimensions meet or exceed certain criteria the spam becomes a reportable span
splash zone	The wetted area of a riser or structure or riser immediately above and below the mean water level
SSIV	Subsea Isolation Valve
SSS	Side Scan Sonar. A system that can be used to provide sonar imaging of the seabed
SVT	Sullom Voe Terminal (in Shetland)
TOP	Top of pipe (used in some burial profiles)
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
umbilical	Flexible pipeline manufactured of various materials including steel and plastics typically used to send electrical power, communication signals, chemicals and hydraulic fluid to a manifold or wellhead. An umbilical will include cables and tubes that are covered with an outer sheath to protect them from damage.
UNO	Unless Notified Otherwise
UTM	Universal Transverse Mercator (coordinate system)
WD	West Don
WGS84	World Geodetic System 1984
WI	Water Injection
WLGP	Western Leg Gas Pipeline (PL17)
x	Number of (e.g., 16x = 16 in Number)

ASSESSMENT		DESCRIPTION
On balance this is the best option	Broadly Acceptable / Low & most preferred[1]	The performance of this option the best overall and 'broadly acceptable'. This is the best option.
	Broadly Acceptable / Low & in-between least & most preferred[1]	The performance of this option is marginally worse than the best option and better or worse than others
	Broadly Acceptable / Low & least preferred[1]	The performance of this option is marginally worse than other options that are broadly acceptable.
	Tolerable / Medium Non-preferred[1]	Risks are tolerable and managed to ALARP. Controls and measures to reduce risks to ALARP require identification, documentation, and approval by responsible leader.
On balance this is the worst option	Intolerable / High[1] not acceptable	Impacts are intolerable. Controls and measures to reduce impact to ALARP (at least to Medium) and require identification, documentation, implementation, and approval.

[1] The colour of this highlighted cell is used in the assessment tables – please refer the Summary Tables in Section 1.3, Appendix F and Appendix I.

1. EXECUTIVE SUMMARY

1.1 Overview

A Comparative Assessment of pipelines is a key consideration within the Decommissioning Programmes ('DP') submitted to the Offshore Petroleum Regulator for Environment and Decommissioning ('OPRED').

The Thistle field was discovered in 1972 in the fourth UK acreage licensing round in block 211/18 and 211/19 (licenses P236 and P475). The field is produced over the Thistle Alpha platform (here after referred to as the Thistle platform), a fixed installation providing manned production, drilling, and utilities facilities. The Thistle platform is situated in block 211/18a of the United Kingdom Continental Shelf ('UKCS') and operated by EnQuest Heather Limited. The Thistle field is located ~201 km North-East of Shetland, in a water depth of ~162 m.

The licensing operators for the Thistle field were BNOC, Britoil and BP, that subsequently transferred to DNO in 2003, followed by Lundin in 2004. EnQuest then became the operator in 2010 after demerging of Lundin's UK assets. Thistle is currently operated in partnership between EnQuest and BP, with EnQuest holding over 99% of the total ownership of the site. The decommissioning liabilities are different and are as stated in the Thistle pipeline DP [6].

The Don North-East and Don South-West fields comprise four operating licences, Don North-East (P104, P236 and P296) and Don South-West (P236). The Fields were operated by BP and are located approximately 230 km north-east of the Shetland Islands in Block 211/18a in the United Kingdom sector of the northern North Sea, in a water depth of 160 m. The Fields were discovered in 1976. Oil was first produced in October 1989, and exported via the Thistle platform to the Sullom Voe oil terminal on Shetland. The Don infrastructure outside of the Thistle 500 m safety zone has already been decommissioned following approval of the Don DP [1] more than a decade ago.

This combined comparative assessment report has been prepared in support of the Decommissioning Programmes for the Thistle pipelines [2] and for the Don [6] pipelines inside the Thistle 500 m safety zone.

Pipeline burial status

This document presents a comparative assessment for decommissioning the following Thistle and Don pipelines:

Thistle pipelines:

- PL13, 16in concrete weight coated ('CWC'), surface laid on approach to the platforms, but otherwise trenched and left to backfill naturally, with multiple exposures and spans (3,645 m), ~12.69 km long.
- PL4555, 8in (and piggybacked) trenched and buried with no exposures, ~10.26 km long.
- PL4556, 8in, trenched and buried with no exposures, ~23.75 km long.

As PL74 and PL75 (both 16in CWC, ~2.4 km long) are laid on the surface of the seabed and not trenched, they will be completely removed in accordance with mandatory requirements. Therefore, they are not subject to a comparative assessment.

Don pipelines:

- PL598, 8in, trenched and buried, ~0.57 km (overall length, ~17.34 km).
- PL599, 8in, trenched and buried but exposed at KP0.427 for 18 m, measured from the pipeline end flange near Thistle, ~0.57 km (~17.34 km).
- PL600 (including cores PL600, PL600.1 through PL600.6 (herein after referred to as PL600

throughout this document), 70mm umbilical, trenched and buried, ~0.56 km (~17.73 km).

- PLU6267, 88mm umbilical, trenched and buried, 0.54 km (~17.73 km).

The lengths in brackets are the lengths of the pipelines quoted in the Don DP [1] and are provided for completeness and context.

The decommissioning options are described as follows:

- **Complete removal** – This involves the complete removal of the pipelines by whatever means would be most practicable and acceptable from a technical perspective.
- **Partial removal or remediation** – PL13 and PL599 only. Partial removal would involve removing exposed or potentially unstable sections of pipelines. Remediation involves post-trenching or the deposition of rock to make the remaining pipeline safe for leaving *in situ*. This option is relevant for those pipelines that are known to have exposures or spans.
- **Leave *in situ*** –This involves leaving the pipeline(s) *in situ* with no remedial works.

For partial removal, remediation or leave *in situ* there will be a need to verify the pipeline stability and burial status via future surveys.

Surface laid sections of PL13, PL598, PL599, PL600, PL4555, PL4556 and PLU6267 on the final approaches will be removed in accordance with mandatory requirements, regardless of the decommissioning option selected.

Method

The assessment considered five criteria for both the short-term decommissioning activities and the longer-term for 'legacy' related activities. The criteria were: technical feasibility, safety related aspects with three sub-criteria, environmental aspects with five sub-criteria, societal effects with three sub-criteria and cost.

Since the decommissioning of the surface laid ends of the pipelines on the final approaches is the same irrespective of which option is pursued, except for cost, the decommissioning of these is not included in this assessment. Any differences are incremental to the decommissioning activities associated with surface laid infrastructure.

The sections of PL598, PL599, PL600 and PLU6267 outside of the Thistle 500 m zone have already been decommissioned and were subject to a comparative assessment included in the Don DP [1]. As the section inside the Thistle 500 m zone are an extension of the wider Don field pipelines the findings of the original comparative assessment were examined to confirm if the approach and findings would be valid for the pipelines inside the Thistle 500 m zone.

The assessment for PL13 was subject to a detailed review in a meeting participated by the project team and representatives from the section 29 notice holders.

Summary tables for all the pipelines with the detailed text removed to allow a comparison of the colour-coded results arising from the assessment are presented in section 1.3. The detailed assessment tables are included in Appendix F (PL13), Appendix G (PL4555 and PL4556) and Appendix H (Don pipelines).

1.2 Conclusions

1.2.1 Conclusion for Thistle pipelines

For all pipelines (PL13, PL4555, PL4556) all decommissioning options are technically feasible and there is little to choose from a societal perspective, which means that the key differentiators are safety, environmental impact, and cost. Most of the decommissioning works would be executed using remotely operated equipment, although in the case of partial or complete removal handling

of recovered material on vessel deck will usually involve deck crew, and the number of individual sections (>1,100 for PL13) to be dealt with is not insignificant. This is why the participants at a comparative assessment review meeting considered that from a safety perspective complete removal of PL13 would be a significant and non-preferred undertaking. The deposition of rock would all be conducted remotely using a fall pipe vessel. Following decommissioning the aim should be for a clear seabed with no residual snag hazards remaining once the options have been implemented. For PL13 this means that exposures (which include spans) should either be removed or buried under deposited rock. Historical evidence would suggest that removal of the spans would not prevent the occurrence of spans in future, and there is evidence of snagged fishing nets having occurred in the area for all three concrete coated pipelines.

After the surface laid ends have been removed down to trench depth, burial of the remaining length of the PL13 (9,071 m) would result in the deposition of up to ~29,300 Te of rock onto the seabed to ensure a consistent profile. Once the surface laid ends have been removed, most of the pipeline is buried inside the trench. Burial of the PL13 exposures (1,888 m) would result in the deposition of up to ~6,100 Te of rock on the seabed. Given the spread or distribution of the exposures and spans, implementation of this approach would be inefficient and with the introduction of scour around isolated deposits of rock is unlikely to prevent the need for further remedial work in future. This means that it would be beneficial to carry out a more detailed assessment of requirements when applying for a marine license nearer the time when the decommissioning activities will be carried out.

By completely removing the pipelines the risk of snagging would be removed in perpetuity, and although there would be little risk of snagging from PL4555 and PL4556 that are buried.

Energy requirements and emissions to air would be such that there would be a difference between options. However, the gap between complete removal, partial removal (to a lesser extent) and leave *in situ* narrows when indirect energy requirements and emissions required for replacement of unrecovered material are accounted for. Temporary impacts on the seabed resulting from removal operations for the pipelines would be negligible. As the pipelines are predominantly manufactured from steel (PL4555 and PL4556) or steel and concrete (PL13) this would not be detrimental to the local environment.

For all pipelines (PL13, PL4555, PL4556), the complete removal option would the most expensive option to implement, with leave *in situ* being the least. For PL13 the cost of partial removal (including the surface laid ends) would be almost as much as complete removal. This is because of the start-stop nature of the partial removal operation[2]. For PL13 the most cost-effective way of dealing with the exposures in PL13 would be deposit rock along the full length of the pipeline(s).

For the complete removal option once completed, no more costs would be incurred for future pipeline surveys while pipelines or parts thereof that are left *in situ* would be subject to future pipeline inspections.

1.2.2 Conclusion for Don pipelines

Technical aspects

As indicated in the original assessment, from a purely technical perspective, the complete removal option is technically feasible for all the Don pipelines within the Thistle 500 m zone. Recovery of the sections in the 500 m zone would be more readily achievable than for the rest of the pipelines.

From a safety perspective, given that the activities and techniques – including the remediation option instead of partial removal, are frequently used in the North Sea it is assumed that the risks

[2] For example, locating the pipeline ends to be cut, executing the cut, removing the cut sections of pipe and depositing rock on the ends.

from all hazards relating to 'cut and lift' and reverse reel methods of removal as well as excavation would be broadly acceptable. For project personnel, the threat to safety increases with the volume of work and materials dealt with, and by inference in the short-term the leave *in situ* option would present the least threat to the safety of offshore and onshore project personnel.

The complete removal option would result in no materials left in the seabed. The partial removal option (PL599) and leave *in situ* options would result in materials being left to degrade naturally. The pipelines are predominantly manufactured from steel, although they are coated with EPDM. However, the slow rate of decomposition of degraded material would not be detrimental to the local environment because the decomposition process will occur very gradually over tens if not hundreds of years [10]. The umbilicals have a higher content of composite materials (~10%) and so would take much longer than steel to decompose. The deposition of the composite materials would also likely occur very gradually over hundreds of years, and so would at little detriment to the local marine environment.

The main commercial activity in the area is demersal fishing. Should they be left *in situ*, the Don pipelines can be expected to remain buried and therefore the commercial aspects of demersal fishing in the area – once the Thistle 500 m zone has been rescinded, would be unaffected. Historically the average value of fish landed per km^2 in the Thistle area is small.

By inspection the removal of the pipelines inside the Thistle 500 m zone would be a small incremental addition in cost to the overall scope. If the incremental increase in cost can be pro-rated to the % increase in scope (i.e. an additional 1,669 m to 51,120 m[3]) there would be a less than 5% increase in overall removal costs, remembering that the original recommendation was that the Don pipelines be left *in situ* following decommissioning.

For PL599, at more than three times to cost of partial removal and four times the cost of leave in situ, the cost of burying the short exposed section under rock would be the most expensive option.

1.3 Summary tables for the Thistle and Don pipelines

Note the white coloured boxes in the following tables mean that either there is nothing to differentiate the options or that the sub-criteria are not applicable ('n/a').

For PL13 as well as partial removal, the remediation options considered were post-trenching, and the deposition of rock.

For colour codes refer the bottom of the Table of Abbreviations.

[3] Combined overall length = 52,789 m, less the lengths inside the Thistle 500 m zone (1,669 m).

1.3.1 Assessment summary tables for PL13

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION			LEAVE *IN SITU*
				PARTIAL REMOVAL	REMEDIATION		
Technical	**Offshore Execution**	Risk of project failure			Post-trenching	Rock	
		Technological challenge					n/a
		Technical challenge			Post-trenching	Rock	
	Legacy	Risk of project failure					
		Technological challenge					
		Technical challenge					
Safety	**Offshore Execution**	Health & safety risk offshore project personnel			Rock (part PL)	Rock (complete PL)	
		Health & safety risk to mariners					
		Safety risk onshore project personnel					
	Legacy	Health & safety risk offshore project personnel					
		Health & safety risk to mariners					
		Safety risk onshore project personnel					
Environmental	**Offshore Execution**	Energy & emissions					
		Seabed disturbance, *temporary*					
		Effect on water column					
		Waste creation & recycling					
	Legacy	Energy & emissions					
		Seabed disturbance, *permanent*			Rock (part PL)	Rock (complete PL)	
		Effect on water column					
		Waste creation and recycling					
Societal	**Offshore Execution**	Effect on commercial activities					
		Employment					
		Communities or impact on amenities					
	Legacy	Effect on commercial activities					
		Employment					
		Communities or impact on amenities					
Cost	**Offshore Execution**				Rock (part PL)	Rock (complete PL)	
	Legacy						
Recommended option						●	

1.3.2 Assessment summary tables for PL4555 and PL4556

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	LEAVE *IN SITU*
Technical	**Offshore Execution**	Risk of project failure		
		Technological challenge		
		Technical challenge		
	Legacy	Risk of project failure		
		Technological challenge		
		Technical challenge		
Safety	**Offshore Execution**	Health & safety risk offshore project personnel		
		Health & safety risk to mariners		
		Safety risk onshore project personnel		
	Legacy	Health & safety risk offshore project personnel		
		Health & safety risk to mariners		
		Safety risk onshore project personnel		
Environmental	**Offshore Execution**	Energy & emissions		
		Seabed disturbance, *temporary*		
		Effect on water column		
		Waste creation and recycling		
	Legacy	Energy & emissions		
		Seabed disturbance, *permanent*		
		Effect on water column		
		Waste creation and recycling		
Societal	**Offshore Execution**	Effect on commercial activities		
		Employment		
		Communities or impact on amenities		
	Legacy	Effect on commercial activities		
		Employment		
		Communities or impact on amenities		
Cost	**Offshore Execution**	**PL4555**		
		PL4556		
	Legacy			
Recommended option from comparative assessment				●

1.3.3 Assessment summary tables for Don PL598, PL600, PLU6267

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	LEAVE *IN SITU*
Technical	**Offshore Execution**	Risk of project failure		
		Technological challenge		n/a
		Technical challenge		
	Legacy	Risk of project failure		
		Technological challenge		
		Technical challenge		
Safety	**Offshore Execution**	Health & safety risk offshore project personnel		
		Health & safety risk to mariners		
		Safety risk onshore project personnel		
	Legacy	Health & safety risk offshore project personnel		
		Health & safety risk to mariners		
		Safety risk onshore project personnel		
Environmental	**Offshore Execution**	Energy & emissions		
		Seabed disturbance, *temporary*		
		Effect on water column		
		Waste creation and recycling		
Environmental	**Legacy**	Energy & emissions		
		Seabed disturbance, *permanent*		
		Effect on water column		
		Waste creation and recycling		
Societal	**Offshore Execution**	Effect on commercial activities		
		Employment		
		Communities or impact on amenities		
	Legacy	Effect on commercial activities		
		Employment		
		Communities or impact on amenities		
Cost	**Offshore Execution**	**PL598**		
		PL600 & PLU6267		
	Legacy	**ALL PIPELINES**		
Recommended option from comparative assessment				

1.3.4 Assessment summary tables for Don PL599

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION		LEAVE *IN SITU*
				PARTIAL REMOVAL	DEPOSITION OF ROCK	
Technical	**Offshore Execution**	Risk of project failure				
		Technological challenge				n/a
		Technical challenge				
	Legacy	Risk of project failure				
		Technological challenge				
		Technical challenge				
Safety	**Offshore Execution**	Health & safety risk offshore project personnel				
		Health & safety risk to mariners				
		Safety risk onshore project personnel				
	Legacy	Health & safety risk offshore project personnel				
		Health & safety risk to mariners				
		Safety risk onshore project personnel				
Environmental	**Offshore Execution**	Energy & emissions				
		Seabed disturbance, *temporary*				
		Effect on water column				
		Waste creation and recycling				
Environmental	**Legacy**	Energy & emissions				
		Seabed disturbance, *permanent*				
		Effect on water column				
		Waste creation and recycling				
Societal	**Offshore Execution**	Effect on commercial activities				
		Employment				
		Communities or impact on amenities				
	Legacy	Effect on commercial activities				
		Employment				
		Communities or impact on amenities				
		PL599 (Mob/demob costs included)				
		PL599 (Mob/demob costs ignored)				
	Legacy	**ALL PIPELINES**				
Recommended option from comparative assessment						

1.4 Recommendations

The recommendations are considered to provide an appropriate balance between the technical, safety, environmental, societal, and economic aspects of the assessment.

1.4.1 Recommendations for Thistle pipelines

For PL13, historical survey data for the last decade or so would appear to indicate that some form of intervention or remediation would be required for exposed or span sections once the pipeline has been decommissioned.

Following decommissioning, PL4555 and PL4556 can be expected to remain buried once the pipeline ends have been removed up to the point where they enter burial in rock.

The following recommendations are presented for consideration:

- PL13. Remove the surface laid sections of the pipeline on approaches to the Thistle and Dunlin 'A' platforms in accordance with mandatory requirements. Bury the remaining section of the pipeline inside the trench under rock. This will result in ~29,300 Te of rock being deposited on the pipeline.
- PL4555 & PL4556. Leave *in situ*. Completely remove all pipespools and associated protection and stabilisation features; completely remove surface laid sections up to the point of burial in rock and completely remove all protection and stabilisation features. Deposit up to ~15 Te of rock on both ends of each pipeline. Total rock up to ~60 Te.
- Leave deposited rock *in situ*.

1.4.2 Recommendations for Don pipelines

Inside the Thistle 500 m zone, a short, exposed section 18 m long was found in PL599. Once decommissioning activities have been completed the Don pipelines can be expected to remain buried. When taken in the context of the overall Don field pipelines, the recommendation for pipelines PL598, PL599, PL600 and PLU6267 is as follows:

- Remove the pipe bridge along with the pipelines and umbilicals contained on it in accordance with mandatory requirements.
- Remove the surface laid ends from the end of the pipe bridge down to trench depth.
- Bury the cut ends under deposited rock.
- Examine the status of the 18 m long exposure at KP0.427 (measured in 2013 from the pipeline flange at Thistle) in PL599 and agree a remediation strategy. The options are: 1) leave 'as is', 2) remove the exposed section and bury the cut ends under deposited rock, or 3) bury the exposed length under deposited rock). The preference would likely be to leave the exposure *in situ* and subject the area to monitoring as part of a wider pipeline monitoring strategy. Following the survey of PL599 the final decommissioning solution will be discussed and agreed with OPRED.

2. INTRODUCTION

2.1 Overview

The Thistle field was discovered in 1972 in the fourth UK acreage licensing round in block 211/18 and 211/19 (licenses P236 and P475). The field is produced over the Thistle Alpha ('Thistle') platform, a fixed installation providing manned production, drilling, and utilities facilities. The Thistle installation is situated in block 211/18a of the UKCS and operated by EnQuest Heather Limited. The Thistle field is located ~201 km North-East of Shetland, in a water depth of ~162 m. Refer Figure 2.2.2 below.

The Thistle jacket was installed in 1976 with the topsides' modules being installed in the following year. Oil production commenced in February 1978 and ceased in 2020.

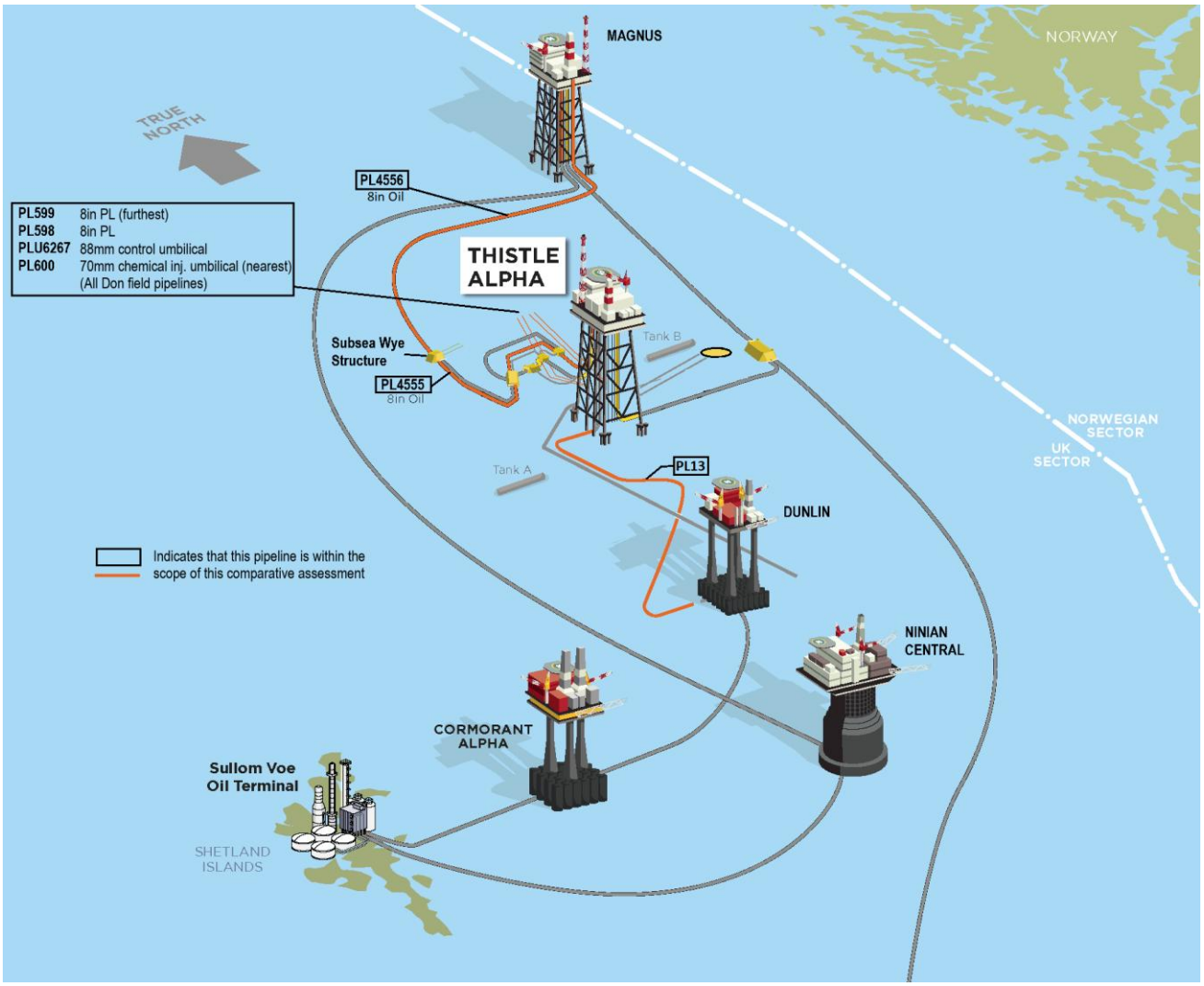


Figure 2.1.1: Thistle in relation to other assets and infrastructure

Before the Northern Producer was decommissioned, production from the Conrie, Don South-West, West Don and Ythan fields was exported to Thistle using PL2578 (the section between the Wye and Thistle being renumbered PL4555) with the produced fluids being commingled with the production from Thistle and exported to Dunlin. As the Dunlin platform was to be decommissioned, in 2019 the Dunlin Fuel Gas Import ('DFGI') project was implemented. This involved the installation of a new pipeline and various modifications to the existing pipeline

infrastructure to allow produced fluids to be exported via Magnus instead of Dunlin. This involved installing two new pipelines, PL2852 and PL4556, and repurposing PL2578 as an export pipeline from Thistle rather than act as an import pipeline for Northern Producer which was shortly due to be decommissioned. PL2578 was renumbered PL4555 as part of the process. Some pipespools were removed from PL13 near Dunlin.

The Don North-East and Don South-West fields comprise four operating licences, Don North-East (P104, P236 and P296) and Don South-West (P236). The Fields were operated by BP and are located approximately 230 km north-east of the Shetland Islands in Block 211/18a in the United Kingdom sector of the northern North Sea, in a water depth of 160 m. The Fields were discovered in 1976. Oil was first produced in October 1989, and exported via the Thistle Installation to the Sullom Voe oil terminal on Shetland. Following approval of the Don Decommissioning Programmes ('DP') [1] over a decade or so ago the Don pipeline infrastructure has already been partly decommissioned. The original Don Field is illustrated in Figure 2.1.2:

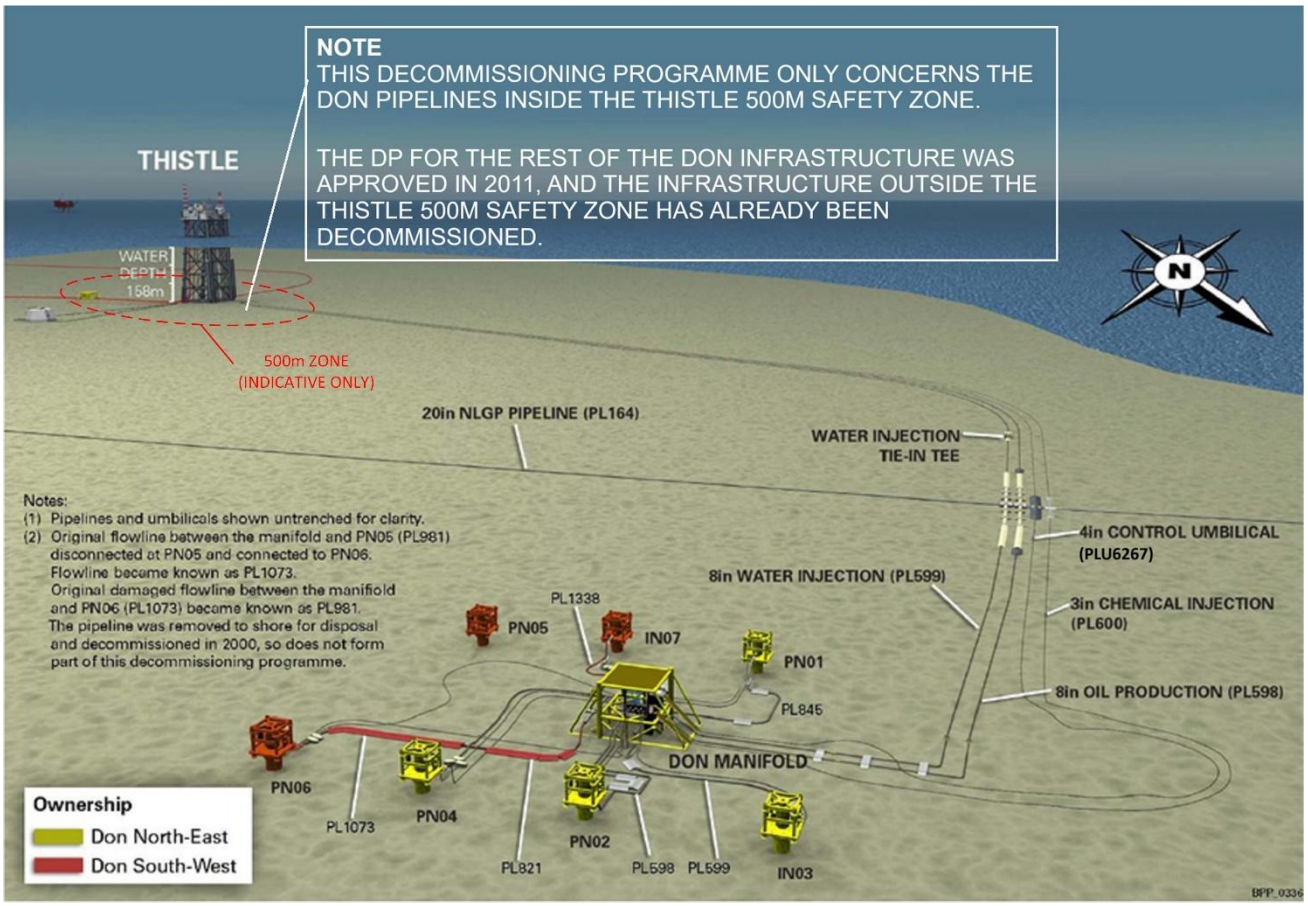


Figure 2.1.2: The Don field assets and infrastructure

The pipelines connected to the Thistle platform within the scope of this comparative assessment are as follows:

Thistle

- PL13 16in CWC oil export pipeline to Dunlin.12.69 km long.
- PL4555 8in oil export pipeline to Wye structure, 10.26 km long. This pipeline continues as PL4556 to Magnus, 23.75 km long.

As PL74 and PL75 (both 16in CWC, ~2.4 km long) are laid on the surface of the seabed and not trenched, they will be completely removed in accordance with mandatory requirements. Therefore, they are not subject to a comparative assessment.

PL13, PL74 and PL75 are logged in the Interim Pipeline Regime and are subject to Disused Pipeline Notifications. PL2579 is piggybacked to PL4555 and was included in the DP for DSW and WD which was approved in August 2021 [1].

Don

- PL598, 8in oil production pipeline inside Thistle 500 m zone, 567 m long.
- PL599 8in water injection pipeline inside Thistle 500 m zone, 570 m long.
- PL600 70mm chemical injection umbilical inside Thistle 500 m zone, 560 m long.
- PLU6267 88mm control & monitoring umbilical inside Thistle 500 m zone, 539 m long.

2.2 Purpose

Pipelines associated with Thistle, Don South-West ('DSW') and West Don ('WD') fields, Northern Leg Gas Pipeline ('NGLP') and Don field are connected to the Thistle installation. Out of these, excluding the risers and excluding PL74 and PL75, the Thistle and Don pipelines are subject to the comparative assessment presented in this report. All the pipelines are out of use. The Don pipelines have been included at the request of the Thistle and Don operators with agreement from OPRED.

The Don pipelines have already been subject to a comparative assessment, and theoretically the assessment would apply to the whole of the pipelines from the Don manifold to the Thistle platform. In the Don DP, the assessment is described as applying to the "pipelines and umbilicals between the Don field and Thistle". As a separate DP is prepared for the Don infrastructure inside the 500 m zone, it is appropriate to provide an overview of the original comparative assessment and explore whether there are any aspects specific to the infrastructure inside the Thistle 500 m zone that would change the original recommendation.

Following public, stakeholder and regulatory consultation, the Thistle [6] and separate Don [2] pipeline DPs will each be submitted in full compliance with the OPRED guidance notes [12]. As per the guidance notes, pipeline decommissioning options require to be comparatively assessed. If the condition of the mattresses or grout bags precludes their safe or efficient removal, then any proposal to leave them in place must also be supported by an appropriate comparative assessment of the options.

The DP(s) explain the principles of the removal activities and is supported by an Environmental Appraisal [7] and this Comparative Assessment.

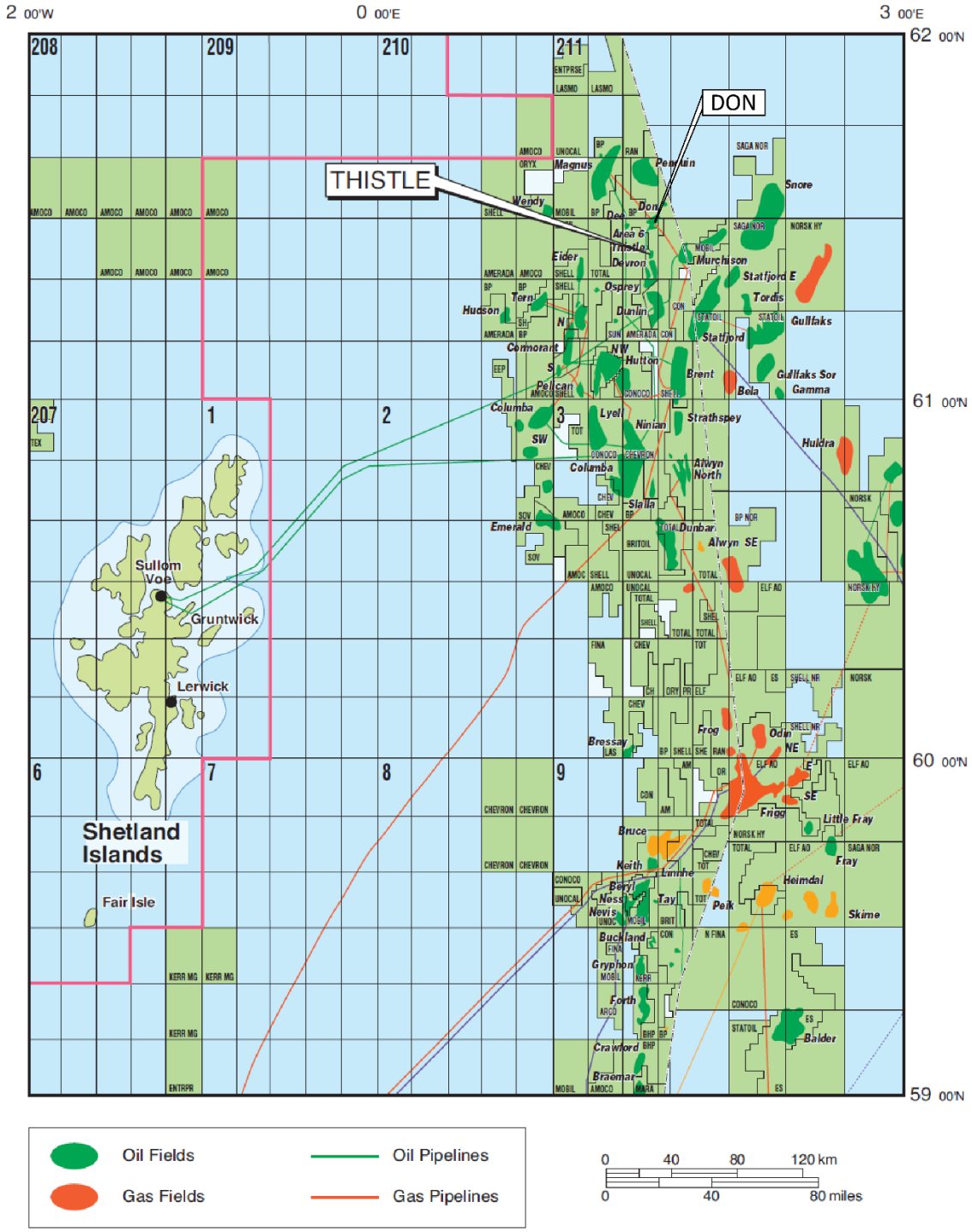


Figure 2.2.1: Locality of Thistle and Don within wider North Sea area

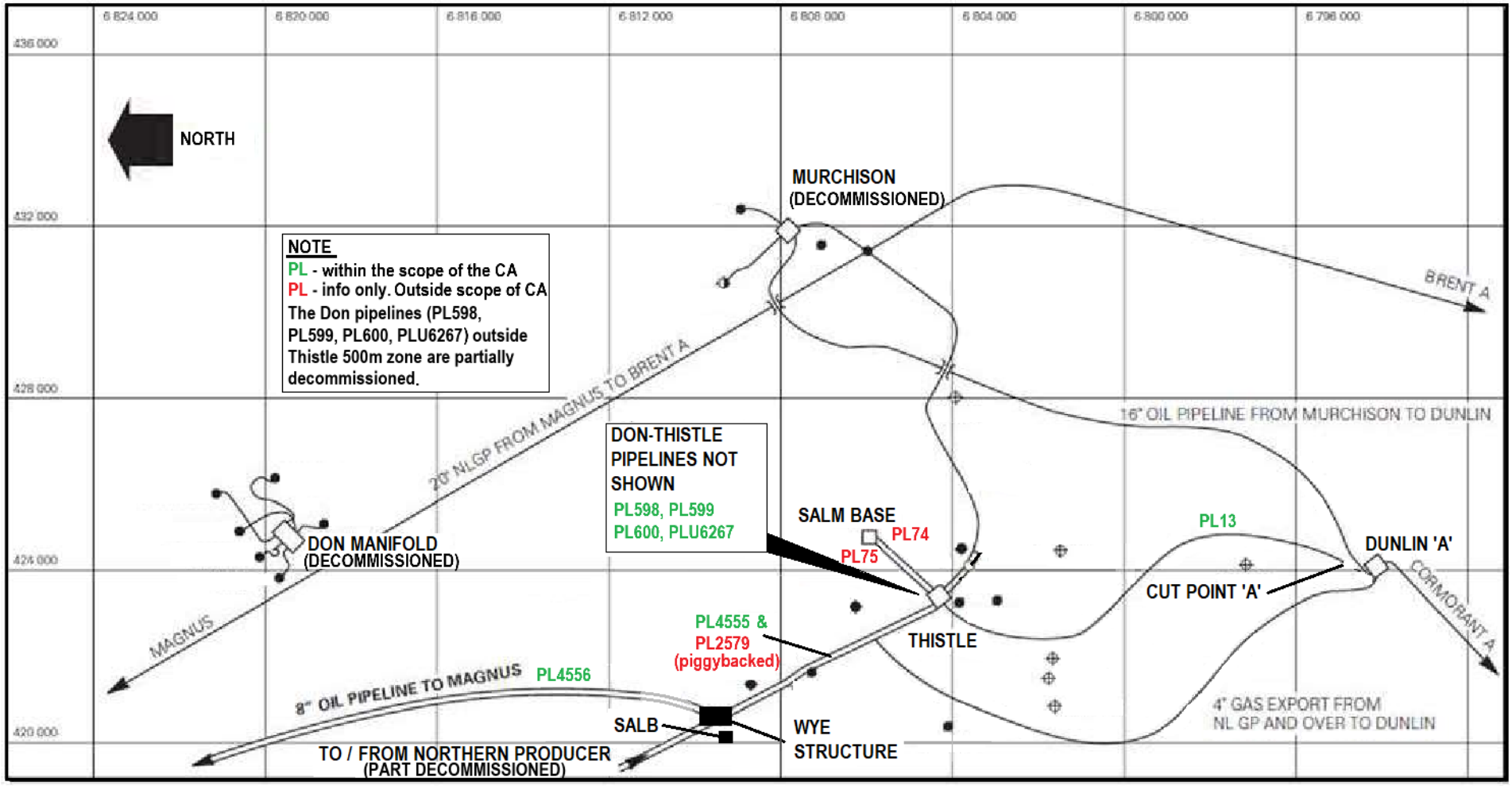


Figure 2.2.2: Locality of Thistle & Don in relation to other assets and infrastructure[4]

[4] Murchison, Don manifold, Northern Producer, PL2852, have all been decommissioned and Dunlin 'A' and SALB will be decommissioned in due course.

3. ENVIRONMENTAL SETTING

3.1 Bathymetry and seabed features

The Thistle installation and its 500 m zone is situated in block 211/18a of the UKCS and operated by EnQuest. The Thistle field is located ~201km North-East of Shetland. The local area was subject to an Environmental Baseline Survey in 2021 [9].

The general water depth within the survey area ranged from 151.8 m in the southeast to 169 m in the northwest with a natural slope of 0.06°. A drill cuttings pile can be found within the Thistle area with two distinct piles which merge in the centre present at the north and southwestern platform legs with bathymetric highs of 6.2 m and 8.6 m respectively. The locations of the pipelines are such that they are not affected by the presence of the drill cuttings.

The side-scan sonar data obtained in the survey indicated medium reflectivity across most of the sampling area relating to the ambient muddy sand sediment. Areas of higher reflectively were typically associated with areas close to the platform which corresponded to the mixed sediment present consisting of cohesive silt with drill cuttings material intermixed with coarse sediment and There are various features adjacent to the platform, including numerous anthropogenic debris (e.g., construction and fishing activities, exposed infrastructure etc.), in addition to potential pockmarks / seabed depressions. There is evidence of seabed depressions, often recorded to contain gravel and/or cobbles and were also frequently inhabited by fish, particularly ling (Molva molva). Due to the size and circular shape of these depressions, they appear to be "unit pockmarks". Methane derived authigenic carbonates ('MDAC') is often formed within larger pockmarks and can form bubbling reefs and the Annex I habitat "Submarine structures made by leaking gases". Due to the size and circular shape of these depressions, they appear to be "unit pockmarks". However, the Thistle pre-decommissioning environmental survey report [9] confirmed that no Annex 1 habitats were to be found within these depressions in the survey area.

Most of the seabed near Thistle consists of sedimentary sands with varying small contributions of fines and gravels outside of the area affected by the drill cuttings. Gravel was the least dominant proportion of the sediment across the EBS areas outside the physical limit of the Thistle cuttings pile.

3.2 Habitat sensitivities

The Thistle field and the sections of Don pipelines inside the 500 m zone lie approximately 100 km from any areas of special importance (Figure 3.2.1). The North-east Faroe-Shetland Channel Marine Protected Area ('MPA') is located approximately 110 km northwest and the Pobie Bank Reef Special Area of Conservation ('SAC') is located approximately 100 km southwest of the Thistle platform, respectively. The most likely sensitive habitats (Annex I, UK Post-2010 Biodiversity Framework and OSPAR) are biogenic reefs formed by the cold-water coral Desmophyllum pertusum or mussels (*Modiolus modiolus* or *Mytilus edulis*), cobble reefs (from glacial deposits) and carbonate mounds or structures produced from leaking gas (i.e., around active pockmarks). Please refer to [13] for an explanation of Annex I Habitats.

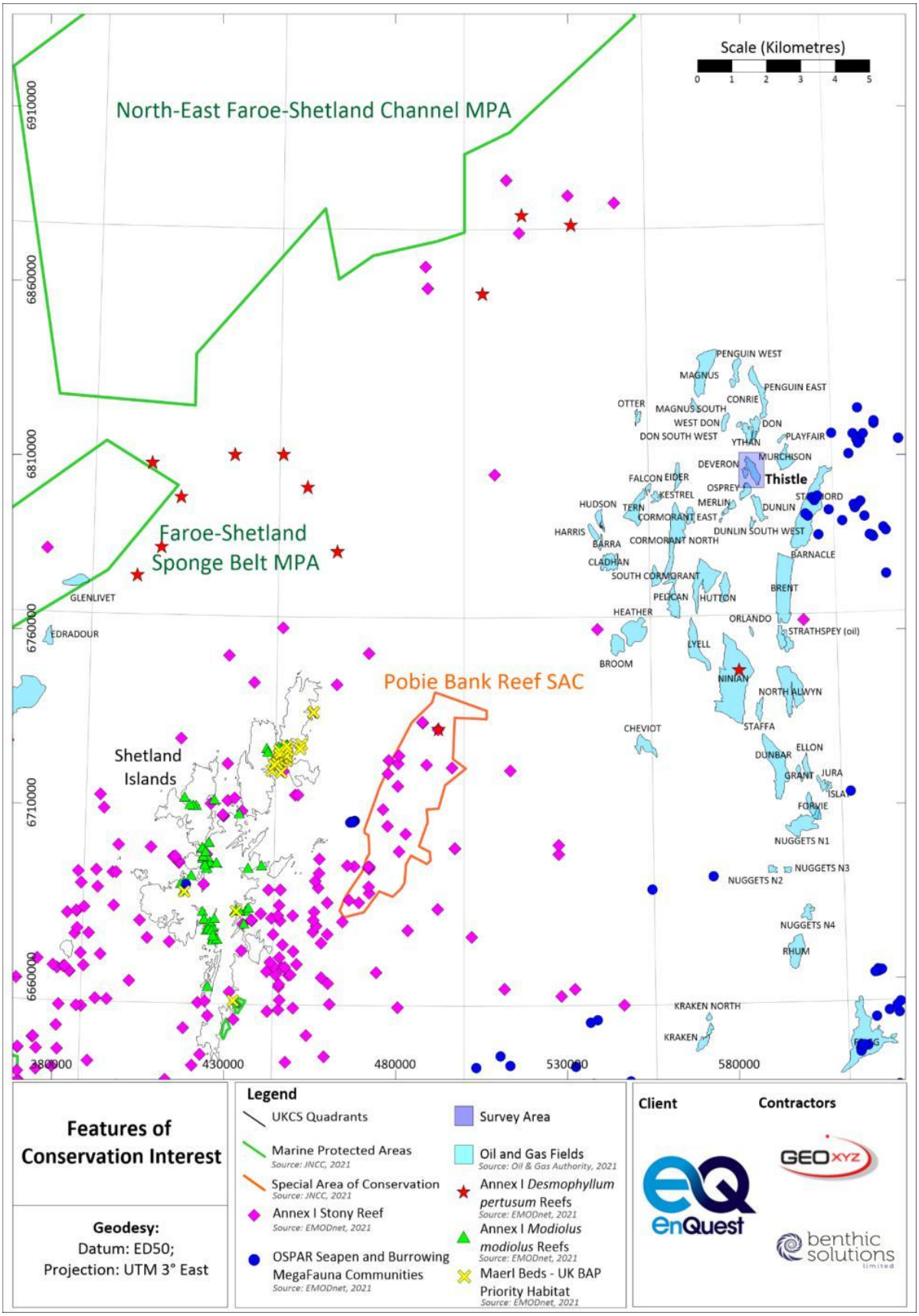


Figure 3.2.1: Features of conservation Interest in relation to Thistle

3.3 Commercial fishing

The Thistle pipelines and the Don pipelines (within the Thistle 500 m zone) are contained within International Council for the Exploration of the Seas ('ICES') rectangle 51F1 (Figure 2.2.1). An analysis of the fishing activity between 2015 and 2021 would suggest that fishing from ICES area 51F1 has contributed little to the overall UK fishing effort [11]. This is indicated in Figure 3.3.2. with demersal fishing being the dominant fishing method in terms of value Figure 3.3.2. Returns from shellfish landings from the area are so low that they don't register on the graphs, and pelagic fishing effort has most recently only registered in 2021, after several years of insufficient to be registered.

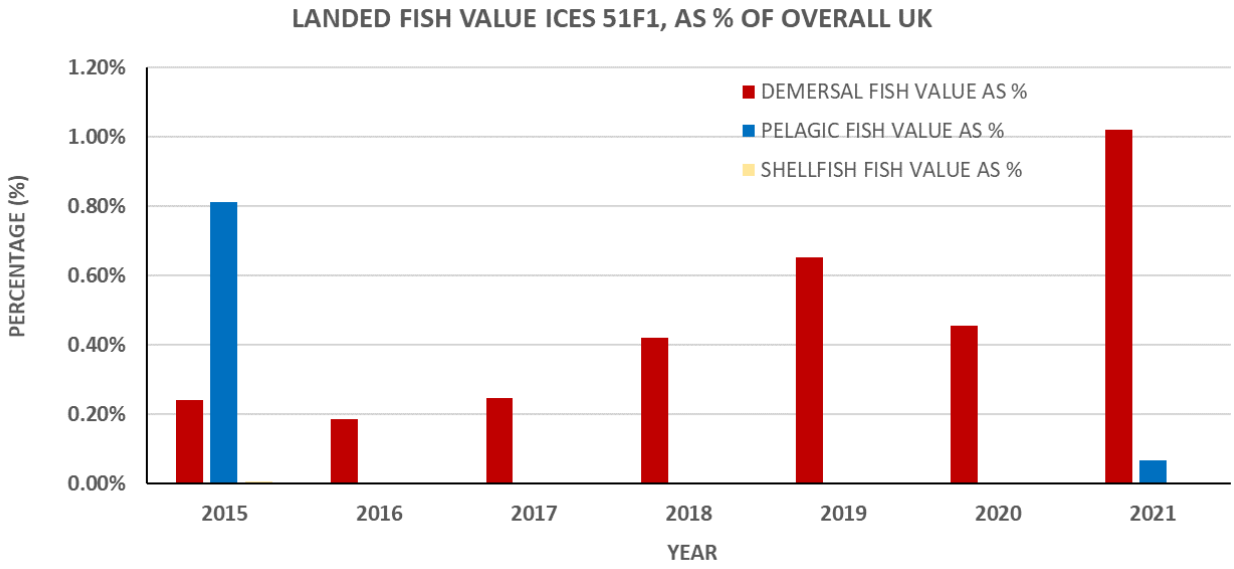


Figure 3.3.1: Value of fish landings from 51F1 as a percentage of UK fishing effort

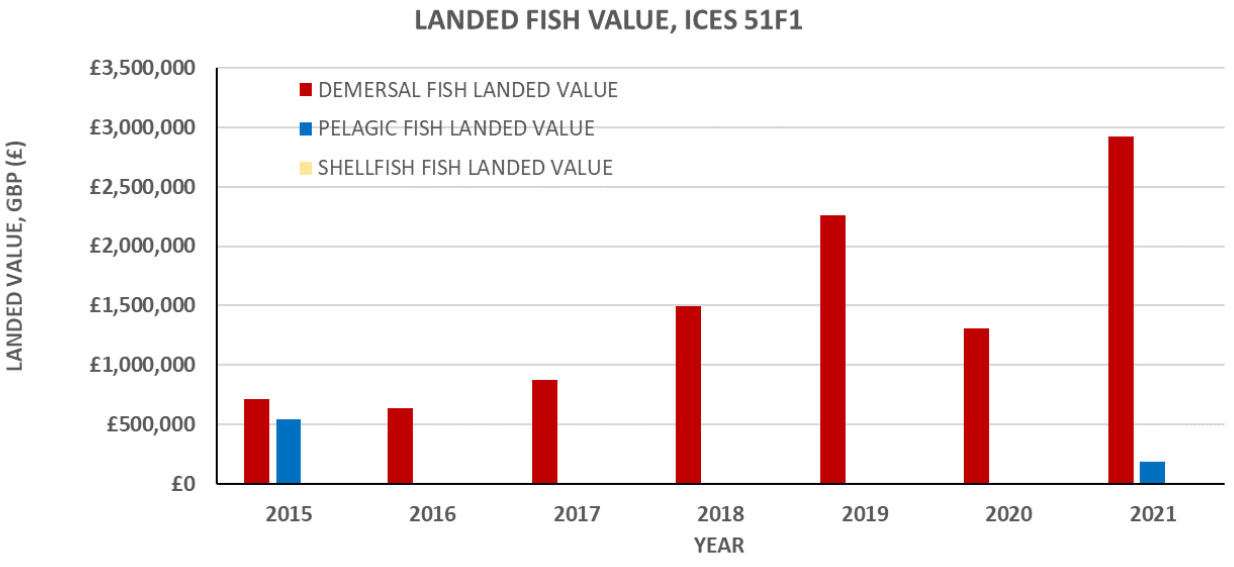


Figure 3.3.2: Value of fish landings from 51F1

Landed fish value and average landed fish value per km^2 within ICES rectangle 51F1 can be seen in the Figure 3.3.3.

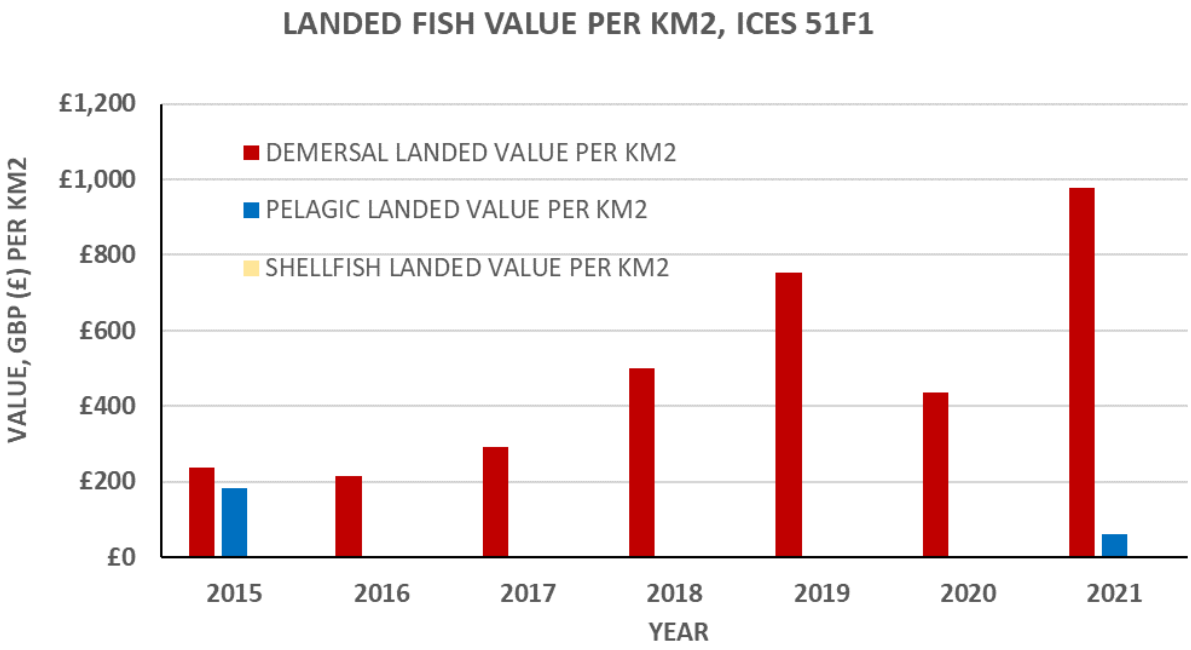


Figure 3.3.3: Value per km^2 for fish landed from ICES 51F1

The foregoing indicates that the area is not significantly important to commercial fisheries, and this is consistently reflected in data from the past seven years up to 2021.

In the years between 2015 and 2021 the maximum value of demersal, pelagic and shellfish landed per km^2 per annum from ICES Rectangle 51F1 was £977.37 (2021), £181.56 (2015) and £4.32 (2019) respectively. This is calculated by dividing the commercial value of fish landed by the area of ICES Rectangle 51F1 (2,991 km^2). The figures indicate a modest increase in the overall value of fishing in the area.

3.4 Other commercial activity

Although the North Sea has substantial traffic of commercial ships trading between North Sea and Baltic ports, the density of shipping in the Thistle area is low, with approximately 0.2 – 0.5 vessels passing each week.

Other commercial activities in the area are related to several oil and gas installations but there is no offshore renewable related activity in the area.

3.5 Pipeline stabilisation and protection features

3.5.1 Deposited rock

An examination of the Thistle and Don related documentation suggests that apart from providing protection and stability at some pipeline crossings, rock has only been used to protect and stabilise PL4555 and PL4556. The presence of rock or otherwise is explained in section 3.5.1 below.

Material that is left in place will preserve the marine habitat that will have established over the time it has been on the seabed, and in this case its presence will not have a negative impact on the environment, nor impact on the safety of other users of the sea.

Methods that could be used to remove the rock include:

- dredging the rock and disposing of the material at an approved offshore location.
- dredging the rock and transporting the material to shore to be disposed of in an appropriate manner.
- lifting the rock using a grab vessel, depositing in a hopper barge, and transporting it to shore for appropriate disposal.
- Dispersal of the rock (but not recovery) using a Mass Flow Excavator ('MFE').

All these proposed methods would impact on the seabed and associated communities, create sediment plumes, and require additional vessel use with the associated environmental impacts, safety risks, impacts on other users of the sea and additional costs.

While it is considered physically possible to remove deposited rock, the decommissioning philosophy in this document is consistent with the guidance notes [12], with all deposited rock being left *in situ*.

Any rock deposited associated with third-party pipeline crossings is out of scope.

There is no rock associated with the Don pipelines inside the Thistle 500 m zone.

3.5.2 Concrete mattresses

There are some concrete mattresses associated with PL4555 and PL4556, but otherwise concrete mattresses have been used sparingly. Some were used on PL13 on the approach to Dunlin, but these have been removed. Mattresses that have been used are typically 6m x 2m x 0.15m or 6m x 3m x 0.15m. According to the survey data, grout mattresses that might have been used for remediation of spans are approximately half these sizes. The location of mattresses as found in the Thistle pipeline surveys is recorded in Table B.1.1 in Appendix B, although spuriously there are no data for 2014 (Figure 3.5.1).

Figure 3.5.1: Examples of grout mattresses used for remediation (2014)

Those concrete mattresses that are found to be exposed will be recovered while those grout mattresses[5] that are buried and/or used to support the pipeline as part of span remedial works (e.g., Figure 3.5.1) will be left *in situ*. The locations and condition of each of the concrete mattresses and proposals for decommissioning are detailed in the Thistle pipeline DP [6]. Please also refer to the schematics in Appendix D.

[5] A grout mattress may be described as a mattress shell or external fabric that has been injected with grout *in situ*. These are typically used to provide an intermediate support to the pipeline and reduce the length of a span.

There are no concrete mattresses associated with the Don pipelines inside the Thistle 500 m zone.

3.5.3 Sand and grout bags

Some sand or grout bags have been used in and around the Wye structure for PL4555 or PL4556 but otherwise few are recorded in the 'as built' data. The quantities noted in the Thistle pipeline Decommissioning Programme [6] has been estimated using engineering judgement based on drawings and design sketches.

The intention will be to completely remove all the sand or grout bags when decommissioning the pipelines. Although several different methods could be used to remove the sand and cement bags, from a practical perspective it is not known whether the bag material has remained intact.

An examination of the Don related documentation suggests that apart from an unspecified number of sand or grout bags associated with PL598 between KP0.011 and KP0.013 (Figure E.2.1) there are no protection and stabilisation features associated with the Don pipelines.

The intention will be to completely remove all the sand or grout bags when decommissioning the pipelines.

3.6 Assumptions, limitations, and gaps in Knowledge

The most significant assumptions, limitations and knowledge gaps relating to the comparative assessment are listed below. In addition, it should be noted that the presentation of the different categories of risks for comparison has required a degree of engineering judgement, which includes the following technical assumptions:

- Technically, removal of PL13 and PL4555 (along with piggybacked PL2579) could be achieved using the 'cut and lift' method, assuming that any overlying sediment could be excavated or displaced to allow access.
- Technically, removal of PL598, PL599 within the Thistle 500 m zone could be achieved. Given the age of the pipelines the most likely method of removal would be 'cut and lift', although if their technical integrity could be assured it is possible that they could be removed using reverse reel, with the 'cut and lift' method being adopted as a contingency measure. Using reverse reel assuming that the overlying sediment or deposited rock could be displaced to allow the pipeline(s) to be pulled from the trench.
- Technically, removal of PL4556 could be achieved using reverse reel assuming that the overlying sediment or deposited rock could be displaced to allow the pipeline(s) to be pulled from the trench.
- Technically, removal of PL600 and PLU6267 inside the Thistle 500 m zone could be achieved using reverse reel assuming that the overlying sediment could be displaced to allow the umbilical(s) to be pulled from the trench.
- Any third-party pipeline crossings discussed in this comparative assessment would be left undisturbed as they are out of scope.
- Historical survey data would indicate that snagged fishing equipment has been found on PL13. On the rare occasions that reportable spans associated with PL13 have been found, they have been recorded as a snagging hazard via Kingfisher Information Services on FishSAFE (www.fishsafe.eu).
- Historical survey data would indicate that if PL598, PL599 (except for a short exposed section), PL600 and PLU6267 remain buried they would not pose a snagging hazard. The short exposed section in PL599 will be assessed when decommissioning activities are carried out.

The following legacy assumptions have also been made:

- An environmental survey would be required on completion of decommissioning activities irrespective of the decommissioning option implemented so this element is not a differentiator.
- Any pipeline being left *in situ* would be subject to at least three legacy burial surveys.
- The seabed sediment type is such that any spoil heaps created during any decommissioning operations would not present significant snagging hazards.
- In the long term, the deposition of rock over exposed sections or severed pipeline ends would not present snagging hazards.
- The impact of the procuring any new materials such as fabricated items or mining of new rock is ignored.
- Impact on commercial activities is inversely proportional to vessel activity.
- Societal benefits and vessel associated environmental impacts and risks are assumed to be proportional to vessel duration.
- Only a high-level comparison of what differentiates the costs is used.

4. THE PIPELINES

4.1 Overview

As part of the installation process, PL13 was laid in a trench which was left to backfill naturally and PL4555 and PL4556 were trenched with the trench mechanically backfilled. Rock was used to stabilise and protect parts of PL4555 and PL4556. PL4555 is piggybacked with PL2579.

Description	Route	Burial	Length
PL13 16in CWC PL	Thistle to cut point 'A' in Dunlin 500m zone	Trenched, left to backfill naturally	12.69 km
PL4555 8in PL	Thistle ESDV to Wye structure	Riser suspended in seawater. Trenched and buried, concrete mattresses on ends	10.56 km
PL4556 8in PL	Wye structure to ESDV on Magnus	Trenched and buried, concrete mattresses on ends.	23.75 km
NOTE 1. PL4555 is piggybacked with PL2579, the decommissioning of which is dealt with in the Decommissioning Programmes for Conrie, DSW, WD and Ythan [1], approved August 2021.			

Table 4.1.1: Thistle pipeline summary

Description	Route	Burial	Length
PL598 8in pipeline	Limit of Thistle 500 m zone to riser caisson 930 on Thistle	Trenched and buried. Surface laid end at Thistle.	0.57 km (17.44 km)
PL599 8in pipeline		Trenched and buried except for 18 m long exposure (including 2.5 m long span) at KP0.427 Surface laid end at Thistle.	0.57 km (17.34 km)
PL600 88mm umbilical	Riser caisson 930 to limit of Thistle 500 m zone	Trenched and buried. Surface laid end at Thistle.	0.56 km (17.73 km)
PLU6267 70mm umbilical			0.54 km (17.73 km)
NOTE 1. The lengths in brackets are the full lengths of pipelines quoted in the Don DP [1] with the pipelines being routed between the Thistle platform and the Don manifold. These lengths were used in the original comparative assessment included in the Don DP. 2. The 2.5 m long span was not reportable to FishSAFE.			

Table 4.1.2: Don pipeline summary

4.2 Thistle pipelines

4.2.1 PL13 16in oil export pipeline (Thistle to cut end in Dunlin 500m zone)

PL13 is a 16in carbon steel pipeline ~12.69 km long coated with 4.8 mm coat tar epoxy enamel ('CTEE') and furnished with a CWC 36.6 mm. In 2019 as part of the DFGI project works part of the pipeline – a section 85.1m long between cut point 'A' and cut point 'B' was removed near the Dunlin platform. The pipeline is now routed to cut point 'A' in the Dunlin 500m safety zone where it effectively terminates. It used to be crossed by PL2852 a pipeline installed as part of the DFGI project but the section crossing over PL13 having been removed. Although there are drill cuttings at the Thistle platform, PL13 has been found to be exposed next to the Lockheed Chamber at the base of the riser and is therefore not affected by the presence of the drill cuttings. On installation the pipeline was trenched, but the trench was not backfilled.

Over the years the pipeline has been extensively surveyed to maintain its operational integrity and to ensure that it remains in a safe condition. Burial profiles and routing plots are presented for 2008, 2010, 2014, 2016 and 2018 in Figure 4.2.5 to Figure 4.2.17 below. For completeness a seabed and pipeline profile is presented in Figure 4.2.15 for the 2018 survey. The presence of grout mattresses underneath the pipeline in areas populated by multiple spans would suggest that remedial works have been carried out in the past. The CWC suffers from degradation in some areas (Figure 4.2.1), and there is historical evidence of snagged of fishing nets.

Figure 4.2.1: PL13 examples of degraded CWC (2014)

Figure 4.2.2: PL13 snagged fishing nets (2014)

Exposure and span analysis

The burial profiles all show that the pipeline has experienced multiple exposures and spans along much of its length. A summary of the historical data obtained is presented in Table 4.2.1 with more detail - including span lengths and heights, in Table A.1.1 in Appendix A. Since the 2016 survey, about one-third of the pipeline remains exposed, and the number and cumulative length of pipeline spans appear to have increased. Overall, the exposures have been observed throughout the whole length of the pipeline and not in a particular area, and this would make the wholesale

remediation of individual exposures problematic to achieve without dealing with the whole pipeline. Spans appear to mostly occur between KP10.5 and the end of the pipeline in the Dunlin 'A' 500m zone. The data would suggest that without some form of remediation the exposures or spans will not disappear naturally once the pipeline has been decommissioned.

Year	Length surveyed (km)	No. of exposures	∑ Length (m)	Min. exp. length (m)	Max. exp. length (m)	No. of spans	∑ Length (m)	Min. span length (m)	Max. span length (m)
2008	12.234	261	1.215	0.2	30.0	52 (0)	352.8	1.2	15.0
2010	12.232	172	4,689	0.6	775.7	13 (0)	141.0	5.2	18.7
2012	12.232	165	4,468	0.1	696.0	10 (0)	75.0	5.1	12.6
2014	*0.739*	*2*	*720*	*205.5*	*514.4*	*1*	*12.3*	*12.3*	*12.3*
2016	11.069	140	3,265	1.1	700.9	23 (4)	210.4	1.1	28.0
2018	11.635	150	3,645	0.1	697.9	66 (5)	358.0 (78.1)	0.9	25.3

NOTES

1. The exposure data for 2008 are calculated, using the depth of cover profile obtained during the pipeline survey. No length of exposure or length of span data are recorded in the event listings.
2. Only part of the pipeline was surveyed in 2014 from the Dunlin riser flange to outside the Dunlin 500m zone, noting that this was before implementation of the DFGI project and the installation of PL2852.
3. Figure in brackets under "No. of SPANS" is the number of *reportable* spans noted from an examination of the events listings.

Table 4.2.1: PL13 historical exposure and span summary

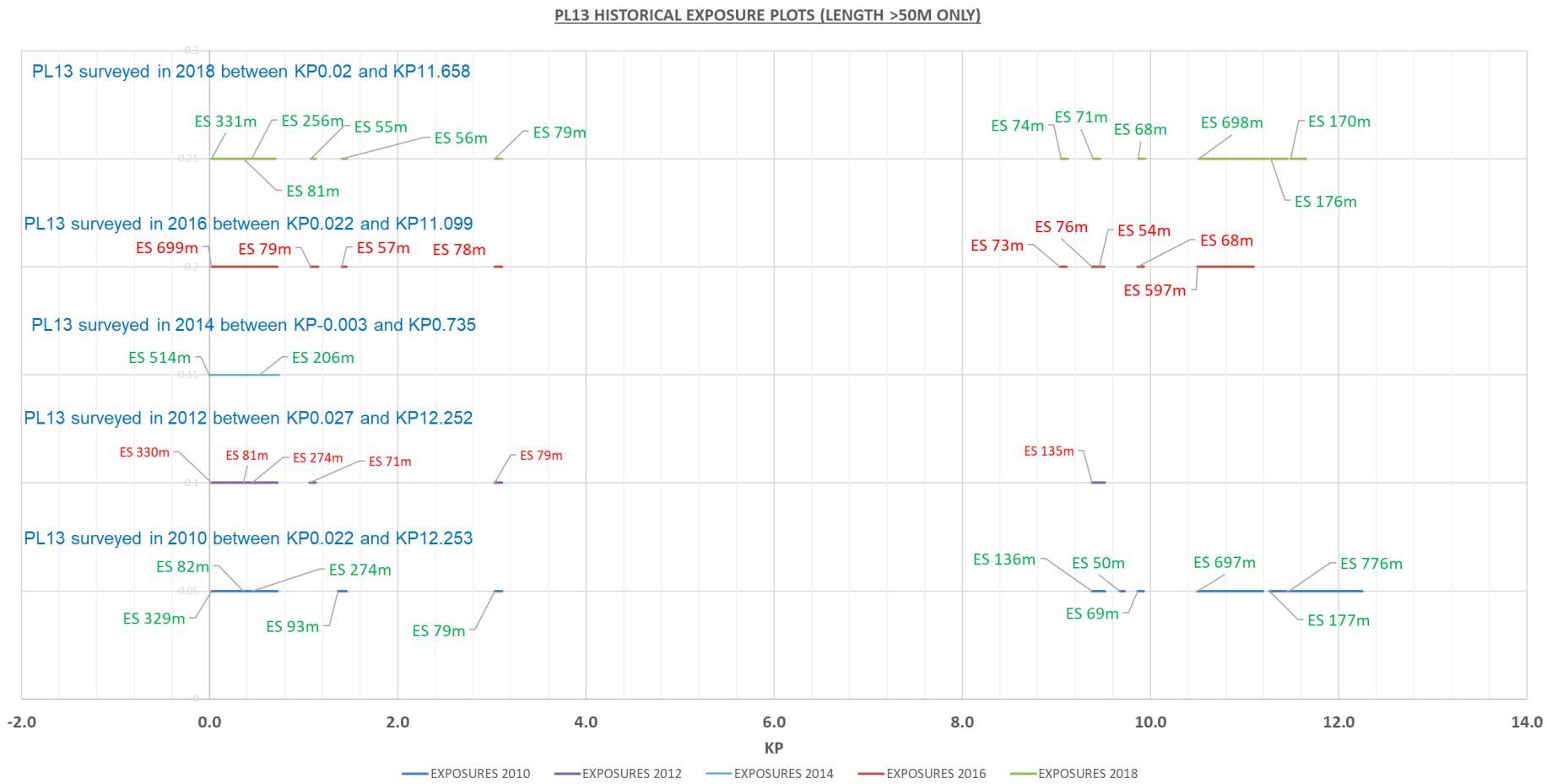


Figure 4.2.3: PL13 comparison of historical exposures (>50m long, 2010 to 2018)

Figure 4.2.4: PL13 comparison of historical spans (>10m long, 2010 to 2018)

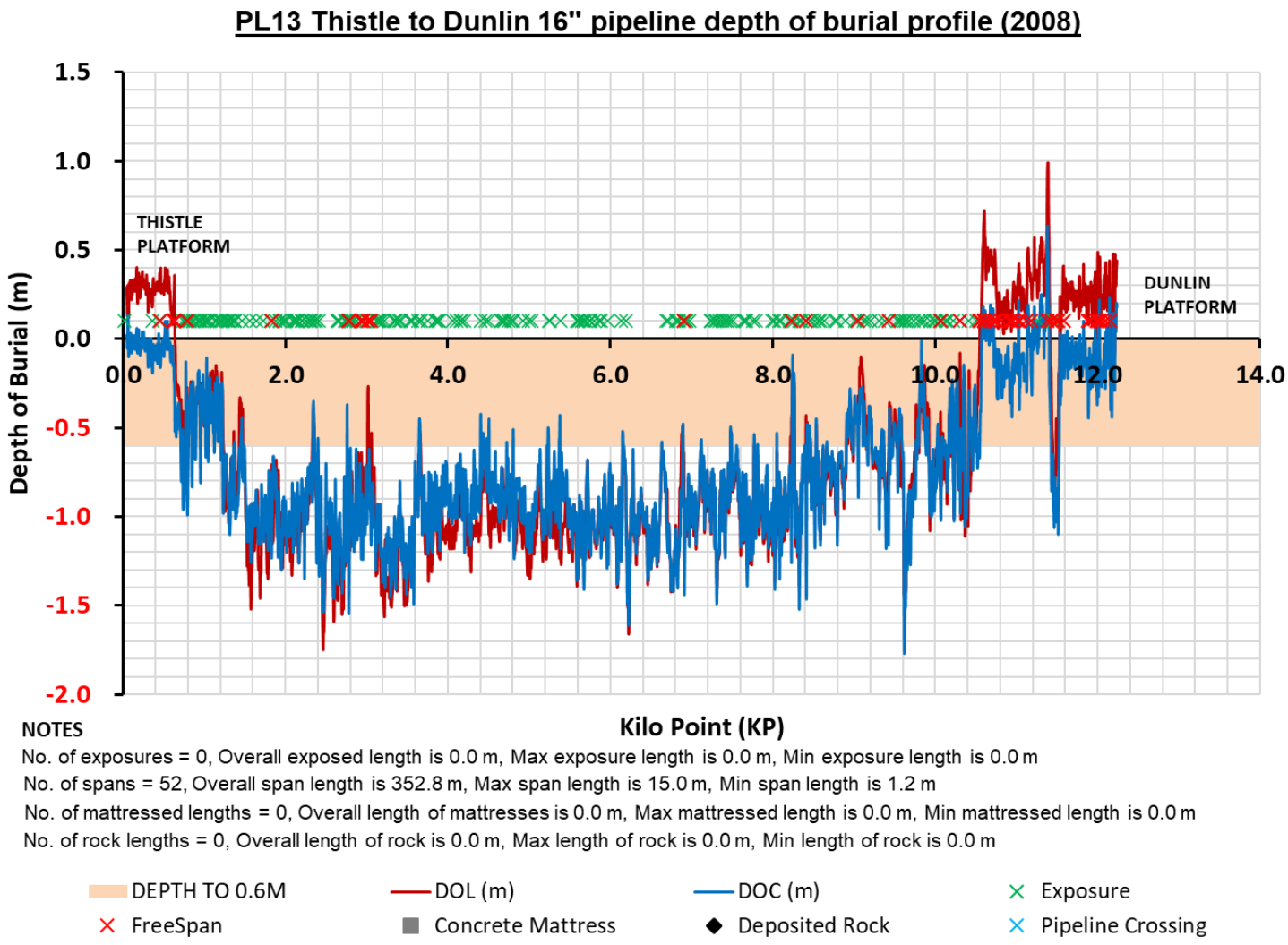


Figure 4.2.5: PL13 pipeline depth of burial profile (2008)

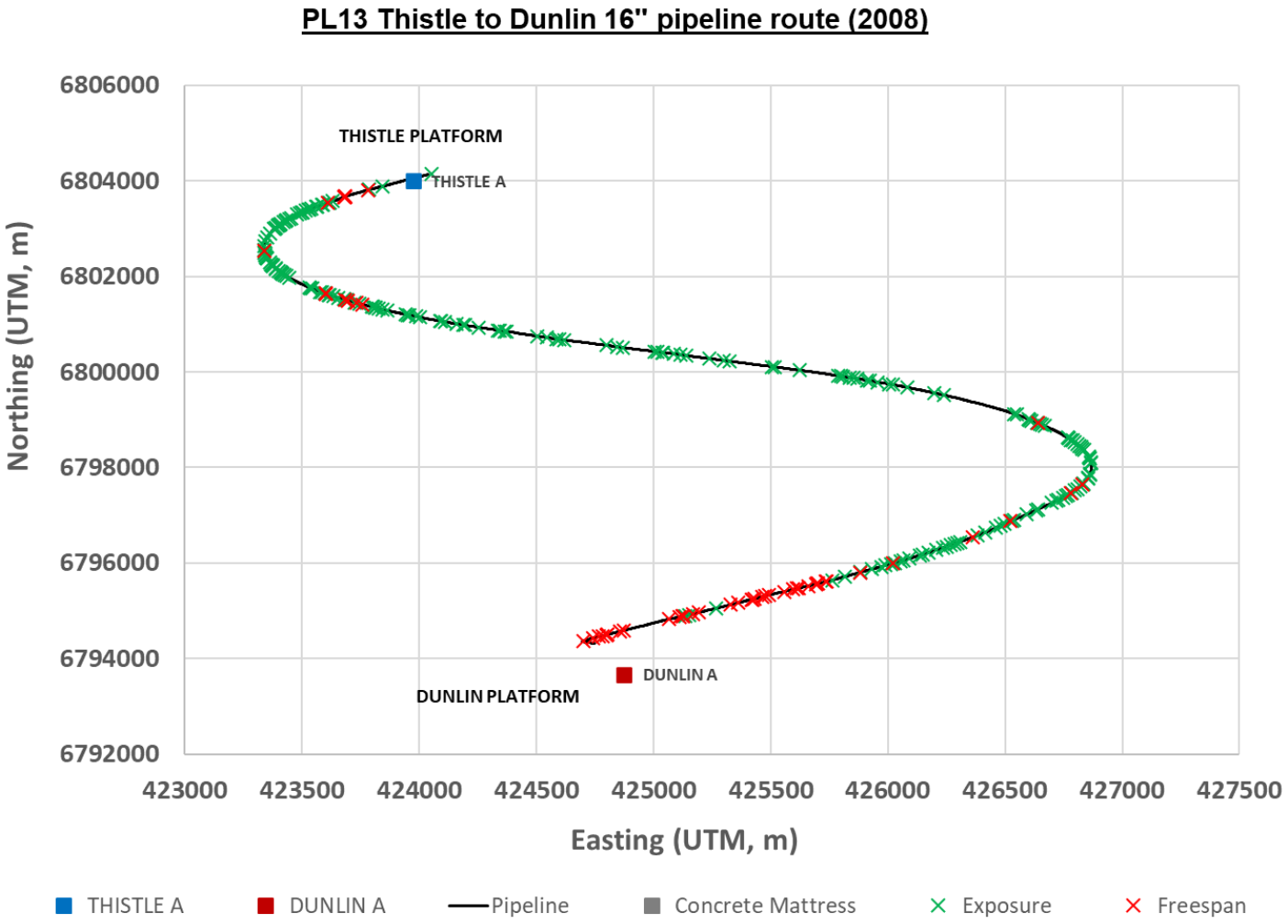


Figure 4.2.6: PL13 pipeline route (2008)

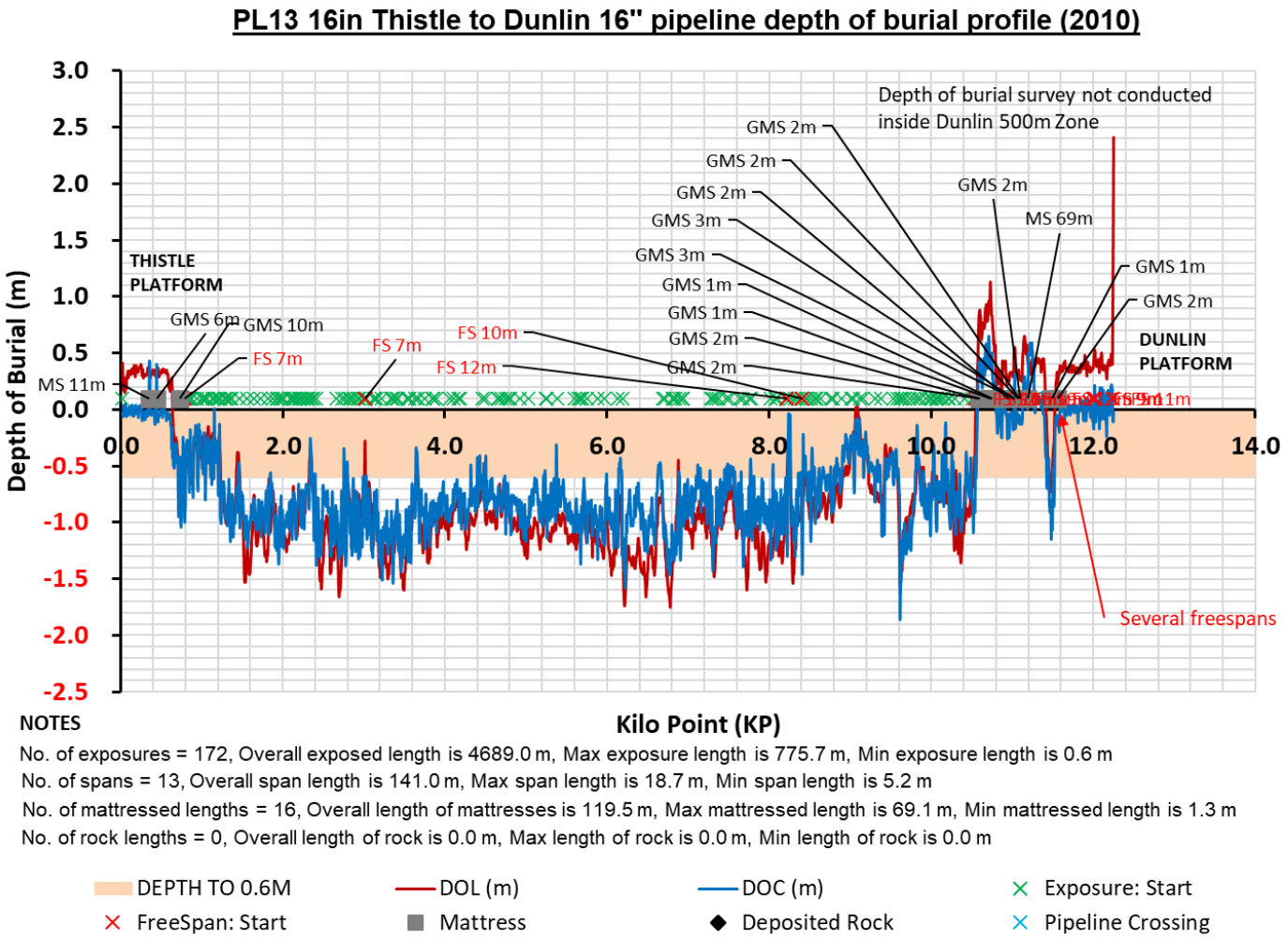


Figure 4.2.7: PL13 pipeline depth of burial profile (2010)

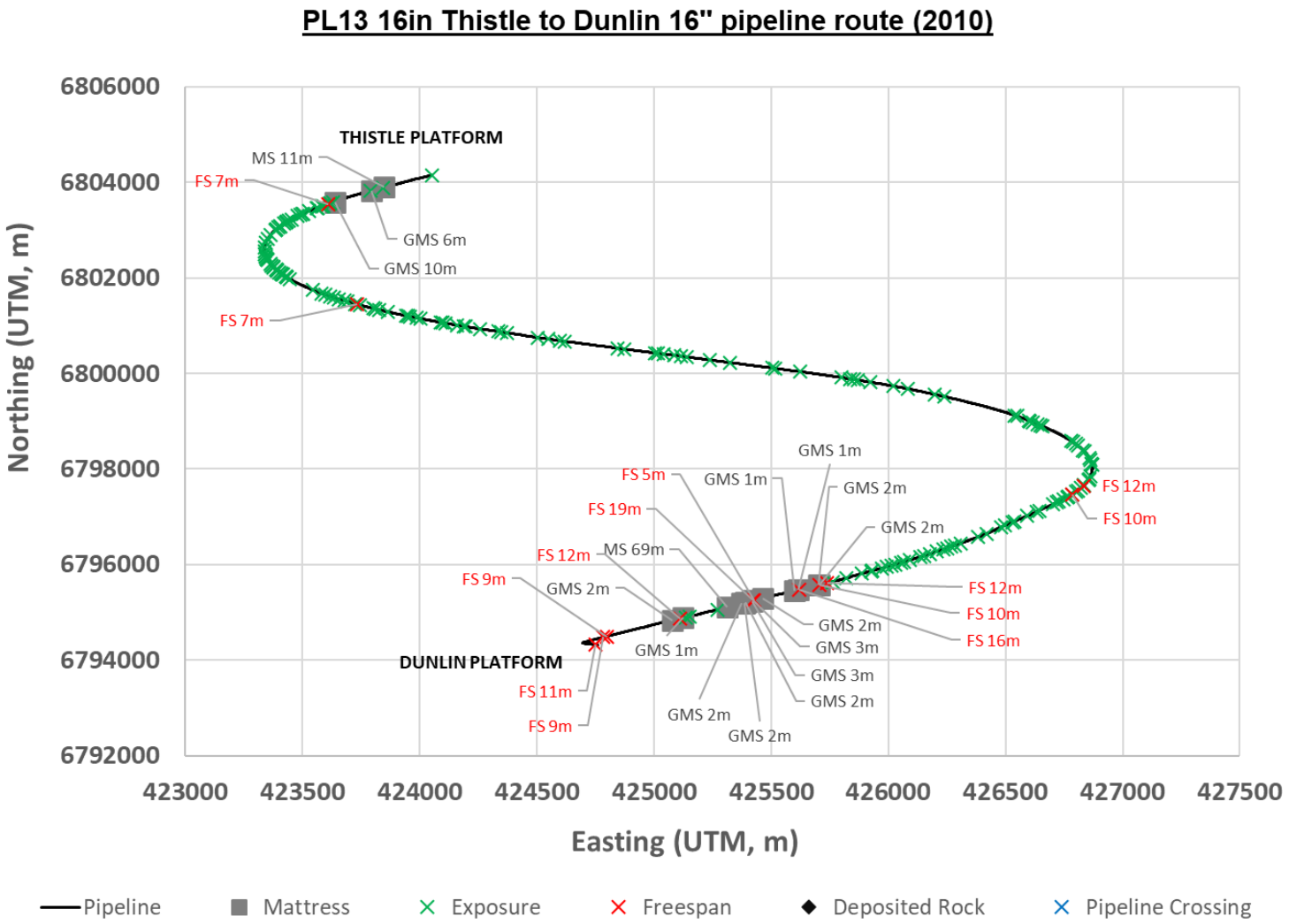


Figure 4.2.8: PL13 pipeline route (2010)

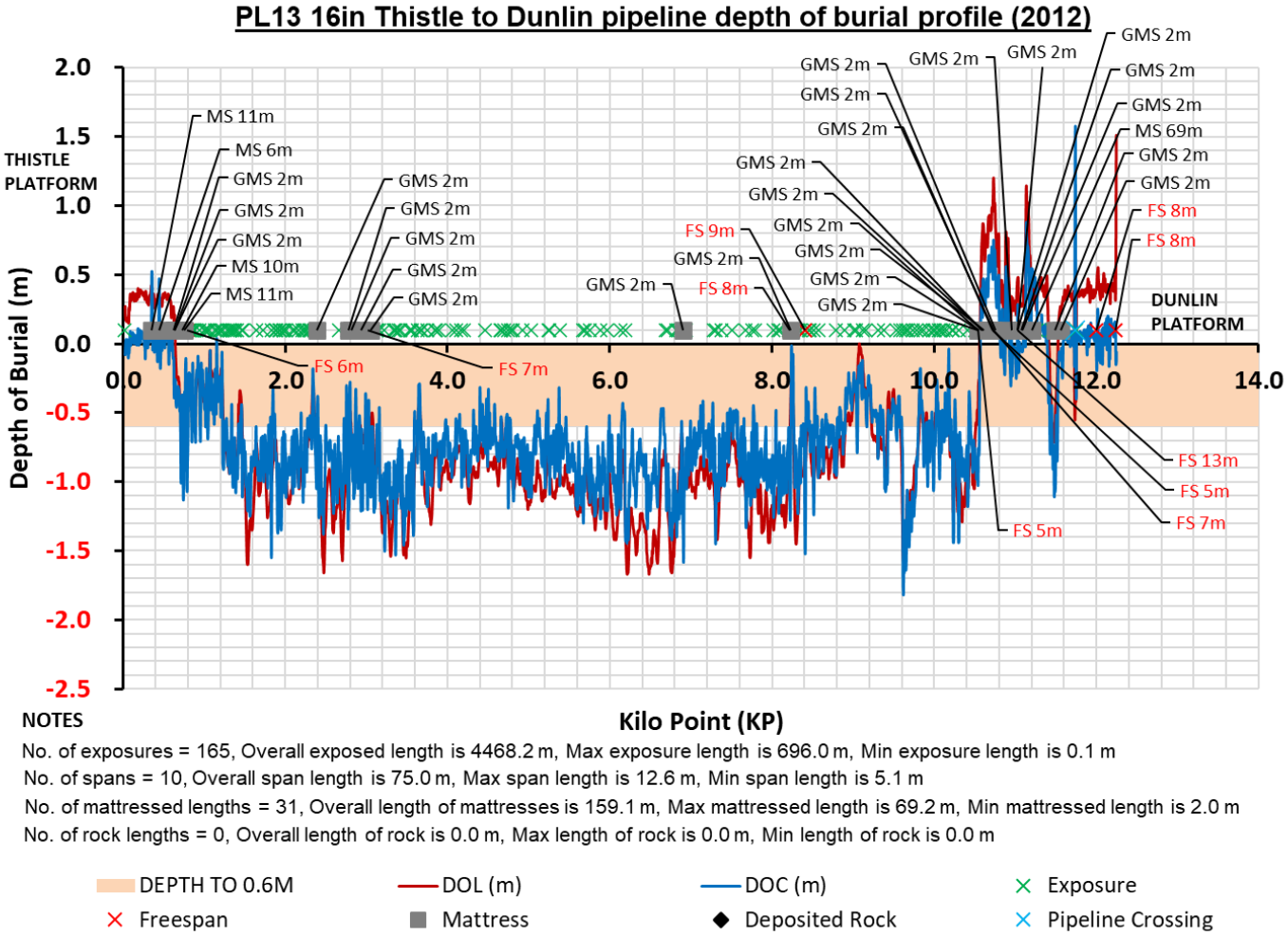


Figure 4.2.9: PL13 pipeline depth of burial profile (2012)[6]

[6] Length (or width) of grout mattresses indicative only; not stated within survey data.

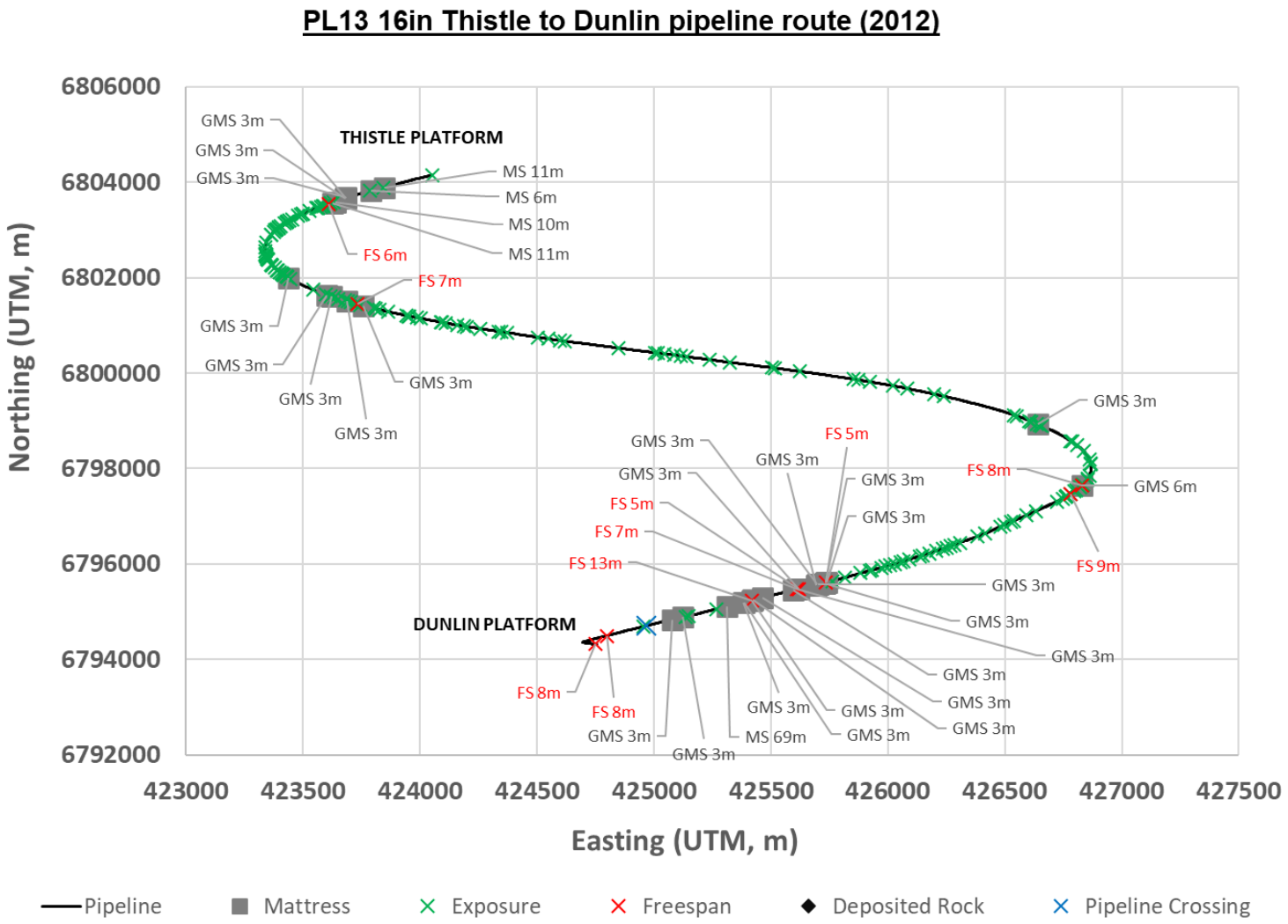


Figure 4.2.10: PL13 pipeline route (2012)

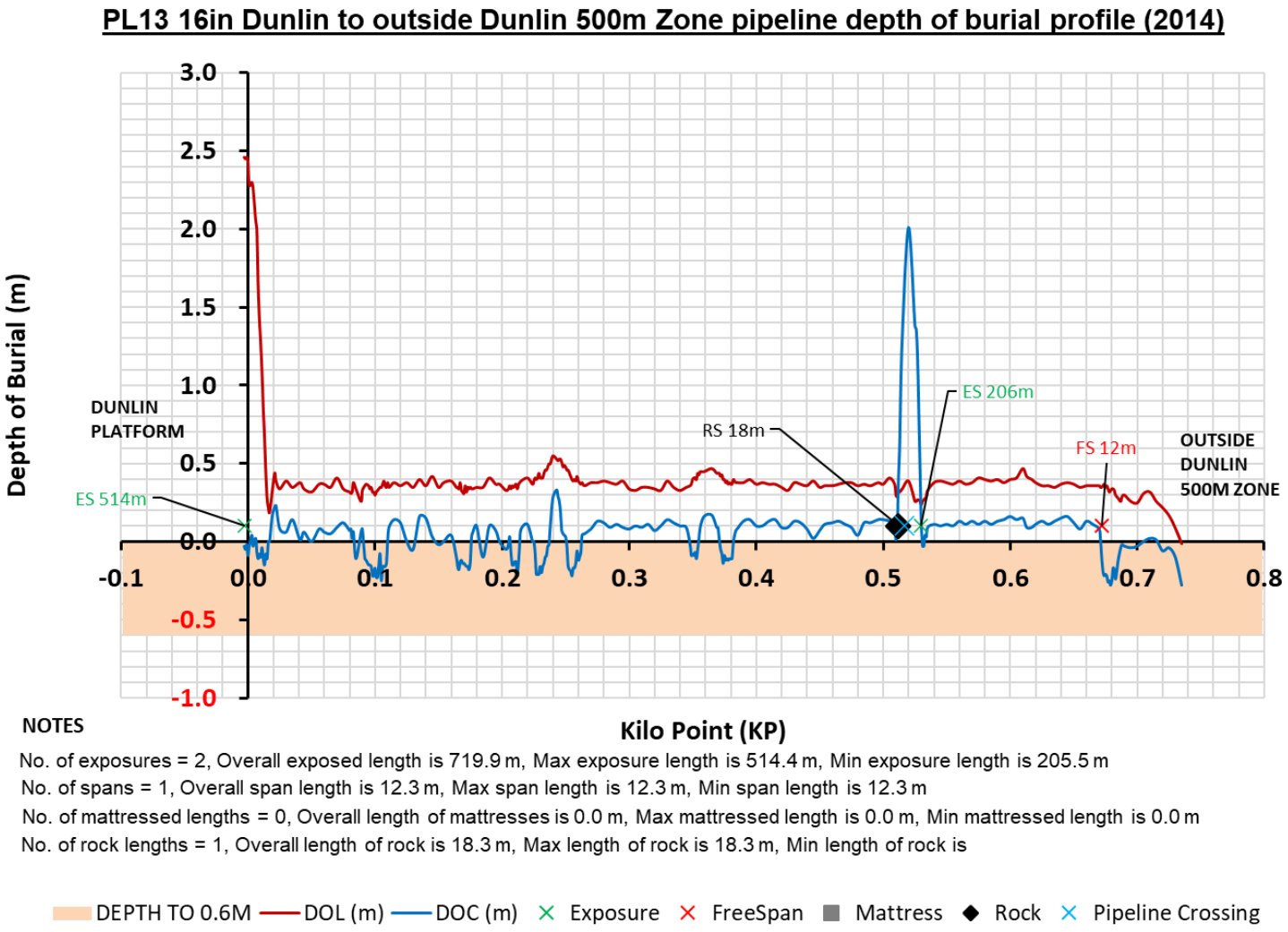


Figure 4.2.11: PL13 pipeline depth of burial profile (2014)

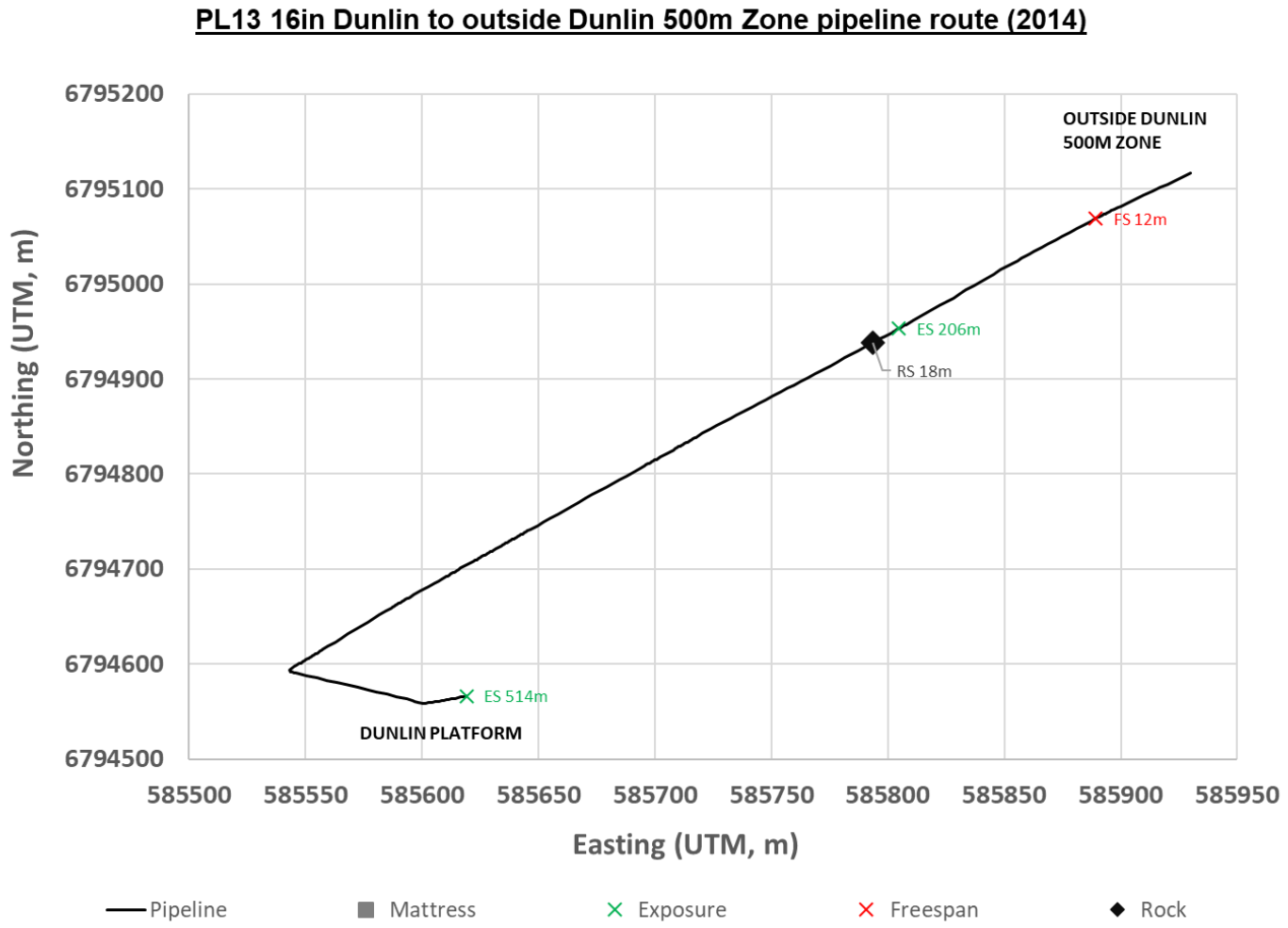


Figure 4.2.12: PL13 pipeline route (2014)[7]

[7] The Eastings and Northings data recorded in the original pipeline survey appear spurious.

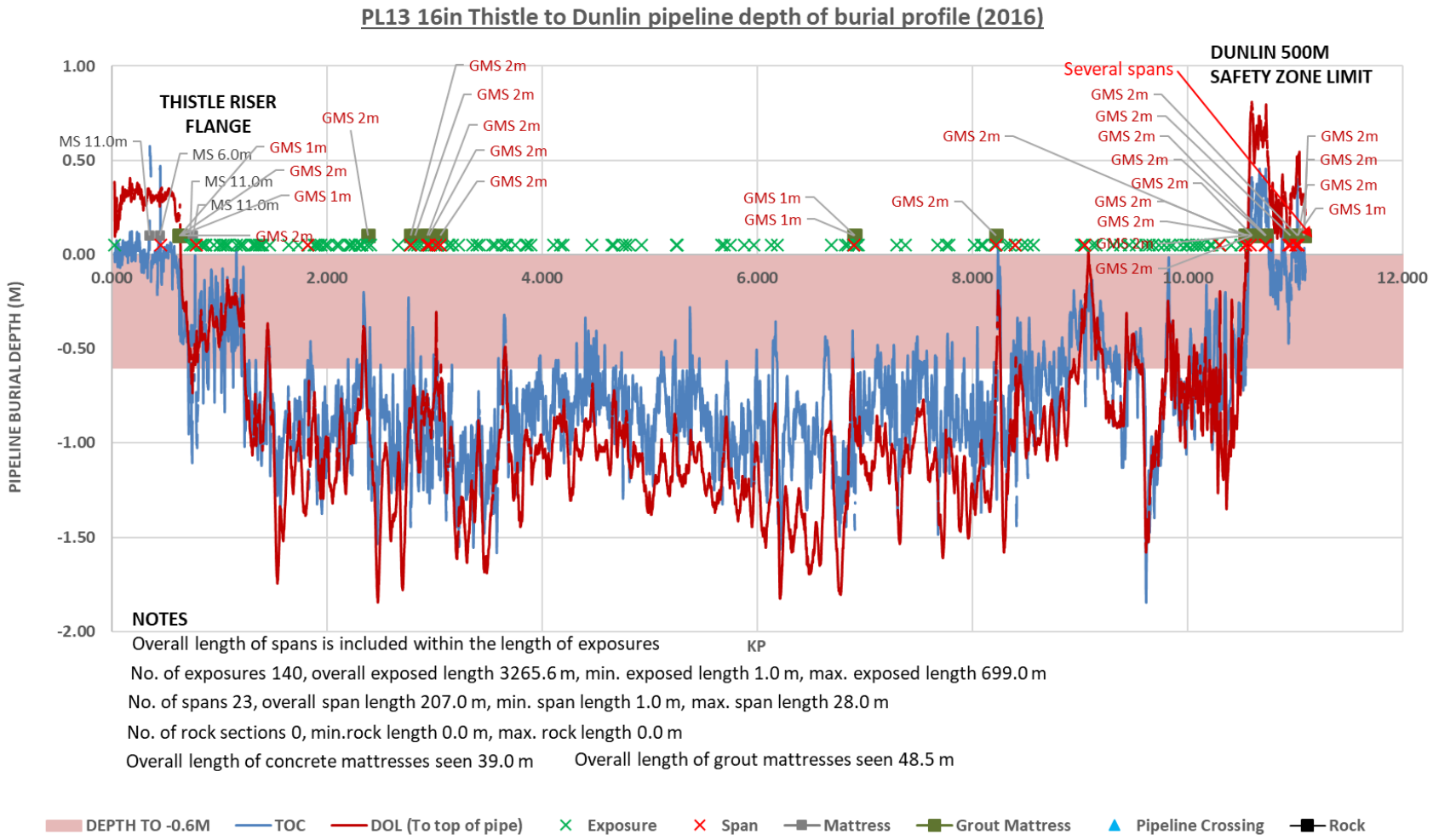


Figure 4.2.13: PL13 pipeline depth of burial profile (2016)[8]

[8] Length (or width) of grout mattresses indicative only; not stated within survey data.

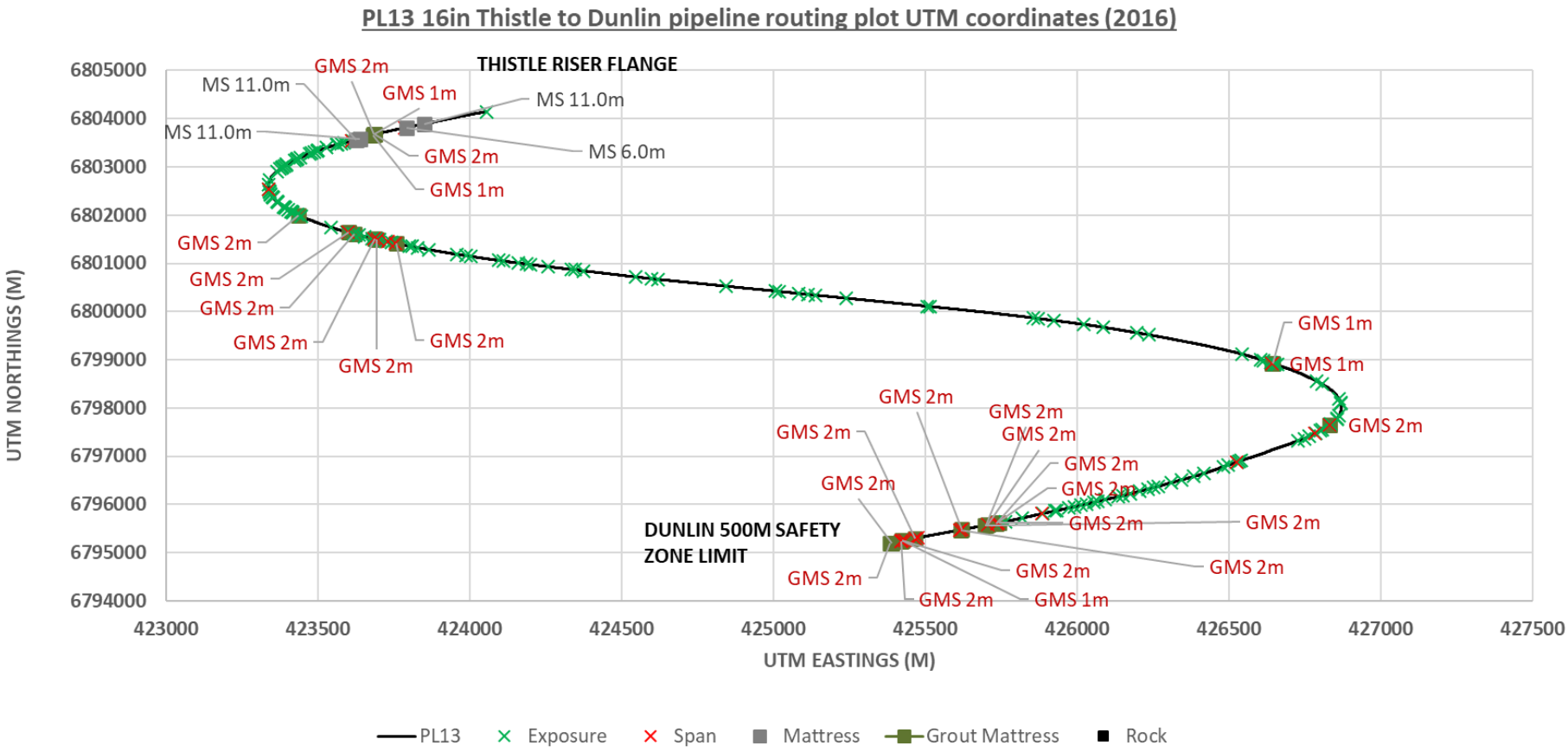


Figure 4.2.14: PL13 pipeline route (2016)

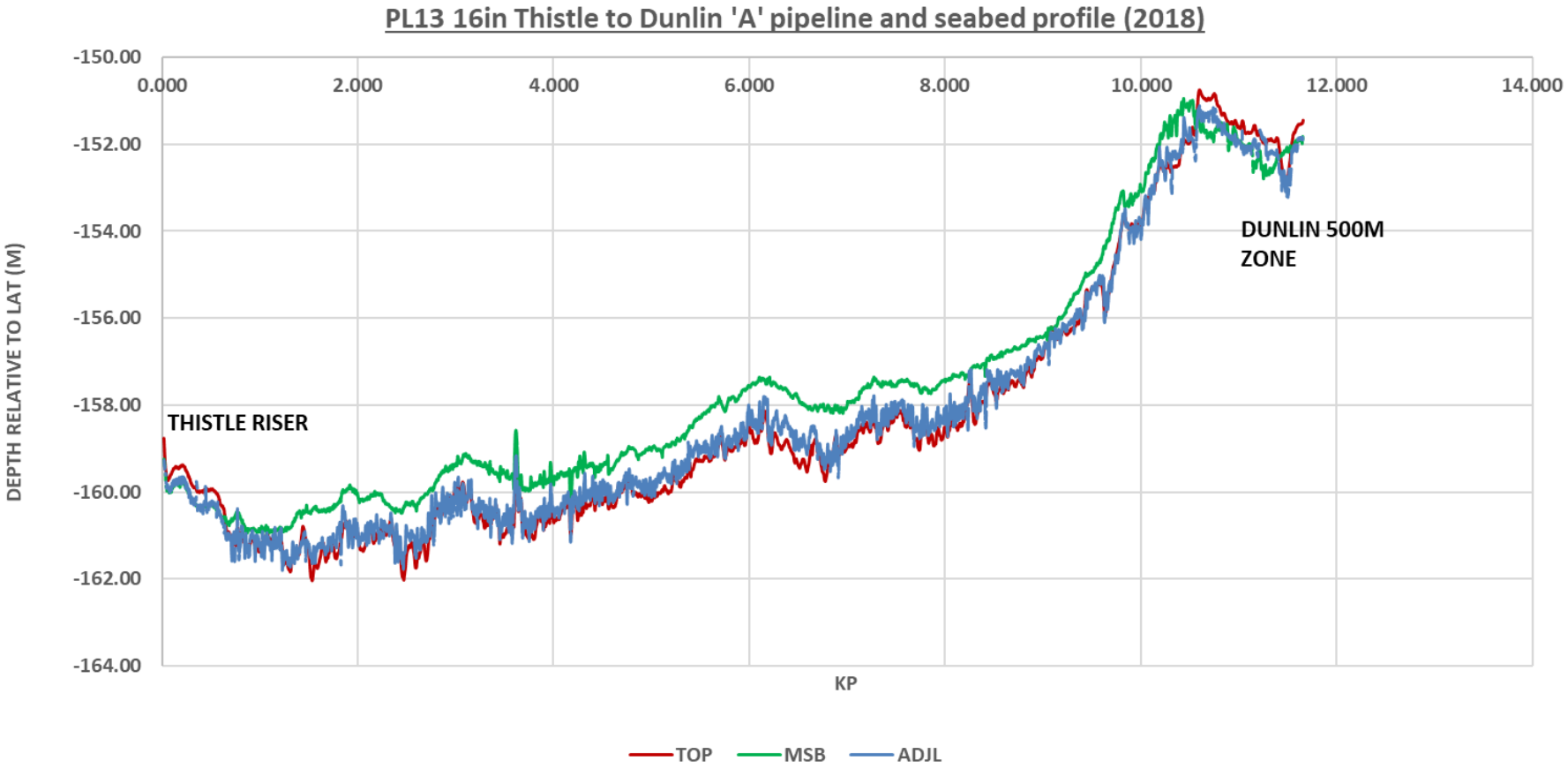


Figure 4.2.15: PL13 seabed and pipeline profile (2018)

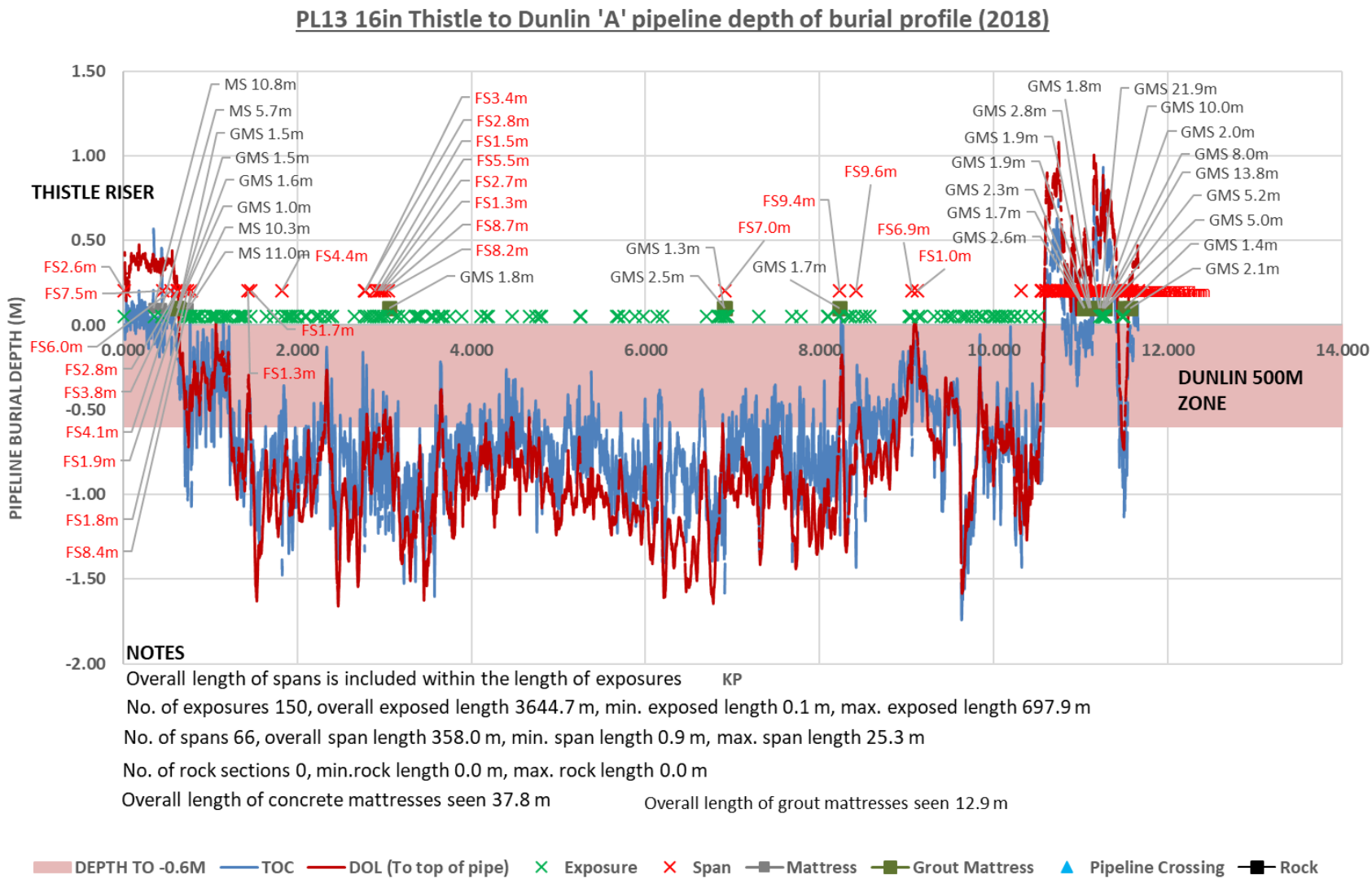


Figure 4.2.16: PL13 pipeline depth of burial profile (2018)

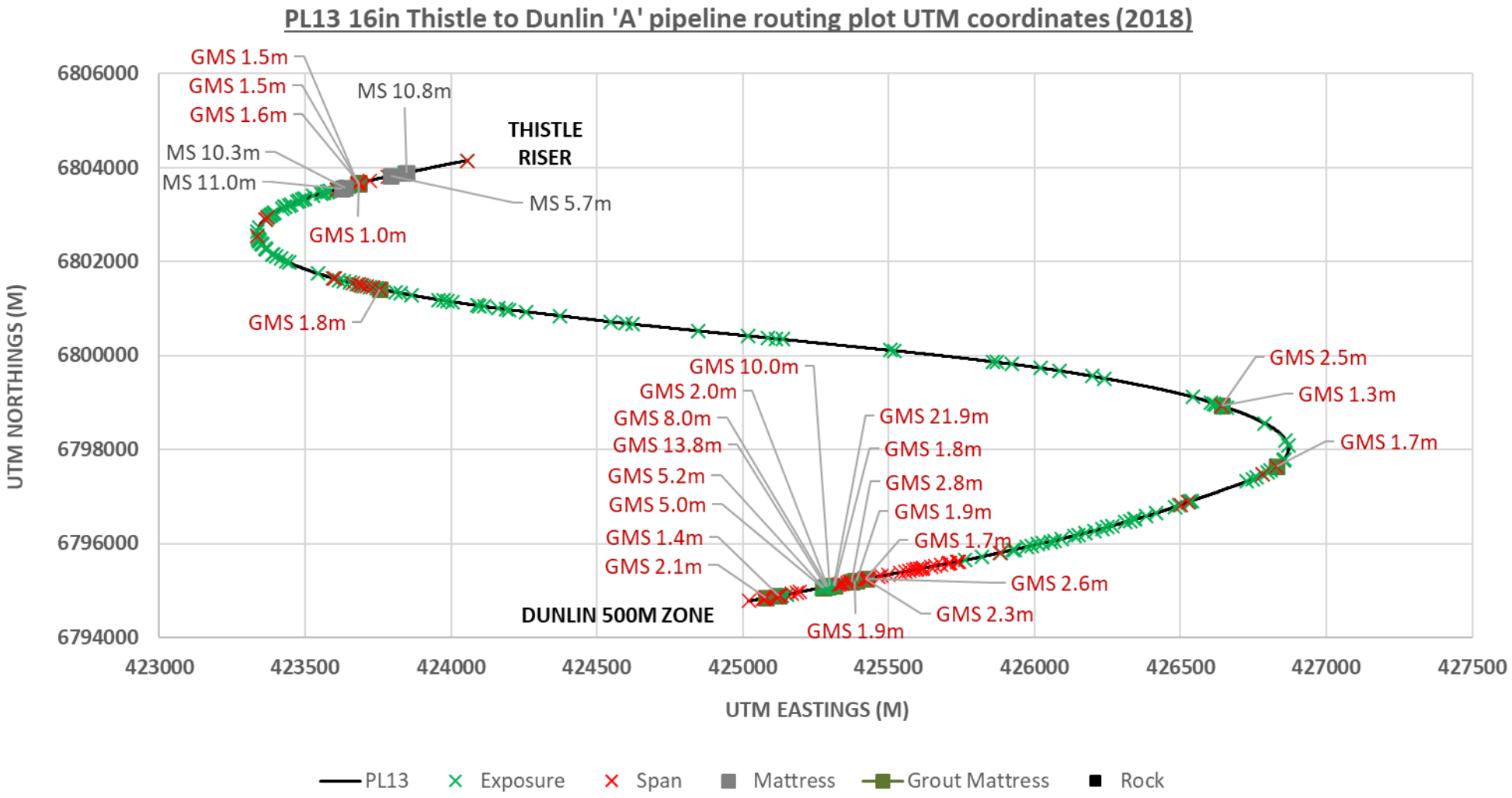


Figure 4.2.17: PL13 pipeline route (2018)

4.2.2 PL4555 8in Thistle SSIV to Wye structure pipeline

PL4555 is an 8in carbon steel pipeline connected to the Thistle platform via a 300m long flexible riser. The carbon steel section of the pipeline is ~10.26 km long and coated with 3 mm 3-Layer Polypropylene ('3LPP') coating. The pipeline is routed from the Thistle SSIV to the Wye structure. In April 2019 part of PL2578 which used to be rerouted between Thistle and the disused Single Anchor Leg Base ('SALB') as shown in Figure E.4.1, was repurposed as an export route for Thistle and renumbered PL4555. PL2578 (now PL4555) was piggybacked by PL2579, a 3in carbon steel pipeline also coated using 3LPP. On installation the pipelines were trenched, and the trench was backfilled with rock.

Most of the pipeline(s) lies in a trench overlain with deposited rock. On approach to the Wye structure, and on approach to the Thistle SSIV inside the Thistle 500m zone both pipelines are protected and stabilised by concrete mattresses.

Figure 4.2.18, Figure 4.2.19, Figure 4.2.21 and Figure 4.2.23 all show that both pipeline(s) have a reasonable depth of cover inside the trench. No exposures or spans are evidenced except possibly at the ends, and these would be removed as part of any decommissioning activities in accordance with mandatory requirements.

The decommissioning of PL2579 is dealt with in the Decommissioning Programmes for the Conrie, Don South-West, West Don and Ythan pipelines [3].

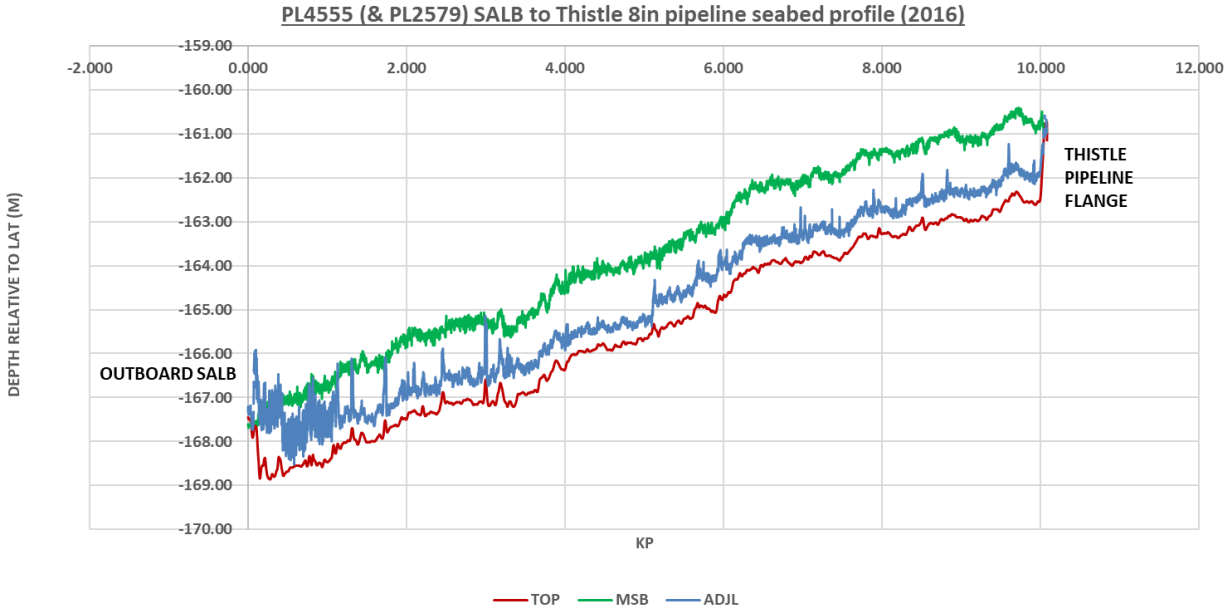


Figure 4.2.18: PL4555 (& PL2579) pipeline and seabed profile (2016)

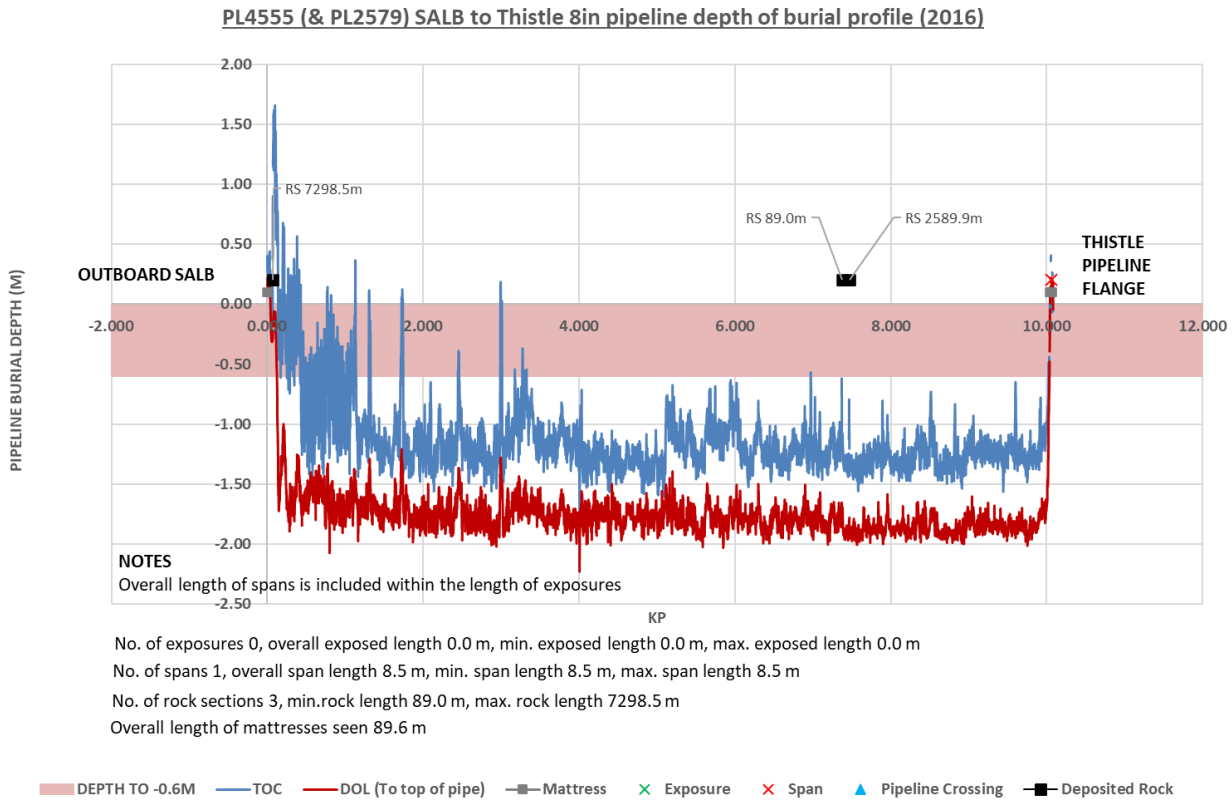


Figure 4.2.19: PL4555 (& PL2579) pipeline depth of burial profile (2016)

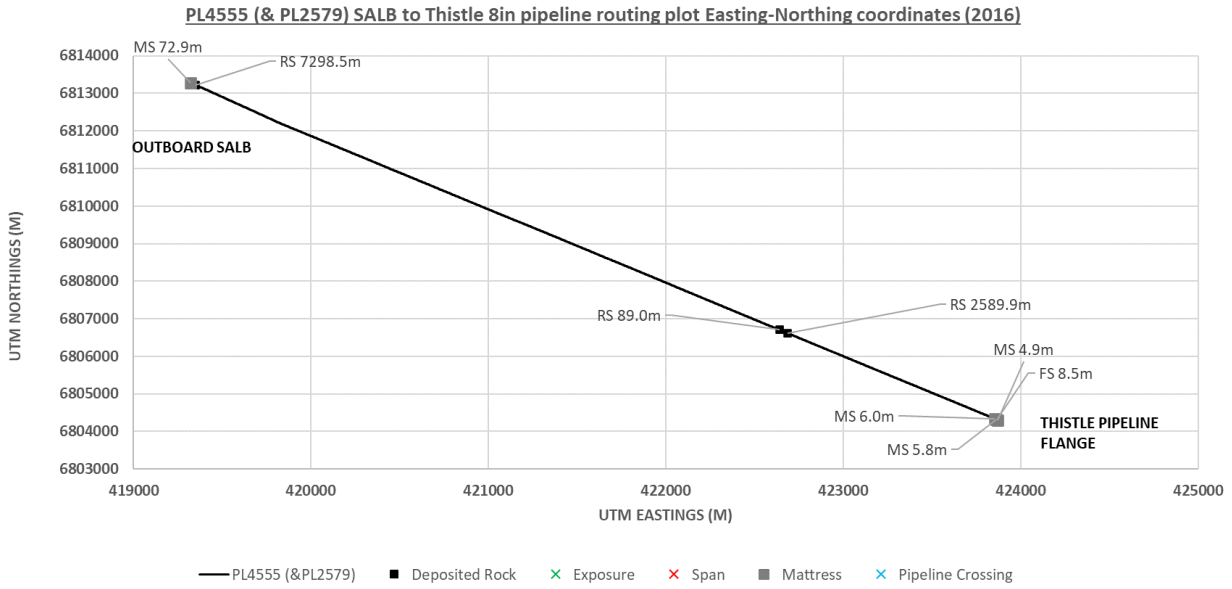


Figure 4.2.20: PL4555 (& PL2579) pipeline route (2016)

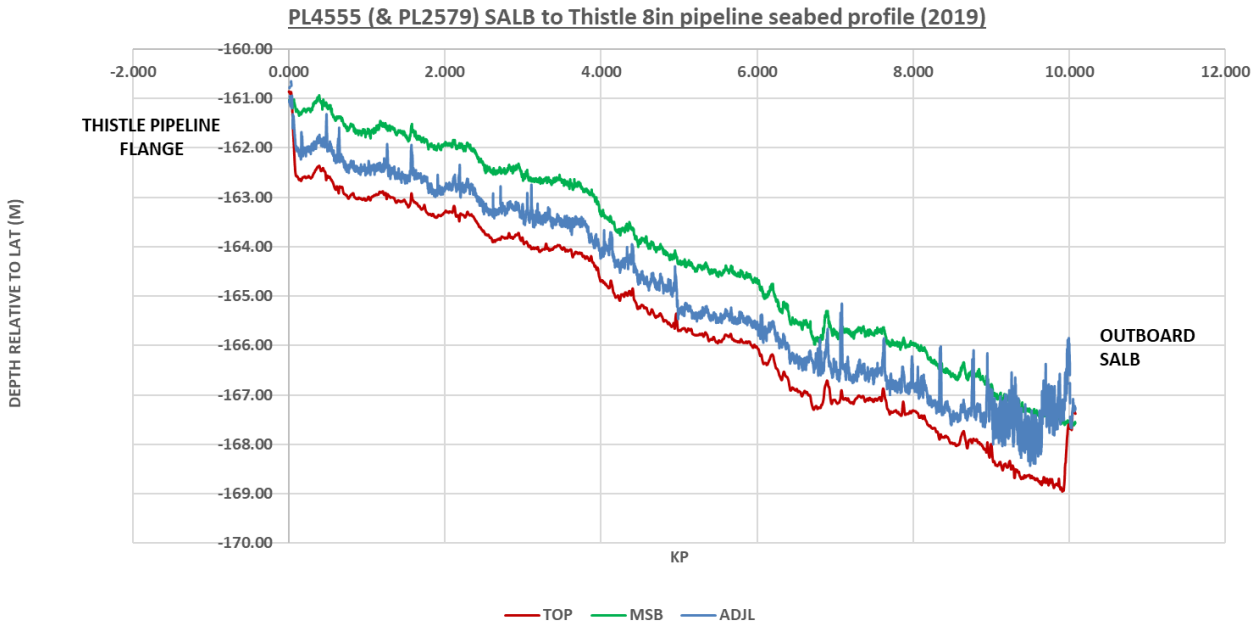


Figure 4.2.21: PL4555 (& PL2579) seabed and pipeline profile (2019)

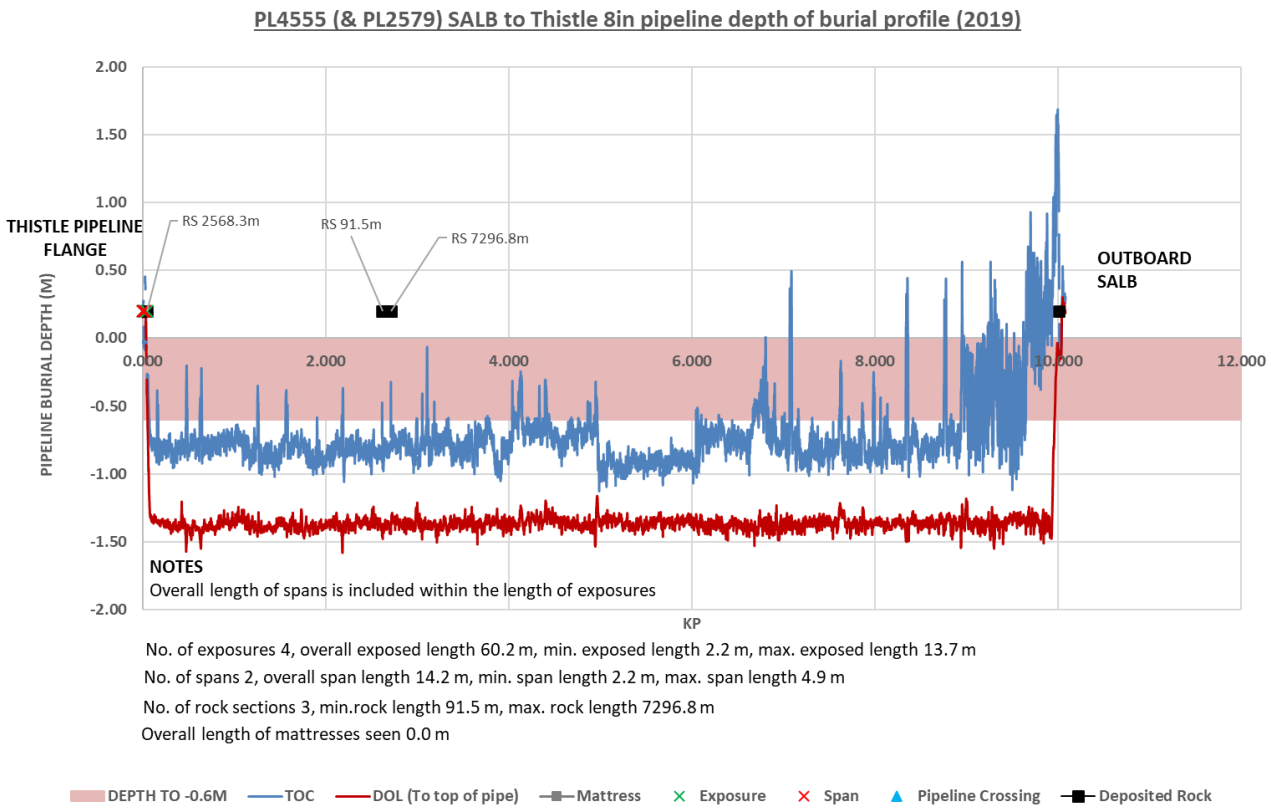


Figure 4.2.22: PL4555 (& PL2579) pipeline depth of burial profile (2019)

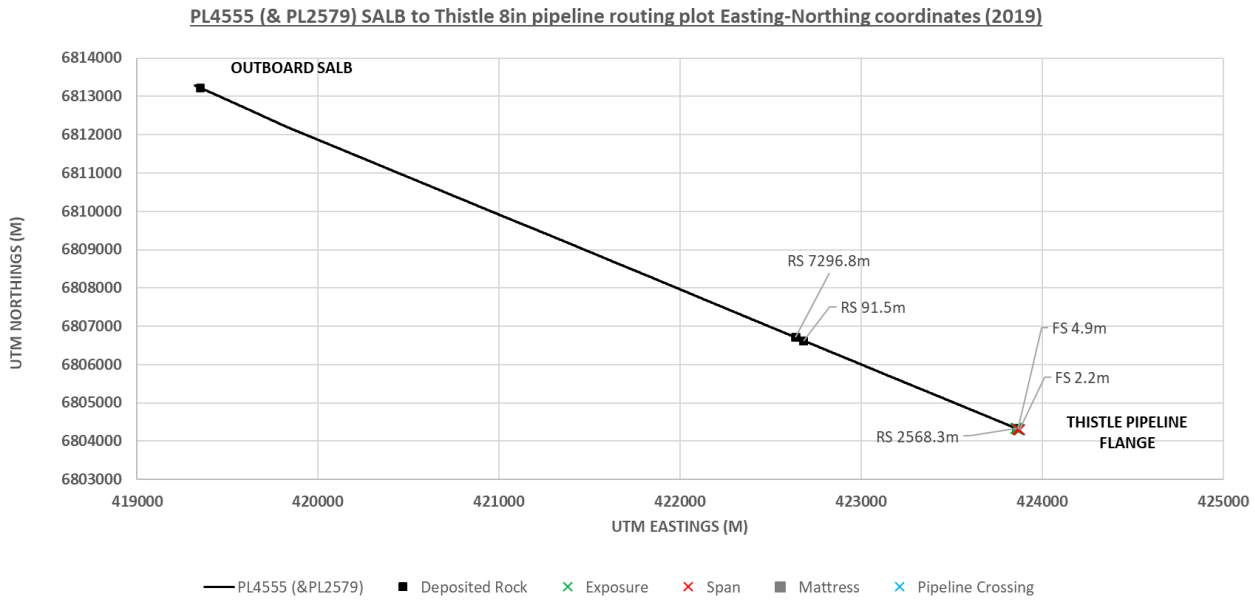


Figure 4.2.23: PL4555 (PL2579) pipeline route (2019)

4.2.3 PL4556 8in Wye structure to Magnus pipeline

PL4556 is an 8in carbon steel pipeline ~23.75 km long (from the Wye Structure to the ESDV on Magnus) coated using 3 mm 3-Layer Polypropylene ('3LPP') coating. The pipeline is routed from the Wye structure to the Magnus platform and was installed in 2019. Excerpts from the as-built alignment sheets are included in Appendix A. The pipeline was trenched with the trench backfilled. Rock (total length 875 m) was deposited over areas that were perceptible to upheaval buckling or as protection and stabilisation at pipeline crossings near Magnus. No exposures or spans were observed in the as-built alignment sheets which are cropped and presented in Appendix C.

In 2021, as part of the Northern Producer decommissioning activities a short 26 m length of pipespool near the Wye structure was removed and taken to shore.

4.3 Don pipelines

From the Don field until near the Thistle platform the pipelines and umbilicals follow the same route, approximately 25 m apart. At Thistle, they converge onto the pipe bridge at the base of riser caisson 930. A comparative assessment for the Don pipelines was included in the Don DP [1], although the limits of the Don comparative assessment are not explicit. In the Don DP the entire pipeline lengths and burial status is described, although elsewhere in the DP it is stated that the material quantities *exclude* those within the Thistle 500 m zone.

4.3.1 PL598 8in oil export pipeline

PL598 is an 8in carbon steel pipeline ~17.44 km long, routed between the Don manifold and the Thistle platform. The pipeline is coated with 13 mm thick Ethylene Propylene Diene Monomer ('EPDM') which is a rubber used for thermal insulation. When the pipeline was installed, it was trenched with the trench actively backfilled. The tie in pipe spool is 85 m long between the pipeline flange and the bottom of pipe bridge and this is coated with EPDM 13 mm thick and a 50 mm thick CWC 81 m long. This equates to most of the length of the pipespool. The length of pipeline inside the Thistle 500 m zone is ~567 m. The pipeline has been out of service since 2003 [1].

The Don manifold has been removed, and the pipeline has been partly decommissioned. Prior to being partly decommissioned, the pipeline was subject to annual inspections in the period 1990

to 2002. According to the Don DP, PL598 has had a consistent burial profile with a typical depth of cover ranging between 0.3 m and 0.5 m, with very few spans. All spans had been remediated by 1994. The CA in the Don DP concluded that the pipeline would remain stable once it has been decommissioned [1].

The most recent pipeline survey was conducted in 2013 and no exposures or spans were found inside the 500 m safety zone. More recent survey data have not been found.

4.3.2 PL599 8in seawater pipeline

PL599 is an 8in carbon steel pipeline ~17.34 km long, routed between the Don manifold and the Thistle platform. The pipeline is coated with 13mm thick EPDM which is a rubber used for thermal insulation. When the pipeline was installed, it was trenched with the trench actively backfilled. The tie in pipe spool is 85 m long between the pipeline flange and the bottom of pipe bridge and this is coated with EPDM 13 mm thick and a 50 mm thick CWC 81 m long. This equates to most of the length of the pipespool. The length of pipeline inside the Thistle 500 m zone is ~570 m. The pipeline has been out of service since 2003 [1].

The Don manifold has been removed, and the pipeline has been partly decommissioned. Prior to being partly decommissioned, the pipeline was subject to annual inspections in the period 1990 to 2002. According to the Don DP [1] PL599 has had a consistent burial profile with a depth of cover ranging between 0.24 m and 0.53 m. Spanning has not been a concern for this pipeline, and no remedial works have been required. The CA in the Don DP concluded that the pipeline would remain stable once it has been decommissioned [1].

The most recent pipeline survey was conducted in 2013, and beyond the surface laid section(s) near Thistle, a partly (50% - top half) exposed section ~18 m long was found starting at KP0.427 (measured from pipeline flange at Thistle), and this contained a 2.5 m long x 0.1 m high span (starting at KP0.438). The span was not reportable to FishSAFE. It is not known whether the exposure or span still exists because more recent survey data have not been found.

4.3.3 PL600 70 mm chemical injection umbilical

PL600 is a 70 mm diameter chemical injection umbilical ~17.73 km long comprising hoses, copper wire and filler, all protected by a double layer of galvanised steel wire housed in a 70 mm nominal diameter polyethylene outer sheath. Due to blockages of an unknown source at locations unknown, the cores of umbilical PL600 have not been flushed and the pipeline was subject to a chemical permit and risk assessment at the time of the Don DP [1]. The umbilical cores contain Sureflo SI677, Surflo 6422, and Sureflo H356 and Methanol. For details of the cross-section refer Appendix D. When the umbilical was installed, it was trenched with the trench actively backfilled with a design of 0.3 m depth of cover. The length of umbilical inside the Thistle 500 m zone is ~560 m. The length of mostly surface laid umbilical between riser caisson 930 on the Thistle jacket and trench depth is estimated as 125 m.

The Don DP reported that there was one span located at the Thistle tie-in. This will be removed along with the surface laid infrastructure. The DP reported that the trenched (and buried) condition was expected to continue due to the secure soil and low seabed currents associated with the area.

4.3.4 PLU6267 88 mm control umbilical

PLU6267 is an 88 mm diameter hydraulic control umbilical ~17.73 km long comprising hoses, copper wire and filler, all protected by a double layer of galvanised steel wire housed in an 88 mm nominal diameter polyethylene outer sheath. For details of the cross-section refer Appendix D. When the umbilical was installed, it was trenched with the trench actively backfilled with a design of 0.3 m depth of cover. The length of umbilical inside the Thistle 500 m zone is ~540 m. The length of mostly surface laid umbilical between riser caisson 930 on the Thistle jacket and trench depth is

estimated as 125 m.

According to the Don DP [1], the control umbilical was subject to annual inspections between 1991 and 1998, and then every two years from 1998 until when the Don DP was submitted for approval in 2011, PLU6267 had experienced a consistent burial profile, with the level of exposure in the field being low. Except for the surface laid section on the approaches at the Don manifold and Thistle, the umbilical was reported to be buried. The DP reported that the trenched (and buried) condition was expected to continue due to the secure soil and low seabed currents associated with the area.

4.4 Pipeline crossings

4.4.1 Thistle pipeline crossings

PL4555 crosses over the Don pipelines PL598, PL599, PL600 and PLU6267 (Figure E.1.1). PL4556 crosses over several pipelines near Magnus as shown in Figure E.5.1. More details are available in the Thistle pipeline DP [6].

For oil and gas related infrastructure, this can usually be determined by the pipeline number. The higher pipeline number crosses over the top of a pipeline with a lower identification number, so for example, PL4555 crosses over PL598. This is illustrated in Figure 4.4.1. There can be exceptions, for example where older umbilical or electrical cables were installed a while ago, but only recently assigned a pipeline ID.

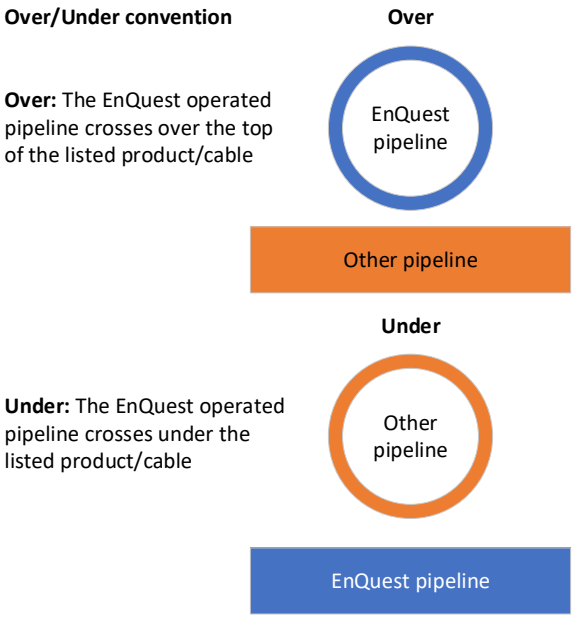


Figure 4.4.1: Over/under convention for pipeline crossings

4.4.2 Don pipeline crossings

The Don pipelines are crossed by several third-party pipelines inside the Thistle 500 m zone as indicated in Figure E.2.1. The overlying pipelines in the Thistle 500 m zone will be removed in accordance with mandatory requirements.

4.5 Dealing with pipeline crossings

The various pipeline and cable crossings may impact or may be impacted by the decommissioning options described in section 5.1. The potential impacts are summarised in Table 4.5.1 and illustrated in Figure 4.5.1, although we have not considered this level of detail in the comparative assessments.

Decommissioning option	Newer pipeline on top	Older pipeline underneath[9]
Full removal	Remove the pipeline subject to PL crossing agreement.	No impact on option
Partial removal or remedial work	n/a	
Leave *in situ*	No impact on option as none of the leave *in situ* options would involve removing a pipeline from underneath another pipeline; leave the EnQuest or Don pipeline *in situ*.	

Table 4.5.1: Impact of pipeline crossings on pipeline decommissioning options

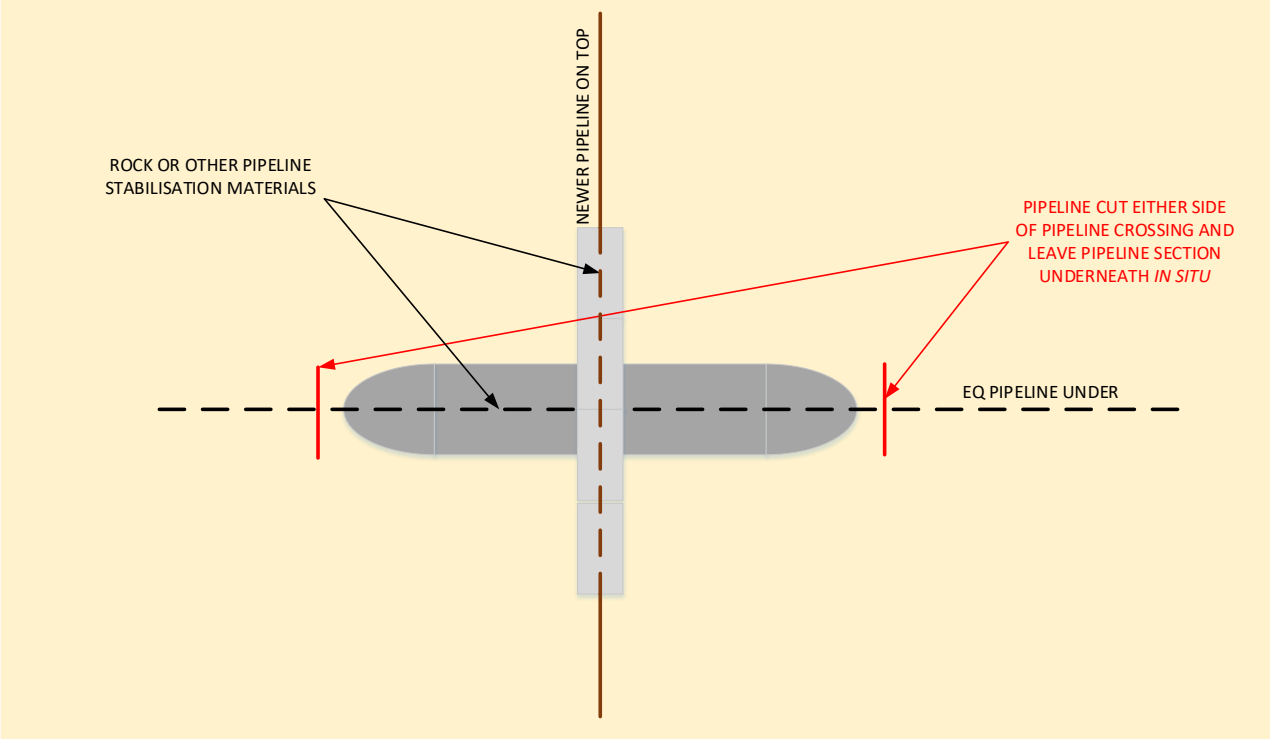


Figure 4.5.1: Pipeline underneath being removed

[9] Although it is noted here that there would be no discernible impact on the decommissioning option, permission would need to be granted from the owner of the older pipeline to carry out any works in the vicinity.

5. DECOMMISSIONING OPTIONS

5.1 Pipeline decommissioning

There is an implicit assumption that options for re-use of the pipelines (e.g. carbon capture, use and storage) have been exhausted or implemented prior to the facilities and infrastructure moving into the decommissioning phase and associated comparative assessment. This is because the technical and commercial aspects of the reuse option can take much longer than the time taken to approve a DP. Therefore, this option has been excluded from the assessment. The decommissioning options considered for the Don and Thistle pipelines are:

- **Complete removal** – This involves the complete removal of the pipelines by whatever means would be most practicable and acceptable from a technical perspective.
- **Partial removal or remediation** – PL13 and PL599 only. Partial removal would involve removing exposed or potentially unstable sections of pipelines. Remediation would involve post-trenching or the deposition of rock to make the remaining pipeline safe for leaving *in situ*. This option is relevant for those pipelines that are known to have exposures or spans. There will be a need to verify their status via future surveys.
- **Leave *in situ*** – This involves leaving the pipeline(s) *in situ* with no remedial works, but likely needing to verify their status via future surveys dependent on discussion with OPRED.

Surface laid sections of PL13, PL598, PL599, PL600, PL4555, PL4556 and PLU6267 on the approaches will be removed in accordance with mandatory requirements, regardless of the decommissioning option selected.

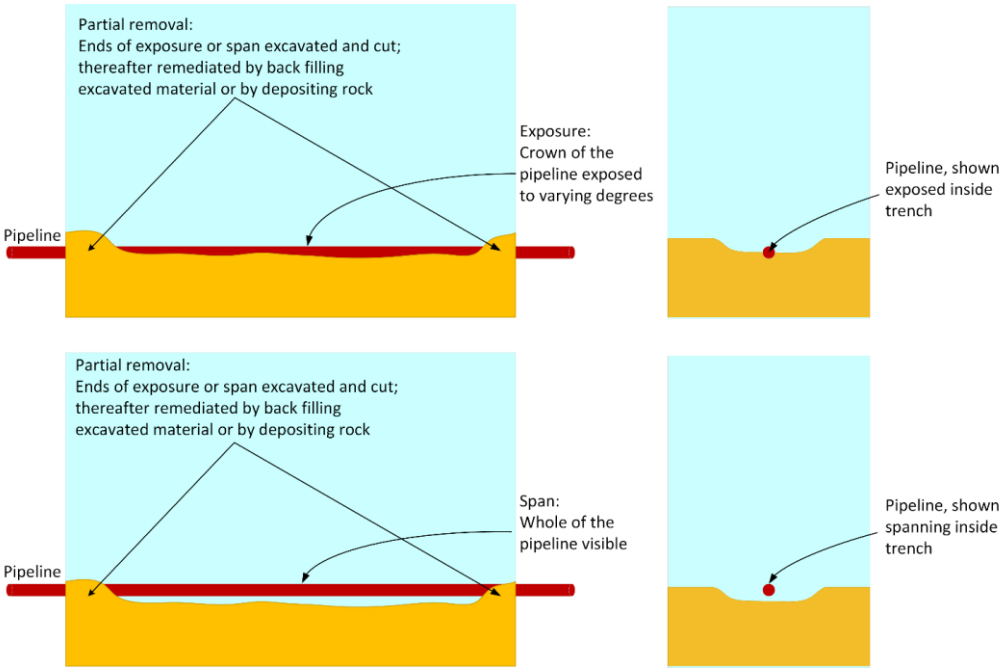


Figure 5.1.1: Exposures, spans & partial removal

The method for decommissioning of flexible risers (PL4555) or surface laid sections on the approaches for trenched and buried pipelines (PL4555, PL4556) is the same irrespective of which option is pursued. Therefore, decommissioning of these parts of the pipelines are not included in the assessment, although all options include removal of features such as surface laid pipespools and surface laid pipeline ends. The extent of removal will be discussed with OPRED and formally agreed for PL13 via submission of a decommissioning PWA variation.

5.1.1 Thistle pipeline summary

Following an analysis of the extent to which the pipeline is buried, the decommissioning options considered for the Thistle pipelines are summarised in Table 5.1.1:

Pipeline ID	Complete removal	Partial removal or remedation	Leave *in situ*	Comments	Exposed length (m)
PL13	X	X	X	Variable depth of cover, exposures & spans exist	Approx. 1/3
PL4555	X		X	Trenched, buried, covered with rock full length	n/a
PL4556	X		X	Trenched, buried, part covered in 875 m rock	n/a

Table 5.1.1: Thistle pipeline decommissioning options

Further details of the decommissioning options for the Thistle pipelines are described in Table 5.1.3 below. The activities in these sections could be undertaken using a variety of vessel type. Vessel type might include a construction support vessel ('CSV'), an ROV support vessel ('ROVSV'), or a pipelay vessel, a rock discharge vessel, or a mixture of all of them, depending on the activities being undertaken.

5.1.2 Don pipeline summary

Following an assessment of the quality of burial, the decommissioning options considered for the Don pipelines are summarised in Table 5.1.2:

Pipeline ID	Complete removal	Partial removal or remediation	Leave *in situ*	Comments	Exposed length (m)
PL598	X		X	Trenched and buried	n/a
PL599	X	X	X	Trenched and buried with one exposure 18 m long starting at KP0.427 observed in 2013	18 m
PL600	X		X	Trenched and buried	n/a
PLU6267	X		X	Trenched and buried	n/a

Table 5.1.2: Don pipeline decommissioning options

Further details of the decommissioning options for the Don pipelines are described in Table 5.1.4 below. The activities in these sections could be undertaken using a variety of vessel type. Vessel type might include a CSV, an ROVSV, or a pipelay vessel, a rock discharge vessel, or a mixture of all of them, depending on the activities being undertaken.

Item Description	Complete removal	Partial removal or remediation	Leave *in situ*
PL13	Uncover buried sections of PL13 using an MFE. Completely remove using the 'cut and lift' method.	Once the pipeline ends have been removed in accordance with mandatory requirements, partial removal of pipeline using 'cut and lift' or remediate exposed by deposition of rock.	Leave *in situ*.
Trenched and buried section of PL4555 and PL4556	Uncover the pipeline(s) using an MFE. Completely remove rigid pipelines either using reverse reel or the 'cut and lift' method as contingency.	n/a	Leave *in situ* with no remedial work being carried out.
Surface laid section of pipe spools and protected and stabilised with concrete mattresses on approaches to Wye structure (PL4555, PL4556), Thistle (PL4555) and Magnus (PL4556).	Remove. Remove all surface laid pipespools and associated sand and cement bags and concrete mattresses.	n/a	Same as complete removal option.

Table 5.1.3: Decommissioning the Thistle pipelines

Item Description	Complete removal	Partial removal or remediation	Leave *in situ*
Sections on pipe bridge.	Remove the pipe bridge along with sections of pipeline(s) supported by it.	Same as complete removal.	Same as complete removal.
Surface laid section of pipe spools (PL598, PL599) and umbilicals (PL600, PLU6267) on approaches to / from Thistle.	Remove. Remove all surface laid pipespools, umbilical sections down to trench depth and remove all associated grout bags.	Same as complete removal.	Same as complete removal.
PL598, PL599 buried section inside trench to edge of Thistle 500 m zone.	Uncover the pipeline(s) using an MFE. Completely remove using the reverse reel method (noted that this method was discounted in the Don DP [1]) although if their integrity cannot be assured, use the 'cut and lift' method as contingency.	PL599 only. Remove exposed section using the 'cut and lift' method and bury the cut ends under deposited rock or remediate exposed (18 m long) section including 2.5 m long span by deposition of rock along the full exposed length.	Leave *in situ*. with no remedial work being carried out.
PL600, PLU6267 buried section inside trench to edge of Thistle 500 m zone.	Uncover the pipeline(s) using an MFE if necessary. Completely remove umbilicals using reverse reel (PL600, PL6267) with the 'cut and lift' method as contingency.	n/a	Leave *in situ*.

NOTES

1. Theoretically the complete removal option only applies to the edge of the Thistle 500 m zone. However, the assessment and findings of the Don comparative assessment will be extended to the pipelines inside the Thistle 500 m zone to determine whether the Don comparative assessment remains valid for the pipelines within this area.

Table 5.1.4: Decommissioning the Don pipelines inside Thistle 500 m zone

6. COMPARATIVE ASSESSMENT

6.1 Method

No scores have been determined. However, risk matrices have been used to determine if the planned and unplanned impacts would be for example broadly acceptable, possibly acceptable, unlikely to be acceptable or not acceptable. Cells coloured red indicate high risk, high impact, and less desirable outcomes. Green coloured cells indicate less risk, less impact, and more desirable outcomes. Cells coloured orange sit in-between red and green and may or may not be less, or more, desirable. It should be noted that societal score looked at beneficial outcomes as well as detrimental outcomes. Where a comparison of options varies by shades of green rather than by red or orange it means there is little to choose between the options.

High costs also attract a 'less desirable outcome', and for each pipeline the cost of implementing a decommissioning option is compared against the others. A relatively high cost therefore would be coloured red whereas a relatively low cost would be coloured green. All costs are assessed in relation to the cheapest cost but normalised against the cost of the most expensive option. To normalise the decommissioning costs, for each pipeline the most expensive option is assigned '10' and the other costs – which will be less than '10' are compared against this. For more details concerning the cost assessment refer Appendix I.

6.1.1 Thistle pipelines

PL13, PL4555, and PL4556 are subject to a comparative assessment. The approach to the comparative assessment is largely qualitative and carried out at a level that is sufficient to differentiate the options. However, in some cases, for example such as cost, it can be necessary to examine the differences in more detail and quantitatively to provide clarity. The comparative assessment considers generic evaluation criteria and specific sub-criteria in line with OPRED guidance notes [12]. These elements are considered for short-term work as the assets are decommissioned as well as 'legacy' impacts and risks over the longer term. Please refer Table 6.1.1.

6.1.2 Don pipelines

PL598, PL599, PL600 and PLU6267 outside of the Thistle 500 m zone have already been partially decommissioned and were subject to a comparative assessment included in the Don DP [1]. The indications are that the Don pipeline CA included in the DP addressed the whole of the buried pipelines. It is unlikely that the overall intent of the Don pipeline CA was to exclude the infrastructure inside the Thistle 500 m when the burial status (i.e. exposures) of the ends are included in the description. Nevertheless, as the section inside the Thistle 500 m zone are an extension of the wider Don field pipelines so it is appropriate to examine whether the original approach and findings remain valid for the pipelines inside the Thistle 500 m zone.

The Don CA reported that the selection of the most suitable decommissioning option for the Don facilities involved consideration of the following criteria:

- Technical (feasibility, complexity, and risk).
- Safety (offshore and onshore hazards/risks).
- Environmental (ecosystem impacts, energy, and waste).
- Social (effects on other users of the sea, e.g. shipping and fishing).
- Economics (costs and economic impact).

Noted that the Don pipeline comparative assessment used "weightings" and "scores", but as explained in section 6.1.1, to be consistent with the Thistle pipeline assessment a narrative based

approach is used here. This CA has been conducted independently of that for the Don DP [1].

CRITERIA	DEFINITION	SUB-CRITERIA (Short-term & Legacy, UNO)	COMMENTS
Technical	A technical evaluation of the complexity of a job that can be expected to proceed without major consequence or failure if it is adequately planned and executed.	Risk of project failure. Technological challenge. Technical challenge (legacy).	The risk of project failure given the technical and technological challenges. The technical challenge considers the viability of a task should the technology be available. The technological challenge concerns the availability of specific technologies to perform a task and the extent of research & development that may be required. Technically, complete removal of the pipelines would most likely be achievable, but significant complications could arise because the pipelines are buried. The 'cut and lift' method of removal is tried and tested for relatively short pipelines but would be avoided for longer pipelines several km long. Reverse reeling of pipelines has been achieved for small diameter pipelines but not for pipelines with significant depth of cover. The technical aspects of post-trenching and the deposition of rock are a consideration.
Safety	An assessment of the potential health and safety risk to people directly or indirectly involved in the programme of work offshore and onshore, or who may be exposed to risk as the work is carried out.	Health and safety risks for project personnel carrying out decommissioning activities offshore. Residual risks to marine users on successful completion of decommissioning. Safety risks for project personnel engaged in carrying out decommissioning activities onshore.	Typical offshore hazards might include loss of dynamic positioning, sudden movements during pipeline recovery works, dropped objects, collision between vessels, dealing with residual quantities of hazardous materials. Typical diving hazards might include, loss of heat or air supply, trapped cables and hoses, trapped limbs. After decommissioning has been completed typical hazards could relate to exposed pipelines leading to possibility of fishing net snagging. Consider effects of a change in scour patterns due to the deposition of rock. Typical onshore hazards might include dealing with residual hazardous materials, onshore cutting, sudden movements or dropped objects.

CRITERIA	DEFINITION	SUB-CRITERIA (Short-term & Legacy, UNO)	COMMENTS
Environmental	An assessment of the significance of the risks / impacts to the environmental receptors because of operational activities or the legacy aspects.	Energy and emissions to atmosphere.	The assets are located outside of environmentally sensitive areas, so the dominant environmental criteria would likely be the effect on the seabed, the amount and type of waste recovered, or replacement materials needing to be manufactured to compensate for materials left *in situ*. The pipelines are not within a SCA or an MPA.
		Effect on seabed: Seabed disturbance and area affected. Permanent disturbance more significant than temporary disturbance.	
		Effect on water column: • Liquid discharges to sea • Liquid discharges to surface water • Noise.	
		Waste creation and use of resources such as landfill. Recycling and replacement of materials.	
Socio-economic	Assesses the significance of the work on societal activities, including offshore and onshore activities associated with the complete programme of work for each option and the associated legacy impact. This includes all the "direct" societal effects (e.g., employment on vessels undertaking the work) as well as "indirect" societal effects (e.g., employment associated with services in the locality to onshore work, accommodation, etc.).	Effects on commercial activities e.g., fishing	Decommissioning of pipelines on individual projects involves work that is generally temporary in nature. On its own this type of work might typically lead to an extension of employment rather than new employment. Any impact on commercial fishing offshore is temporary and of relatively short duration.
		Employment.	
		Communities or impact on amenities.	
Economics or Cost	Difference in cost.	Difference in cost compared for like-for-like activities; pipeline ends included in the comparison on the basis that they would incur mobilisation and demobilisation activities. This means that activities such as partial removal and complete removal, would incur incremental cost increases should the same vessels be used. Normalised to demonstrate a sense of scale.	In the short-term it is cheaper to do nothing, but this needs to be compared with the need for future surveys and potential remedial work.

Table 6.1.1: Comparative Assessment method – criteria & sub-criteria

6.2 Comparative Assessment for Thistle pipelines

The 'complete removal', 'partial removal' and 'leave *in situ*' decommissioning options are compared for pipeline PL13. The 'complete removal' and 'leave *in situ*' decommissioning options are compared for pipelines PL4555 and PL4556.

6.2.1 Technical considerations

PL13

All three decommissioning options are technically feasible, although post-trenching can be problematic for pipelines whose coatings have degraded and for areas where rock or boulders are present. As PL13 is concrete weight coated with a degree of deterioration in some places, post-trenching is not a viable option.

The PL13 16in pipeline is concrete weight coated and would be a candidate for recovery using the 'cut and lift' method, but not reverse reel. This is because reverse reeling is not generally considered viable for concrete coated pipelines as they cannot be reeled onto the reel without the coating cracking and falling off the pipeline. The concrete coated pipe is not designed to develop the bending stresses expected with reverse reeling when taking account of the weight of concrete coating. Reverse S lay or J lay is also not feasible for concrete coated pipelines. Whichever method is used, there will be potential issues with the deterioration of the concrete coating over time resulting in sections falling off during recovery. There could also be uncertainties over the condition and structural integrity of the pipeline(s) which could lead to failure during recovery. To the author's knowledge reverse S lay or J lay has not been used for recovering pipelines in the industry.

Although repetitive, the 'cut and lift' method would be feasible but would take a significant amount of time to achieve. Should the pipeline be recovered in road transportable lengths between 10 m and 12 m long this would mean between 80 and 100 sections being recovered per km of pipeline. For the PL13 pipeline which is ~12.69 km long, recovery using the 'cut and lift' method would be a significant undertaking and maybe an unrealistic prospect. For the removal of buried pipelines any overlying sediment (or rock) would need to be removed or displaced to uncover the pipelines or before they could be recovered. The removal or displacement of sediment or rock would be typically done using an MFE. By aggregating the survey data[10], 7.179 km of PL13 is buried (i.e. 5.511 km is exposed, 3.623 km of which is surface laid (the ends of the pipeline outside of the trenched section) and would be removed anyway to satisfy the mandatory requirement for a clear seabed).

From a technical perspective the partial removal and leave *in situ* decommissioning options are also feasible. For the partial removal option, the deposition of rock would need to be needed to bury any cut pipeline ends and this would be technically achievable.

Technically, instead of partial removal there could be a case to be made for the deposition of rock along part or all the pipeline(s) and this would also be technically feasible. The resulting rock profiles are shown for PL13 in Figure 6.2.1 and Figure 6.2.2 below.

[10] Remembering that only 11.069km was surveyed in 2018 compared to an overall length 12.69km.

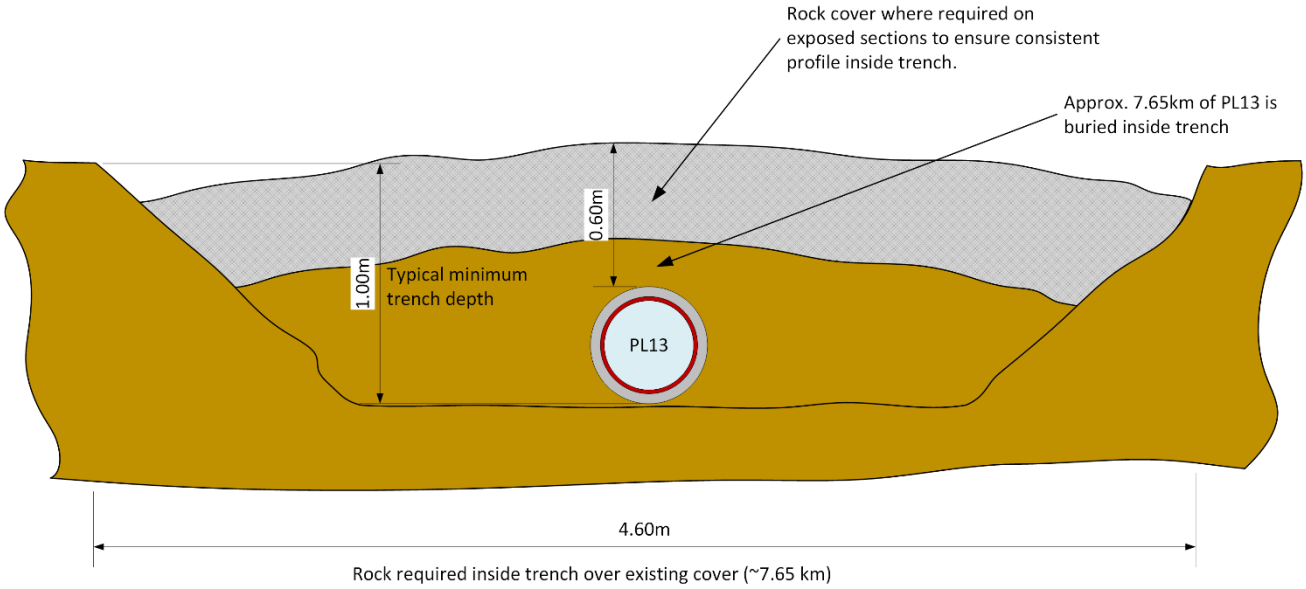


Figure 6.2.1: PL13 new rock over existing cover inside trench

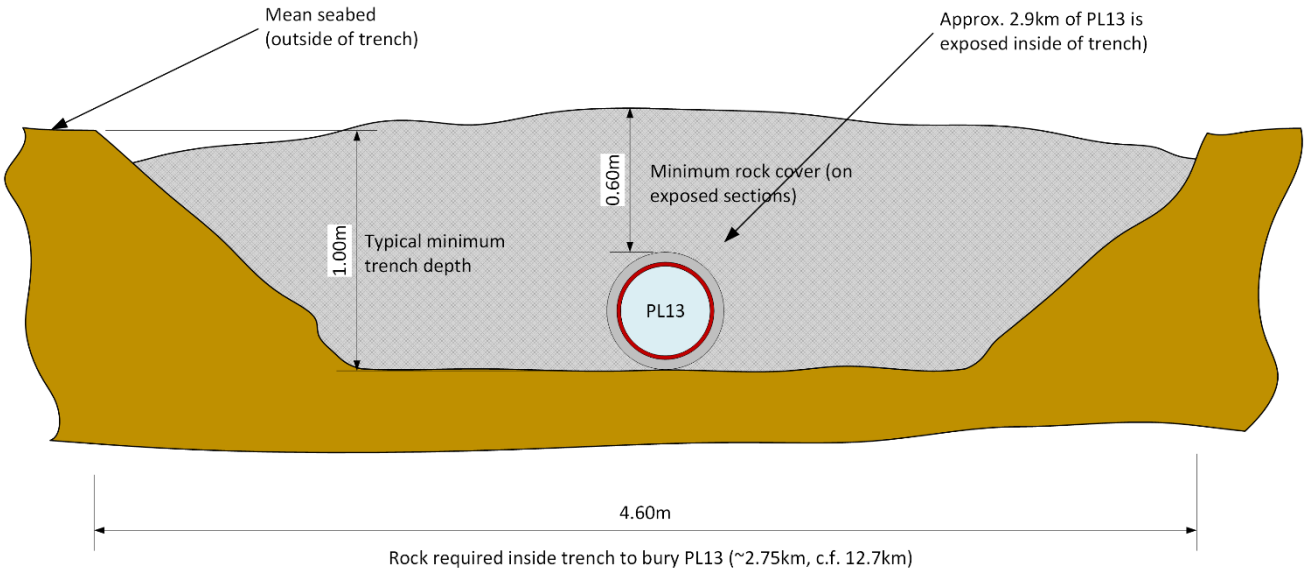


Figure 6.2.2: PL13 new rock over exposed pipeline inside trench

PL4555 and PL4556

Both the complete removal and leave *in situ* decommissioning options are technically feasible.

For PL4555, technical feasibility and practicality is influenced by the 8in rigid pipeline being piggybacked with 3in pipeline (PL2579). However, both pipelines could be recovered in sections using the 'cut and lift' method. This would involve dispersal of the existing deposited rock followed by 'cut and lift' operations. Although the 'cut and lift' method has been used for relatively short lengths of pipeline, the length of pipeline(s) would probably render the 'cut and lift' approach impractical.

PL4556 would be a candidate for removal using the 'reverse reel' method although the 'cut and lift' method of removal has been used for relatively short lengths and could be used as a fall-back

method of recovery if need be. There is limited experience in reverse reeling individual trenched and buried pipelines and for this method of removal given the depth of burial it is likely that the overlying sediment would need to be removed to uncover the pipeline inside the trench before they would be recovered.

6.2.2 Safety considerations

The difference in potential safety risk between the options is sufficiently large that a HAZID was not considered necessary at this stage. A HAZID would ordinarily be carried out as part of the preparatory activities.

Safety risk to offshore project personnel

The key differences between the options are as follows.

- Should divers be required, the risk to divers (and personnel on the vessel) from hydrocarbon or hazardous substance releases from recovered pipelines will be greater for complete removal than for either partial removal or leave *in situ* due to the larger volume of material that would be recovered.
- Risk associated with 'cut and lift' operations (PL13, PL4555) is not insignificant. Assuming the pipeline(s) could successfully be excavated from a technical perspective the operation should be relatively straightforward. However, to ensure road transportable lengths, the 'cut and lift'; operations would require between ~80 to ~100 sections or pipe to be removed *per km* of pipeline. Arguably, from a safety perspective this would likely be manageable, but the associated risks would increase with the number of operations needing to be performed, and the amount of material needing to be transferred and handled on the vessel; Fewer such project risks would be incurred for the leave *in situ* decommissioning option.
- Risk associated with reverse reeling operations for complete removal of PL4556, with the pipeline needing to be spooled onto a reel on a subsea support vessel being attached to the pipeline. The risk to personnel and assets would therefore be greater for complete removal option than for leave *in situ*.
- Increased risk to all activities due to adverse weather is greater for complete removal than for partial removal and leave *in situ* as the vessels would be in the field for longer.
- Remediation option instead of partial removal option. Risk associated with deposition of rock either along part or all of the trenched section of PL13. The operational risks would increase with the amount of material involved but can be expected to be lower than that associated with removal operations. To have to carry out the operation at all would present more of a risk than doing nothing.
- Risk associated with legacy survey activities that is, the risks associated with vessels being used are greater for the leave *in situ* option than for complete removal. Typically, in the UK a minimum of three legacy surveys would be required to confirm the condition and stability of subsea pipelines left *in situ*.

Given that the activities and techniques are frequently used in the North Sea, the risks from all hazards relating to 'cut and lift' and reverse reel methods of removal would be broadly acceptable. It is acknowledged that there is relatively little experience of reverse reeling a trenched and buried pipeline and therefore this risk could be higher but still tolerable if sufficient mitigation and control measures are adopted.

Short-term safety risk to fishermen and other marine users

The risk to mariners in the short-term is aligned with the duration the activities would be undertaken in the field. While decommissioning operations are underway the duration of vessels

in the field would be longer for either the complete removal or partial removal (or remediation) options than for leave *in situ*. Reverse reel and to an extent 'cut and lift' would mean that the vessel is attached to a pipeline and could not move out of the way quickly. However, a vessel management plan would address the mitigations required and this is aspect not likely to be of concern.

For the leave *in situ* option at most only the pipeline ends would be dealt with and the duration of the vessels in the field would generally be much shorter for this option.

Therefore, while decommissioning activities are occurring, the risk to fishermen and other marine users would be least for the leave *in situ* option. Any interference would take the form of minor alterations to normal operating practices, and such deviations would be so small as to not be significant. On this basis the potential impact associated with any of the decommissioning options can be considered low.

Residual safety risk to fishermen and other marine users

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear, specifically demersal trawl boards. As explained in section 3.3, demersal trawling is the dominant type of fishing in the area. For demersal (and shellfish) trawling activities there is a potential for snagging on equipment left on the seabed, including spoil mounds and pipelines that remain exposed on the seabed after decommissioning activities have been completed.

By completely removing the pipelines the risk of snagging would be removed in perpetuity. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea.

PL13 was laid in an open trench that was left to backfill naturally. Historical data would indicate that about 1.888 km would remain exposed once the surface laid sections have been removed with some non-recordable spans being present. As evidenced in the more recent pipeline survey data the frequency and combined length of exposures and spans for these PL13 has been increasing over time. This suggests that without some form of remediation the exposures or spans will remain in place after the pipeline has been decommissioned. Any exposures or spans being remediated would require inspections and pipeline monitoring to continue.

Decommissioning activities that minimise the disturbance to the seabed, reduce the likelihood of creating snag hazards / spoil mounds and that leave the seabed free of equipment will minimise the impact on local fishing activities; this will be no different from the current situation. Should the pipelines be left *in situ* 'as is', span management activities would need to continue for leave *in situ*. Although the complete removal and to a lesser extent partial removal of buried pipelines have the potential to leave spoil mounds that present snagging hazards, it is possible that with extra effort these could be dispersed, or they would disappear over time. Although demersal fishing is used in the area, the type of fishing equipment used is unlikely to be affected by the presence of spoil mounds. Removal of surface laid pipelines should not leave any significant spoil mounds behind.

Health & safety risk to onshore project personnel

The key differences between the options are as followed:

- Risks associated with cutting the pipeline(s) resulting in injury would be greater for complete removal due to the higher quantity of material returned to shore compared with the partial removal and leave *in situ* options.
- Risks associated with lifting and handling pipeline sections are also greater for complete removal and to a lesser extent partial removal due to larger quantities of material being returned to shore.

- For the remediation option involving the deposition of rock would require rock to be quarried. To do this at all would incur risks that would otherwise not be incurred.

Many of the hazards described in the foregoing safety assessment are common to both decommissioning options. Based on the differences, the leave *in situ* option gives rise to lower risks to onshore personnel for the following reasons:

- Less offshore work.
- Less onshore handling.
- Unloading pipespools from a vessel has been done before, but to do this at all for the complete removal and partial removal options would increase the risk to onshore personnel as compared to the leave *in situ* option.
- Unspooling of pipelines from a reel has been done before, but to have to do this at all increases the risk for onshore personnel compared to the leave *in situ* option.

However, for PL13 to execute 'leave *in situ*' without any form of partial removal or remediation is unlikely to be a successful decommissioning option over the longer-term. It can be expected that remedial works will be required.

6.2.3 Environmental considerations

Planned energy use, emissions, and discharges

The duration that vessels would be are required in the field for the complete removal and partial removal (or remediation) would be longer than required for leave *in situ*. For PL13 & PL4555 ('cut and lift'), PL4556 ('reverse reel'), vessels would be in the field longer. In both instances the time in the field would be longer than for the leave *in situ* option.

The deposition of rock on exposures would take less vessel time than the removal of exposed sections for the partial removal option.

Vessel times would be reflected in the planned liquid discharges to sea, noise, energy requirements and resulting missions to air. Conversely, the legacy surveys would be required for partial removal (or remediation) and leave *in situ* but not after complete removal. In the case of partial removal and leave *in situ*, the possibility of remedial works could increase with the number of pipeline ends left behind after exposures or spans have been removed or left behind.

The amount of cutting, lifting and disposal requirements are related to the length of pipeline recovered. Therefore, the discharge to sea, discharges to surface water, noise in water from cutting, seabed disturbance from excavation and lifting, and the potential use of landfill space would all be greater for the complete and partial removal options than for leave *in situ*.

Energy requirements and emissions to air would be such that there would be a difference between options. However, the gap between complete removal, partial removal (to a lesser extent) and leave *in situ* narrows when indirect energy requirements and emissions required for replacement of unrecovered material are accounted for.

Planned and unplanned impacts on the seabed sediments

The complete removal option would result in no materials left in the seabed, although during removal operations the likelihood of concrete spalling or breaking off from sections of the concrete weight coated pipelines during cutting and lifting operations would be greatest, and some of this material – despite best intentions, may be left *in situ*.

While the complete removal option would result in no materials being left in or on the seabed, the partial removal and leave *in situ* options would result in materials being left *in situ* to degrade naturally.

As the pipelines are predominantly manufactured from steel (PL4555 and PL4556) or steel and concrete (PL13) this would not be detrimental to the local environment as the deposition of degraded concrete and steel materials would likely occur very gradually over tens if not hundreds of years [10]. Any raw material not recovered would need to be replaced by newly manufactured material for any new products.

The temporary and permanent impacts on the seabed that would arise from implementing the various decommissioning options are summarised in Table 6.2.1 and Table 6.2.2. The options presented in these tables are as follows:

PL13

- Complete removal.
- Remove exposures (PL13) bury ends with rock.
- Rock on exposures only.
- Rock on all of remaining pipeline inside trench.
- Leave *in situ* without remediation.

Should the exposures or spans be removed with the ends buried under deposited rock, it is worth noting that a change in scour patterns could result, with unpredicted spans developing elsewhere in the pipeline(s).

PL4555 and PL4556

- Complete removal.
- Leave *in situ* 'as is'.

The temporary, permanent impacts on the seabed or combinations thereof (up to 0.51km^2) will be small as a percentage (equivalent to ~0.02%) of the of the area (2,991 km^2) of ICES rectangle (51F1) that contains Thistle related infrastructure.

If rock is used as a form of remediation for the PL13 exposures, the quantities of rock would be significant.

- PL13 - Rock on exposures only, 11,770 Te
- PL13 - Rock on complete pipeline, 40,987 Te

Dimensions				Temporary	Permanent				
				PL removed	PL *in situ*	Spot rock *in situ*		Rock *in situ*	
Pipeline ID	**Decommissioning option**	**Length remaining (m)**	**No. of exposures**	**10 m wide**	**5 m wide**	**49 m²**	**25 Te**	**10 m wide**	**Σ Te**
PL13	Complete removal (incl. surface laid ends)	0 km		0.127 km²	n/a	n/a	n/a	n/a	n/a
PL13 exposures	Remove ends and remove exposures	9.07 km	135	0.055 km²	0.036 km²	0.013 km²	6,775 Te	n/a	n/a
	Remove ends, rock on exposures only	9.07 km		0.036 km²	0.036 km²	Neg	n/a	0.019 km²	6,100 Te
	Remove ends, rock on PL incl. exposures	9.07 km		0.036 km²	0.045 km²	n/a	n/a	0.091 km²	29,300 Te
PL13	Leave *in situ* (after PL ends removed)	9.07 km		0.036 km²	0.045 km²	Neg	n/a	n/a	n/a

NOTE:

1. The overall length of PL13 including the surface laid ends is 12.69 km. Combined length of surface laid pipeline ends is 3.623 m. Combined length of exposed section is 1.888 km. Once the surface laid ends have been removed down to trench depth the length of the remaining pipeline is 9.071 km.
2. Assumes 25 Te spot rock would be deposited on cut 16in CWC pipeline end(s), covering an area 49 m².
3. Assumes the density of rock in air is 1,500 kg/m³, using 3.2 Te/m (trenched) to bury a 16in CWC pipeline or parts thereof."
4. "Neg (Negligible)" means that the value does not register to three decimal places when using km²

Table 6.2.1: PL13 summary of temp. and permanent impacts on seabed

Dimensions				Temporary	Permanent		
				PL removed	PL *in situ*	Spot rock *in situ*	Spot rock *in situ*
Pipeline ID	**Decommissioning option**	**Length**	**No. of exp / spans**	**10 m wide**	**5 m wide**	**25 m²**	**15 Te**
PL4555	Complete removal	10.3 km	n/a	0.103 km²	n/a	n/a	n/a
	Leave *in situ* (remove surface laid ends)	10.3 km	n/a	n/a	0.051 km²	50 m² (negligible)	30 Te
PL4556	Complete removal	23.75 km	n/a	0.238 km²	n/a	n/a	n/a
	Leave *in situ* (remove surface laid ends)	23.75 km	n/a	n/a	0.119 km²	50 m² (negligible)	30 Te

NOTE

1. Assumes 15 Te spot rock is deposited on each 8in cut pipeline end covering an area 25 m².

Table 6.2.2: PL4555, PL4556 summary of temp. and permanent impacts on seabed

Waste management

Material for pipelines that are recovered as part of a decommissioning programme can be recycled but in this case could not be re-used 'as is', as the materials would have suffered deformation during the recovery process. Often recycling is the only realistic option and such materials can be split into their component parts such as steel and concrete, and these can be readily recycled.

The amount of material made available for reuse, recycling or destined for landfill would be directly related to the quantity recovered. However, experience would suggest that once recovered to shore, very little material would be destined for landfill. The concrete weight coating would likely be crushed and recycled along with the steel material. Conversely, any material left *in situ* would need to be replaced by the manufacture of new material.

In adopting a remediation option rather than partial removal, the deposition of newly quarried rock would mean that new material would be deposited on the seabed while at the same time no materials would be recovered for reuse or recycling. The partial removal option would likely need the deposition of rock to bury any cut pipeline ends.

6.2.4 Societal considerations

Commercial

While the vessels are present in the field and activities are being undertaken the area would not be accessible for fishing. Therefore, the magnitude of the impact on commercial activities is related to the number and duration of vessels.

Activities which involve removal or reburial would implicitly disturb the seabed. Therefore, since complete removal would require more activities on the seabed it will have a higher short-term impact on commercial fishing.

The main commercial activity in the area is demersal fishing. At some point the potential effects of decommissioning could be loss of fishing revenue due to exclusion from fishing grounds, disturbance of the seabed or loss of, or damage to fishing equipment. Notwithstanding the loss of fishing equipment, as discussed in section 3.3, historically the average value of fish landed per km^2 in the Thistle area is relatively small. Note that there is historical evidence of snagged fishing nets on PL13.

In the years between 2015 and 2021 the maximum value of demersal, pelagic and shellfish landed per km^2 per annum from ICES Rectangle 51F1 was £977.37 (2021), £181.56 (2015) and £4.32 (2019) respectively, giving a maximum total of £1,163.25. This is calculated by dividing the commercial value of fish landed by the area of ICES Rectangle 51F1 (2,991 km^2). The figures indicate a modest increase in the overall value of fishing in the area during the latter years.

The length of pipeline PL13 is 12.69 km. If its continued presence would mean that a 250 m corridor along the pipeline would not be accessible for fishing, the equivalent area would be 4.25 km^2. Conservatively this would mean the loss of revenue 4.25 km^2 x £1,163 = £4,940 per annum based on the maximum total figure derived previously.

Therefore, while decommissioning activities are occurring the complete removal option can be expected to have a greater impact on fishing activities as it would have the longest duration and the greatest amount of activity disturbing the seabed. Leave *in situ* and to a large extent partial removal or deposition of rock would involve leaving the pipelines where they are, and unless the pipelines are buried this could result in residual snag hazards and damage to fishing gear. Surveys may need to be undertaken to confirm that the pipelines remain stable and buried. While these surveys are being undertaken fishing activity may be disrupted for a short time, but the impact can be expected to be minimal and managed using standard procedures. Typically, at least three post

decommissioning surveys would be required; the exact magnitude of the impact will be dependent on the type, frequency and duration of the surveys required.

Employment

The complete removal and partial removal (or remediation) options would require longer vessel time and more waste management requirements. These options would therefore impact more positively on employment than leave *in situ*. However, the effect on employment would likely result in the continuation of existing jobs rather than lead to the creation of new employment opportunities. The significance of the positive impact is low.

Communities

The port and the disposal site have yet to be established. However, they will be existing sites which are used for oil and gas activities and hold the permits required for the management of waste. The communities around the port and the waste disposal sites can therefore be expected to have adapted to the types of activities required, and the decommissioning activities associated with this project would be an extension of the existing situation. Therefore, the effect on communities is not a significant differentiator of the options.

6.2.5 Cost considerations

More details of the cost assessment for the pipelines are presented in Appendix I, Table I.4.1. The assessment takes account of the need for a post-decommissioning survey and assumes that at least 3x future surveys will be required.

For PL13, based on 2018 survey data, the partial removal option assumes that ~3,645 m of exposures would be recovered to shore or be subject to remediation measures. Complete removal of PL13 would be the most expensive option, costing slightly more than the partial removal option, while leave *in situ* would cost the least. The cost of depositing rock on the exposures would be circa. 10% of the partial removal option but remedial works would likely be required in future. All options are more expensive than the leave *in situ* option. Post-trenching is not a viable alternative.

For PL13 the most cost-effective method for dealing with the exposures (and spans) would be to deposit rock along the full length of the pipeline(s). This option would also more expensive than the leave *in situ* option. Post-trenching is not a viable alternative.

The cost of leave *in situ* would be the least expensive of the options but if PL13 are decommissioned with no remediation although remedial works can be expected in future. This would reduce the difference in cost between partial removal (or remediation) and leave *in situ*.

As PL4556 is piggybacked by PL2579 (which is out of scope). The cost of complete removal using the 'cut and lift' method would be almost 10x more expensive than leave *in situ*.

For PL4556, once exposed in the trench the reverse reel method of recovery would be more efficient than 'cut and lift' and the cost of complete removal would almost 5x the cost of leave *in situ*. The leave *in situ* option would attract the least cost.

6.3 Comparative Assessment for Don pipelines

The 'complete removal' and 'leave *in situ*' decommissioning options are compared for the Don pipelines. PL599 is also assessed for the partial removal or remediation option.

6.3.1 Technical considerations

It would be technically feasible to recover all the Don pipelines or parts thereof within the Thistle 500 m zone. Once the surface laid ends have been removed, it would be technically feasible to leave the trenched and buried pipelines *in situ*.

PL598 and PL599

The original comparative assessment concluded that due to possible integrity concerns pipelines PL598 and PL599 could not be recovered using reverse-reel, reverse J lay or reverse S lay. Therefore, they would be recovered using the 'cut and lift' method. As the pipelines are buried it is likely that the overlying sediment would need to be displaced to expose the pipelines before recovery from the trench.

Although repetitive, the 'cut and lift' method would be feasible but is more time-consuming to achieve. Should the pipeline(s) be recovered in road transportable lengths between 10 m and 12 m long this would mean between 45 and 60 sections being recovered for each pipeline from Thistle to the edge of the 500 m zone. This would be achievable.

PL600 and PLU6267

The original comparative assessment concluded that both PL600 and PLU6267 could be recovered using reverse-reel, and as they are routed parallel to each other 25 m apart, theoretically they could be recovered at the same time. However, the assessment did note that further detailed engineering would be required to confirm suitability, practicability and to identify the assurances required. The shallow depth of burial would suggest that the umbilicals could be removed without the need to displace the overlying sediment, but as a contingency, use of a MFE would be available as would the 'cut and lift' method of removal.

6.3.2 Safety considerations

The difference in potential safety risk between the options is sufficiently large that a HAZID was not considered necessary at this stage. A HAZID would ordinarily be carried out as part of the preparatory activities.

Safety risk to offshore project personnel

The key differences between the options are as follows.

- Risk to divers and personnel on the vessel – divers if used, and risk to personnel on the vessel from hydrocarbon or hazardous substance releases from recovered pipelines would be greater for complete and partial removal options than for leave *in situ* due to the larger volumes of material recovered.
- Risk associated with 'cut and lift' operations. Assuming the pipelines could successfully be excavated, from a technical perspective the operation should be relatively straightforward. However, to ensure road transportable lengths of between 10 m and 12 m, the 'cut and lift'; operations would require between ~80 to ~100 sections of pipe to be removed *per km* of pipeline, noting that theoretically[11] only up to ~570 m (equating to between 45 and 60 sections) of each of the Don pipelines would be removed. From a safety perspective this would arguably be manageable, but the associated risks would increase with the number of operations needing to be performed and the amount of material being transferred and handled on the vessel; no such risks would be incurred for the leave *in situ* option.
- Risk associated with reverse reeling operations and risks associated with the vessel being attached to the pipelines. The risk to personnel and assets would therefore be greater for complete removal option, than for leave *in situ*.
- Increased risk to all activities due to adverse weather would be greater for the complete and partial removal options than for leave *in situ* as the vessels would be in the field for longer.
- Risk associated with the potential requirement to deposit rock along a short length of PL599.

[11] Up to the edge of the Thistle 500 m zone

The operational risks would increase with the amount of material involved but can be expected to be low. To have to carry out the operation at all would present more of a risk than doing nothing.

- Risk associated with legacy survey activities. The risks associated with vessels being used for future surveys would be greater for the leave *in situ* option than for complete removal. Given the length involved, the partial removal option would take a similar amount of time as the leave *in situ* option. The operational risks are such that any safety concerns would be low, but to have to carry out the surveys at all would present more of a risk than doing nothing. Typically, in the UK a minimum of three legacy surveys would be required to confirm the condition and stability of subsea pipelines left *in situ*.

Given that the activities and techniques are frequently used in the North Sea and manageable, and most, if not, all the work would likely be conducted using remote operations, the health and safety risks from all hazards would be broadly acceptable.

Short-term safety risk to fishermen and other marine users

The risk to mariners in the short-term is aligned with the duration of the activities in the field. While decommissioning operations are underway the duration of vessels in the field would be longer for either the complete removal (and to a lesser extent for partial removal) option than for leave *in situ*. Reverse reel and to an extent 'cut and lift' would mean that the vessel is attached to a pipeline and could not move out of the way quickly. However, as the operational work would like be conducted while the Thistle 500 m zone remains in place, it is likely that any interference would take the form of minor alterations to normal operating practices during transits. Such deviations would be so small as to not be significant and the marine traffic in the local area would not be affected.

The short-term safety risk for the partial removal option (PL599) would be marginally higher than leave *in situ* but the amount of work would be so small as to make no material difference to the options.

Residual safety risk to fishermen and other marine users

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear. The type of fishing in the area is mostly demersal fishing. For demersal trawling therefore, there is a potential for snagging on equipment left on the seabed, including spoil mounds. However, for the pipelines being considered here – except for a short section of PL599 (potentially 18 m long) that may require remediation, the pipelines can be expected to remain buried with no exposures.

Decommissioning activities that minimise the disturbance to the seabed, reduce the likelihood of creating snag hazards or spoil mounds and that leave the seabed free of equipment will minimise the impact on local fishing activities.

Although the complete removal and partial removal option (PL599) have the potential to leave spoil mounds that present snagging hazards, it is possible that with extra effort these could be dispersed or given the location would disappear over time.

Therefore, both complete removal and leave *in situ* options would leave the seabed free of potential snagging hazards unless any spans are reportable to FishSAFE. No exposures or spans have been found over the years except for an exposure on PL599 at KP0.427 observed in 2013. Depending on what changes have occurred since the 2013 survey, this exposure may need remediation, but the residual risk would be low.

Health & safety risk to onshore project personnel

The key differences between the options for onshore personnel will broadly be the same as those described for the Thistle pipelines in section 6.2.2 above. For brevity the discussion won't be

repeated here, other than to add,

- Unspooling of umbilical from a reel has been done before, but to have to do this at all for the complete removal option would increase the risk for onshore personnel compared to the leave *in situ* option.

6.3.3 Environmental considerations

Planned and unplanned energy use, emissions, and discharges

The amount of cutting, lifting and disposal requirements are related to the length of pipeline being recovered and this will be reflected in vessel time. The duration that vessels would be required in the field for the complete removal and to an extent the partial removal option (for PL599 only) would be longer than required for leave *in situ*. Conversely, the legacy surveys would only be required for partial removal and leave *in situ* options and not after complete removal, and in the case of partial removal the small possibility of remedial works would remain.

Energy requirements and emissions to air would be such that there would be a difference between options, but when considering only the pipelines inside the Thistle 500 m zone, once the pipeline ends at Thistle have been accounted for the difference would be small. The gap between complete removal and leave *in situ* and to an extent partial removal would narrow slightly when indirect emissions and energy requirements – such as that required for replacement of unrecovered material – are accounted for.

In relation to the impacts of leaving the wider Don pipeline infrastructure *in situ*, the increase in planned energy use, emissions, and discharges from decommissioning the pipelines inside the Thistle 500 m zone is very small.

Planned and unplanned impacts on the seabed sediments

The complete removal option would result in no materials left in the seabed. The leave *in situ* option would result in materials being left to degrade naturally. The main pipelines are predominantly manufactured from steel, and this would not be detrimental to the local environment because the deposition of degraded steel materials would likely occur very gradually over tens if not hundreds of years [10]. The umbilicals have a higher content of composite materials (~10%) and so would take much longer than steel to decompose and would likely occur very gradually over hundreds of years, and so would at little detriment to the local marine environment.

Assuming that the removal of all the buried pipelines within the Thistle 500 m zone would affect a 85 m wide corridor[12], the overall area affected would be ~0.048 km^2. This is equivalent to a ~3.22 % of the area that would be affected by the complete removal of the pipelines from between the Don manifold and the Thistle platform. This would be a very small increase and negligible as a percentage of the area of ICES 51F1. None of the removal activities would be done in the protected areas.

Assuming that leaving all the buried pipelines *in situ* would affect a 5m wide corridor, the overall area permanently affected is negligible. In relation to the impacts of leaving the wider Don pipeline infrastructure *in situ*, the increase in impact on the seabed from decommissioning the pipelines inside the Thistle 500 m zone is very small.

[12] The pipelines and umbilicals are routed in parallel approximately 25 m apart. Total corridor width = 75 +2 x 5 m =85 m.

Waste management

The key differences between the decommissioning options are broadly the same as those discussed in section 6.2.3 above. For brevity the discussion is not repeated here.

6.3.4 Societal considerations

The societal considerations would be broadly the same as those discussed in 6.2.4 above and so for brevity the discussion shall not be repeated here. There is a slight difference in that the decommissioning activities would all be conducted within the Thistle 500 m zone, and so if the Thistle 500 m zone remains in place until the Don decommissioning works have been completed, in the short-term fishing activity would or should not be affected.

The Don pipelines can be expected to remain buried and therefore once the Thistle 500 m zone has been rescinded would not be a hindrance to the resumption of demersal fishing in the area.

6.3.5 Cost considerations

In the Don DP [1] the costs are ranked, and no values are assigned to the cost element of the comparative assessment. In the Don DP CA it is acknowledged that some of the decommissioning cost components would be shared between the pipelines and umbilicals, e.g. management, detailed engineering, studies etc, and costs had been calculated based on pipelines and umbilicals being decommissioned at the same time.

In the original assessment it was concluded that there is a significant cost difference between leave *in situ* and complete removal and this is reflected in the "cost ranking" [1].

In addressing complete removal of the pipelines inside the Thistle 500 m zone, leave *in situ* would attract the least cost, while in the complete removal option would be the most expensive. Partial removal would add an incremental cost to leave *in situ*. Should a fall pipe vessel be deployed to deposit rock along the full length of the exposure this could add a disproportionate cost unless the work can be combined with rock deposition work in the area. This is because the fall pipe vessel would otherwise attract mobilisation and demobilisation costs. Further details may be found in Table I.5.1 and Table I.5.2, in Appendix I.5.

Assuming mobilisation and demobilisation costs would be shared with a wider portfolio of work, the complete removal of PL598 and PL599 would be approximately twice the cost of leave *in situ*, whereas complete removal of PL600 and PLU6267 would be approximately a one-third more than the cost of leave *in situ*. Partial removal of PL599 would be approximately one-fifth more expensive than leave *in situ*, and unless the cost of mob and demob of the fall pipe vessel could be shared with a wider portfolio of work, the deposition of rock on the exposure would cost more than twice that of complete removal.

It can be determined that the removal of the pipelines inside the Thistle 500 m zone would be a small addition in cost to the overall scope. If the small increase in cost can be pro-rated to the % increase in scope (i.e. an additional 1,669 m to 51,120 m[13]) there would be a less than 5% increase in overall removal costs. For PL599, at more than three times the cost of partial removal and four times the cost of leave *in situ*, the cost of burying the short exposed section under rock would be the most expensive option.

[13] Combined overall length = 52,789 m, less the lengths inside the Thistle 500 m zone (1,669 m).

7. CONCLUSIONS

7.1 Thistle pipelines

7.1.1 Overview

PL13 is a 16in concrete weight coated pipeline that is 12.69 km long. PL13 was laid in a trench except for the surface laid ends. PL4555 is an 8in pipeline piggybacked by a 3in pipeline (PL2579). PL4555 and PL4556 (also an 8in pipeline) were trenched and buried, although PL4555 (and PL2579) is also buried under deposited rock.

Using 2018 survey data, PL13 suffers from exposures along 1.888 km of its length and 10% of the cumulative length of exposed section of pipeline were characterised as spans. A few of the PL13 spans were recordable to FishSAFE. The more recent survey data for this pipeline would indicate that the number and extent of spans shows no sign of abating. Both PL4555 and PL4556 are buried throughout the full length of the pipelines.

The deposition of rock was considered instead of the partial removal option, but post trenching of concrete weight coated pipelines is not considered viable.

The assessment considered five criteria for both the short-term decommissioning activities and the longer-term for 'legacy' related activities. The criteria were: technical feasibility, safety related risks with three sub-criteria, environmental with four sub-criteria, societal effects with three sub-criteria and cost.

7.1.2 Conclusions

Technical aspects

On the approaches PL13 is surface laid before entering a trench.

Where applicable, all three decommissioning options would be technically feasible. For the removal options, where buried (applies only to PL13, PL4555 and PL4556), the pipelines would need to be excavated from within sediment in the trench or from within rock but technically this is achievable.

The exposed sections in PL13 could be buried under deposited rock instead of implementing the partial removal option. However, the location or distribution of the exposures or spans means that the removal or remediation of individual lengths would give rise to an inefficient schedule of work and would likely lead to scour. Scour will give rise to additional spans in future, potentially leading to more remedial works in future.

Safety aspects

From a safety perspective, given that the activities and techniques – including the deposition of rock instead of partial removal, are frequently used in the North Sea the risks from all hazards relating to 'cut and lift' and reverse reel methods of removal as well as excavation would be broadly acceptable.

Most of the decommissioning works would be executed using remotely operated equipment, although in the case of partial or complete removal handling of recovered material on vessel deck will usually involve deck crew, and the number of individual sections (>1,000 for PL13 overall) to be dealt with is not insignificant. This is why the participants at a comparative assessment review meeting considered that from a safety perspective complete removal of PL13 would be a significant and non-preferred undertaking. The deposition of rock along the full length of a pipeline would all be conducted remotely using a fall pipe vessel.

For all decommissioning options it can be expected that any interference on other seafarers would

take the form of minor alterations to normal operating practice. Such deviations would be so small as to not be significant. Therefore the potential impact of deviations to route on any of the decommissioning options is small.

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear, specifically demersal trawl boards. Although the complete and partial removal of buried pipelines have the potential to leave spoil mounds that present snagging hazards, it is possible that with extra effort these could be dispersed, or they would disappear over time. Although demersal fishing is used in the area, the type of fishing equipment used is unlikely to be affected by the presence of spoil mounds left behind following removal of a buried pipeline. The removal of surface laid pipelines should not leave any significant spoil mounds behind.

By completely removing the pipelines the risk of snagging would be removed in perpetuity. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea. Assuming the remaining sections of pipelines would remain buried, the partial removal option or deposition of rock would also satisfy the requirement to remove snagging hazards. Note that the deposition of rock in discrete areas could result in scour and more pipeline spans in future.

Outside of the 500m safety zones at Thistle, Dunlin and Magnus, leaving PL13 *in situ* as they are, with exposures and spans continuing to exist would be no discernable change to the existing situation providing the spans continue to be monitored and remediated where they exceed FishSAFE criteria. This means, however, that for the leave *in situ* and partial removal or remediation option, pipeline inspections, monitoring, and the potential remediation of any exposures and span management activities would need to continue.

Environmental aspects

Vessels would be required in the field longer for the complete removal and partial removal options than for leave *in situ* and this would be reflected in the use of energy, emissions to air, noise, and planned discharges to sea.

While the complete removal option would result in no materials left in the seabed, the partial removal and leave *in situ* options would result in materials being left *in situ* to degrade naturally. As the pipelines are predominantly manufactured from steel (PL4555 and PL4556) or steel and concrete (PL13) this would not be detrimental to the local environment. Any raw material not recovered would need to be replaced by newly manufactured material for any new products.

The temporary and permanent impacts on the seabed or combinations thereof (up to 0.47km^2) will be small as a percentage (equivalent to ~0.02%) of the of the area (2,991 km^2) of ICES rectangle (51F1) that contains Thistle related infrastructure.

Burial of the combined full length of pipelines PL13 would result in the deposition of up to ~29,300 Te (rounded value) of rock onto the seabed. Burial of exposures (PL13) would result in the deposition of up to ~6,100 Te of rock on the seabed. but given the spread or distribution of the exposures and spans, implementation of this approach would be inefficient and is unlikely to prevent the need for remedial work in future.

Societal aspects

While the vessels are present in the field and activities are being undertaken the area would not be accessible for fishing. Therefore, the magnitude of the impact on commercial activities is related to the number and duration of vessels in the area.

The main commercial activity in the area is demersal fishing. The potential effects could be loss of fishing revenue due to exclusion from fishing grounds, disturbance of the seabed or loss of, or damage to fishing equipment.

Notwithstanding the loss of fishing equipment – for which there is historical evidence that this has occurred on all the concrete coated pipelines, historically the average value of fish landed per km^2 in the Thistle area is small. The combined length of pipelines PL13, PL4555 and PL4556 is 46.7 km. If, simplistically, it can be assumed that their continued presence would mean that a 250 m corridor along the pipelines would not be accessible for fishing, the equivalent area would be 11.68 km^2. Conservatively this would mean the loss of revenue 11.68 km^2 x £1,163 = £13,583 per annum, based on the maximum total figure derived previously.

In pursuing any of the decommissioning options the effect on employment would likely result in the continuation of existing jobs, rather than lead to the creation of new employment opportunities. The effect on communities near the port sites is not considered a significant differentiator between options.

Cost

For all pipelines the leave *in situ* option would be the cheapest. For PL13 the partial removal option would cost almost as much as complete removal. This is because of the start-stop nature of the partial removal operation[14]. For PL13 the most cost-effective way of dealing with the exposures would be to deposit rock along the full length of the pipeline inside the trench. The difference in cost for the different options is summarised in Table 7.1.1.

Pipeline ID	Leave *in situ*	Partial removal or remediation		Complete removal	Rock, full pipeline
		Partial removal	Remediation using rock		
PL13	2.9	9.3	3.3	10.0	4.0
PL4555	0.6	n/a	n/a	10.0	n/a
PL4556	2.9	n/a	n/a	10.0	n/a

NOTES

1. All costs have been normalised against a maximum value of 10. Refer section 6.1.
2. All partial removal or remediation lengths subject to confirmation nearer the time of decommissioning: Ends PL13 ~3.645 km. Cumulative length of exposures 1.888 km. Given the distribution of exposures (PL13) implementation of the partial removal option would be an inefficient use of resources and not recommended.
3. For PL13, once the surface laid end sections have been removed, remediation of the pipeline would involve the deposition of rock along the whole length remaining inside the trench (9.071 km).

Table 7.1.1: Summary of normalised cost assessment (incl. surveys)[15]

For the complete removal option once completed, no more costs would be incurred for future pipeline surveys while pipelines - or parts thereof, that are left *in situ* would be subject to future pipeline inspections.

For PL13, historical survey data for the last decade or so would appear to indicate that some form of intervention or remediation would be required for exposed or span sections once the pipelines have been decommissioned.

Following decommissioning, PL4555 and PL4556 can be expected to remain buried once the pipeline ends have been removed up to the point where they enter burial in rock.

[14] For example, locating the pipeline ends to be cut, executing the cut, removing the cut sections of pipe and depositing rock on the ends.
[15] For an explanation of the colour coding refer Table I.1.1 in Appendix I.1.

7.1.3 Recommendations

The following recommendations are presented for consideration:

- PL13. Remove the surface laid sections of the pipeline on approaches to the Thistle and Dunlin 'A' platforms in accordance with mandatory requirements. Bury the remaining section of the pipeline inside the trench under rock. This will result in ~29,300 Te of rock being deposited on the pipeline.
- PL4555 & PL4556. Leave *in situ*. Completely remove all pipespools and associated protection and stabilisation features; completely remove surface laid sections up to the point of burial in rock and completely remove all protection and stabilisation features. Deposit ~15 Te of rock on both ends of each pipeline. Total rock ~60 Te.
- Leave deposited rock *in situ*.

These proposals are considered to provide an appropriate balance between the technical, safety, environmental, societal, and economic aspects of the assessment.

7.2 Don pipelines

7.2.1 Overview

PL598 and PL599 are 8in pipelines coated with 13mm thick EPDM. When installed both pipelines were trenched and actively backfilled. A pipeline survey in 2013 indicated that PL599 was ~50% exposed (i.e. the crown and top half of the pipeline was visible) at KP0.457 for a length of 18 m and within this exposure the pipeline was found to span for 2.5 m. The status of this exposure or span is not known. Within the Thistle 500 m safety zone the lengths of the pipelines are estimated to be 567 m and 570 m respectively and for context between the Don manifold and Thistle platform the overall lengths of the pipelines are 17.44 km and 17.34 km respectively.

If the exposed section in PL599 is found to exist in future surveys, the need for possible remedial works for the exposed section is not significant provided a fall pipe vessel is not mobilised specifically for the task. The options for PL599 are:

- Leave *in situ* with no remediation, and monitor.
- Remove the exposed section and bury the cut ends with rock.
- Bury the exposed section in rock.

PL600 and PLU6267 are umbilicals with outside diameter 70mm and 88mm respectively. Within the Thistle 500 m zone the lengths of these umbilicals are each estimated as 560 m and 539 m. For context it is noted that between the Thistle platform and the Don manifold the length of both umbilicals is 17.7 km [1].

As a result of submission and approval of the Don DP in 2011 the pipelines have all been partly decommissioned, with most of the decommissioning works outside the Thistle 500 m zone having been completed. The indications are that the CA included in the Don DP addressed the whole of the buried pipelines but to be sure a separate comparative assessment has been conducted in support of the DP for the sections inside the Thistle 500 m zone. This assessment takes cognisance of the Don DP pipeline comparative assessment and explores whether the original results would remain valid for the sections of pipelines inside the Thistle 500 m zone.

Apart from taking note of the original comparative assessment the approach used here is the same as that described for the Thistle pipelines.

7.2.2 Conclusions

Technical aspects

From a purely technical perspective, the complete removal option is technically feasible for the full extent of the Don pipelines within the Thistle 500 m zone. In the original CA the 'cut and lift' method was considered the most viable method for the complete removal of PL598, PL599 and removal of the sections inside the Thistle 500 m zone would be an extension of this activity. Reverse reel could probably be used to recover the umbilicals (PL600, PLU6267) with 'cut and lift' being available as a contingency. Although the operations would be repetitive, complete removal using the 'cut and lift' method would be achievable.

Safety aspects

From a safety perspective, given that the activities and techniques – including the deposition of rock instead of partial removal, are frequently used in the North Sea the risks from all hazards relating to 'cut and lift' and reverse reel methods of removal as well as any excavation would be broadly acceptable. For project personnel, the threat to safety increases with the volume of work and materials dealt with, and by inference in the short-term the leave *in situ* option would present the least threat to the safety of offshore and onshore project personnel.

While decommissioning activities are underway, should the decommissioning work be conducted while the Thistle 500 m zone remains in place, the risk to fishermen and other marine users would be limited to potential vessel collisions during transits. In any event, any interference would take the form of minor alterations to normal operating practices, and such deviations would be so small as to not be significant. On this basis the potential impact associated with any of the options on other mariners can be considered small.

The greatest risk relating to mariners is likely to be concerned with snagging of fishing gear such as demersal trawl boards as demersal trawling is the dominant type of fishing in the area. For demersal (and shellfish) trawling activities there is a potential for snagging on equipment left on the seabed, including spoil mounds and pipelines that remain after decommissioning activities have been completed.

By completely removing the pipelines the risk of snagging would be removed in perpetuity, but according to the original assessment, the remaining sections of pipelines can be expected to remain buried. Therefore, once the partial removal option or deposition of rock has been implemented the requirement to remove snagging hazards would be satisfied. This would mean that there would be nothing to differentiate the decommissioning options. Post decommissioning verification of a clear seabed would confirm that PL599 exposure would not present a snagging hazard.

Environmental aspects

Vessels would be required in the field longest for the complete removal option, and to a very small extent longer for partial removal (PL599 only) than for leave *in situ* and this would be reflected in the use of energy, emissions to air, noise, and planned discharges to sea.

The complete removal option would result in no materials left in the seabed. The partial removal option (PL599) and leave *in situ* options would result in materials being left to degrade naturally. The pipelines are predominantly manufactured from steel, although they are coated with EPDM. However, the slow rate of decomposition of degraded material would not be detrimental to the local environment because with the exception of a short exposed section of PL599 they are buried, and the decomposition process would occur very gradually over tens if not hundreds of years [10]. The umbilicals have a higher content of composite materials (~10%) and so would take much longer than steel to decompose. The deposition of composite materials would also likely occur

very gradually over hundreds of years, and so would at little detriment to the local marine environment.

Assuming that the removal of all the buried pipelines inside the Thistle 500 m zone would affect a 85 m wide corridor[16], the overall area affected would be ~0.048 km^2. This is equivalent to a ~3.22 % of the area that would be affected by the complete removal of these pipelines. This would be a very small increase on a much wider scope associated with the removal of the Don pipelines and would be negligible as a percentage of ICES 51F1. None of the removal activities would be done in the protected areas.

If it can be assumed that leaving all the buried pipelines *in situ* would affect a 5m wide corridor, the overall area permanently affected is negligible.

Any material recovered would most likely be recycled. Any material left *in situ* would need to be replaced with new material. The percentage of material as a proportion of the overall length already being left *in situ* is small.

Societal aspects

The decommissioning activities would all be conducted within the Thistle 500 m zone, but even if the 500 m zone had been relinquished beforehand, fishing activity would not be affected.

The main commercial activity in the area is demersal fishing. Once decommissioning had been completed, the potential effects could be loss of fishing revenue due to exclusion from fishing grounds, disturbance of the seabed or loss of, or damage to fishing equipment.

The Don pipelines can be expected to remain buried and therefore once the Thistle 500 m zone has been rescinded the commercial aspects of demersal fishing in the area would be unaffected. That a short exposed section of PL599 would not be detrimental to fishing activities in the area would be confirmed by a post decommissioning verification of a clear seabed.

Cost

By inspection the removal of the pipelines inside the Thistle 500 m zone would be a small incremental addition in cost to the wider and overall Don pipeline decommissioning scope. If the incremental increase in cost can be pro-rated to the % increase in scope (i.e. an additional 1,669 m to 51,120 m[17]) there would be a less than 5% increase in overall removal costs.

For PL599, at more than three times to cost of partial removal and four times the cost of leave in situ, the cost of burying the short exposed section under rock would be the most expensive option.

7.2.3 Recommendations

Outside the Thistle 500 m zone and within, although a short, exposed section 18 m long was found in PL599, following decommissioning activities – where the surface laid ends are removed and possible remedial works undertaken for PL598, the Don pipelines can be expected to remain buried.

When considering only those sections of pipelines inside the 500 m zone there could be a case to be made to remove the short sections of pipeline (total length 1,669 m) between the Thistle platform and the edge of the 500 m zone. However, when taken in the context of the overall Don field pipelines, they are not separate entities. The recommendation is as follows:

- Remove the pipe bridge along with the pipelines and umbilicals contained on it in accordance

[16] The pipelines and umbilicals are routed in parallel approximately 25 m apart. Total corridor width = 75 +2 x 5 m =85 m.
[17] Combined overall length = 52,789 m, less the lengths inside the Thistle 500 m zone (1,669 m).

with mandatory requirements.

- Remove the surface laid ends from the end of the pipe bridge down to trench depth.
- Bury the cut ends under deposited rock.
- Examine the status of the 18 m long exposure at KP0.427 (measured in 2013 from the pipeline flange at Thistle) in PL599 and agree a remediation strategy. The options are: 1) leave 'as is', 2) remove the exposed section and bury the cut ends under deposited rock, or 3) bury the exposed length under deposited rock). The preference would probably be to leave the exposure *in situ* and subject the area to monitoring as part of a wider pipeline monitoring strategy. Following the survey of PL599 the final decommissioning solution will be discussed and agreed with OPRED.

8. REFERENCES

Please note the link names presented below have been abbreviated.

[1] BP (2011) Don Decommissioning Programme, DON-BP-001, May 2011. Weblink last accessed 10 June 2023: DON-BP-001.pdf

[2] BP (2023) Don Decommissioning Programme for pipelines in Thistle 500m zone, DECOM-DON-HS-PRO-BP-0305

[3] EnQuest (2021) Decommissioning Programmes for Conrie, Don South-West, West Don and Ythan fields, M4109-ENQ-NPR-DN-00-PRG-0002. Weblink last accessed 13 May 2023: Conrie-DSW-WD-Ythan DP.pdf

[4] EnQuest (2021) Thistle Topsides Decommissioning Programme, M3525-ENQ-HEA-DN-0000-REP-0007. Weblink last accessed 13 May 2023: Thistle_Topsides_Final_DP.pdf

[5] EnQuest (2021) Thistle Upper Jacket Decommissioning Programme, M3525-ENQ-THI-DN-0000-REP-0005

[6] EnQuest (2023) Thistle pipeline Decommissioning Programme, M3525-ENQ-HEA-DN-00-REP-0012

[7] EnQuest (2023) Thistle pipeline decommissioning Environmental Appraisal, M3525-XOD-ENS-DN-0000-ENS-0001

[8] GXY (2021) Thistle Pre-Decommissioning Survey 2021, Final Cuttings Pile Sampling Report, M3525-GXY-THI-DN-0000-REP-0007

[9] GXY (2021) Thistle Pre-Decommissioning Survey 2021, Final Environmental Baseline Survey Results Report, M3525-GXY-THI-DN-0000-REP-0008

[10] HSE (Health and Safety Executive) (1997) The abandonment of offshore pipelines: Methods and procedures for abandonment. Offshore Technology report. HSE Books, Norwich. ISBN-7176-1421-2.

[11] Marine Mammal Organisation (2022) UK sea fisheries annual statistics: Landings by rectangle and estimated EEZ (2016 – 2020)[18]. Weblink last accessed 08 May 2023: UK-sea-fisheries-annual-statistics

[12] OPRED (2018) Guidance Notes, Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, Version 6, Department of Business, Energy, and Industrial Strategy. Weblink last 01 July 2019: Decom_Guidance_Notes_Nov_2018.pdf

[13] The Council of the European Communities (1992) The Habitats Directive, Council Directive 92/43/EEC. Weblink last accessed 29 Sept 2021: Habitats Directive

[18] The data are only available for a rolling 5-yearly sequence. The 2015 data was obtained prior to the 2016 to 2021 update.

APPENDIX A EXPOSURE AND SPANS DETAIL SHEETS

Appendix A.1 PL13 exposures (>50m) and spans (>10m)

YEAR	EXPOSURE LENGTH (M)	KP START	KP END	SPAN LENGTH (M)	KP START	KP END	SPAN HEIGHT (M)	COMMENT
2010	329.1	0.022	0.351					
2010	81.6	0.362	0.444					
2010	274.0	0.450	0.724					
2010	69.9	1.061	1.131					
2010	93.0	1.366	1.459					
2010	79.4	3.033	3.112					
2010				12.3	8.219	8.232	N/A	Span not reportable
2010	74.5	9.039	9.114					
2010	135.7	9.379	9.515					
2010	50.5	9.677	9.727					
2010	69.5	9.862	9.932					
2010	697.5	10.500	11.198	12.5	10.538	10.551	N/A	Span not reportable
2010				10.3	10.592	10.603	N/A	Span not reportable
2010				16.3	10.721	10.737	N/A	Span not reportable
2010				18.7	11.026	11.045	N/A	Span not reportable
2010	177.1	11.267	11.444					.
2010	775.7	11.474	12.250	11.7	11.51	11.521	N/A	Span not reportable
2010				11.4	12.238	12.25	N/A	Span not reportable
2012	329.9	0.023	0.352					
2012	81.4	0.363	0.445					
2012	274.1	0.451	0.725					
2012	70.7	1.061	1.131					
2012	55.0	1.404	1.459					
2012	79.1	3.033	3.112					

YEAR	EXPOSURE LENGTH (M)	KP START	KP END	SPAN LENGTH (M)	KP START	KP END	SPAN HEIGHT (M)	COMMENT
2012	73.9	9.041	9.114					
2012	135.0	9.380	9.515					
2012	68.8	9.863	9.932					
2012	696.0	10.502	11.198					
2012	175.8	11.268	11.444					
2012				12.6	11.032	11.044	0.18	Span not reportable
2012	254.8	11.475	11.730					
2012	501.7	11.749	12.251					
2016	699.0	0.022	0.723					
2016				11.0	0.783	0.794	0.20	Reportable span
2016	79.0	1.075	1.154					
2016	57.0	1.403	1.46					
2016	78.0	3.032	3.111					
2016				10.0	8.222	8.232	0.38	Reportable span
2016	73.0	9.039	9.113					
2016	54.0	9.458	9.512					
2016	68.0	9.861	9.93					
2016	597.0	10.500	11.097					
2016				28	10.589	10.617	0.23	Reportable span
2016				10	10.729	10.740	0.18	Reportable span
2016				13	10.955	10.968	0.11	Span not reportable
2016				15	11.006	11.021	0.18	Reportable span
2018	330.8	0.020	0.351					
2018	81.4	0.362	0.443					
2018	255.8	0.449	0.705					
2018	55.1	1.074	1.129					
2018	55.6	1.402	1.458					
2018	78.8	3.032	3.11					
2018	73.9	9.050	9.124					

YEAR	EXPOSURE LENGTH (M)	KP START	KP END	SPAN LENGTH (M)	KP START	KP END	SPAN HEIGHT (M)	COMMENT
2018	70.5	9.391	9.461					
2018	68.0	9.873	9.941					
2018	697.7	10.513	11.255					
2018				10.2	10.557	10.567	0.3	Reportable span
2018				25.3	10.605	10.630	0.2	Reportable span
2018				12.5	10.968	10.981	0.2	Reportable span
2018				12.5	11.021	11.034	N/A	Span not reportable.
2018				16.6	11.043	11.060	0.1	Span not reportable
2018				16.1	11.185	11.201	0.1	Span not reportable
2018	175.8	11.279	11.455					
2018				15.6	11.409	11.425	0.1	Span not reportable
2018	170.0	11.487	11.657					
2018				14.7	11.521	11.536	0.2	Reportable span
2018				15.4	11.585	11.601	0.2	Reportable span

Table A.1.1: PL13 historical exposures (>50m long) and spans (>10m long)

APPENDIX B PL13 MATTRESS LOCATIONS

Appendix B.1 PL13 mattress locations (based on survey data)

YEAR	MATTRESS LENGTH (M)	KP START	KP END	WIDTH	UNDER/OVER
2008	N/A	N/A	N/A	N/A	No mattresses recorded
2010	10.96	0.351	0.362	N/A	Over PL13
2010	5.96	0.444	0.450	N/A	As above
2010	10.41	0.729	0.739	N/A	As above
2010	2.01	10.591	10.593	N/A	Under PL13
2010	2.01	10.593	10.600	N/A	As above
2010	1.65	10.598	10.729	N/A	As above
2010	1.65	10.600	10.755	N/A	As above
2010	1.4	10.728	10.960	N/A	As above
2010	1.4	10.729	11.025	N/A	As above
2010	1.29	10.754	11.032	N/A	As above
2010	1.92	10.958	11.080	N/A	As above
2010	2.79	11.022	11.088	N/A	As above
2010	2.92	11.029	11.104	N/A	As above
2010	1.93	11.078	11.267	N/A	As above
2010	2.08	11.086	11.491	N/A	As above
2010	1.9	11.102	11.558	N/A	As above
2010	69.11	11.198	0.362	N/A	Over PL13
2010	1.4	11.490	0.450	N/A	Under PL13
2010	1.8	11.556	0.739	N/A	As above
2014	N/A	N/A	N/A	N/A	No mattresses recorded
2016	11	0.351	0.362	1.2	Over PL13
2016	6	0.443	0.449	1	Over PL13
2016	11	0.728	0.739	1.5	Over PL13
2016	11	0.753	0.764	1.5	Over PL13
2018	10.77	0.351	0.362	N/A	Over PL13
2018	5.7	0.443	0.449	N/A	As above
2018	1.01	0.624	0.625	N/A	Under PL13
2018	1.55	0.628	0.629	N/A	As above
2018	1.48	0.631	0.632	N/A	As above
2018	1.51	0.633	0.635	N/A	As above
2018	10.29	0.728	0.738	N/A	Over PL13
2018	11.04	0.753	0.764	N/A	As above
2018	1.8	3.053	3.054	N/A	Under PL13, not supporting
2018	1.34	6.905	6.906	N/A	Under PL13, supporting
2018	2.51	6.908	6.910	N/A	Under PL13, not supporting
2018	1.65	8.229	8.230	N/A	Under PL13, supporting

YEAR	MATTRESS LENGTH (M)	KP START	KP END	WIDTH	UNDER/OVER
2018	2.6	11.034	11.037	N/A	As above
2018	1.68	11.038	11.039	N/A	As above
2018	2.34	11.041	11.043	N/A	As above
2018	1.93	11.09	11.092	N/A	As above
2018	1.94	11.099	11.101	N/A	As above
2018	2.77	11.114	11.117	N/A	As above
2018	1.84	11.211	11.212	N/A	Over PL13
2018	21.93	11.212	11.234	N/A	As above
2018	9.98	11.235	11.244	N/A	As above
2018	1.95	11.245	11.247	N/A	As above
2018	8.03	11.247	11.255	N/A	As above
2018	13.82	11.255	11.269	N/A	As above
2018	5.24	11.269	11.274	N/A	As above
2018	4.98	11.274	11.279	N/A	As above
2018	1.39	11.503	11.504	N/A	As above
2018	2.13	11.568	11.570	N/A	Under PL13, not supporting

Table B.1.1: PL13 mattress locations as found in pipeline surveys

APPENDIX C PL4556 AS-BUILT ALIGNMENT SHEETS

Appendix C.1 PL4556 legend for as-built alignment sheets

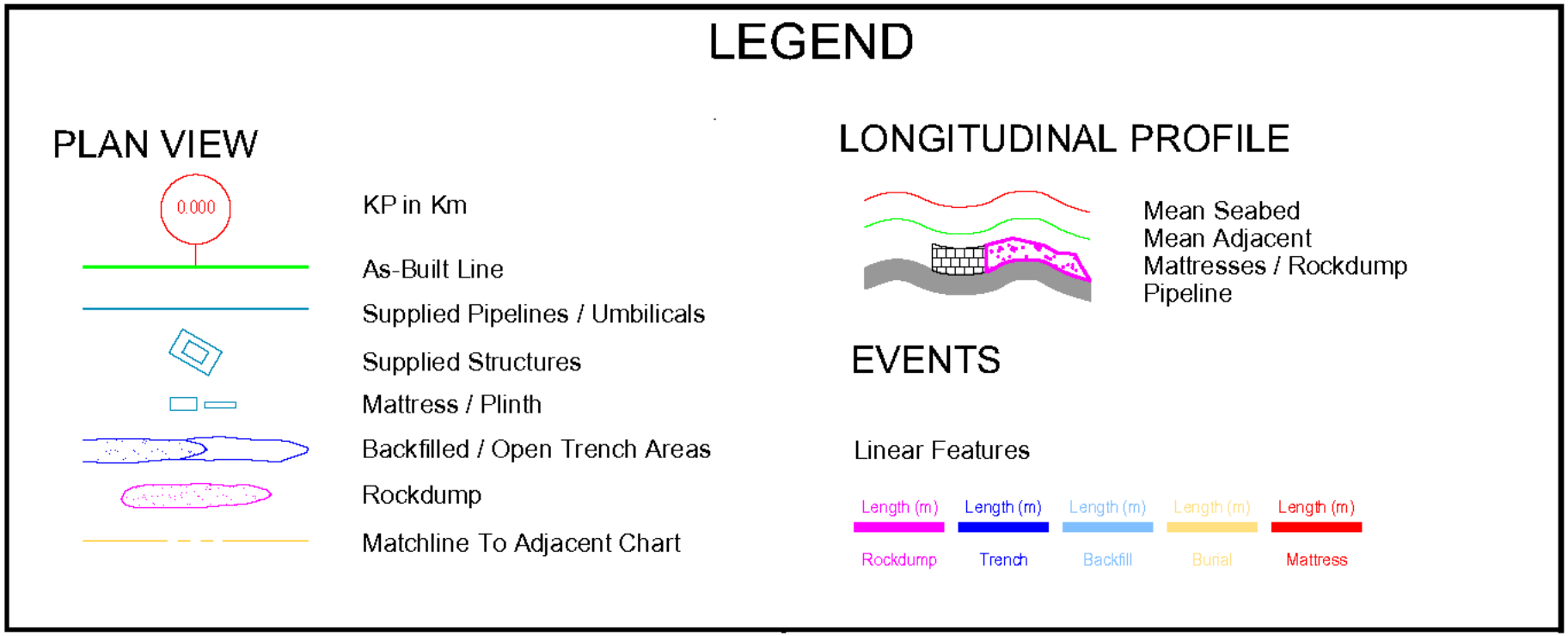


Figure C.1.1: PL4556 As-built alignment sheet legend

Appendix C.2 PL4556 As-built alignment sheet KP-0.000 to KP1.287

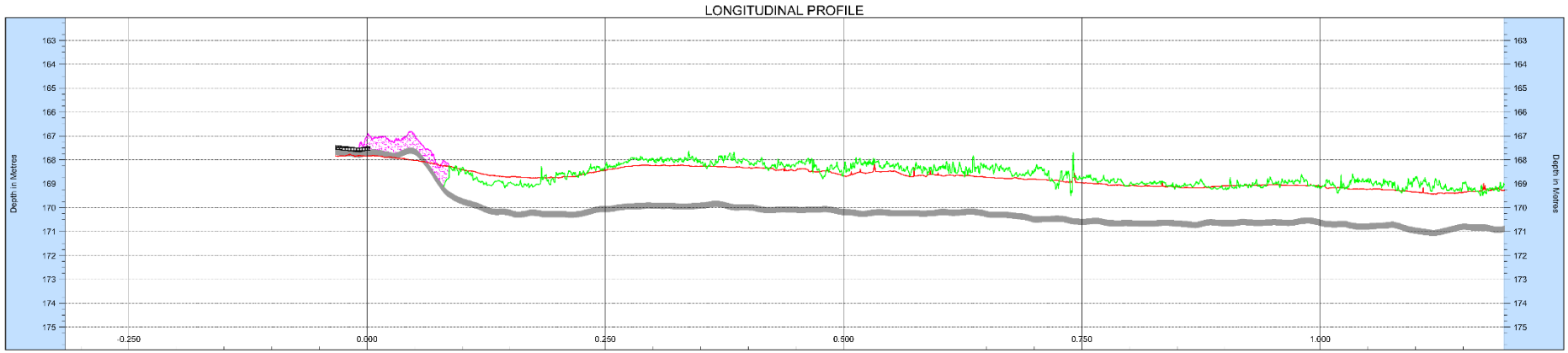


Figure C.2.2: PL4556 As-built alignment sheet KP-0.000 to KP1.287

Appendix C.3 PL4556 As-built alignment sheet KP1.098 to KP2.608

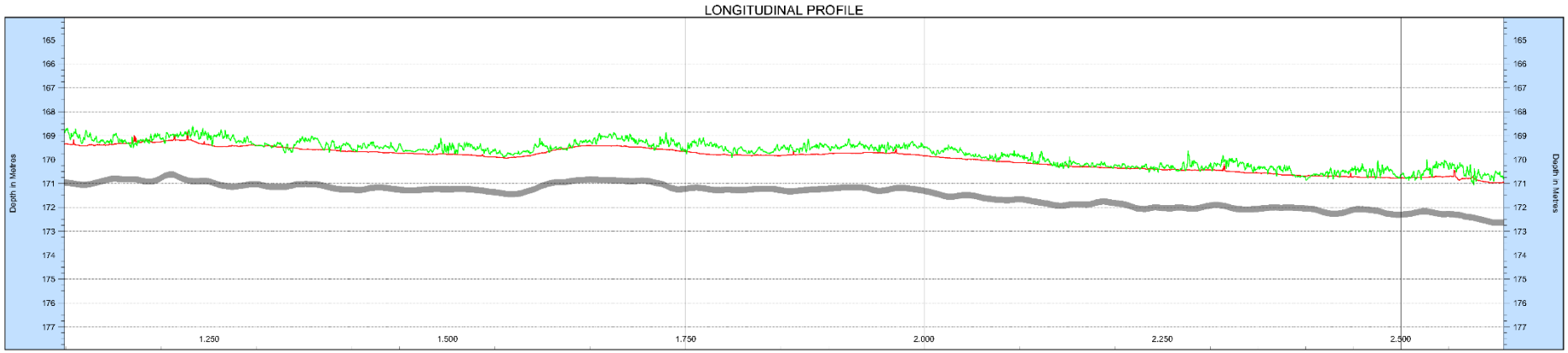


Figure C.3.3: PL4556 As-built alignment sheet KP1.098 to KP2.608

Appendix C.4 PL4556 As-built alignment sheet KP2.508 to KP4.018

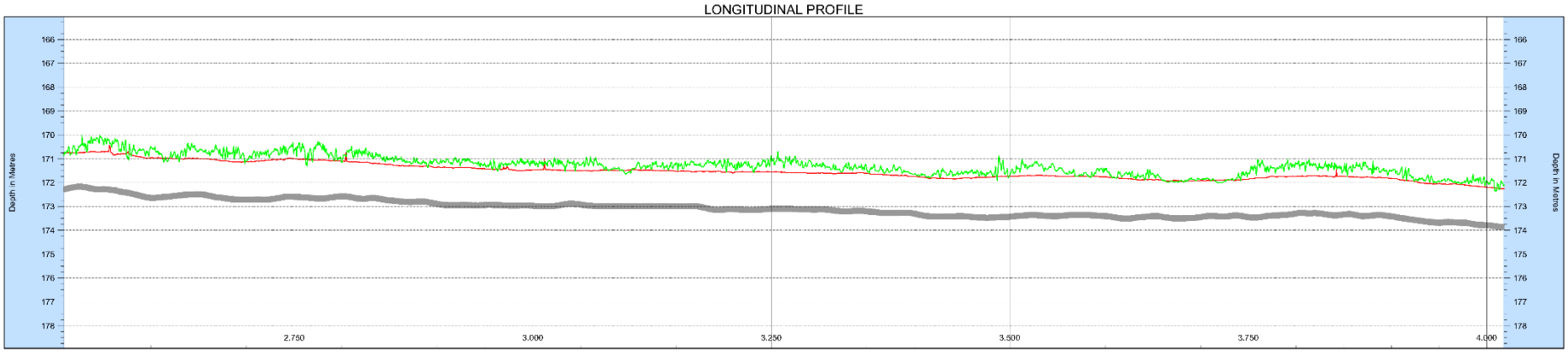


Figure C.4.1: PL4556 As-built alignment sheet KP2.508 to KP4.018

Appendix C.5 PL4556 As-built alignment sheet KP3.922 to KP5.432

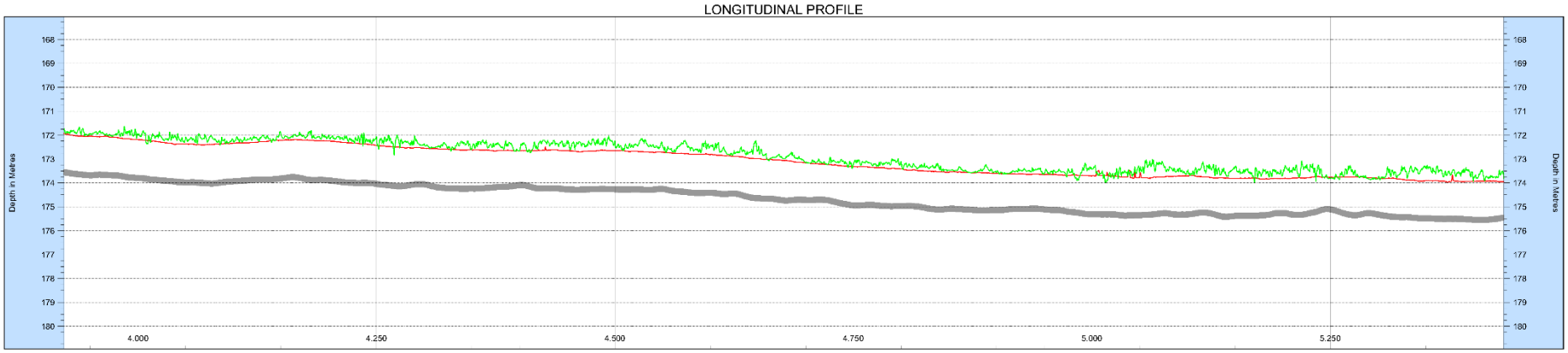


Figure C.5.2: PL4556 As-built alignment sheet KP3.922 to KP5.432

Appendix C.6 PL4556 As-built alignment sheet KP5.351 to KP6.861

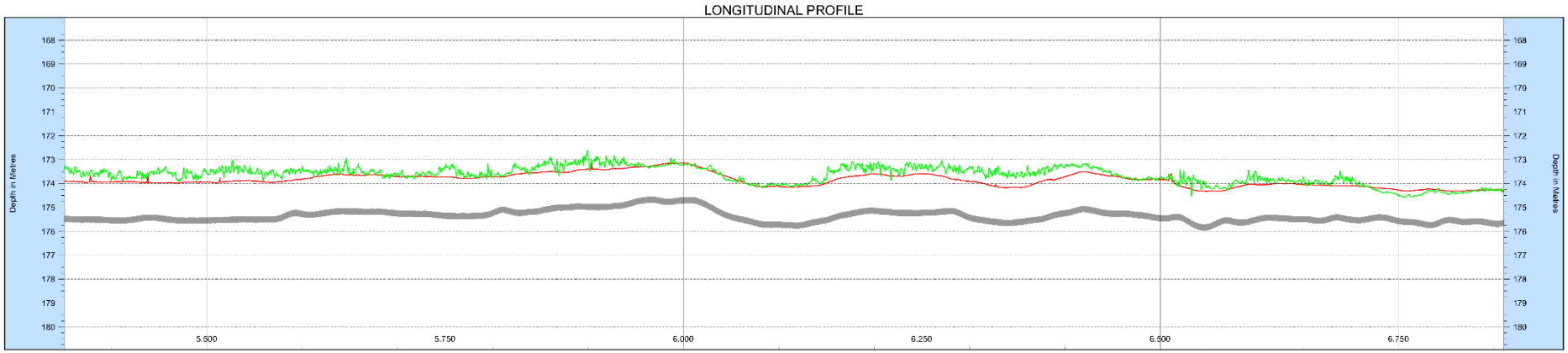


Figure C.6.3: PL4556 As-built alignment sheet KP5.351 to KP6.861

Appendix C.7 PL4556 As-built alignment sheet KP6.776 to KP8.286

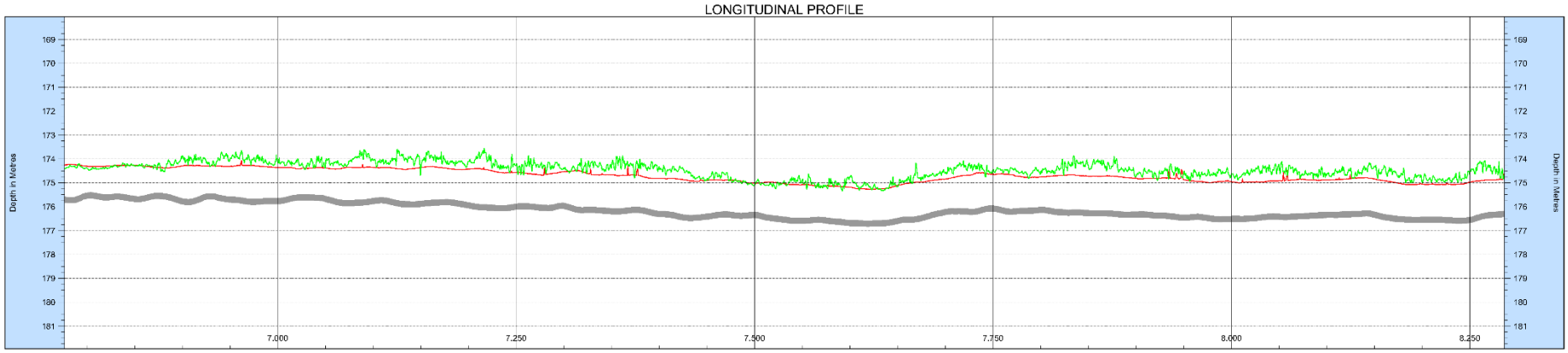


Figure C.7.4: PL4556 As-built alignment sheet KP6.776 to KP8.286

Appendix C.8 PL4556 As-built alignment sheet KP8.188 to KP9.698

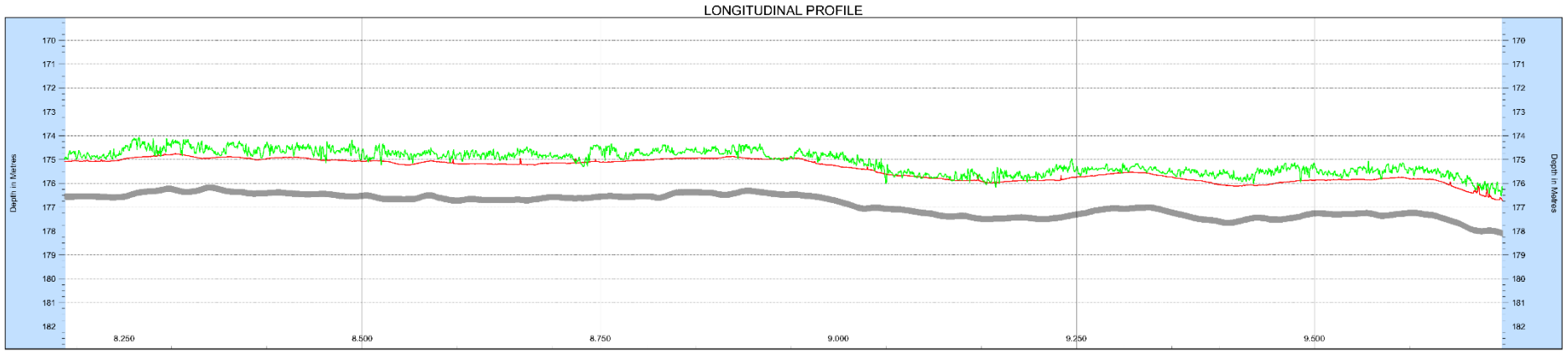


Figure C.8.5: PL4556 As-built alignment sheet KP8.188 to KP9.698

Appendix C.9 PL4556 As-built alignment sheet KP9.600 to KP11.110

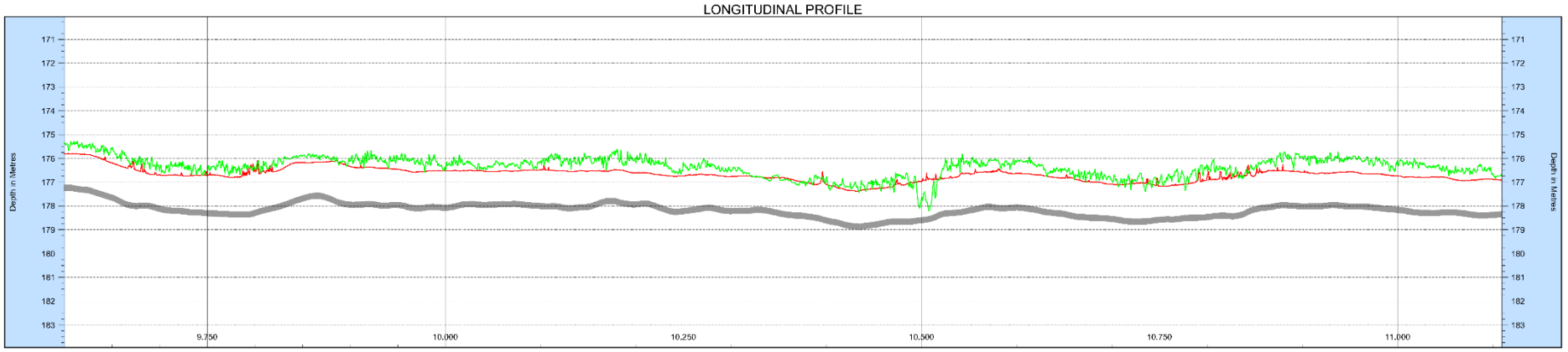


Figure C.9.6: PL4556 As-built alignment sheet KP9.600 to KP11.110

Appendix C.10 PL4556 As-built alignment sheet KP11.010 to KP12.520

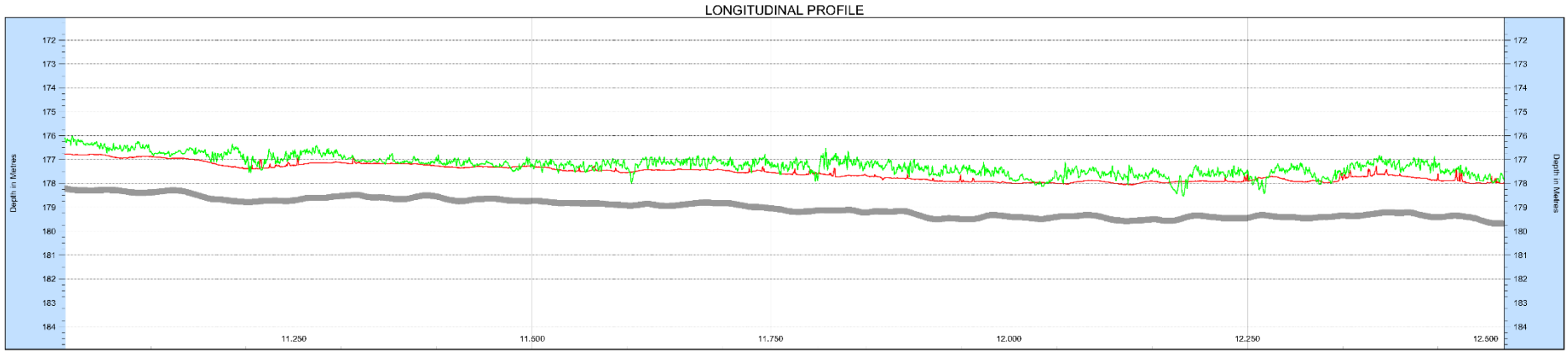


Figure C.10.7: PL4556 As-built alignment sheet KP11.010 to KP12.520

Appendix C.11 PL4556 As-built alignment sheet KP12.420 to KP13.930

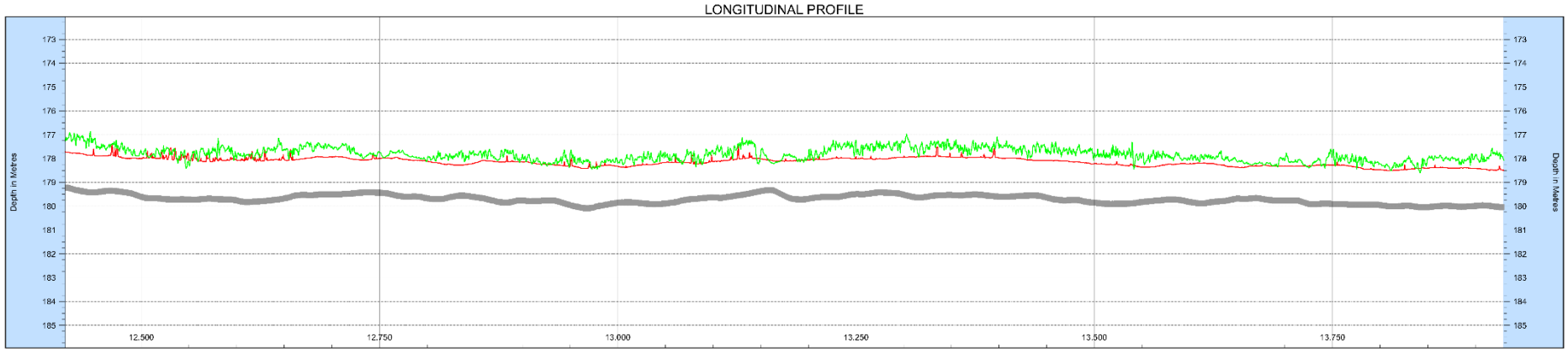


Figure C.11.8: PL4556 As-built alignment sheet KP12.420 to KP13.930

Appendix C.12 PL4556 As-built alignment sheet KP13.830 to KP15.340

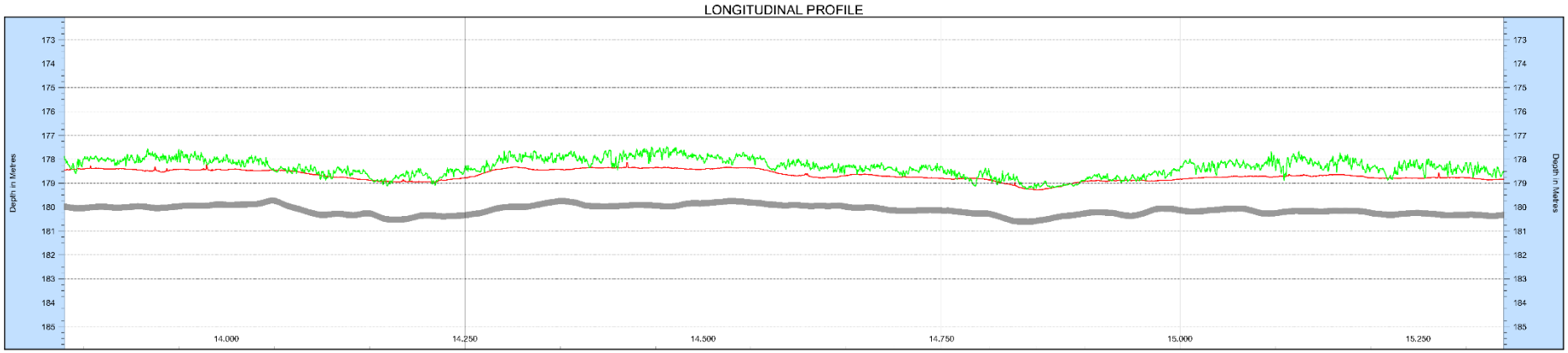


Figure C.12.9: PL4556 As-built alignment sheet KP13.830 to KP15.340

Appendix C.13 PL4556 As-built alignment sheet KP15.240 to KP16.750

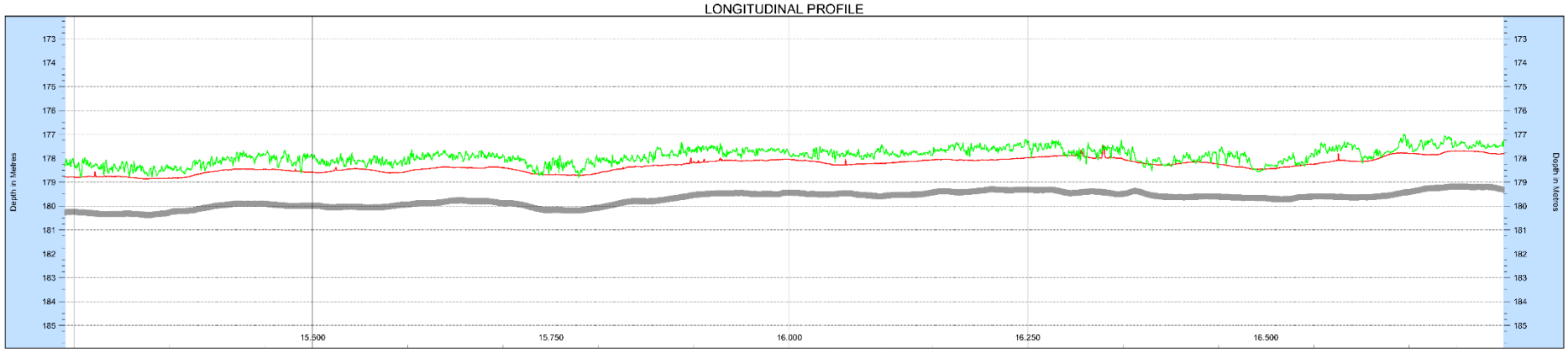


Figure C.13.10: PL4556 As-built alignment sheet KP15.240 to KP16.750

Appendix C.14 PL4556 As-built alignment sheet KP16.650 to KP18.160

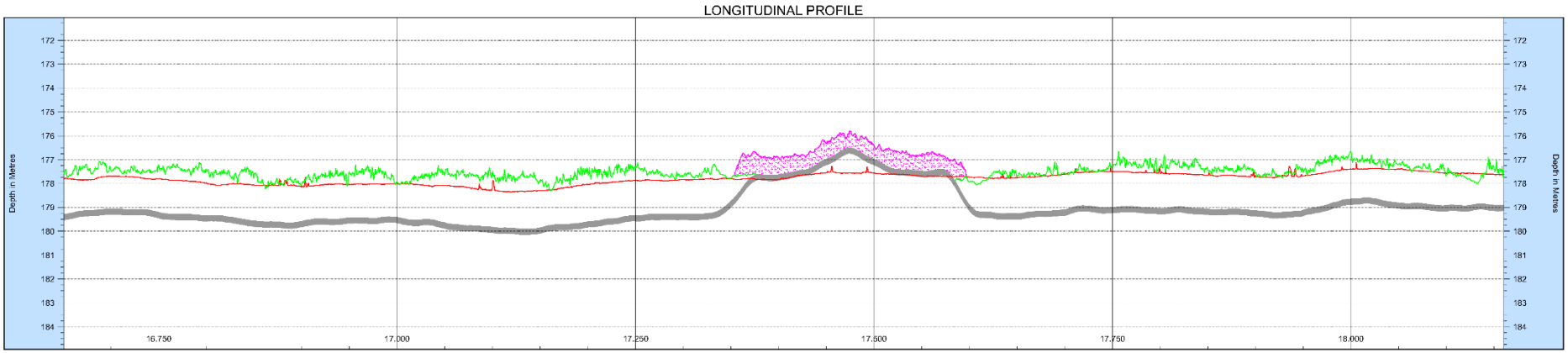


Figure C.14.11: PL4556 As-built alignment sheet KP16.650 to KP18.160

Appendix C.15 PL4556 As-built alignment sheet KP18.065 to KP19.575

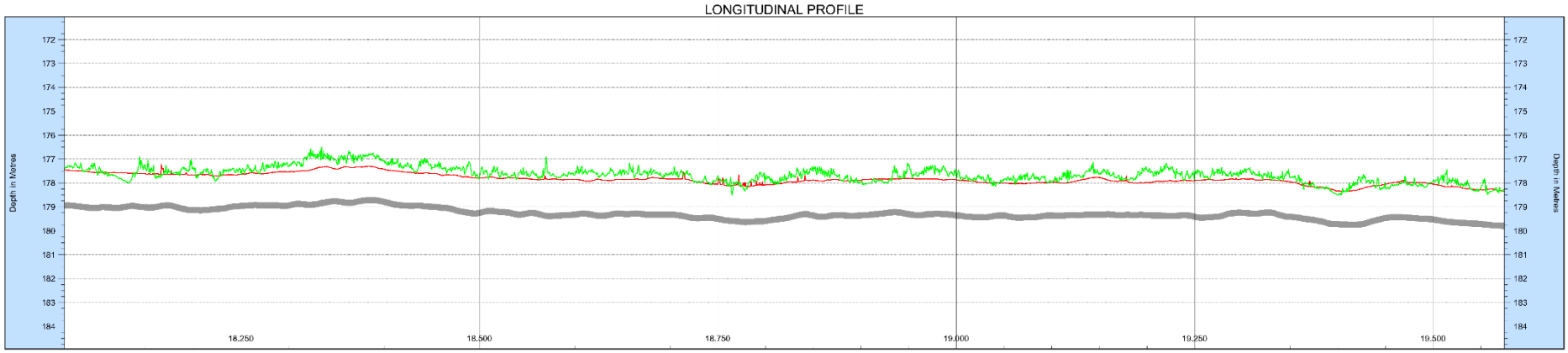


Figure C.15.12: PL4556 As-built alignment sheet KP18.065 to KP19.575

Appendix C.16 PL4556 As-built alignment sheet KP19.493 to KP21.003

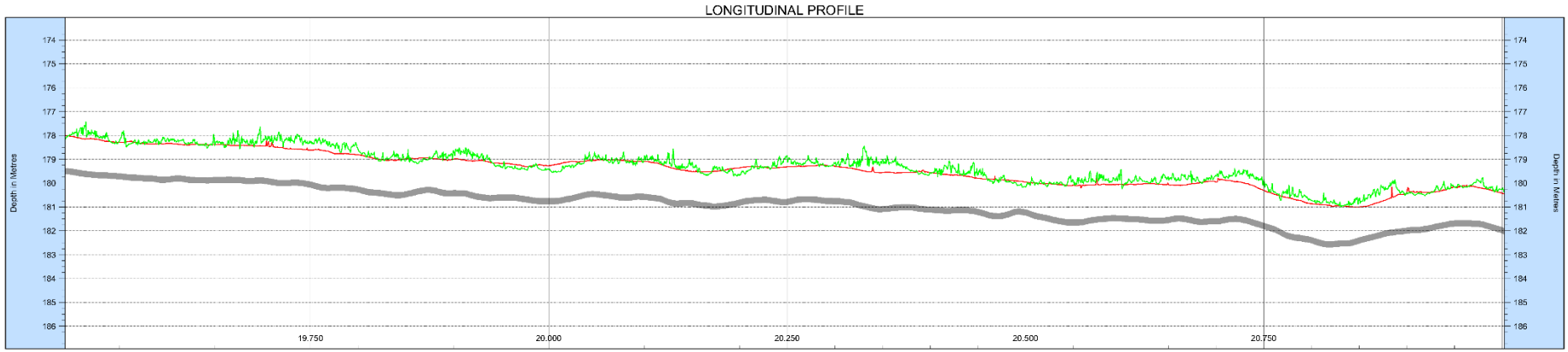


Figure C.16.13: PL4556 As-built alignment sheet KP19.493 to KP21.003

Appendix C.17 PL4556 Rock as-built alignment sheet KP20.903 to KP22.413

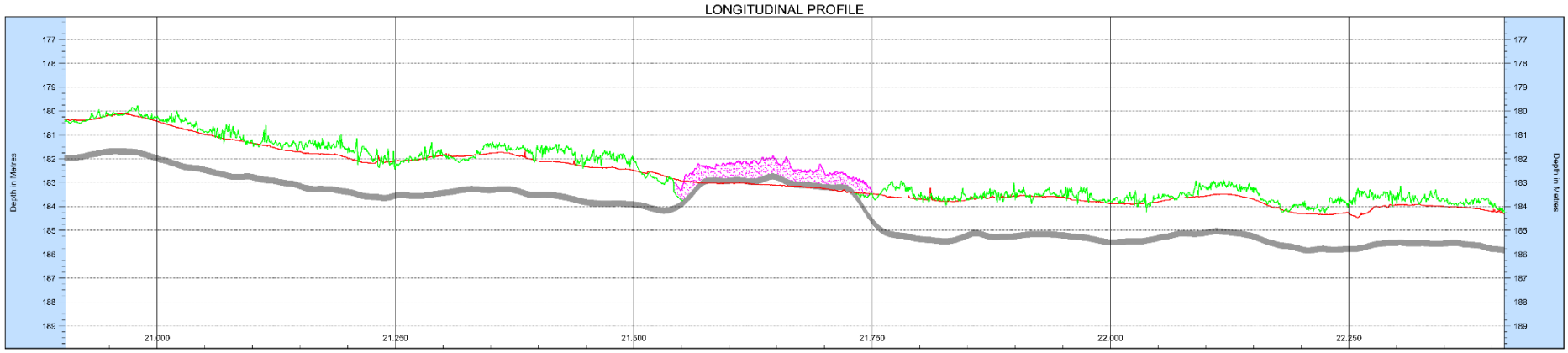


Figure C.17.14: PL4556 As-built alignment sheet KP20.903 to KP22.413

Appendix C.18 PL4556 As-built alignment sheet KP22.315 to KP23.302

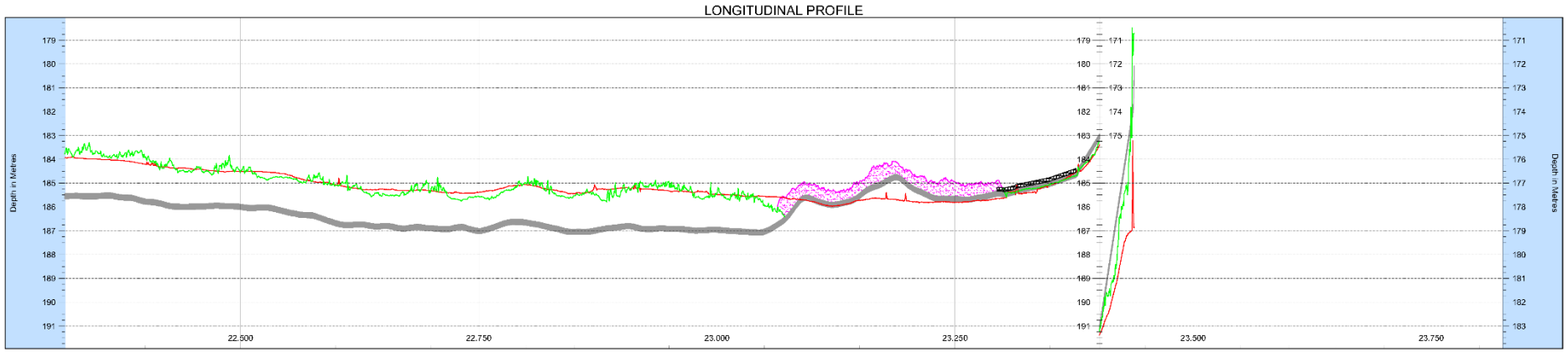
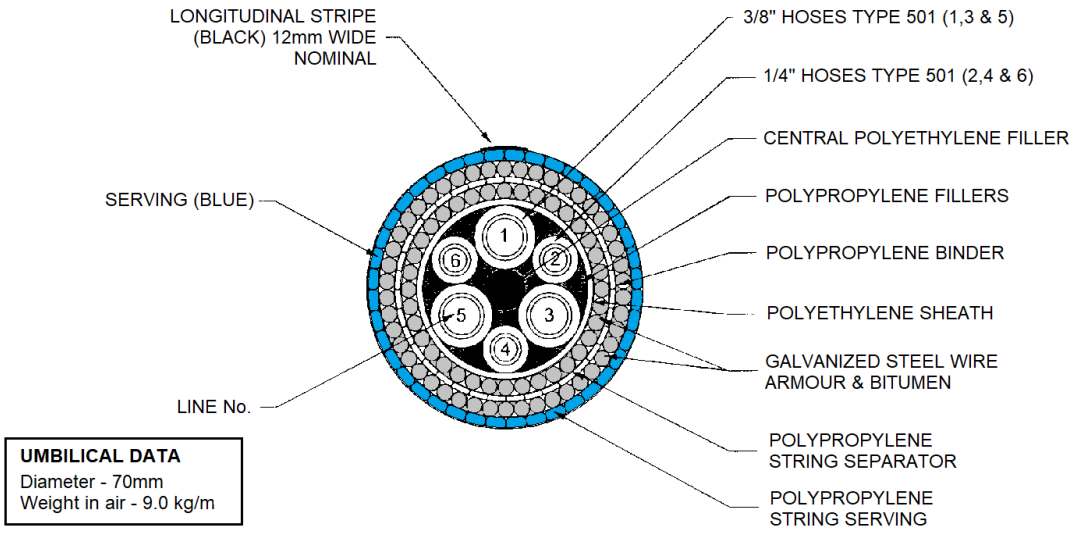


Figure C.18.15: PL4556 As-built alignment sheet KP22.315 to KP23.302

APPENDIX D UMBILICAL CONSTRUCTION

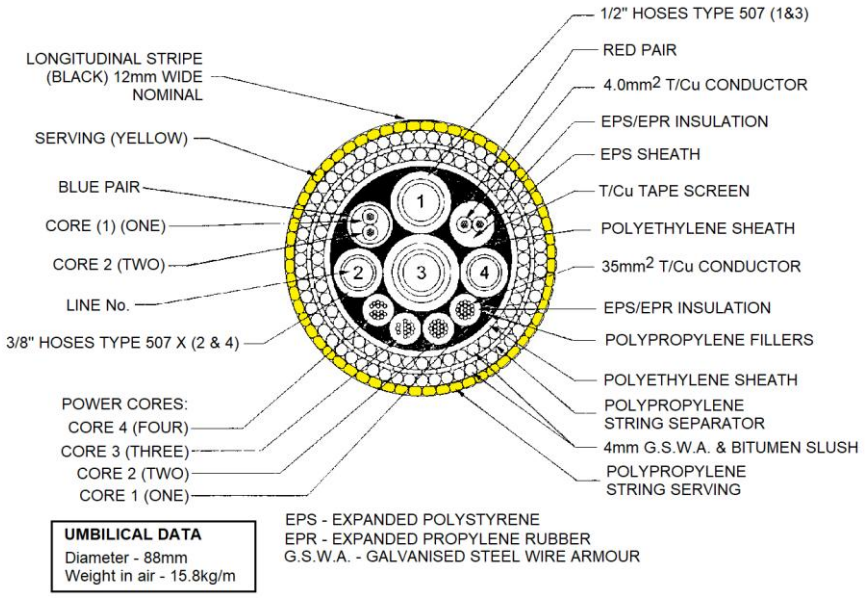
Appendix D.1 PL600 chemical injection umbilical



CROSS SECTION THROUGH CHEMICAL INJECTION UMBILICAL

Figure D.1.1: PL600 chemical injection umbilical construction

Appendix D.2 PLU6267 control umbilical details



CROSS SECTION THROUGH CONTROL UMBILICAL

Figure D.2.1: PLU6267 hydraulic control umbilical construction

APPENDIX E FIELD LAYOUTS

Appendix E.1 Thistle approaches (PL13, PL74, PL75 & PL4555)

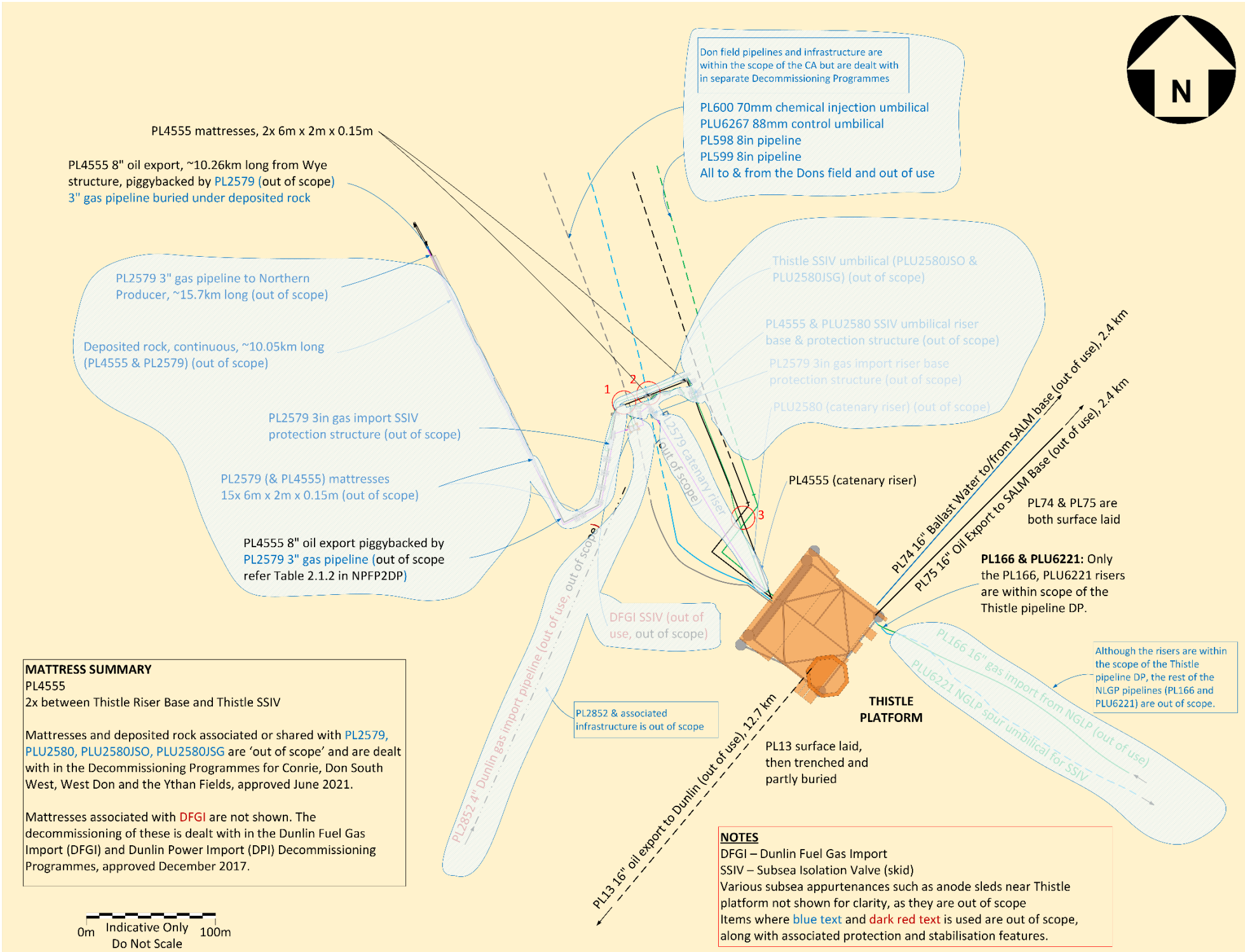


Figure E.1.1: Thistle platform approaches (PL13, PL74, PL75, PL4555 & PLU6221)

Appendix E.2 Don pipeline approaches at Thistle

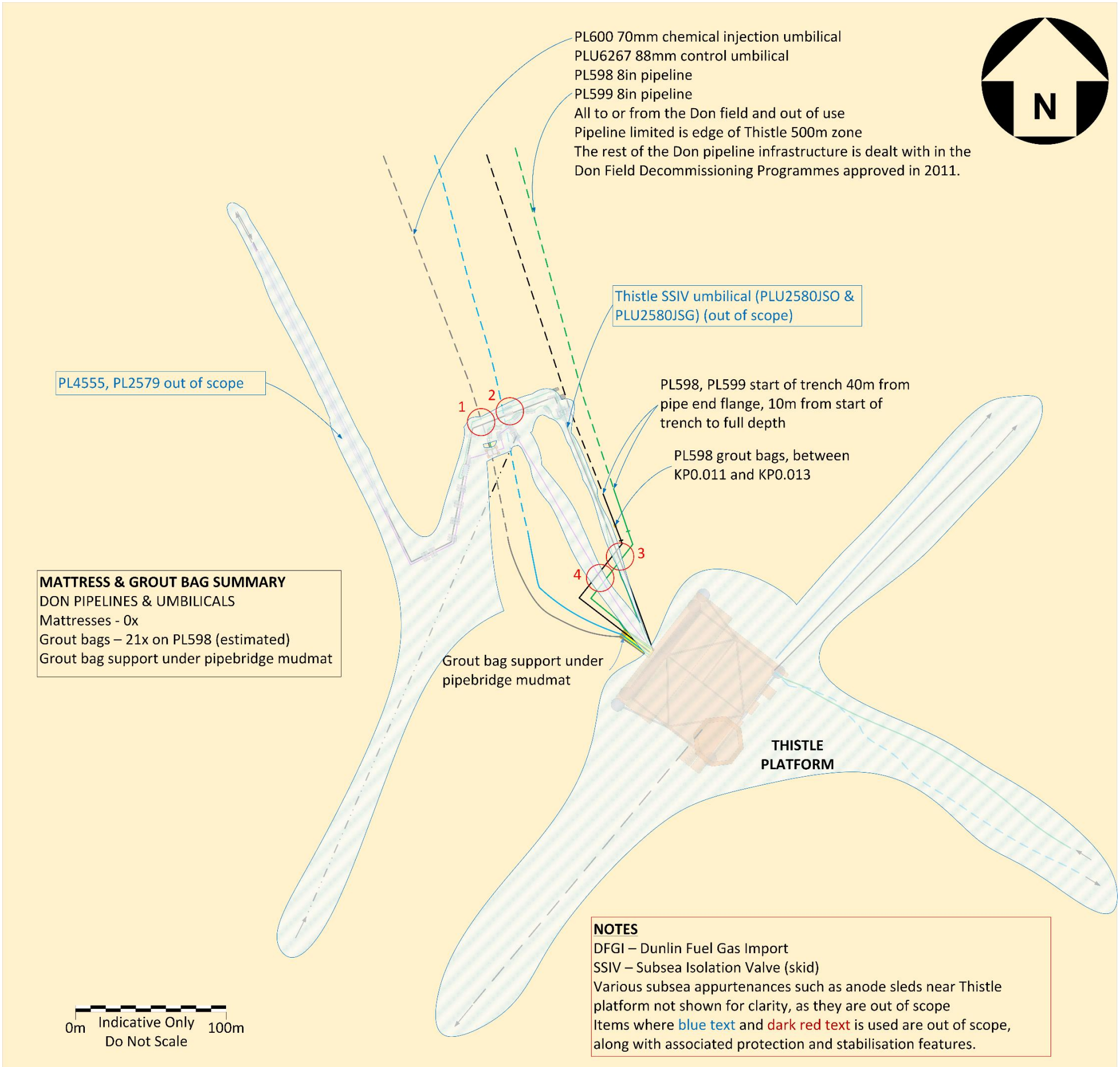


Figure E.2.1: Don pipelines at Thistle platform approaches (PL598, PPL599, PL600, PLU6267)

Appendix E.3 Dunlin ‘A’ approaches (PL13)

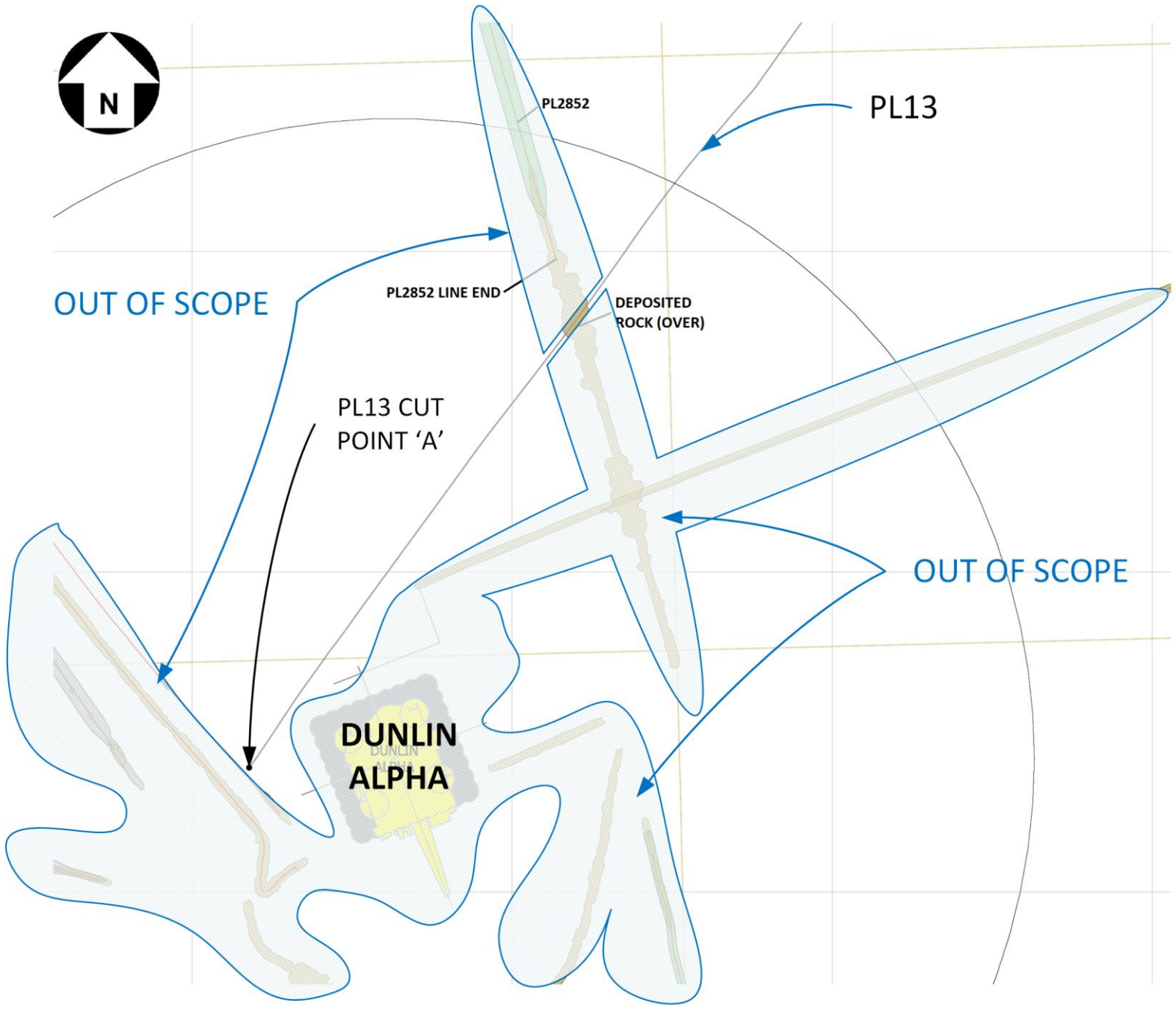


Figure E.3.1: Dunlin ‘A’ approaches (PL13)

Appendix E.4 Wye structure (PL4555, PL4556)

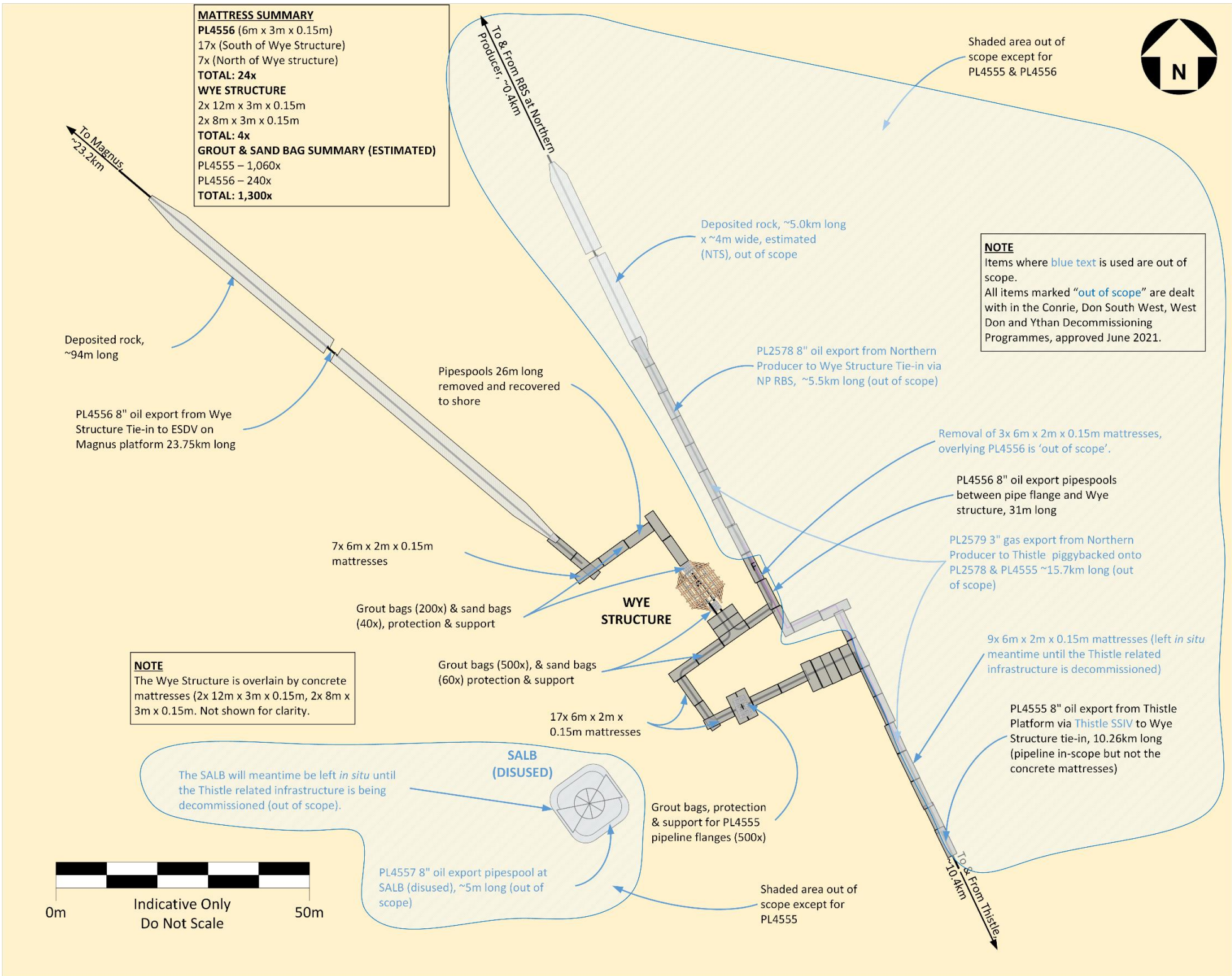


Figure E.4.1: Wye structure approaches (PL4555 & PL4556)

Appendix E.5 Magnus (PL4556)

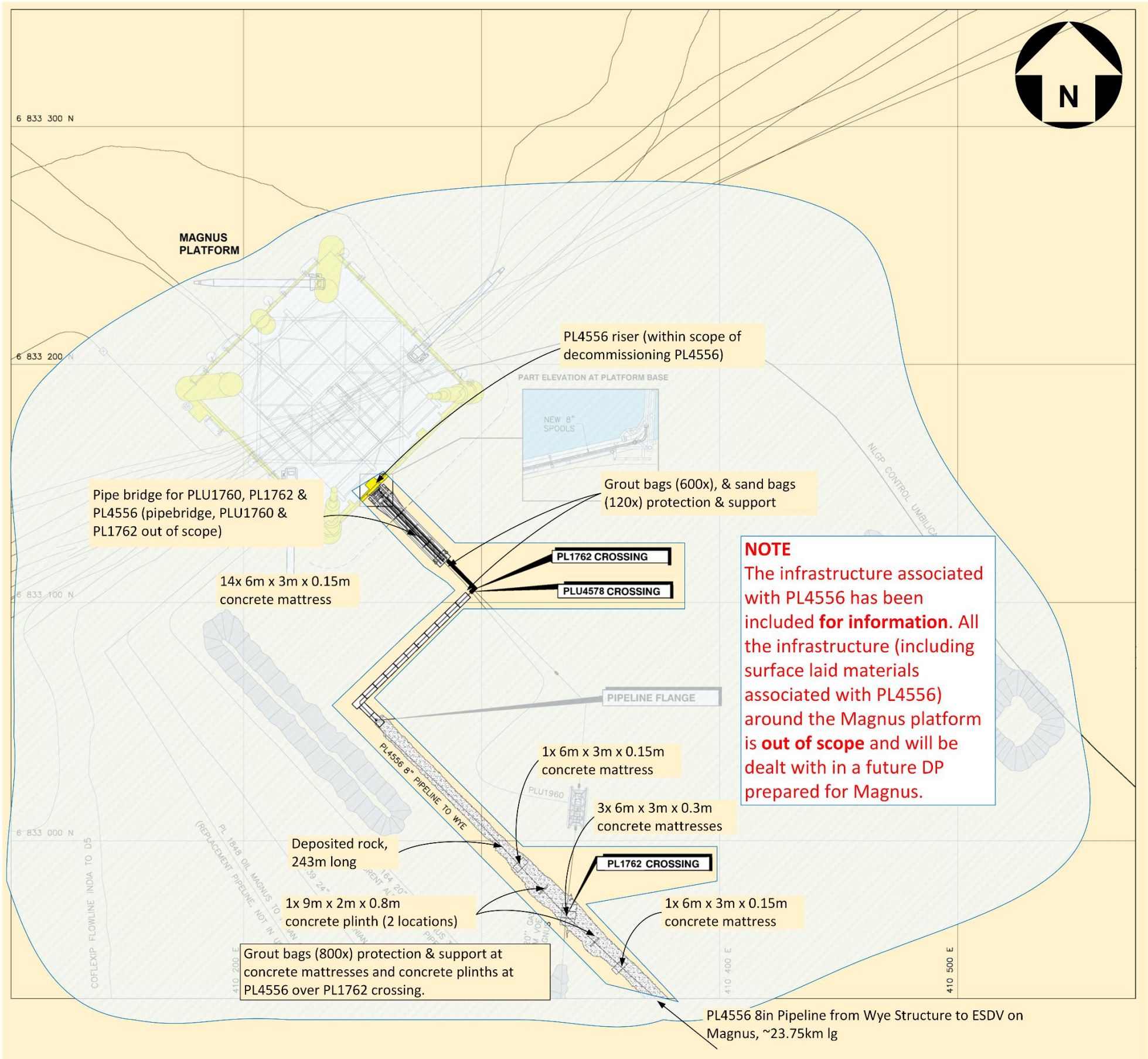


Figure E.5.1: Magnus approaches (PL4556)

APPENDIX F PL13 CA SUMMARY TABLES

Appendix F.1 Technical assessment for PL13

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION	LEAVE *IN SITU*
Technical	**Offshore Execution**	Risk of project failure	Technically, complete removal of the pipelines would be achievable with little chance of project failure. Using 'cut and lift' for PL13, including the surface laid ends, length of pipeline to be recovered is ~12.69 km (9.071 km excl. the surface laid ends).	**Partial removal.** Technically, partial removal of the exposed sections of PL13 would be achievable with little chance of project failure. Partial removal of exposures all executed using the 'cut and lift' method. Total length of exposures 3.645 km. Total length of spans (0.358 km, 0.078.1 km recordable) using 2018 data.	Technically, the pipelines could be left *in situ*.
				Post-trenching. The CWC will have suffered from spalling which renders post-trenching unviable. This means that there would be a high chance of project failure.	
				Rock. Technically it would be possible to deposit rock on the individual exposures or spans or the full pipeline. This has been done before with no risk of project failure.	
		Technological challenge	Technology is currently available to excavate, cut and recover the pipelines to shore as well as to remediate the pipelines (deposition of rock)		n/a
		Technical challenge	Technically there is equipment available to remove all the pipelines.	**Partial removal.** Technically there is equipment available to partially remove the pipelines.	Fully exposed but stable surface laid and buried pipeline(s) with exposures have been left *in situ* before so this approach would be technically achievable although future monitoring and remedial works can be expected.
				Post-trenching. Technically there is equipment available for post trenching activities. However, the spalling CWC reduces the efficiency and viability of the post-trenching option for these pipelines.	
				Rock. A fall pipe vessel could be used for the deposition of rock and has been used before in the field.	
Technical	**Legacy**	Risk of project failure	No pipeline surveys would be required in future.	Pipeline surveys have been undertaken in the past, so this would be achievable with no complications. Inspection, Repair and Maintenance ('IRM') remedial works have also been undertaken in the past, so this would be achievable	
		Technological challenge		The technology is currently available for carrying out pipeline surveys and any remedial works in future.	
		Technical challenge		There would be no technical issues associated with carrying out pipeline surveys or any remedial works in future.	

Table F.1.1: Technical assessment for PL13

Appendix F.2 Safety assessment for PL13

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION	LEAVE *IN SITU*
Safety	**Offshore Execution**	Health & safety risk offshore project personnel	More offshore work than partial removal or leave *in situ*. Excavation of the pipelines and recovery, either using 'cut and lift'. The work associated with 'cut and lift' would be repetitive (typically ~80 to ~100 lengths of pipe per km) but manageable from an HSE perspective. With appropriate engineering and pipeline integrity checks and planning reverse reel method would also be manageable from an HSE perspective. Most of the work could be done using equipment operated remotely and achieved without using divers. Material handling on vessel decks could be automated given the right resources and focus. 'Tolerable' rather than 'preferred' owing to the quantity of cuts and material transfers from seabed to vessel involved. Complete removal 108 operational days in the field, incl. nominal 15% NPT (excl. mob/demob which would be shared with wider field work). Theoretically manageable from an HSE perspective but involves ~1,142 lifts.	**Partial removal**. 90 operational days in the field incl. nominal 15% NPT (excl. mob/demob). Involves ~329 lifts for exposures, ~32 lifts for spans, ~7 lifts for recordable spans. **Rock** (**part** pipeline). Deposition of rock activities for part or all the pipelines would be performed using a fall pipe vessel and remotely operated equipment. 4 operational days in the field (incl. 2x days mob/demob, 1x day survey). **Rock** (**complete** pipeline)**.** Deposition of rock activities for part or all the pipelines would be performed using a fall pipe vessel and remotely operated equipment. 17 operational days in the field (incl. 2x days mob/demob, 1x day survey, 2x port visits 3 days each visit).	Only pipeline ends to be dealt with. Less offshore work than for complete removal. Experience in the UKCS a of removal of pipeline sections. Significantly less work and therefore a shorter duration of activities than for complete removal. Nominal 1 operational day (excl. mob/demob). Involves ~2 lifts.
		Health & safety risk to mariners	The risk to mariners in the short term would be aligned with the duration the activities would be undertaken in the field. Vessels in the field for complete removal would be in the field for longer (~108 operational days) than for partial removal or leave *in situ*. The 'cut and lift' method would also restrict the ability of a vessel to move out of the way, but for a relatively short time.	**Partial removal**. Duration of vessels in the field would be longer than for leave *in situ* but less than for complete removal. **Rock**. Duration of vessels in the field would be longer (~11 operational days) than for leave *in situ* but much less than for complete removal.	Only the pipeline ends would be dealt with; duration of vessels in the field would be shorter than for complete removal and partial removal.
		Safety risk onshore project personnel	Significantly more off-loading, off-reeling, onshore cutting, lifting, and material handling associated with disposal of the pipelines; presents an increased safety risk to personnel. Up to ~1,142 items, bundled or put into transport baskets offshore. The work would all be manageable from an HSE perspective.	**Partial removal**. Significantly less off-loading, onshore cutting, lifting, and material handling associated with disposal of the pipelines than for the complete removal option and so would present less of a safety risk to personnel than for complete removal but more of a safety risk than for leave *in situ*. Up to ~329 items, bundled or put into transport baskets offshore. The work would all be manageable from an HSE perspective. **Rock**. Quarrying and loading onto a fall pipe vessel will be required but otherwise the work is autonomous.	No onshore work except for that possibly associated with the pipeline ends, which would be required for any of the decommissioning options.
Safety	**Legacy**	Health & safety risk offshore project personnel	No pipeline surveys or remediation related activities.	Pipeline surveys would be required, remedial work may also be required, but these activities may be considered routine with well managed risks and would be of short duration.	Pipeline surveys would be required, remedial work will likely also be required, but these activities may be considered routine with well managed risks and would be of short duration.
		Health & safety risk to mariners	No infrastructure left therefore no residual snag hazards. Lower risk as potential snag hazards completely removed. Although bottom dredging, demersal fishing nets should not adversely interact with the temporary excavations.	If the extent or number of exposures or spans increases, degradation of the pipelines could change the risk, but the risks of snagging from exposures or individual spans would remain low providing IRM activities continue. Deposition of rock along the full length of pipeline would be preferrable to limiting the work to exposures or spans.	Although no different to the current situation, snag hazards will remain as evidenced by fishing net debris. Post decommissioning surveys and existing data provide evidence that any pipeline spans or exposures are limited, but the risk would remain.
		Safety risk onshore project personnel	Little to differentiate the options, although future remedial works may require handling of materials onshore.		

Table F.2.1: Safety assessment for PL13

Appendix F.3 Environmental assessment for PL13

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION	LEAVE *IN SITU*
Environmental	**Offshore Execution**	Energy & emissions	Energy use and resulting emissions for this option would be higher than for leave *in situ*, but no energy and emissions would be needed to create new steel material ~108 operational vessel days.	**Partial removal**. Energy use and resulting emissions for this option slightly more than needed for leave *in situ*. Some replacement material required. Less energy use than needed for complete removal ~90 operational vessel days.	Least amount of energy used, and least emissions generated in the short term, although any gains would be offset by the energy and emissions required to create new material to replace that which would be left *in situ*.
				Rock. Less energy etc than for complete removal ~17 operational days. New material required to replace material left *in situ*.	
		Seabed disturbance, area *temporarily* affected (less significant than permanent disturbance)	The amount of seabed disturbed would be directly related to the length of pipeline being removed. The area **temporarily** affected (0.13 km^2) would be largest for this option.	**Partial removal**. The area **temporarily** affected by the removal of exposures ~1.888 km), equivalent area ~0.055 km^2) would be less than half of that affected by the complete removal.	The smallest area of seabed would be temporarily disturbed in the short-term with the leave *in situ* option. By inspection the area impacted would be negligible.
				Rock. No **temporary** affect. Permanent affect only. n/a.	n/a
		Disturbance to Protected Area	n/a. The Thistle pipelines are not within a Special Conservation Area or a Marine Protected Area.		
		Effect on Water Column: • Liquid discharges to sea • Liquid discharges to surface water • Noise.	Discharges and releases to the water column are related to the duration of activities and on balance would be greatest for the complete removal option ~108 operational days.	Discharges and releases to the water column are related to the duration of activities. **Partial removal** ~90 operational days (exposures).	Discharges and releases would be least for the leave *in situ* option, particularly in the short-term.
				Rock. ~17 operational days for complete pipeline, ~4 days for just exposures.	
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	This option would result in the largest quantity of material being returned to shore (3,371 Te) for recycling. No material would be lost as no material would be left *in situ*.	**Partial removal**. This option would result in less material being returned to shore (501 Te) than for complete removal but more than for leave *in situ*.	Only the surface laid pipeline ends would be returned to shore for recycling (~8 Te). Newly manufactured material would be needed to replace the material not recovered to shore.
				Rock. This option would result in no material being returned to shore, but rock would be a resource consumed during decommissioning works.	
Environmental	**Legacy**	Energy & emissions	n/a	**Partial removal**. Pipeline surveys will be required. Possible remedial work.	Pipeline surveys. It is likely that remedial work will be required in future.
				Rock. Pipeline surveys required. No remedial work.	
		Seabed disturbance, area *permanently* affected	n/a	**Partial removal**. Remove exposures, spot rock on cut PL ends. Area **permanently** affected by remaining pipeline and rock deposited on cut pipeline ends would be: 6,775 Te (0.013 km^2).	The area **permanently** affected would be 0.049 km^2. However, remedial works will likely be required in future, resulting in an increased area of seabed permanently affected.
				Rock. Rock on all **exposures** and both PL ends, quantity of rock 6,100 Te (0.019 km^2) Overall area permanently affected by rock and presence of undisturbed pipeline (9.071 km) is 0.055 km^2.	
				Rock. Permanent disturbance. The amount of rock used on complete **length** of the pipeline left in situ (9.071 km) would be ~29,300 Te (affecting an area 0.136 km^2)	
		Disturbance to Protected Area	n/a. The Thistle pipelines are not within Special Conservation Area or a Marine Protected Area.		
		Effect on Water Column: • Liquid discharges to sea • Liquid discharges to surface water • Noise.	No pipeline surveys required as the pipelines would have been completed removed.	Pipeline surveys will be required.	Pipeline surveys would be required, Remedial works will likely be required in future.
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	As the pipeline(s) would have been removed, no further waste would be created.	Remedial works may or may not be required in future.	Remedial works will likely be required in future.

Table F.3.1: Environmental assessment for PL13[19]

[19] Any rock that is used for remedial work will have a permanent effect on the seabed and is therefore considered as a legacy impact.

Appendix F.4 Societal assessment for PL13

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION	LEAVE *IN SITU*
Societal	**Offshore Execution**	Effect on commercial activities	The impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal.	The overall impact of decommissioning vessel traffic on local commercial activities such as fishing would be less than for complete removal but more than for the leave *in situ* option. The impact of remedial activities such deposition of rock on local commercial activities such as fishing would be less than for complete removal.	The impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for leave *in situ*.
		Employment	Decommissioning activities associated with the complete removal of pipelines would contribute greatest to the continuity of employment but given the overall duration of activities there is little to differentiate the options.		
		Communities or impact on amenities	For any ports and disposal sites the any increase in work would be larger than for partial removal or leave *in situ*, but a relatively small increase in the overall work burden. Complete removal would result in 4,845 Te of material being recovered to shore.	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal but more than for leave *in situ* option. Including removal of surface laid pipeline ends partial removal would result in ~1,399 Te of material being brought back to shore.	Decommissioning activities associated with leave *in situ* would contribute the least to continuity of work in ports and disposal sites. Removal of just the ends would result in ~169 Te of pipeline material being brought to shore.
Societal	**Legacy**	Effect on commercial activities	Once the pipelines have been completely removed there would be no commercial impact on fishing activity.	Once the pipelines have been partially removed or remediated there should be no commercial impact on fishing activity.	The length of PL13 is 12.69 km. Assuming a 250 m wide corridor equates to loss of revenue 3.17 km^2 x £1,163 = £3,689 per annum, based on the maximum total figure derived previously.
		Employment	No future opportunities for continuation of employment.	Survey related work, little or no difference between partial removal and leave *in situ*.	

Table F.4.1: Societal assessment for PL13

Appendix F.5 Cost assessment for PL13

CRITERIA	ASPECT	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION			LEAVE *IN SITU*
			PARTIAL REMOVAL, & PL ENDS	REMEDIATION PART PL	REMEDIATION FULL PL	
Cost	**Offshore Execution**	Using the 'cut and lift' method, the cost of complete removal would cost almost 4x more than the cost of leave *in situ*.	Partial removal, >75% of the cost of complete removal.	Cost of depositing rock along exposed sections would be >25% of the cost of complete removal.	Deposition of rock along full length of pipeline <15% of the cost of complete removal.	The cost of leave *in situ* would be the more expensive than remediation of the wole least expensive of the options. Future remedial work would reduce the difference in cost between the options.
Cost	**Legacy**	No pipeline burial surveys would be required in future.	Future burial surveys would be required.			Future burial surveys would be required. The need for remedial works in future would reduce the difference in cost between complete removal and leave *in situ* options.

Table F.5.1: Cost assessment for PL13

APPENDIX G PL4555 AND PL4556 CA SUMMARY TABLES

Appendix G.1 Technical assessment for PL4555 and PL4556

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	LEAVE *IN SITU*
Technical	**Offshore Execution**	Risk of project failure	Technically, complete removal of the pipelines would be achievable with little chance of project failure. PL4555 (piggybacked with PL2579) using 'cut and lift' and PL4556 using reverse reel. There is relatively little experience in UKCS with reverse reeling pipelines through seabed sediment, but it would be achievable. Length of PL4555 is ~10.56 km and PL4556 is ~23.75 km.	Technically, the pipelines could be left *in situ*.
		Technological challenge	Technology is currently available to excavate, cut and recover the pipelines to shore as well as to remediate the pipelines (deposition of rock)	n/a
		Technical challenge	Technically there is equipment available to remove all the pipelines.	Fully exposed but stable surface laid and buried pipeline(s) with exposures have been left *in situ* before so this approach would be technically achievable although future monitoring and remedial works can be expected.
Technical	**Legacy**	Risk of project failure	No pipeline surveys would be required in future.	Pipeline surveys have been undertaken in the past, so this would be achievable with no complications. Inspection, Repair and Maintenance ('IRM') remedial works have also been undertaken in the past, so this would be achievable
		Technological challenge	No pipeline surveys would be required in future.	The technology is currently available for carrying out pipeline surveys and any remedial works in future.
		Technical challenge	No pipeline surveys would be required in future.	There would be no technical issues associated with carrying out pipeline surveys or any remedial works in future.

Table G.1.1: Technical assessment for PL4555 and PL4556

Appendix G.2 Safety assessment for PL4555 and PL4556

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	LEAVE *IN SITU*
Safety	**Offshore Execution**	Health & safety risk offshore project personnel	More offshore work than partial removal or leave *in situ*. Excavation of the pipelines and recovery, either using 'cut and lift' for PL4555 (piggybacked by PL2579) or reverse reel for PL4556. For PL4555 the work associated with 'cut and lift' would be repetitive (typically ~80 to ~100 lengths of pipe per km) but manageable from an HSE perspective. With appropriate engineering and pipeline integrity checks and planning reverse reel method would also be manageable from an HSE perspective. Most of the work could be done using equipment operated remotely and achieved without using divers. Material handling on vessel decks could be automated given the right resources and focus. 'Tolerable' rather than 'preferred' owing to the quantity of cuts and material transfers from seabed to vessel involved. Up to ~923 lifts.	Only pipeline ends to be dealt with. Less offshore work than for complete removal. Experience in the UKCS a of removal of pipeline sections. Significantly less work and therefore a shorter duration of activities than for complete removal.
		Health & safety risk to mariners	For PL4556 using the reverse reel method would mean that the vessel would be attached to a pipeline and could not move out of the way quickly.	Only the pipeline ends would be dealt with; duration of vessels in the field would be shorter than for complete removal and partial removal.
		Safety risk onshore project personnel	Significantly more off-loading, off-reeling, onshore cutting, lifting, and material handling associated with disposal of the pipelines; presents an increased safety risk to personnel. The work would all be manageable from an HSE perspective.	No onshore work except for that possibly associated with the pipeline ends, which would be required for any of the decommissioning options.
Safety	**Legacy**	Health & safety risk offshore project personnel	No pipeline surveys or remediation related activities.	Pipeline surveys would be required, remedial work will likely also be required, but these activities may be considered routine with well managed risks and would be of short duration.
		Health & safety risk to mariners	No infrastructure left therefore no residual snag hazards. Lower risk as potential snag hazards completely removed. Although bottom dredging, demersal fishing nets should not adversely interact with the temporary excavations.	Degradation of the pipeline if it remains buried, would not change the risk.
		Safety risk onshore project personnel	Little to differentiate the options, although future remedial works may require handling of materials onshore.	

Table G.2.1: Safety assessment for PL4555 and PL4556

Appendix G.3 Environmental assessment for PL4555 and PL4556

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	LEAVE *IN SITU*
Environmental	**Offshore Execution**	Energy & emissions	Energy use and resulting emissions for this option would be higher than for leave in situ, but no energy and emissions would be needed to create new steel material ~19.5 operational vessel days for each pipeline. Operational days for PL4555 (& PL2579) ~55 days. Operatonal days for PL4556 ~32 days.	Least amount of energy used, and least emissions generated in the short term, although any gains would be offset by the energy and emissions required to create new material to replace that which would be left *in situ*.
		Seabed disturbance, area *temporarily* affected (less significant than permanent disturbance)	PL4555 (& PL2579) and PL4556. The amount of seabed disturbed would be directly related to the length of pipeline being removed. The area **temporarily** affected (PL4555 0.10 km^2, PL4556 0.24 km^2) would be largest for this option.	For this option the seabed would be left largely undisturbed.
		Disturbance to Protected Area	n/a. The Thistle pipelines are not within a Special Conservation Area or a Marine Protected Area.	
		Effect on Water Column: • Liquid discharges to sea • Liquid discharges to surface water • Noise.	Discharges and releases to the water column are related to the duration of activities and on balance would be greatest for the complete removal option.	Discharges and releases would be least for the leave *in situ* option, particularly in the short-term.
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	This option would result in the largest quantity of material being returned to shore. No material would be lost as no material would be left *in situ*. PL4555 ~989 Te PL4556 – 2.198 Te	Only the surface laid pipeline ends would be returned to shore for recycling. Newly manufactured material would be needed to replace the material not recovered to shore. PL4555 & PL4556 - 29 Te
Environmental	**Legacy**	Energy & emissions	No pipeline burial surveys or remedial would be required as the pipelines would have been completely removed. n/a	Pipeline surveys required in future.
		Seabed disturbance, area *permanently* affected	None	The area **permanently** affected due to the continuing presence of the pipelines is as follows: PL4555 ~0.05 km^2 PL4556 ~0.120 km^2 No remedial work will be required.
		Disturbance to Protected Area	n/a. The Thistle pipelines are not within Special Conservation Area or a Marine Protected Area.	
		Effect on Water Column: • Liquid discharges to sea • Liquid discharges to surface water • Noise.	No pipeline surveys required as the pipelines would have been completed removed.	Pipeline surveys would be required, and remedial works will likely be required in future.
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	As the pipeline(s) would have been removed, no further waste would be created.	Pipeline surveys would be required, and remedial works will likely not be required in future.

Table G.3.1: Environmental assessment for PL4555 and PL4556

Appendix G.4 Societal assessment for PL4555 and PL4556

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	LEAVE *IN SITU*
Societal	**Offshore Execution**	Effect on commercial activities	The impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal.	The impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for leave *in situ*.
		Employment	Decommissioning activities associated with the complete removal of pipelines would contribute greatest to the continuity of employment but given the overall duration of activities there is little to differentiate the options.	
		Communities or impact on amenities	For any ports and disposal sites the any increase in work would be larger than for partial removal or leave *in situ*, but a relatively small increase in the overall work burden. Complete removal would result in 7,117 Te of material being recovered to shore.	Decommissioning activities associated with leave *in situ* would contribute the least to continuity of work in ports and disposal sites. Removal of just the ends would result in ~169 Te of pipeline material being brought to shore.
Societal	**Legacy**	Effect on commercial activities	Once the pipelines have been completely removed there would be no commercial impact on fishing activity.	No legacy effect on commercial activities.
		Employment	No future opportunities for continuation of employment.	Survey related work
		Communities or impact on amenities	No opportunities for continuity of work in ports and disposal sites.	Few opportunities for continuity of work in ports and disposal sites other than associated with survey related.

Table G.4.1: Societal assessment for PL4555 and PL4556

Appendix G.5 Cost assessment for PL4555 and PL4556

CRITERIA	ASPECT	COMPLETE REMOVAL	LEAVE *IN SITU*
Cost	**Offshore Execution**	PL4555 (piggybacked by PL2579 which is out of scope). Using the assumption that PL4555 (& PL2579) would be removed using the 'cut and lift' method, the cost of complete removal >10x cost of leave *in situ*.	The cost of leave *in situ* would be the least expensive of the options.
		PL4556. Using the assumption that PL4556 would be removed using the 'reverse reel' method, the cost of complete removal ~5x cost of leave *in situ*.	The cost of leave *in situ* would be the least expensive of the options.
Cost	**Legacy**	Should the pipeline(s) have been completely removed no pipeline burial surveys would be required in future.	Future burial surveys would be required. The premise is that if three successive surveys demonstrate that the pipeline remains stable no more surveys would be required. The need for remedial works in future would reduce the difference in cost between complete removal and leave *in situ* options.
NOTE: 1. Legacy burial surveys: Assumes that the remedial works have been carried out effectively and that no remedial works would be required in future.			

Table G.5.1: Cost assessment for PL4555 and PL4556

APPENDIX H DON PIPELINE CA SUMMARY TABLES

Appendix H.1 Technical assessment for Don pipelines

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION	LEAVE *IN SITU*
Technical	**Offshore Execution**	Risk of project failure	Technically, complete removal of the Don pipelines and umbilicals would be achievable with little chance of project failure. Total length of pipelines inside the 500 m zone is ~1,669 m.	There is no risk of project failure for the partial removal and leave *in situ* option.	
		Technological challenge	Technology is currently available to excavate, cut and recover the pipelines to shore as well as to remediate the pipelines (deposition of rock)		n/a
		Technical challenge	Technically there is equipment available to remove the pipelines.	PL599. Technically there is equipment available to remove the short-exposed section.	Trenched and buried pipeline(s) with short exposures have been left *in situ* before so this approach would be technically achievable although future remedial works may be expected for PL599.
				PL599. Fall pipe vessel could be used for the deposition of rock on the exposed section of PL599 although the work should be combined with other rock deposition related activities in the area, otherwise it would be a relatively inefficient use of resources.	
Technical	**Legacy**	Risk of project failure	No pipeline surveys and no remedial work would be required in future.	Pipeline surveys and IRM related work have been undertaken in the past, so this would be achievable with no complications.	
		Technological challenge			
		Technical challenge			

Table H.1.1: Technical assessment for Don pipelines

Appendix H.2 Safety assessment for Don pipelines

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION	LEAVE *IN SITU*
Safety	**Offshore Execution**	Health & safety risk offshore project personnel	More offshore work than partial removal or leave *in situ*. Excavation of the pipelines and recovery, either using 'cut and lift' or reverse reel for smaller pipelines. The work associated with 'cut and lift' would be repetitive (typically ~80 to ~100 lengths of pipe per km) but manageable from an HSE perspective. With appropriate engineering and pipeline integrity checks and planning reverse reel method would also be manageable from an HSE perspective. Most of the work could be done using equipment operated remotely and achieved without using divers. Material handling on vessel decks could be automated given the right resources and focus.	The work is commensurate with normal IRM related activities. There is little to differentiate the partial removal (PL599 only) and leave *in situ* options.	
		Health & safety risk to mariners	As the work would likely be conducted in the Thistle 500 m zone while it remains in place, the risk to mariners in the short term would likely be limited to potential collisions during transits. Any interference would likely take the form of minor alterations to normal operating practices. Duration of vessels in the field would be slightly longer than for partial removal (PL599) and leave *in situ*. There is little to differentiate the options.		
		Safety risk onshore project personnel	More off-loading, off-reeling, onshore cutting, lifting, and material handling associated with disposal of the pipelines; presents an increased safety risk to personnel. The work would all be manageable from an HSE perspective.	The work is commensurate with normal IRM related activities. There is little to differentiate the partial removal (PL599 only) and leave *in situ* options.	
Safety	**Legacy**	Health & safety risk offshore project personnel	No pipeline surveys or remediation related activities.	Pipeline surveys would be required but they would be commensurate with normal IRM related activities.	
		Health & safety risk to mariners	No infrastructure left therefore no residual snag hazards.	Post decommissioning surveys and existing historical data provide evidence that except for a short-exposed section in PL599 at KP0.427 the pipelines are buried and will likely remain buried, therefore the risk to mariners from snagging would be low.	
		Safety risk onshore project personnel	There is little to differentiate the options.		

Table H.2.1: Safety assessment for Don pipelines

Appendix H.3 Environmental assessment for Don pipelines

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION	LEAVE *IN SITU*
Environmental	**Offshore Execution**	Energy & emissions	Energy use and resulting emissions for this option would be higher than for leave *in situ*, but no energy and emissions would be needed to create new steel material.	In overall terms, there is little to differentiate partial removal – which affects PL599 only and leave *in situ*. Least amount of energy used, and least emissions generated in the short term, although any gains would be offset by the energy and emissions required to create new material to replace that which would be left *in situ*.	
		Seabed disturbance, area *temporarily* affected (less significant than permanent disturbance)	The amount of seabed disturbed would be directly related to the length of pipeline being removed. The area **temporarily** affected (570 x 85 m = 0.048 km^2) would be largest for this option. If the pipelines are to be severed at the edge of the Thistle 500 m zone, rock (~4 x 15 Te = 60 Te) will need to be deposited on the severed pipeline ends rather than at trench depth near Thistle. The deposition of rock on the pipeline ends would be required for all decommissioning options.	PL599 **partial removal**. The amount of seabed disturbed would be directly related to the length of pipeline being removed. The area **temporarily** affected (0.0002 km^2) would be negligible.	The smallest area of seabed would be temporarily disturbed in the short-term with the leave *in situ* option.
		Disturbance to Protected Area	n/a. Being limited to the lengths inside the 500m zone the Don pipelines are not within a Special Conservation Area or a Marine Protected Area.		
		Effect on Water Column: • Liquid discharges to sea • Liquid discharges to surface water • Noise.	Discharges and releases to the water column are related to the duration of activities being undertaken and would therefore be greatest for the complete removal option.	Discharges and releases to the water column are related to the duration of activities being undertaken and overall would be a largely the same for partial removal and leave *in situ*.	
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	This option would result in the largest quantity of material being returned to shore. No material would be lost as no material would be left *in situ*.	In overall terms the quantity of material being returned to shore would be similar for partial removal and leave *in situ*. Newly manufactured material would be needed to replace the material not recovered to shore.	
Environmental	**Legacy**	Energy & emissions	No pipeline burial surveys or remedial would be required as the pipelines would have been completed removed.	Overall there is little to differentiate partial removal - which only affects PL599 and leave *in situ*.	
		Seabed disturbance, area *permanently* affected	Complete removal of the pipelines inside the Thistle 500 m zone while the rest of the Don pipelines are left *in situ*, means that 4 x 15 = 60 Te of rock would be deposited on cut ends, impacting 100 m^2 (0.0001 km^2) of seabed. Virtually the same impact as for leave *in situ*. The differentiator would be the area of seabed impacted by leaving pipelines *in situ*.	Partial removal. PL599. Additional area **permanently** affected by addition of rock (2 x 15 Te = 30 Te) on **cut ends** of the exposed section. Area affected 2 x 25 = 50 m^2 (0.00005 km^2). Area **permanently** affected by addition of rock put on pipeline ends severed at Thistle at trench depth = 4 x 15 Te = 60 Te. Area impacted by leaving other pipelines *in situ* along with rest of PL599 is ~0.008 km^2. Overall area impacted is similar to that impacted by leave *in situ*.	Area of seabed **permanently** affected by leaving Don pipelines inside 500 m zone left *in situ* is 0.008 km^2. Add rock on pipeline ends: 4 x 15 = 60 Te, additional area affected 4 x 25 = 100 m^2 (0.0001 km^2). Unlikely remedial works will be needed in future.
				Remediation. PL599. The amount of seabed disturbed would be directly related to the length of exposure being buried under rock. The area **permanently** affected would be approx. 8 m wide which is slightly larger than for leave *in situ* (approx.. 5m wide), but the difference is insignificant. The amount of rock required to bury the exposed section would be ~18 m x 3.5 Te/m = 63 Te (c.f. 30 Te for partial removal).	
			No pipeline burial surveys or remedial would be required as the pipelines would have been completed removed.	Pipeline surveys don't normally impact the seabed. Unlikely remedial works will be required in future if included as part of decommissioning scope. Little to differentiate partial removal and leave *in situ* as the scope of partial removal is so small.	Pipeline surveys don't normally impact the seabed. Low probability that remedial works will be required.
		Disturbance to Protected Area	n/a. Being limited to the lengths inside the 500m zone the Don pipelines are not within a Special Conservation Area or a Marine Protected Area.		
		Effect on Water Column: • Liquid discharges to sea • Liquid discharges to surface water • Noise.	No pipeline burial surveys or remedial would be required as the pipelines would have been completed removed.	There is little to differentiate partial removal – which only affects PL599 and leave *in situ*.	
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	As the pipeline(s) would have been removed, no further waste would be created.	There is little to differentiate partial removal – which only affects PL599 and leave *in situ*.	

NOTE

1. Following approval of the Don DP, the Don pipelines outside the Thistle 500 m zone are to be left *in situ*. Therefore, any environmental impacts inside the Thistle 500 m zone would result in a small incremental difference to the original decommissioning proposals.

Table H.3.1: Environmental assessment for Don pipelines

Appendix H.4 Societal assessment for Don pipelines

CRITERIA	ASPECT	SUB-CRITERIA	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION	LEAVE *IN SITU*
Societal	**Offshore Execution**	Effect on commercial activities	The impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal. It's possible that any removal works would be carried out while the Thistle 500 m zone remains active, in which case any impacts on fishing activity would be minimal.	The impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for partial removal or remediation (PL599) and leave *in situ*. There is nothing to differentiate the partial removal and leave *in situ* options.	
		Employment	Decommissioning activities associated with the complete removal of pipelines would contribute greatest to the continuity of employment.	Employment opportunities would be less than for complete removal but more than leave *in situ*. Overall there is nothing to choose between partial removal which only applies to PL599 and leave *in situ*.	
		Communities or impact on amenities	For any ports and disposal sites the any increase in work would be larger than for partial removal or leave *in situ*, but a relatively small increase in the overall work burden. Complete removal of the pipeline material inside the Thistle 500 m zone would result in 140 Te of material being recovered to shore.	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal, and there is nothing to differentiate partial removal and leave *in situ*. Partial removal and leave *in situ* would result in ~61 Te of material being brought to shore. Removal of 18 m section would result in an additional 1.5 Te of material being recovered to shore.	
Societal	**Legacy**	Effect on commercial activities	No impact as no legacy related activities would be required.	Impact of survey vessel traffic on local commercial activities such as fishing would be less for than complete removal but there would be nothing to differentiate partial removal and leave *in situ*.	
		Employment	No future opportunities for continuation of employment.	Survey related work, little or no difference between partial removal and leave *in situ*.	
		Communities or impact on amenities	No opportunities for continuity of work in ports and disposal sites.	Few opportunities for continuity of work in ports and disposal sites other than associated with survey related. Little difference between partial removal and leave *in situ*.	

Table H.4.1: Societal assessment for Don pipelines

Appendix H.5 Cost assessment for Don pipelines

CRITERIA	ASPECT	COMPLETE REMOVAL	PARTIAL REMOVAL OR REMEDIATION		LEAVE *IN SITU*
			PARTIAL REMOVAL, & PL ENDS	REMEDIATION PART PL	
Cost	**Offshore Execution**	PL598. PL598 would be removed using the 'cut and lift' method, the cost of complete removal would cost an order of magnitude more than the cost of leave *in situ*.	n/a	n/a	PL598. The cost of leave *in situ* would be the least expensive of the options.
		PL599. PL599 would be removed using the 'cut and lift' method. the cost of complete removal would be less than the cost of partial removal.	PL599. Partial removal is slightly more expensive than leave *in situ*.	PL599. Cost of depositing rock along exposed section would be the most expensive option if mob/demob costs are born solely by the Don Pipeline decommissioning project.	PL599. As above.
		PL599. PL599 would be removed using the 'cut and lift' method. the cost of complete removal would be less than the cost of partial removal.	PL599. Partial removal is slightly more expensive than leave *in situ*.	*PL599. Cost of depositing rock along exposed section would be the most expensive option. Mob/demob costs ignored on the basis that the mob/demob cost could be shared across a number of scopes..*	PL599. As above.
		PL600. Assuming that PL600 would be removed using the 'reverse reel' method, the cost of complete removal >10x cost of leave *in situ*.	n/a	n/a	PL600. The cost of leave *in situ* would be the least expensive of the options.
		PLU6267. Assuming PLU6267 would be removed using the 'reverse reel' method, the cost of complete removal ~5x cost of leave *in situ*.	n/a	n/a	PLU6267 The cost of leave *in situ* would be the least expensive of the options.
Cost	**Legacy**	Should the pipeline(s) have been completely removed no pipeline burial surveys would be required in future.		Future burial surveys would be required. The premise is that if three successive surveys demonstrate that the pipeline remains stable no more surveys would be required.	

NOTE

1. By separate calculation it can be determined that the removal of the pipelines inside the Thistle 500 m zone would be a small addition in cost to the overall scope. If the small increase in cost can be pro-rated to the % increase in scope (i.e. an additional 1,669 m to 51,120 m) there would be a less than 5% increase in overall removal costs.
2. n/a – this option isn't applicable. Refer Table 5.1.2.

Table H.5.1: Cost assessment for Don pipelines

APPENDIX I COST AS A DIFFERENTIATOR

Appendix I.1 Overview

The following section details the quantitative comparative assessment made to distinguish the decommissioning options. Note that the figures quoted do not account for the overall costs of decommissioning the pipelines – they only account for the difference in cost once activities common to both options have been discounted.

The costs have been normalised and categorised as indicated in Table I.1.1. Refer section 6.1.

High / Intolerable & not acceptable	Medium / Tolerable non-preferred	Low/Broadly acceptable, least preferred	Low/Broadly acceptable, could be preferred	No colour	Low/Broadly acceptable, most preferred
Most expensive and more than 10x least expensive cost.	Most expensive option if less than 10x more expensive than cheapest option, or costs more than 75% of most expensive cost.	Costs more than 50% of most expensive cost.	Costs more than 25% of most expensive cost.	Cost less than 25% of the most expensive cost but more than the cheapest cost.	Cheapest cost.

Table I.1.1: Categories of impact – cost assessment

Appendix I.2 Thistle pipeline assumptions

The following key assumptions have been used in the cost by difference assessment:

- Operator and contractor management and engineering costs are excluded on the basis that this cost would be incurred whichever decommissioning option would be pursued.
- Any pipelines being removed would need to be excavated if they are fully or partially buried.
- Mobilisation and demobilisation cost of construction vessels are *excluded* for two reasons: The first is because mobilisation and demobilisation costs would be incurred for the overall decommissioning activity, not just for one pipeline, and the other is that for the purposes of this assessment it has been assumed that the same type of vessel – an anchor handling vessel, furnished with reels, ROV equipment, excavation equipment and hydraulic cutting spread.
- Mobilisation costs for a fall pipe rock installation vessel are *included*. The reason for this is that while construction vessels would be used for most if not all the decommissioning operations, the fall pipe rock installation vessels would be used specifically for installing rock on the affected areas.
- For surveys it has been assumed that one post-decommissioning pipeline survey would be required for each pipeline, and (at least) three legacy pipeline surveys for those instances where a pipeline or part thereof would be left *in situ* following completion of decommissioning activities.
- The costs associated with mobilisation and demobilisation of survey vessels is *excluded* since it is not a differentiator, and because mobilisation and demobilisation costs would be incurred for the overall survey activity, not just for one pipeline.
- For PL4555 (at the Wye structure) and PL4556 (at the Wye structure and at Magnus) the removal of mattresses is accounted for in the assessment and assumes that for all decommissioning options they would be removed.
- It is assumed that individual rigid pipelines with CWC such as PL13 would be removed using 'cut and lift.
- It is assumed that piggybacked pipelines such as PL4555 (& PL2579) would be removed using 'cut and lift'.
- It is assumed that PL4556 would be reverse reeled separately onto a subsea support vessel.
- For PL4555 and PL4556, leave *in situ* assumes a length of surface laid pipelines being removed to burial depth at the end of transition either at the bottom of the trench or in deposited rock. This is likely to be conservative meaning that if the length of pipeline recovered is less, the cost by difference between complete removal and partial removal would increase.

Appendix I.3 Don pipeline assumptions

As per Thistle pipelines, except:

- It is assumed that PL598 and PL599 would be removed using the 'cut and lift' method.
- It is assumed that umbilicals PL600 and PLU6267 would be completely removed by reverse reel separately onto a subsea support vessel.

Appendix I.4 Thistle pipeline decommissioning cost by difference

Pipeline ID	Pipeline types	End removal length	Partial removal length (incl. ends)	Complete removal length	Concrete / Grout Mattresses	Leave *in situ* (remove ends)	Partial removal (incl. ends)	Remove ends, rock on exposures / spans	Complete removal	Rock on complete pipeline (excl. ends)
PL13	16"CWC	3,623m	5,511m	12,690m	25	2.8	9.2	3.3	10.0	4.0
PL4555	8"	412m	0m	10,260m	17	0.6	n/a	n/a	10.0	n/a
PL4556	8"	226m	0m	23,750m	15	2.9	n/a	n/a	10.0	n/a

NOTES

1. All costs have been normalised against a maximum value of 10. Refer section 6.1.
2. The assessment assumes that for the leave *in situ* option, the surface laid sections of PL13 (3,623 m) would be removed down to trench depth. For partial removal, an additional 1,888 m of the pipeline would be removed, giving a total of 5,511 m.
3. For PL4555 and PL4556 for the leave *in situ* option it is assumed that the surface laid ends would have been removed to burial depth, and that the protection and stabilisation features have also been removed. The 'end removal length' is based on the total length of mattresses that would need to be removed. Note that for PL4555 at the Thistle end the removal of mattresses is dealt with in the Conrie, DSW, WDE and Ythan Decommissioning Programmes [1].
4. The assessment assumes 1x post decommissioning survey would be required irrespective of the decommissioning options, and 3x legacy surveys would be required for any pipelines being left *in situ*.
5. Post-trenching is not a viable alternative from a technical perspective for concrete coated pipelines (PL13) and is not required for PL4555 or PL4556.
6. Broad metrics: full removal: PL13 – 'cut & lift' (200m/day), PL4556 – 'reverse reel' (5 km/day), PL4555 and PL4556 surface laid end sections - 'cut & lift'; rock fall pipe vessel 1,500 to 2,000 Te/day = ~1.5 km/day.

Table I.4.1: Thistle PL decom – dims for normalised cost assessment (incl. surveys)

Pipeline ID	Pipeline types	End removal length	Partial removal length (incl. ends)	Complete removal length	Concrete / Grout Mattresses	Leave *in situ* (remove ends)	Partial removal (incl. ends)	Remove ends, rock on exposures / spans	Complete removal	Rock on complete pipeline (excl. ends)
PL13	16"CWC	3,623m	5,511m	12,690m	25	2.9	9.2	3.2	10.0	3.9
PL4555	8"	412m	0m	10,260m	17	0.6	n/a	n/a	10.0	n/a
PL4556	8"	226m	0m	23,750m	15	2.9	n/a	n/a	10.0	n/a

NOTES

1. All costs have been normalised against a maximum value of 10. Refer section 6.1.
2. The assessment assumes that for the leave in situ option, the surface laid sections of PL13 (3,623 m) would be removed down to trench depth. For partial removal, an additional 1,888 m of the pipeline would be removed, giving a total of 5,511 m.
3. For PL4555 and PL4556 for the leave *in situ* option it is assumed that the surface laid ends would have been removed to burial depth, and that the protection and stabilisation features have also been removed. The 'end removal length' is based on the total length of mattresses that would need to be removed. Note that for PL4555 at the Thistle end the removal of mattresses is dealt with in the Conrie, DSW, WDE and Ythan Decommissioning Programmes [1].
4. Post-trenching is not a viable alternative from a technical perspective for concrete coated pipelines (PL13) and is not required for PL4555 or PL4556.
5. Broad metrics: full removal: PL13 – 'cut & lift' (200 m/day), PL4556 – 'reverse reel' (5 km/day), PL4555 & PL4556 surface laid end sections - 'cut & lift'; rock fall pipe vessel 1,500 to 2,000 Te/day = ~1.5 km/day.
6. For comparison of operational decommissioning works this table excludes the cost of surveys.

Table I.4.2: Thistle PL decom – dims for normalised cost assessment (excl. surveys)

Appendix I.5 Don pipeline decommissioning cost assessment

Pipeline ID	Pipeline types	End removal length	Partial removal length (incl. ends)	Complete removal length	Mattresses	Leave *in situ* (remove ends)	Partial removal (incl. ends)	Remove ends, rock on exposures	Complete removal
PL598	8in	150m	0m	567m	0	4.7	n/a	n/a	10.0
PL599	8in	150m	168m	570m	0	2.7	3.1	10.0	5.8
PL599	*8in*	*150m*	*168m*	*570m*	*0*	*4.7*	*5.4*	*9.2*	*10.0*
PL600	70mm	150m	0m	560m	0	10.0	n/a	n/a	1.8
PL627	88mm	150m	0m	539m	0	10.0	n/a	n/a	1.8

NOTES:

1. All costs have been normalised against a maximum value of 10.
2. For the leave *in situ* option, it is assumed that the surface laid ends would have been removed to burial depth. The 'end removal length' is based on the total length of mattresses that would need to be removed.
3. The assessment assumes 1x post decommissioning survey would be required irrespective of the decommissioning options, and 3x legacy surveys would be required for any pipelines being left *in situ*.
4. Broad metrics: full removal: PL598 and PL599 – 'cut & lift' (200m/day), PL600 and PLU6267 – 'reverse reel' (5 km/day), Surface laid end sections - 'cut & lift'; rock fall pipe vessel 1,500 to 2,000 Te/day = ~1.5 km/day.
5. Mobilisation costs for a fall pipe rock installation vessel are included. The reason for this is that while construction vessels would be used for most if not all the decommissioning operations, the fall pipe rock installation vessels would be used specifically for installing rock on the affected areas. This is why the cost of depositing rock on the exposures is higher than for both the partial removal and complete removal options.
6. For context, by separate calculation it is estimated that the complete removal costs for the pipelines inside the Thistle 500 m zone would equate to less than 5% of the cost of removing all the Don pipelines.

Table I.5.1: Don PL decom – dims for normalised cost assessment (incl. surveys)

Pipeline ID	Pipeline types	End removal length	Partial removal length (incl. ends)	Complete removal length	Mattresses	Leave *in situ* (remove ends)	Partial removal (incl. ends)	Remove ends, rock on exposure(s)	Complete removal
PL598	8in	150m	0m	567m	n/a	4.4	n/a	n/a	10.0
PL599	8in	150m	168m	570m	n/a	2.5	3.0	10.0	5.8
PL599	*8in*	*150m*	*168m*	*570m*	*0*	*4.4*	*5.1*	*8.9*	*10.0*
PL600	70mm umbilical	150m	0m	560m	n/a	10.0	n/a	n/a	1.8
PL627	88mm umbilical	150m	0m	539m	n/a	10.0	n/a	n/a	1.8

NOTES:

1. Refer notes in Table I.5.1.

Table I.5.2: Don PL decom – dims for normalised cost assessment (excl. surveys)