Perenco UK Limited
Welland Decommissioning Programmes
CLOSE OUT REPORT

Post – Consultation Draft

DOCUMENT CONTROL

Approvals

	Name	Signature	Date
Prepared by	Gareth MacGlennon		02/09/20
Reviewed by	Julie Summerell		02/09/20
Approved by	Eric Baudon		02/09/20

Revision Control

Revision No	Reference	Changes/Comments	Issue Date
0	For Consultation	-	14/07/17
1	Revised to address BEIS comments		30/10/17
2	Revised to address BEIS comments		12/01/18
3	Revised to address BEIS comments		06/02/18
4	Revised to address Consultee comments	Includes timescale & scope agreed with OPRED for post-decom surveys	15/05/18
5	Revised to address BEIS comments	Changes highlighted in yellow.	22/05/20
6	Post-consultation draft	Minor changes updated	10/07/20
7	Revised to address BEIS EMT comments	Minor changes updated	02/09/20

Distribution List

Name	Company	No of Copies
Offshore Decommissioning Unit	BEIS	1

CONTENTS

A. TABLE OF TERMS AND ABBREVIATIONS 4
B. LIST OF TABLES 6
C. TABLE OF FIGURES 6
D. TABLE OF APPENDICES 6

1. COMBINED DECOMMISSIONING PROGRAMMES 7
1.1. Introduction 7
1.2. Background 7
1.2.1. Field History 7
1.2.2. Cessation of Production 9
1.2.3. Summary of Approved Decommissioning Solutions 9
1.3. Decommissioning Programme Outcome 10
1.4. Pipelines 12
1.5. Umbilicals 14
1.6. Platform Wells 14
1.6.1. Platform Well 1 (Well No. 53/4a-6) 15
1.6.2. Platform Well 5 (Tristan - Well No. 53/4a-10) 15
1.6.3. Abandonment of Platform Wells 15
1.7. Subsea Wells 16
1.7.1. Subsea Well 2 (53/4A–5) 17
1.7.2. Subsea Well 3 (49/29B–4) 17
1.7.3. Subsea Well 4 (49/29B-6) 17
1.8. Platform Removal 19
1.9. WHPS Removal 23
1.10. Subsea Stabilisation Features 24
1.11. Cuttings Piles 25
1.12. Overtrawl survey and seabed clearance 25
1.13. Post decommissioning survey 26
2. REVISIONS 26
3. POST-DECOMMISSIONING MONITORING AND EVALUATION 27
4. COSTS 28
5. REFERENCES 29
6. APPENDICES 30
6.1 Well Abandonment Schematics 31
6.2 Clearance Certificates 37
6.3 Welland Post Decommissioning Environmental Survey Summary 40
6.4 Welland Post Decommissioning Inspection Strategy 40
6.5 Re-analysis of Post Decommissioning surveys – Welland field 40
6.6 Welland Post-decommissioning Benthic Survey Regime 40

A. TABLE OF TERMS AND ABBREVIATIONS

Abbreviation	Explanation
bbl	Barrel
BEIS	Department of Business, Energy and Industrial Strategy (formerly DECC)
CA	Comparative Assessment
CoP	Cessation of Production
DECC	Department of Energy and Climate Change (now BEIS)
DP	Decommissioning Programme
DSV	Diving Support Vessel
EZSV	Easy Drill Sub-Surface Valve
ft	feet
GC	Gas Chromatography
HLV	Heavy Lift Vessel
HSE	Health and Safety Executive
ID	Internal Diameter
LTI	Lost Time Incident
LTOBM	Low Toxicity Oil Based Mud
m	Metres
MBES	Multi-beam Echo Sounder
MDRT	Measured Depth Rotary Table
MEG	Monoethylene Glycol
ML	Mudline
MLS	Mudline Suspension
MWS	Marine Warranty Surveyor
NFFO	National Federation of Fishermen's Organisations
NPT	Non Productive Time
NUI	Normally Unattended Installation
OD	Outer Diameter
OGA	Oil & Gas Authority
O & G UK	Oil & Gas UK
P & A	Plug and Abandonment
Perenco	Perenco (UK) Ltd
PL	Pipe Line
psi	Pounds per square inch
ROV	Remotely Operated Vehicle

SNS	Southern North Sea
THC	Tetrahydocannabinol
TRT	Tree Running Tool
UKCS	UK Continental Shelf
WHPS	Well Head Protection Structures
WOW	Waiting on Weather

B. LIST OF TABLES

Table Number	Description	Page
1.1	Summary of Approved Decommissioning Solutions	10
1.2	Summary of Decommissioning Outcomes	11
1.3	Key Dates in the Decommissioning of the Welland Field	11
1.4	Lengths, Diameters, Type of Construction	13
1.5	Cut Off Levels of Wells	18
1.6	Cut Off Levels of Platform Piles	22
1.7	Cut Off Depths of WHPS Piles	24

C. TABLE OF FIGURES

Figure Number	Description	Page
1.1	Welland Field and Surrounding Infrastructure	8
1.2	Welland Field Reservoirs	9
1.3	Welland Field Pipeline Layout	12
1.4	Connections from subsea wells to Welland and Welland to Thames	14
1.5	Summary of Soil Conditions from 1987 WHPS Geotechnical Investigation	19
1.6	Photos showing stiff grey clay stuck to bottom 1.5 – 2.0m of cut WHPS piles	19
1.7	Rambiz HLV lifting Welland topside	20
1.8	Rambiz HLV lifting Welland jacket	21
1.9	Geophysical Survey from 2016	22
1.10	Geophysical Survey from 2013	22
1.11	Welland WHPS Lifted onshore	23

D. TABLE OF APPENDICES

Appendix Number	Description
Appendix 6.1	Well Abandonment Schematics
Appendix 6.2	Clean Seabed Certificates
Appendix 6.3	Post Decommissioning Environmental Survey Summary
Appendix 6.4	Welland Post Decommissioning Inspection Strategy Report

1. COMBINED DECOMMISSIONING PROGRAMMES

1.1. Introduction

This report is the Close-Out Report for the decommissioning of the Welland Field as requested in BEIS "Guidance Notes for the Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998." This states that a report shall be submitted within four months after the completion of offshore work. The issue of the draft Welland close out report was mainly delayed as a result of the laboratories that analyse and test the post-decommissioning environmental samples being inundated with work resulting in a delay in the environmental results being processed.

The completion of the decommissioning work, as defined in the approved Welland Field Decommissioning Programme and subsequent revisions (1) was considered completed when the operational phase of the post decommissioning environmental survey was completed on 18th July 2016.

This report is a joint submission for ***pipelines*** and ***installations*** and where appropriate pipeline and installation issues are segregated within this document.

The last production from the Welland platform and subsea wells was 2003. Following a review of all the options it was decided to decommission the field and the formal cessation of production (CoP) (2) was approved in 2004.

The scope of this document is to report the outcome of the decommissioning operations for the Welland Field including installations, pipelines seabed infrastructure, wellheads and other items as defined in the Welland DP. The close out report documents how key stages of decommissioning were achieved, discusses significant variations from the approved DP and provides information on managing related legacy issues for future activities in the area. This is supported by the data acquired from environmental sampling and other surveys, along with a summary of costs incurred by the execution of decommissioning. Measures taken to manage any potential risks arising from decommissioning operations and remaining features are described at relevant junctures throughout this report.

Perenco UK Ltd on behalf of the holders of the relevant Section 29 Notices issued by the Department of Business, Energy and Industrial Strategy (BEIS) are pleased to confirm that the four Installations and pipelines full decommissioning activities have been completed as approved by the Secretary of State on behalf of the parties to the approved Decommissioning Programmes. The parties to the approved Decommissioning Programmes are:

- Perenco UK Limited & Perenco Gas (UK) Limited
- Tullow Oil PLC / Tullow Oil SK Limited
- First Oil Expro Limited

1.2. Background

1.2.1. Field History

The Welland field is located in Block 49/29b and 53/4a of the United Kingdom Continental Shelf (UKCS) approximately 72 km off the coast of Norfolk in licence blocks P39 & P105. The Welland field consists of three reservoirs, West, North and South. Additionally the Tristan formation was drilled from the Welland Platform. Two platform wells and three subsea wells accessed these various reservoirs. Production commenced in 1990.

The Welland field partners are:	Perenco UK Limited	55.0213%
	Tullow Oil SK Limited	33.7340%
	First Oil Expro Limited	11.2447%

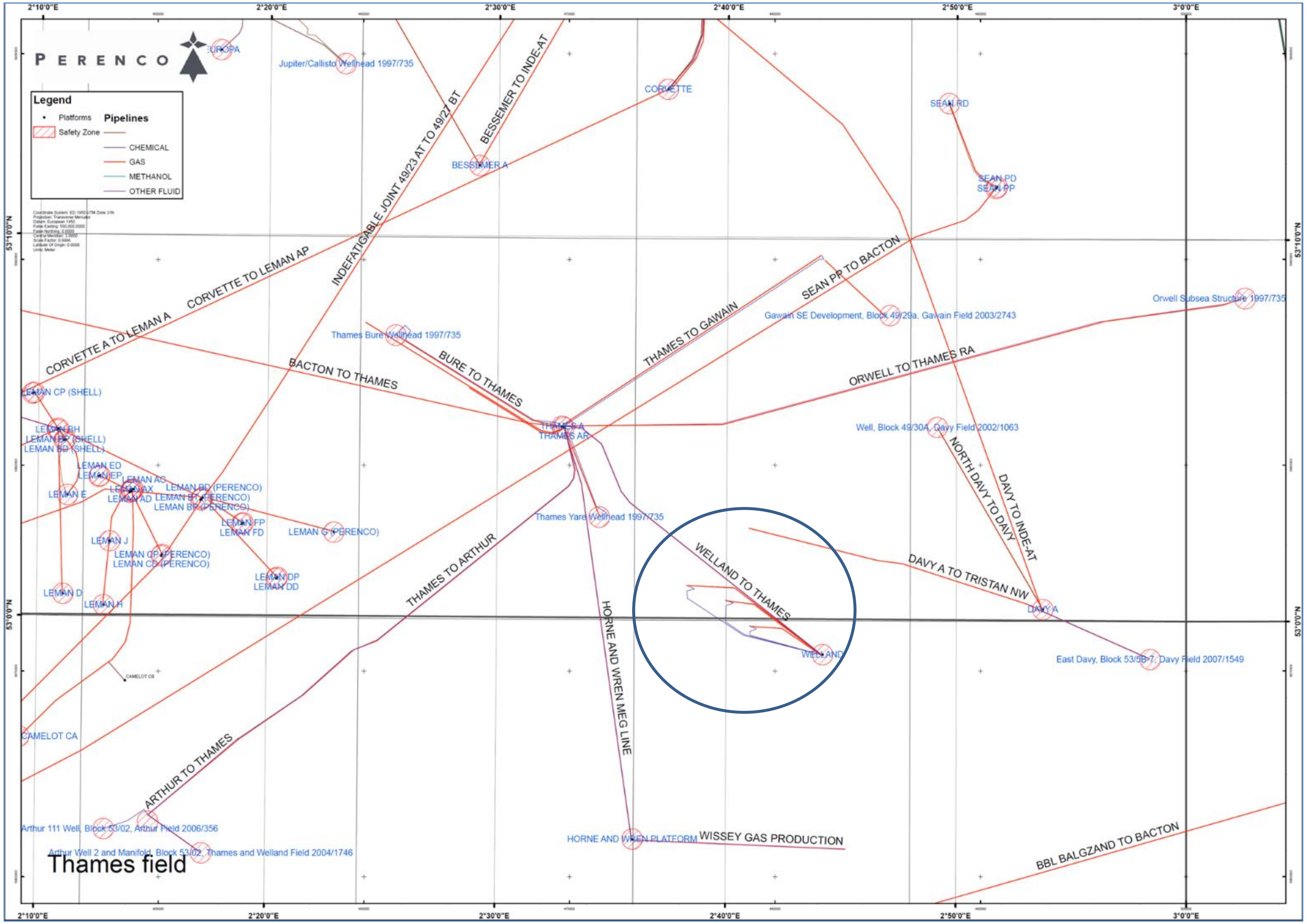


Figure 1.1 – Welland Field and Surrounding Infrastructure

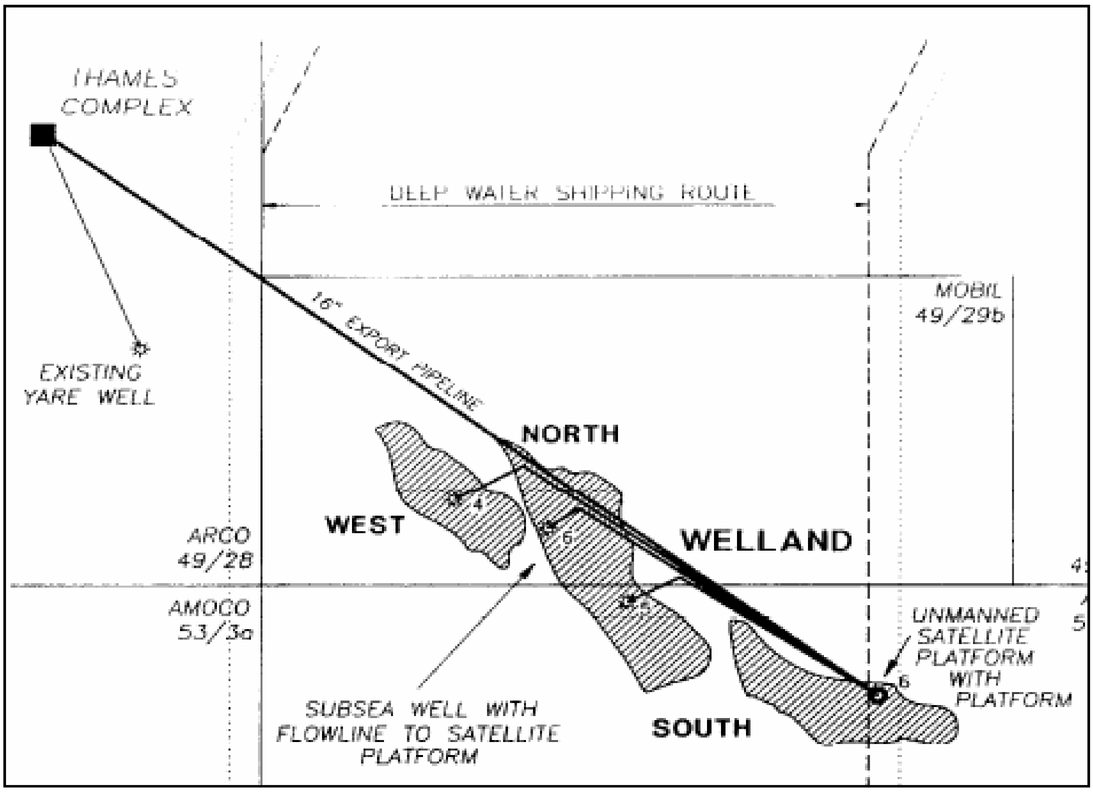


Figure 1.2 - Welland Field Reservoirs

1.2.2. Cessation of Production

The platform was shut in from 2002 and Cessation of Production was applied for by the former operator ExxonMobil in 2004. The Welland Field has been operated by Perenco UK Ltd since 2007. Perenco assessed the feasibility of recommencing production when the field was first acquired (along with the Thames Field), but concluded that this was economically unviable, hence the interval between CoP notification and the submission of the Decommissioning Programme in 2010. The Welland Field Decommissioning Programme was approved by BEIS (formerly DECC) in January 2011.

1.2.3. Summary of Approved Decommissioning Solutions

The approved decommissioning solutions selected for Welland and the main reasons for their selection are listed below in Table 1.1.

Table 1.1 Summary of Approved Decommissioning Solutions

Element	Selected Option	Reason for Selection
Topside	Removal and re-use	One of the Perenco subsidiaries indicated that the Welland installation was suitable for development of a new well outside UKCS waters.
Jacket	Removed and re-cycled for re-use	Large structure with hazard potential for vessels, unsuitable for reuse
Pipelines and Flowlines	Flushed and leave buried in situ	Minimal seabed disturbance, lower energy usage, reduced risk to personnel engaged in activity.
Umbilicals	Leave in situ (buried)	Minimal seabed disturbance, lower energy usage, reduced risk to personnel engaged in activity. Components are not commercially recyclable If re-use is not viable, bulk material will go to landfill.
Subsea Well Protection Frames	Remove by drill rig, heavy lift vessel (HLV) or vessel with crane	Large submerged structures with future hazard potential to fishing activity.
Subsea Stabilisation Features	Removal	Whilst the analysis and comparative assessment findings indicate that leaving the mattresses buried on the seabed would be the preferred option by an overall magnitude of almost two, there was however a preference by some interested parties to remove them. Therefore, removal was to be attempted in the initial stages of the programme to validate the assumptions. A proposal in the form of a mattress CA was sent to BEIS for consideration. It was agreed that the mattresses would be left in-situ.

1.3. Decommissioning Programme Outcome

The preferred decommissioning options for the Welland installations and pipelines were listed in the Decommissioning Programme (1). They are reproduced below in Table 1.2, together with a summary of the outcome for each option. All installations and pipelines were decommissioned in accordance with the preferred options presented in the Decommissioning Programme.

Decommissioning was carried out in two phases:

- Phase 1 – Abandonment of platform wells and subsea wells. Removal of platform
- Phase 2 – Removal of subsea wellhead protection structures.

Table 1.2 Summary of Decommissioning Outcomes	
Preferred Decommissioning Option	**Outcome**
Topside -the 941 tonne topside was refurbished and reused by Perenco in Cameroon	Completed
Jacket and piles to -3m - removed and re- cycled for re-use, verified by independent overtrawl survey by NFFO	Completed
Pipelines and flowlines - flushed, surveyed, and left buried in situ, verified by independent overtrawl survey by NFFO	Completed
Umbilicals - surveyed and left buried in situ, verified by independent overtrawl survey by NFFO	Completed
Three subsea wells – plugged, abandoned and tubulars removed to -3m below seabed, verified by independent overtrawl survey by NFFO	Completed
Three Subsea Wellhead Protection Structures and piles – removed below seabed, dismantled and recycled onshore, verified by independent overtrawl survey by NFFO	Completed
Two platform wells - plugged, abandoned and tubulars removed below seabed, verified by independent overtrawl survey by NFFO	Completed
Concrete mattresses and frond mats – an attempt to remove the mattresses was tried, but was not successful. In accordance with the DP a detailed independent comparative assessment was prepared for Perenco that concluded that mattresses should remain in situ, subject to an overtrawl surveys being undertaken to ensure that there were no snagging hazards. An independent over trawl survey was undertaken by the NFFO (the trade body representing English Fishermen's interests) culminating in clean seabed certificates being issued for all areas of the seabed where pipelines flowlines and associated pipeline stabilisation features are present.	Completed

A number of new technologies and methodologies were pioneered on the Welland project to minimise the risk to personnel and enhance efficiency. These are described in detail in the summaries that follow below.

Table 1.3 chronologically lists the key milestones in the decommissioning of the Welland Field.

Table 1.3 Key Dates in The Decommissioning of the Welland Field			
Phase	**Installation**	**Decommissioning Methodology**	**Date Completed**
1	Platform Well 1	Abandoned	24/09/2010
	Platform Well 5 (Tristan)	Abandoned	24/09/2010
	Subsea Well 2	Abandoned	29/11/2011
	PL674 & 675 disconnection	Disconnected	29/11/2011
	PL678 & 681 disconnected and ends buried	Burial	29/11/2011
	Welland Platform Topside	Removed	18/01/2011
	Welland Platform Jacket	Removed	31/01/2011
	Subsea Well 3	Abandoned	15/05/2011
	PL 676 & 679 disconnected and ends buried	Burial	15/05/2011
	Subsea Well 4	Abandoned	22/05/2011
	PL 677 & 680 disconnected and ends buried	Burial	22/05/2011
	Revision to Installations DP schedule & methodology	Revision	03/01/2014
	Revision to Pipelines DP schedule	Revision	03/01/2014

Table 1.3 Key Dates in The Decommissioning of the Welland Field

2	PL674 & 675 ends buried	Burial	30/09/2014
	WHPS 2	Removed	24/03/2015
	WHPS 3	Removed	25/05/2015
	WHPS 4	Removed	18/07/2015
	Pipelines, mattresses and subsea infrastructure - Overtrawl Survey	Completed	25/05/2016
	Post Decommissioning Environmental Sampling Survey	Completed	18/07/2016

1.4. Pipelines

The pipelines from the three subsea wells to the Welland platform and export pipeline and MEG pipeline connecting the Welland platform to the Thames platform were all cleaned, flushed and isolated. The preferred decommissioning option for the buried subsea pipelines, as detailed in the comparative assessment section of the Decommissioning Programme (1), was to leave them buried in place. The geophysical results report (6) and overtrawl survey (3) of these pipelines, carried out during the summer of 2016, did not encounter any reportable free spans or snags. Clean seabed certificates (5) were issued by the NFFO for those areas of the seabed where these pipelines are present.

All pipelines and umbilicals remain in situ in the seabed. Refer to Figure 1.3 and Table 1.4 for further details.

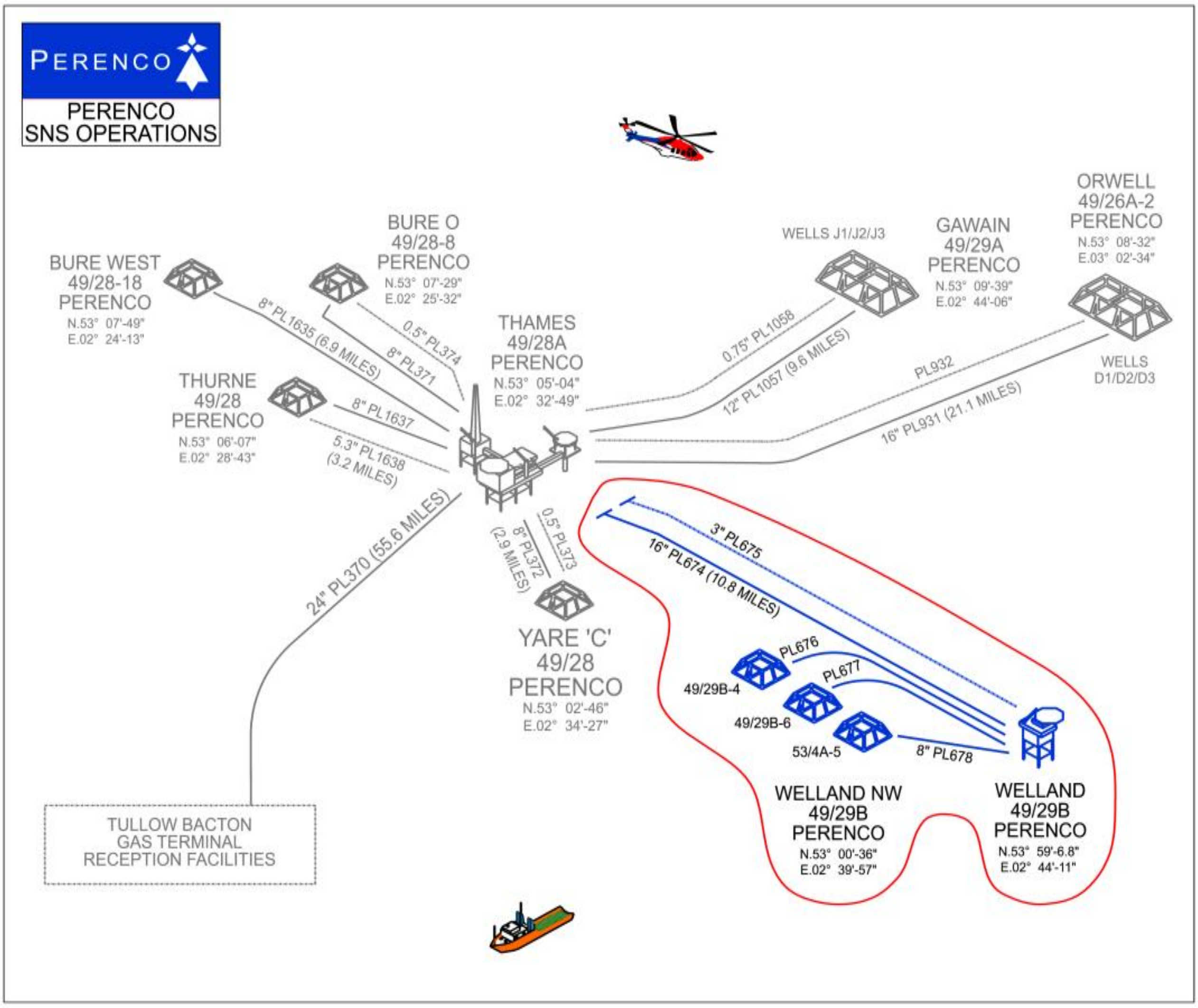


Fig 1.3 – Welland Field Pipeline Layout

Table 1.4 Lengths, diameters, type of construction

Pipeline & flowlines	Number	Diameter	Length, miles	Type of construction	Seabed Status
Welland - Thames Export line	PL674	16"	10.87	X60 Grade Steel, 65mm concrete & 6 mm coal tar	Buried
Welland - Thames MEG line	PL675	3"	10.87	X52 Grade Steel & 0.5mm Fusion Bonded Epoxy	Buried
Well 2 Subsea flowline	PL678	8"	2.61	X60 Grade Steel , 42mm Concrete & 550 microns Fusion Bonded Epoxy	Buried
Well 2 Subsea control umbilical & MEG line	PL681	4" & 0.75"	2.61	Core of shielded electrical power cables surrounded by a shielded communications cable, six thermoplastic hoses and lead fillers. Cores sheathed in polythene & further protected by armoured (steel wire) jacket and covered in an outer polythene sheath.	Buried
Well 3 Subsea flowline	PL676	8"	4.97	X60 Grade Steel , 42mm Concrete & 550 microns Fusion Bonded Epoxy	Buried
Well 3 Subsea control umbilical & MEG line	PL679	4" & 0.75"	4.97	Core of shielded electrical power cables surrounded by a shielded communications cable, six thermoplastic hoses and lead fillers. Cores sheathed in polythene & further protected by armoured (steel wire) jacket and covered in an outer polythene sheath.	Buried
Well 4 Subsea flowline	PL677	8"	3.60	X60 Grade Steel , 42mm Concrete & 550 microns Fusion Bonded Epoxy	Buried
Well 4 Subsea control umbilical & MEG line	PL680	4" & 0.75"	3.60	Core of shielded electrical power cables surrounded by a shielded communications cable, six thermoplastic hoses and lead fillers. Cores sheathed in polythene & further protected by armoured (steel wire) jacket and covered in an outer polythene sheath.	Buried

1.5. Umbilicals

The three umbilicals connecting the subsea wells to the Welland platform and the umbilical that connected the Welland platform to the Thames platform on the back of the export line, were all cleaned, flushed and isolated, refer to Figure 1.4 below. The preferred decommissioning option for the buried umbilicals, as detailed in the comparative assessment section of the Decommissioning Programme (1), was to leave them buried in place. The overtrawl survey (3) of the umbilicals, carried out during the summer of 2016, did not encounter any reportable free spans or snags. Clean seabed certificates were issued by the NFFO for those areas of the seabed occupied by umbilicals.

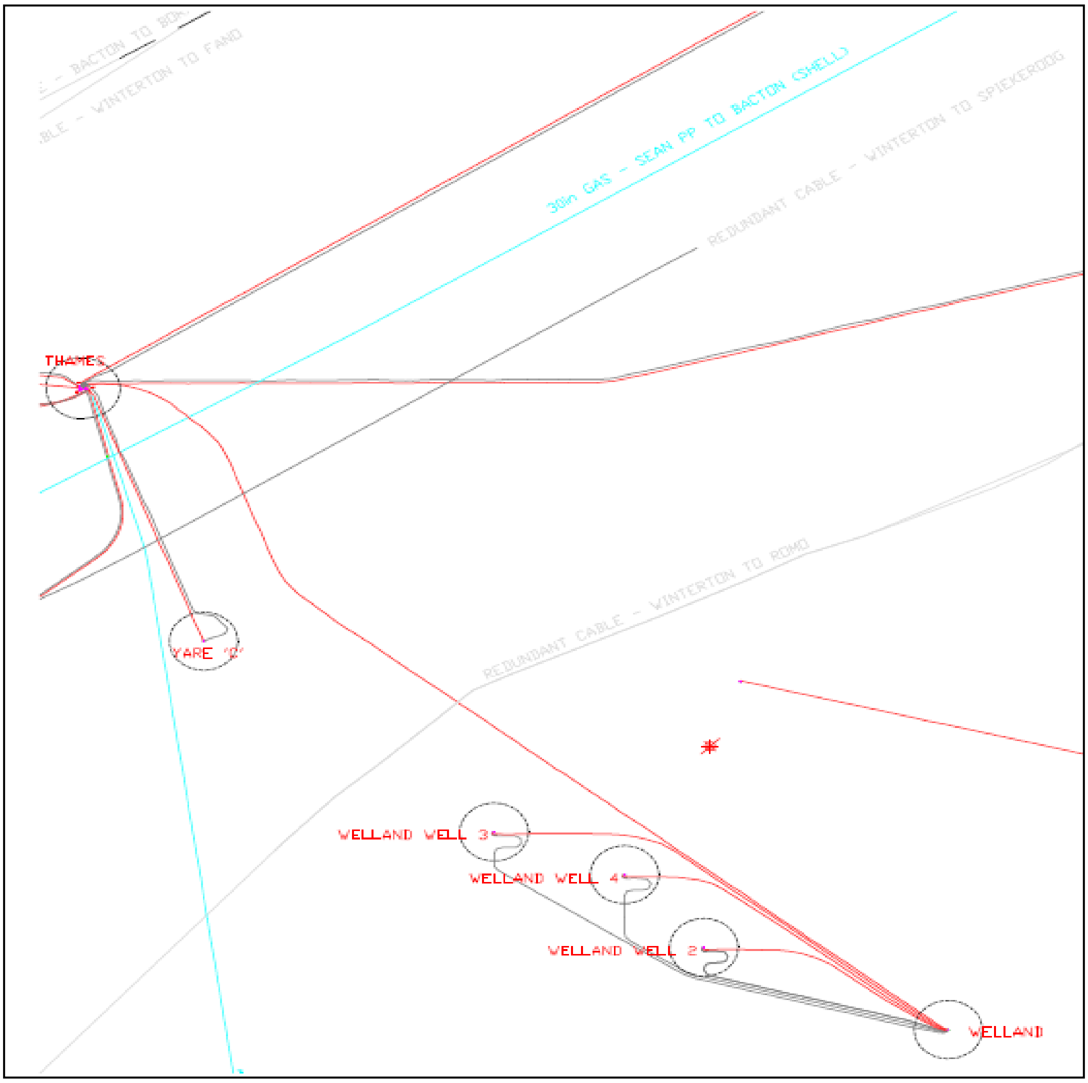


Figure 1.4 – Connections from subsea wells to Welland and from Welland to Thames

1.6. Platform Wells

The two Welland platform wells (Welland 1 and 5) were abandoned as part of a campaign during the period 10th August 2010 to 28th September 2010, including a 12 day period from 12th to 24th September 2010 where the rig was used as accommodation to support platform topside decommissioning operations. The Welland 5 well is sometimes referred to as Tristan in some well documents. The well work was performed by the jack-up drilling rig Energy Enhancer. Both wells had been shut in for an extended period prior to abandonment.

The initial plan had been to abandon the wells in sequence, but having reviewed the platform interface with the rig alongside, it was decided that there would be time saving efficiencies in combining the two operations. Both platform wells were abandoned in line with O&G UK Guidelines. All cement plugging operations were carried out successfully with no reported problems.

Each of the platform well abandonments is briefly described below.

1.6.1. Platform Well 1 (Well No. 53/4a-6)

Plug #1 was a combination permanent cement barrier of 727 ft, from 7,530 ft – 6,803 ft which was tagged and pressure tested to 3,500 psi. This plug isolates the hydrocarbon bearing Leman sandstone from the Bunter sandstone and surface.

Plug #2 was a 500 ft cement plug and isolates the normally pressured water bearing Bunter sandstone from surface. This plug was set on an EZSV at 5,100 ft which was tagged and pressure tested to 3,500 psi.

A further environmental plug consisting of 150 ft of cement was placed below, and up to the mud line.

At the end of the operation the well was fully abandoned, with a stump of 30" casing left in the well (as planned due to jacket design restrictions). The stump was recovered during the jacket recovery operation in 2011.

1.6.2. Platform Well 5 (Tristan - Well No. 53/4a-10)

Plug #1 was a combination permanent cement barrier of 727 ft, from 7,530 ft – 6,803 ft which was tagged and pressure tested to 3,500 psi. This plug isolates the hydrocarbon bearing Leman sandstone from the Bunter sandstone and surface.

Plug #2 was a 500 ft cement plug and isolates the normally pressured water bearing Bunter sandstone from surface. This plug was set on an EZSV at 5,100 ft which was tagged and pressure tested to 3,500 psi.

A further environmental plug consisting of 150 ft of cement was placed below, and up to the mud line.

1.6.3. Abandonment of Platform Wells

The Energy Enhancer rig arrived on location at the Welland platform on 11 August 2010. With three tugs in attendance the rig was successfully pulled onto location alongside the platform.

During the interfacing delay the overall platform well abandonment programme was reviewed and revised. The rig was skidded over the Welland 5 well the slickline was rigged up and a permanent bridge plug set in the tubing below the production packer. After nippling down slickline equipment the Xmas tree was removed from the well. Removal of the tree took longer than planned as the studs and nuts were heavily corroded. (A hot bolting programme was in place once the rig arrived on location, but the corrosion problem persisted throughout the campaign.)

The rig was skidded over the Welland 1 well and the bridge plug was set below the production packer. A 727 ft balanced cement plug. (The cement plug was originally planned to be 1,000 ft long, but problems were encountered with cement supply and the job was cut short. The Well Examiner agreed to accept the shorter plug as it complied with the Oil & Gas UK guidelines. The cement plug was volumetrically pressure tested from the tubing and annulus sides to prove cement in place. The tubing was punched at 5,100 ft MDRT and a 500 ft balanced cement plug spotted via the holes. The cement plug was volumetrically pressure tested from the tubing and annulus sides to prove cement in place and the tubing cut at 1,200 ft MDRT. The tubing was then recovered from the Welland 1 well.

The 13-3/8” casing was also cut at 1,100 ft and an EZSV set inside the 9-5/8” casing at 1,020 ft MDRT. The 9-5/8” and 13-3/8” casing strings were cut at 300 ft and 100 ft for eventual recovery of the wellheads and casing.

The rig was then skidded to the Tristan well where a 1,000 ft cement plug spotted above the packer at 10,305 ft. The cement stinger was pulled out of hole to 5,300 ft in preparation for spotting the next plug and the deep cement plug pressure tested to 3,300 ft in leak-off mode. A 500 ft cement plug was spotted from 4,800 ft MDRT. The cementing stinger was pulled out of the hole on completion of cementing operations and the cement plug pressure tested to 3,300 psi in leak-off mode.

The 9-5/8” casing was cut at 1,000 ft. The 13-3/8” casing was then cut at the same depth. After recovering the casing cutter an EZSV was set at 950 ft and cement squeezed into the two annuli, with cement spotted on the EZSV. The 9-5/8” casing strings were then cut at 300 ft MDRT (below MLS) and at 95 ft MDRT (below surface wellhead). The wellhead and two casing strings were recovered to the rig.

The 30” and 20” casings strings were cut at 272 ft MDRT, which was 10 ft below nominal mudline. The rig was skidded over the spare conductor slot and a drill pipe string run to tag the mudline and establish the true mudline elevation. This was confirmed as 266 ft MDRT. The rig was skidded back over the Tristan well and both strings were cut at 268 ft MDRT. (The Well Examiner was consulted with respect to the shallower cut depth and confirmed that the legal requirement is to leave the sea bed clear of obstructions to other user of the sea. The Oil & Gas UK Guideline recommendation of cutting 10 ft below mudline is not mandatory and was intended to be used as a nominal target only, giving some leeway in case of depth errors etc.) The 30” and 20” strings were recovered together.

The rig was skidded back over the Welland 1 well and the 9-5/8” casing was recovered. The 13-3/8” was successfully cut at 272 ft MDRT. The 20” casing was cut at 268 ft MDRT, along with the 30” and the 20” successfully recovered to surface. The 30” stump, which could not be recovered due to the platform guides being smaller ID then the OD of the 30” connector just above mudline was left in place. [Note that when the platform jacket was recovered during 2011 the 30” stump was also recovered.]

The rig was skidded back over the Tristan well. During the first attempt to stab into the well an apparent depth of 345 ft MDRT was achieved and 65 bbl cement were pumped, but on recovering the string it was discovered that the pipe was bent and it would appear the cement was pumped across the sea bed.

The rig stayed on location for a period of approximately 12 days to assist with platform decommissioning operations. During this period the rig was prepared for moving as far as was practically possible.

The rig departed the Welland platform location at 21:00 on 28 September 2010 for the Welland 2 subsea location.

During the platform well abandonments there were 4 safety incidents, none of which resulted in an LTI. However, 2 were reportable near miss type events and were the subject of full investigations.

1.7. <u>Subsea Wells</u>

Subsea well abandonment operations were carried out towards the end of 2010 and during the summer of 2011 utilising the jack-up drilling rig Energy Enhancer.

The subsea wells were abandoned in line with O&G UK Guidelines. All cement plugging operations were carried out successfully with no reported problems.

Each subsea well abandonment is briefly described below:

1.7.1. Subsea Well 2 (53/4A–5)

Plugging and abandonment of subsea well 2 commenced on the 28th September 2010 and was completed on the 29th November 2010.

Plug #1 was a combination permanent cement barrier of 1,000 ft, from 6,491 ft - 7,491 ft which was tagged and pressure tested to 3,500 psi. This plug isolates the hydrocarbon bearing Leman sandstone from the Bunter sandstone and surface.

Plug #2 was a 500 ft cement plug and isolates the normally pressured water bearing Bunter sandstone from surface. This plug was set on an EZSV at 3,008 ft which was tagged and pressure tested to 3,500 psi.

A further environmental plug consisting of 137 ft of cement was placed below, and up to the mud line.

The wellhead protection structure (WHPS) was left in place and was later removed in 2015.

1.7.2. Subsea Well 3 (49/29B–4)

The well abandonment operations commenced on the 2nd July 2011 and were completed on the 4th August 2011. 34 days were planned for the operation. The actual number of days taken to complete the operations came to 33.The well was abandoned in line with O&GUK Guidelines and consisted of the following:

- Plug #1 being a combination permanent cement barrier of 934 ft which was tagged and pressure tested. This plug isolates the hydrocarbon bearing Leman sandstone from the Bunter sandstone and surface.
- Plug #2 is a 695 ft cement plug and isolates the normally pressured water bearing Bunter sandstone from surface and the shallower normally pressured water bearing Cretaceous chalk. This plug was tagged and pressure tested.

A further 90 ft environmental plug was placed below the mud line. This plug was tagged.

The new activity of the divers installing a blind flange on flowline isolation valve block was planned to take just less than 1 day where the actual operation took over 4 days with 2 ½ days WOW.

The majority of the non-productive time (NPT) was weather related because diver assistance was required. 4.6 days of NPT was incurred during operations to install the subsea tree running tool (TRT).

On the whole, operations on the Texas Deck added time to the planned operations.

1.7.3. Subsea Well 4 (49/29B-6)

The well abandonment operation commenced on 4th August 2011 and was completed on the 31st August 2011. 35 days were planned for the operation. The actual number of days taken to complete the operation came to 27.

The well was abandoned in line with O&GUK Guidelines and consisted of the following:

- Plug #1 being a combination permanent cement barrier of 1,054 ft which was tagged and pressure tested. This plug isolates the hydrocarbon bearing Leman sandstone from the Bunter sandstone and surface.
- Plug #2 is a 457 ft cement plug and isolates the normally pressured water bearing Bunter sandstone from surface. This plug was set on a Drill Gun packer at 3,028 ft and was pressure tested.

A further environmental plug was placed below and up to the mud line.

The total non-productive time for the well, was 4.3 days, which equates to 16% of the total well duration. This includes 2.2 days (8%) waiting on weather.

Table 1.5 Cut off Levels of Wells

Installation	Year well / conductor removed	Year WHPS removed	Conductor depth below mudline at time of removal (m)	Depth below mudline (m) and date of measurement assessment
Platform Well 1	2010		1.85	3.85 (July 2016)
Platform Well 5 (Tristan)	2010		1.85	3.85 (July 2016)
Subsea Well 2	2010	2015	2.50	-
Subsea Well 3	2011	2015	TBC	2.00 (August 2016)
Subsea Well 4	2011	2016	3.0	-

Table 1.5 above gives the cut off levels of the conductors and subsea well conductors and the dates they were removed.

The platform wells' conductors were removed in 2010, since then the scour bowl below the platform has infilled significantly and the depth of burial of the remaining conductor stubs has increased. The depth of the conductor's below the mudline, shown in the last column of Table 1.5, has been calculated from comparison of the levels of the seabed surveyed prior to the wells being abandoned against the geophysical survey of the seabed undertaken last year. This survey indicates that the scour bowl, associated with the presence of the Welland platform, has been infilling generally from South to North, and is now approximately 2.0m higher where the conductors are located.

The subsea wells conductors were removed in 2010 / 2011. The WHPS for these wells remained in place until 2015 and 2016 that the WHPS were removed.

There was some uncertainty regarding the level that subsea well 3's conductor was cut off at in 2011. At the time it was cut this was recorded as being the level of the seabed immediately surrounding the well, but there was some evidence that indicated that the conductor was cut off several feet below the mud line. An independent survey was undertaken in 2016 by Ashtead Technology utilising a TSS440 pipetracker to determine the actual depth of the top of the remaining buried conductor relative to the seabed. This survey confirmed that the conductor was buried at least 2.0m below the level of the seabed and at least 0.5m below the top of the firm clay strata underlying the silt / mud layers.

Perenco had previously agreed with BEIS that the target depth of severance for the WHPS piles and conductor was 3.0m below natural surrounding seabed. However should dredging / excavating to this level prove difficult, target severance depth is 0.3m below the stiff clay layer underlying silt / mud layers.

The geotechnical investigation carried out by Structural Analysis and Geotechnical Engineering Ltd in the Welland field in 1987 found that the stiff clay layer commenced 1.5m below the seabed. This was confirmed when the WHPS were removed. The bottom 1.5m – 2.0m of the WHPS piles were coated with stiff grey clay. The summary table of ground conditions from the original geotechnical investigations carried out for. The wellhead structures is reproduced in Figure 1.5 below. Fig 1.6 shows the stiff grey clay stuck to the surface of the bottom sections of the piles. This proves that wells 3's conductor was cut off well below the top 300mm of the stiff clay layer.

Depth (m)	Description
0 - 1.5	Medium dense silty fine SAND
1.5 - 5.0	Stiff to very stiff silty CLAY with partings and seams of fine sand.
5.0 - 15.5	Medium dense fine SAND

Figure 1.5 – Summary of Soil Conditions from 1987 WHPS Geotechnical Investigation

Fig 1.6 – Photos illustrating Stiff grey clay stuck to bottom 1.5 - 2.0m of cut WHPS pile

1.8. Platform Removal

The time schedule for reuse of the Welland topside dictated that the platform's removal would have to take place during the winter season. The operations concept developed was based on minimising the number of offshore heavy lifts required to keep the weather window required for lifting, to the absolute minimum. There were just two lifts: one for the topsides and the other for the jacket and piles. Antwerp based Scaldis SMC were selected by Perenco as the main dismantlement contractor.

During the late summer / autumn of 2010 preparatory work was carried out to get the platform ready for heavy lift removal. The three subsea wells were isolated, four pipelines were de-pressured, flushed, cleaned and disconnected subsea, and three umbilicals and a piggy-back line were also disconnected subsea.

Spool pieces were removed from the base of the jacket to give lift clearance. The two platform wells were plugged, abandoned and cut below seabed. Topsides inspections, decontamination and weight reduction were carried out, and access hatches and working platforms created around lift points. Risers, umbilicals and service pipework, between the topsides and jacket, were disconnected.

By October 2010 the installation was ready to cut and lift. Power generation had been removed and marine navigation marker buoys installed. No further helicopter access was available due to lift point access through the helideck surface.

Following proactive discussions with the regulators, primarily BEIS and the Health and Safety Executive (HSE). The decommissioning programme was approved on 17th October 2010 and the dismantling safety case were approved on 24th December 2010.

Marine execution equipment, schedules and resources had been in place since 1 December 2010, in a state of readiness that allowed Perenco UK to give the heavy lift contractor Scaldis a large execution window, extending through to March 2011. This was necessary given the prevailing winter conditions and allowed Scaldis to mobilise Rambiz opportunistically, at 24 hours' notice, when an available weather window occurred.

Fig 1.7 - Rambiz HLV Lifting Welland Topside

The first suitable weather window occurred in early January 2011, Rambiz mobilised to the field and installed her anchors with the assistance of the anchor handling tug Fairplay 31. Scaldis riggers connected the lift slings between the deck of the platform and the Rambiz cranes. The cutting contractor executed topsides cuts supplying the cutting head system via an umbilical line back to a control unit on the Rambiz deck.

Given that the operation took place in winter, the activity schedule needed built-in flexibility to cope safely with weather interruptions. For every sub-phase of the operation at least one ‘safe fall-back position’ was identified and appropriate arrangements were put in place. For severing the piles just below the topside, the structural engineers Overdick and cutting contractor Proserv developed a novel cut design that would keep the legs centred on the piles and avoid any damage to the existing stabbing cones inside the piles, which were needed to align the topside on the transport barge grillage.

Proserv conducted several mock-up tests to fine tune the set up and achieve the correct result. In addition to the shape of the cut, a set of contingency clamp-on devices were designed, these would have allowed the platform to survive a severe storm condition even with all the legs cut. This was just one of several contingency solutions developed for a variety of scenarios.

Fig 1.8 - Rambiz HLV Lifting Welland Jacket

On completion of cutting, the latest weather forecast was reviewed by all parties (MWS, Perenco, Rambiz master and Scaldis project team) and authorisation to lift the 960t Welland topside was agreed.

The lifting operations proceeded smoothly with the three cut points separating cleanly. Rambiz moved away from the jacket structure on its anchor cables, making room for the transit barge and tugs to move into position. Docking with pre-installed grillages was achieved at the first attempt followed by sea-fastening, certifications and towing to Flushing in the Netherlands.

Scaldis’ crew then continued with the preparation works for the removal of the jacket, carrying out pile dredging operations to allow internal pile cuts below seabed level. As no immediate lift window was available, Rambiz returned to Flushing and safely executed the lift of the topsides from the transit barge to the quayside so that refurbishment could commence.

Rambiz returned to the field to remove the Welland jacket in the first suitable weather window following the completion of the jacket removal preparation works. Once the first leg-pile of the tripod structure was cut, a 2m insert sleeve was lowered into the pile and located across the cut plane to provide stability assurance for remaining cuts. Prior to cutting the third leg-pile tension was put on the rigging to keep the structure in position during cutting. On completion, Rambiz increased pull on its port crane to gently lift the jacket off the seabed. The jacket remained suspended from the crane ‘in the hook’ during transit to Flushing, where it was lifted onto the quayside.

The topsides were refurbished in Holland and were redeployed on a new jacket in Cameroon for Perenco’s Cameroon subsidiary.

A key factor in the success of this platform removal was the level of co-operation between the operator, regulators and main contractor. This enabled the regulatory requirements to be managed effectively within the engineering scope and design. The opportunistic execution enabled all parties to take responsibility and carry out their activities safely and efficiently.

Table 1.6 Cut off Level of Platform Piles	
Pile	**Cut off depth below mudline (m)**
A3	2.37
B2	4.12
B4	3.92

Table 1.6 above shows the cut off levels for each of the 3 platform piles. Since the platform was removed in 2011 the platform scour bowl has been infilling from South to North, in the direction of the prevailing current. The depth of burial of the tops of the remaining sections of piles (and cut conductors) has therefore significantly increased. The infilling of the Welland former platform site scour bowl can be seen from a comparison of the geophysical survey that was undertaken in 2013 with the geophysical survey of the same area from 2016. Refer to Fig 1.9 and 1.10 below, these show that the platform scour bowl has infilled from South to North.

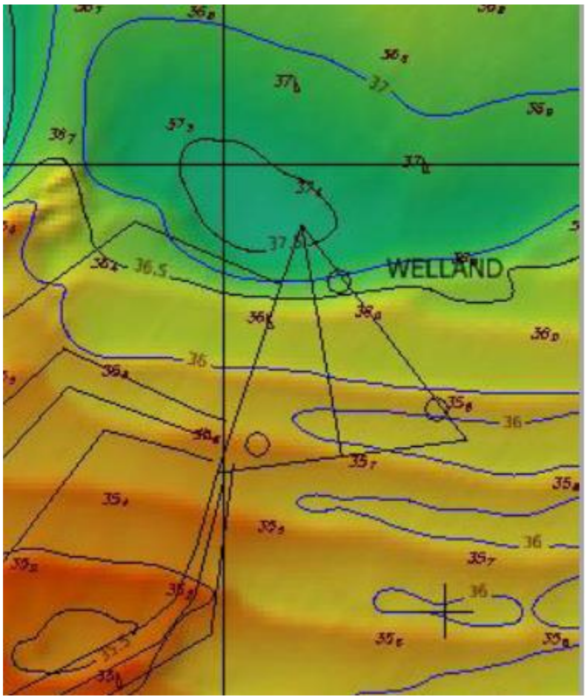


Fig 1.9 - Geophysical survey from 2016

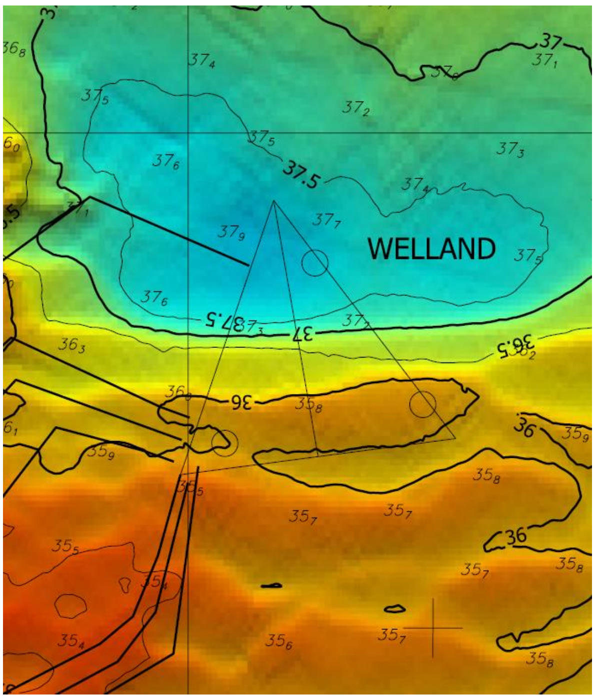


Fig 1.10 - Geophysical survey from 2013

1.9. WHPS Removal

The original wellhead protection structure (WHPS) removal methodology described in the decommissioning programme was to dredge the seabed around and inside the structure using ROVs and divers, to allow the piles to be severed externally by diamond wire cutting or explosive severance. The normal method of dredging the piles and internally cutting them below seabed level, using an internal abrasive water jet cutting tool was not viable because the piles on all three structures had been filled with grout.

The Contractor Boskalis mooted an alternative approach, they proposed building a remotely operated tool that would bore / dredge out the grout in the pile, thereby allowing access for an internal cutting tool. Removing the WHPS in this way brought many benefits: it was inherently safer, as it would allow the WHPS to be removed without divers; it was also far more environmentally friendly, as no external dredging needed to be carried out to form a large crater in the seabed for external cutting access. This was the approach that was adopted and the Decommissioning Programme was revised to reflect this change in methodology.

Fig 1.11 - Welland WHPS Lifted Onshore

The grout boring tool ‘Maurice’ was developed over the summer and autumn of 2014 by the Belgian sub-contractor DECO working in conjunction with Boskalis. Trial tests were carried out at various stages of the tool’s development to verify its performance.

The DSV Protea was dispatched to the Welland field in November 2014 to bore the grout from the piles. This operation proved the viability of the grout boring tool, but the tool kept breaking down and only partially removed grout in two piles.

The tool was reassessed on shore, significant alterations were made which much improved the tools robustness and effectiveness. It took a further mobilisation in January 2015, followed by another round of onshore improvements, before the tool successfully removed the grout from 11 of the 12 piles in March 2015. A single pile remained filled with grout on WHPS 4, a steel plate inside the head of the pile, on top of the grout, blocked the tool from removing the grout.

The sheerleg heavy lift barge Taklift 4 was mobilised in May 2015 to cut the piles with an internal abrasive water jet cutting tool and lift them. After the cutting tool had severed all four piles on a structure, the structure was rigged by an ROV and lifted. WHPS 2 was removed in April 2015 and transported to Flushing in Holland. WHPS 3 was lifted in May 2015 and was also taken to Flushing. An attempt to remove WHPS 4 shortly after, with 3 of the piles cut, but with the fourth pile still intact (this 4th pile with the steel plate over the intact grout was to be pulled from the seabed) was unsuccessful.

Divers were sent to remove the plate in the top of the pile on WHPS 4 in August 2015 the plate was removed by a diver and the grout was successfully removed by the grout boring tool Maurice.

Poor weather over the winter prevented the heavy lift barge from returning to remove WHPS 4. The Taklift 4 was mobilised in spring 2016 and successfully cut the pile and removed WHPS 4 in April 2016.

Table 1.7 shows the depth the piles were cut off below the mudline.

Table 1.7 Cut off Depths of WHPS Piles

WHPS	Piles	Cut off depth below mudline
WHPS 2	A	3.00m
	B	3.20m
	C	3.20m
	D	3.20m
WHPS 3	A	3.20m
	B	3.20m
	C	3.20m
	D	3.20m
WHPS 4	A	3.10m
	B	3.00m
	C	3.10m
	D	3.20m

1.10. Subsea Stabilisation Features

Subsea stabilization features are all associated with the subsea pipelines and constitute 45 concrete mattresses, 85 frond mats and various grout bags/formworks, located at the 3 subsea wellheads, the jacket base and pipeline crossing points.

In accordance with the decommissioning programme, the DSV Constructor attended the field in October 2015 to carry out a detailed survey / inspection of the mattresses and “attempt the removal of several mattresses” it was equipped with a lifting beam with strops that could be attached to the lifting loops along the sides of the mattresses.

The mattresses at the three well sites were all found to be Link-lok type mattresses; the concrete blocks in this type of mattress are interlocked so the ropes linking the blocks were not visible or accessible. The lifting loops along the sides and end of the mattresses had all been cut when the mattresses had been installed. This was standard practice by divers at the time, to avoid lifting loops becoming snag hazards themselves. Furthermore the ropes linking the blocks were steel, not polypropylene. The nature of the mattresses meant that it was impossible to inspect their ropes for corrosion. It was therefore deemed not feasible or safe to attempt a lift of these mattresses. The divers and ROV therefore carried out a thorough inspection of the mattresses at subsea well 2 and the mattresses at the former Welland platform site.

The remaining cut end of the export pipeline, where the platform had been removed, protruded from the side of what remained of the Welland platform seabed scour bowl. This was cut back and left safe so it no longer presented a snagging hazard. This work was summarised in a report that was submitted to BEIS at the time;

Welland Decommissioning Programme – Scour Bowl – Removal of Snagging Hazard, Document No. Perenco 75 r01a dated 25th November 2014. (7)

Following consultation with BEIS, a comprehensive comparative assessment report was produced; Mattress Decommissioning Comparative Assessment (8) evaluating the pros and cons of the various options for decommissioning the mattresses and recommending a preferred decommissioning option. The preferred decommissioning option was to leave the existing mattresses in place, any mattresses that presented a snagging hazard, or potential future snagging hazard, would be removed. BEIS were in broad agreement with the conclusions of the comparative assessment (CA) and requested that Perenco proceed with the next stage of the decommissioning process and carry out an overtrawl survey of the mattresses and pipelines. This overtrawl survey is described in more detail section 1.12 below. No snags were encountered during the overtrawl survey.

1.11. Cuttings Piles

The cuttings piles at all the Welland well sites are generally widely dispersed. This is borne out by the geophysical and environmental survey data for the Welland field and the data gathered during the detailed post decommissioning environmental survey.

The post decommissioning environmental survey was conducted at Welland in two phases. A geophysical survey was first undertaken to survey the seabed in those location where infrastructure is or had been located and acted as reconnaissance for the environmental sampling survey. Any features of interest identified during the geophysical investigation were later sampled. An area of disturbed sediment was identified at each of the three wells and platform locations due to the presence of drill cuttings material. These were present in the predominant tidal direction to the north of the drilling locations. The presence of cuttings appeared to interrupt the overall pattern of megaripples with these areas showing a featureless seabed character. Generally, stations to the north of the platform and the wells seemed to contain more fine sediment, which was influenced by the area of drill cuttings and the northerly current direction in the survey area.

The analysis of total hydrocarbon concentrations for all samples taken in the Welland Field revealed low levels, with only station Wplat_01 recording elevated Tetrahydrocannabinol (THC) concentrations. This was likely due to this station's close proximity to the decommissioned platform location in combination with the predominantly northerly current direction. A closer inspection of the gas chromatography (GC) trace for station Wplat_01 indicated the presence of weathered mixed hydrocarbon input, dominated by suspected low toxicity oil-based muds (LTOBM). Whilst this one elevated concentration was above typical background levels for the Southern North Sea, it was consistent with expected hydrocarbon levels around offshore platforms.

1.12. Overtrawl survey and seabed clearance

Following the successful removal of all three WHPS and BEIS's review of the mattress comparative assessment, Perenco commissioned the National Federation of Fishermen's Organisation (NFFO) to undertake an overtrawl survey of the three subsea well sites, the former Welland platform site and the field pipelines and umbilicals.

The NFFO undertook the overtrawl survey of the Welland field between the 15th and 24th May 2016 using fishing gear representative of the type of fishing gear used in this part of the Southern North Sea (SNS). A standard otter trawl with the addition of scraper chains deployed prior to ground gear specifically designed for strong and constant seabed contact. A trawl net was selected to collect debris at all locations as they went.

During the survey no snags were encountered and no debris was recovered. Clean seabed certificates (4 & 5) for all locations were issued by the NFFO to Perenco. These certificates were then forwarded to BEIS.

Copies of these certificates can be found in appendix 6.1 of this report. Perenco then proceeded with the post decommissioning environmental sampling survey.

1.13. Post decommissioning survey

Bibby Hydromap were appointed by Perenco to undertake the post-decommissioning seabed and environmental sampling survey (6). Bibby Hydromap undertook the survey and subsequent reporting in conjunction with Benthic Solutions. The survey vessel Tethra surveyed the field between 6th and 18th July 2015. It consisted of a geophysical survey and an environmental baseline survey as detailed below.

Geophysical survey – side scan sonar and multibeam echo sounder (MBES) bathymetry survey of the former platform site, subsea wells, pipelines and umbilicals. This survey acted as reconnaissance for the environmental sampling survey as it identified features of interest which were then further investigated by a drop down camera and environmental sampling as required.

Environmental baseline survey – 313 grab samples with camera ground-truthing were taken at 57 locations across the field. These samples were tested for particle size distribution, total organic carbon and moisture content, total hydrocarbon concentration, heavy and trace metals and benthic macrofauna. Camera ground-truthing was used to provide visual assessment of each sample location and to identify any presence of Annex 1 habitats.

The geophysical survey showed that the well casings and cuttings piles were all buried. The results of the pipeline survey indicated that there has been no significant increase in exposures across all pipelines. This was supported by the results of the over trawl survey and subsequent clean seabed certificates (appendix 6.2). A summary of this survey is provided in appendix 6.4.

Despite no significant increase in exposures, the survey did indicate an increase of two non-reportable spans on Pipelines PL674 and PL675 as detailed in the Re-analysis of post decommissioning surveys – Welland field 2019 (9) (appendix 6.5). Further, the increase in total exposure length across all pipelines was confirmed to be 19m as opposed to the 196m originally reported in the survey report. This difference was primarily due to failure to recognise the use of two distinct position reference data being used between reports.

2. REVISIONS

The holders can confirm that the decommissioning programme was executed as approved by the Secretary of State.

The following revisions were all made to the programme, these revisions were all approved by BEIS:

- **Revision to the Installation Decommissioning Programme.** The WHPS removal methodology to allow the use of a prototype grout boring tool to bore out the grout in the piles of the WHPS so they could be severed internally using an abrasive water jet cutter. This methodology was significantly safer and kinder to the environment than the alternative; dredging the seabed and externally severing the piles with a diamond wire or explosives.
- **Revision to the Installation Decommissioning Programme**. The removal of the subsea WHPS took longer than originally envisaged, the prototype grout boring tool took longer to develop and get working correctly, so the decommissioning programme was extended to accommodate this additional time.
- **Revision to the Pipeline Decommissioning Programme.** The delay in the removal of the WHPS also delayed the removal of the pipelines, as it was not possible to carry out the over trawl survey and post decommissioning environmental survey of the seabed whilst the WHPS were still in place.

3. POST-DECOMMISSIONING MONITORING AND EVALUATION

Following completion of the Welland decommissioning operations, Perenco has reviewed all activities to ensure that the scope has been fully executed in accordance with the approved DP, that risks to other sea users has been removed or reduced as far as reasonably practicable and that all regulatory requirements have been met.

An independent third party subsea pipeline engineering consultancy undertook a comprehensive review of the decommissioned Welland field pipelines and infrastructure that remains in situ to determine an appropriate inspection maintenance regime. This review includes a risk based assessment using a modified risk matrix to reflect the potentially longer term degradation mechanisms associated with a system that is not operational and is hydrocarbon free. The review was discussed with OPRED and further re-analysed to account for differences in position reference data between previous surveys.

Following the risk review and subsequent discussions with OPRED, it is proposed that the Welland infrastructure decommissioned in situ (specifically PL674, PL675 and associated flowlines PL676, PL677 & PL678) is inspected at the same time as the Thames Field planned post-decommissioning survey being carried out in the wider Thames area, currently scheduled for completion by Q4 2022. This survey will consist of a depth of pipeline burial assessment. The results of this survey will determine if further surveys will be required for the Welland pipelines and associated flowlines.

In general, environmental sampling did not demonstrate potential harmful or deleterious results however, one location immediately north of the Welland platform (Wplat_01), showed elevated concentrations of hydrocarbon above typical background levels for the Southern North Sea. These levels were however consistent with expected hydrocarbon levels around offshore platforms (10). Additionally, one location (Wplat_02) demonstrated high heavy metal levels. It is proposed that a further environmental survey focussed on these locations should be undertaken during the Thames post-decommissioning survey (fig 3.1). The purpose of this survey will be to confirm that the hydrocarbons and heavy metals at these locations are degrading in situ as expected and will determine if further surveys will be required.

The survey scope will be limited to chemical, heavy metal and THC analysis. No additional macrofauna samples are required and will not form part of the additional survey scope.

The proposed locations have been selected in order to provide a general spread around the areas of interest. The multiple locations will allow for the identification of trends on both an east/west and a north/south axis. The selected locations will also account for any potential movement of contaminants along the predominant current direction (northerly). The locations however are proposed and will be subject to the same restrictions/tolerances as for all surveys (i.e. locations may be adjusted depending on grab failure).

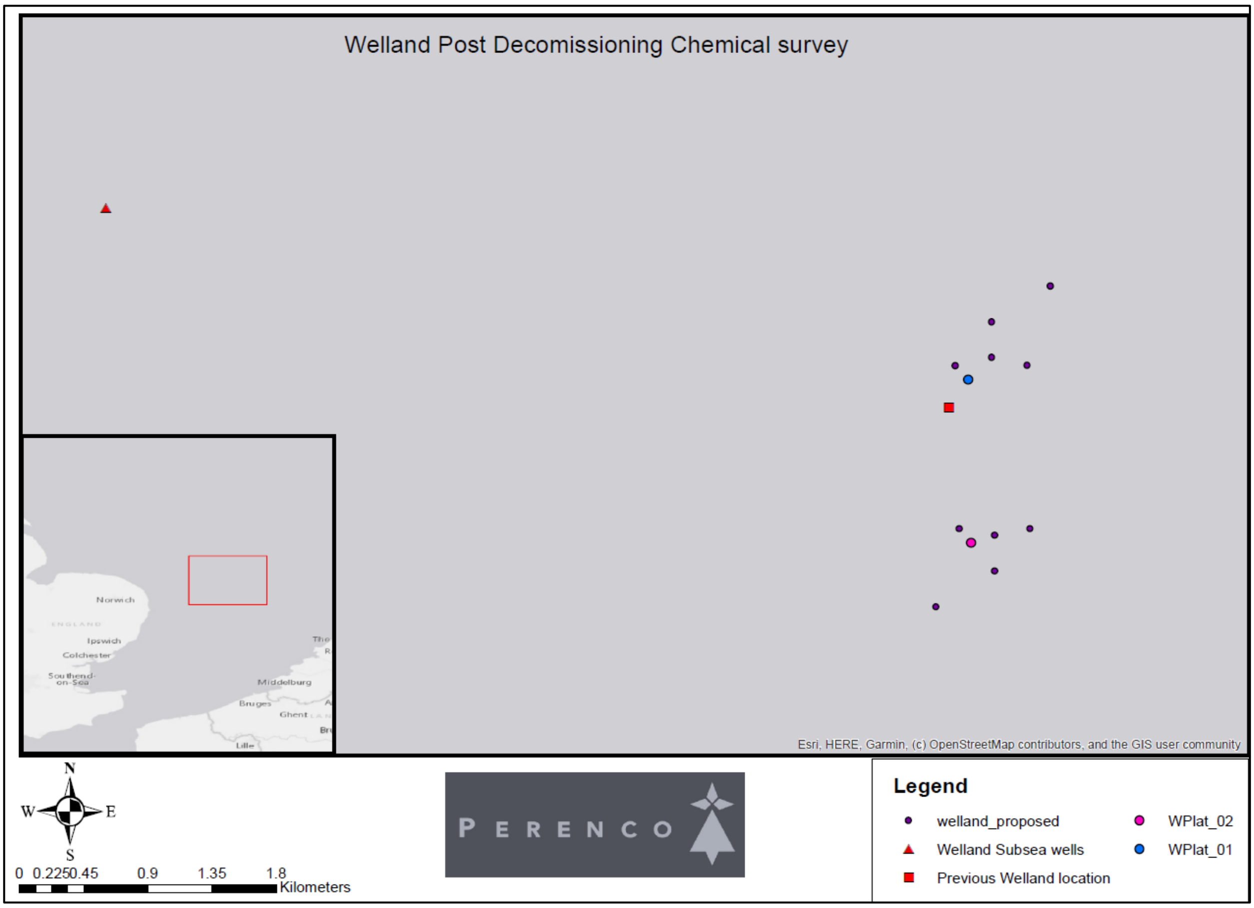


Fig 3.1 – Proposed environmental sampling locations (chemical only) around Wplat_01 and Wplat_02.

4. COSTS

This section reviews the decommissioning costs to date and compares them with the original estimates included in the decommissioning programme. This summary excludes costs for future monitoring of decommissioned infrastructure that remains in situ.

The cost breakdown has been provided to OPRED.

The key differences between the original estimate and actual costs was the cost of the subsea well abandonment. The increase over estimated cost was a result of a number of factors including:

- A lack of as built information leading to technical difficulties on site
- More than anticipated weather down time
- This was the first time that Perenco had undertaken the decommissioning of a gas field, the technical and logistical challenges involved were not fully appreciated when the project was conceived and the original budget estimate was drawn up.

5. REFERENCES

1. Welland Field Decommissioning Programme
2. Welland and Tristan Cessation of Production Document. Doc.No.SG-R-2-00-GN-001
3. National Federation of Fisherman's Organisation (NFFO) Close Out Report
4. NFFO Clean Seabed Certificates (Welland Field)
5. NFFO Clean Seabed Certificates (Welland to Thames Pipeline)
6. Welland Post-Decommissioning Environmental Survey Volume 3 – Geophysical Results Report
7. Welland Decommissioning Programme – Scour Bowl – Removal of Snagging Hazard, Document No. Perenco 75 r01a dated 25th November 2014.
8. Mattress Decommissioning Comparative Assessment, document number SN-BW-AX-RC-FD-000001, dated 1st May 2015
9. Re-analysis of Post Decommissioning surveys – Welland field
10. Harries, D., Kingston, P. F., & Moore, C. (2001). *An Analysis of UK Offshore Oil and Gas Environmental Gas Surveys 1975-95*. The United Kingdom Offshore Operators Association.

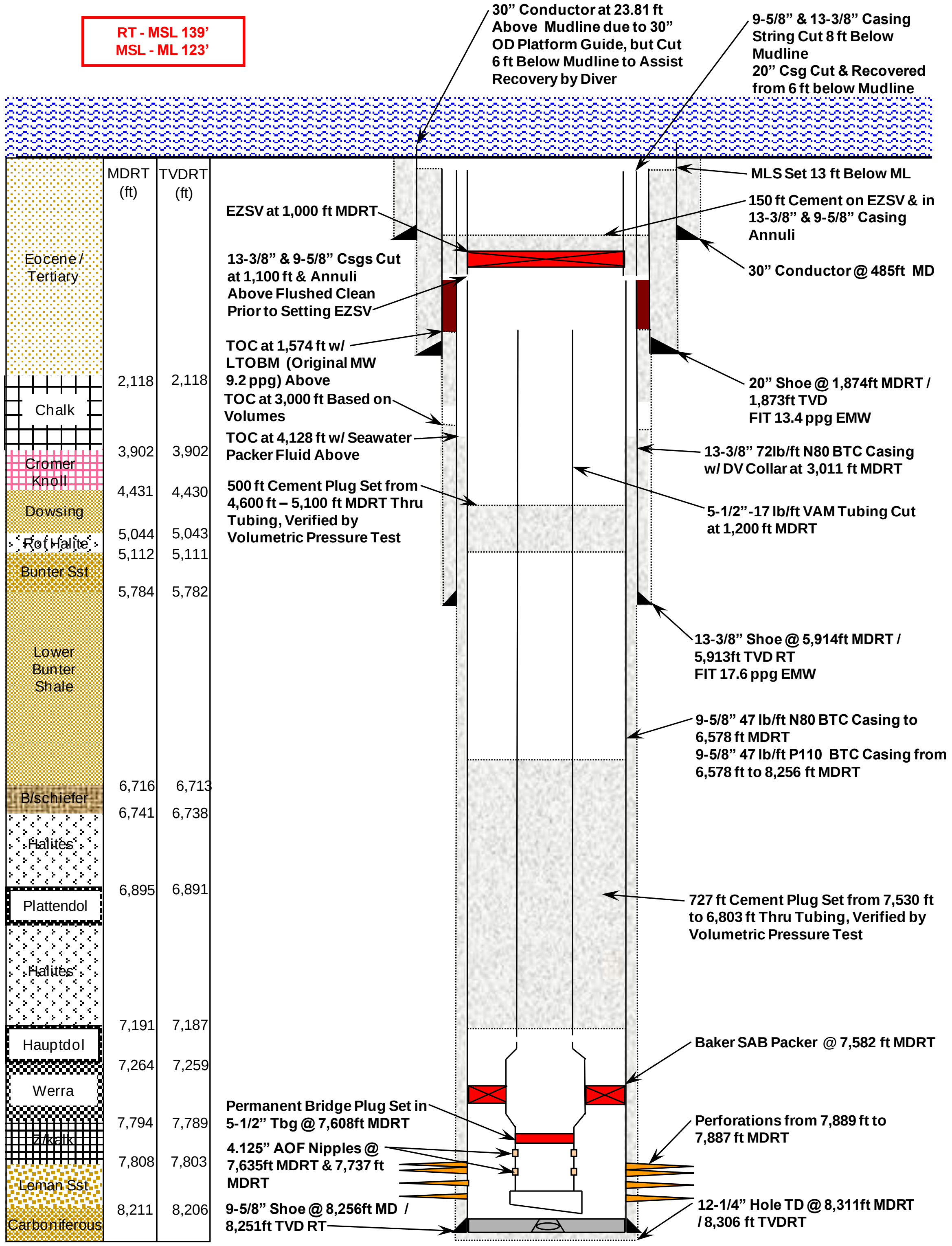
6. APPENDICES

The appendices include the following information/documents:

1. Well Abandonment Schematics
2. Clearance Certificates
3. Welland Post Decommissioning Environmental Survey Summary
4. Welland Post Decommissioning Inspection Strategy
5. Re-analysis of Post Decommissioning surveys – Welland field
6. Welland Post-decommissioning Benthic Survey Regime

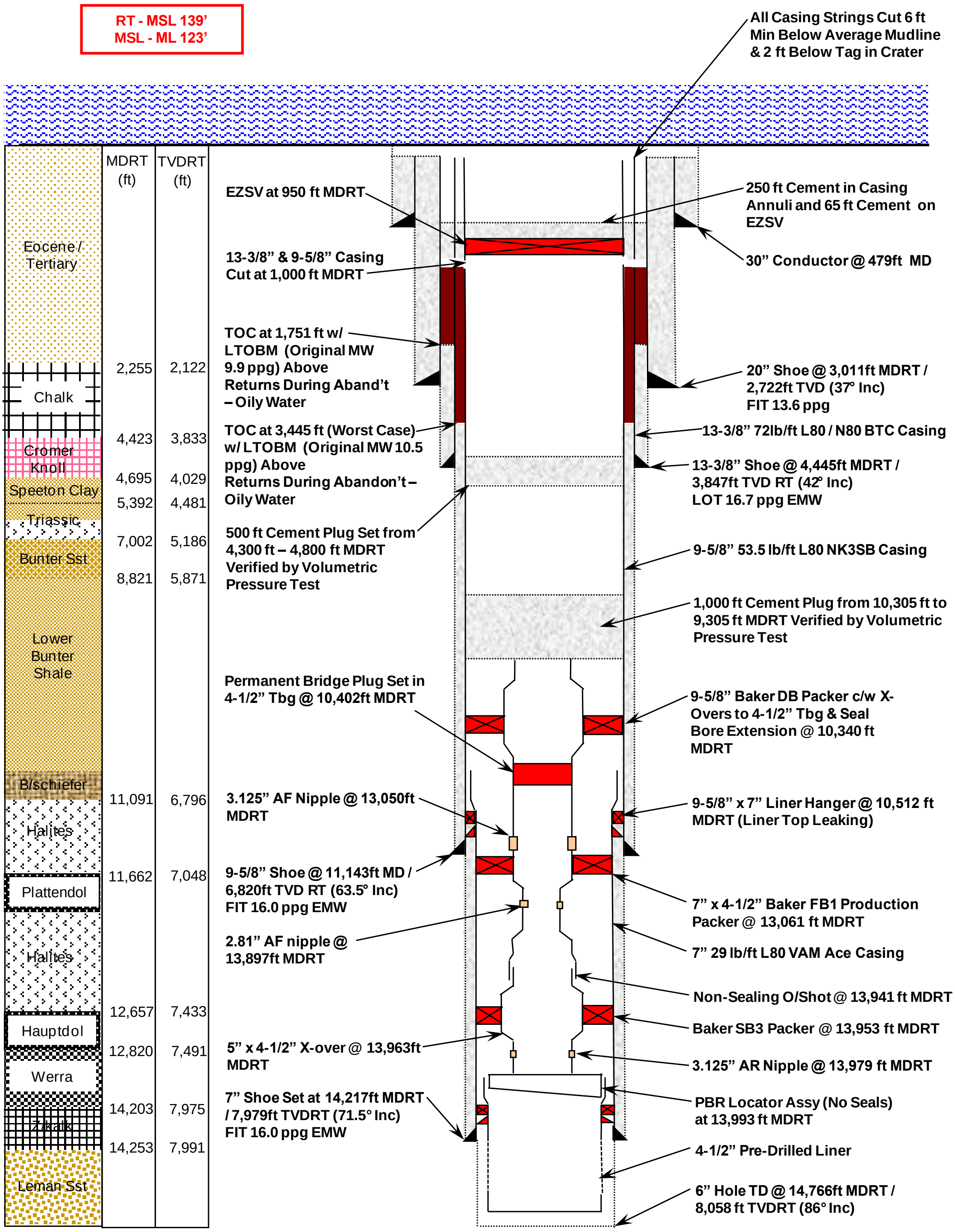
6.1 Well Abandonment Schematics

53/4a-6 (WELLAND 1)
FINAL ABANDONMENT SCHEMATIC



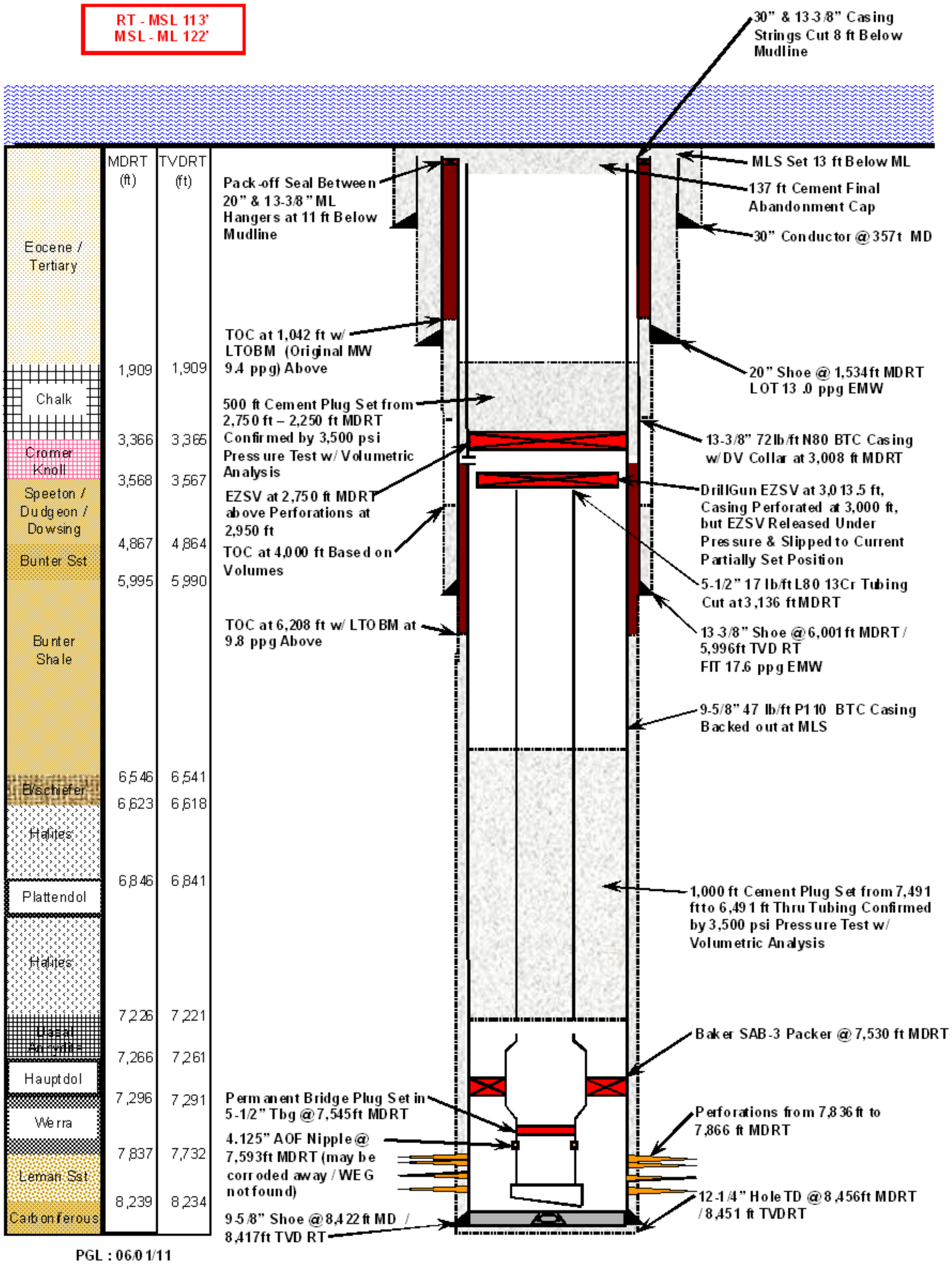
PGL : 30/11/10

53/4a-10 (WELLAND 5 (TRISTAN))
FINAL ABANDONMENT SCHEMATIC

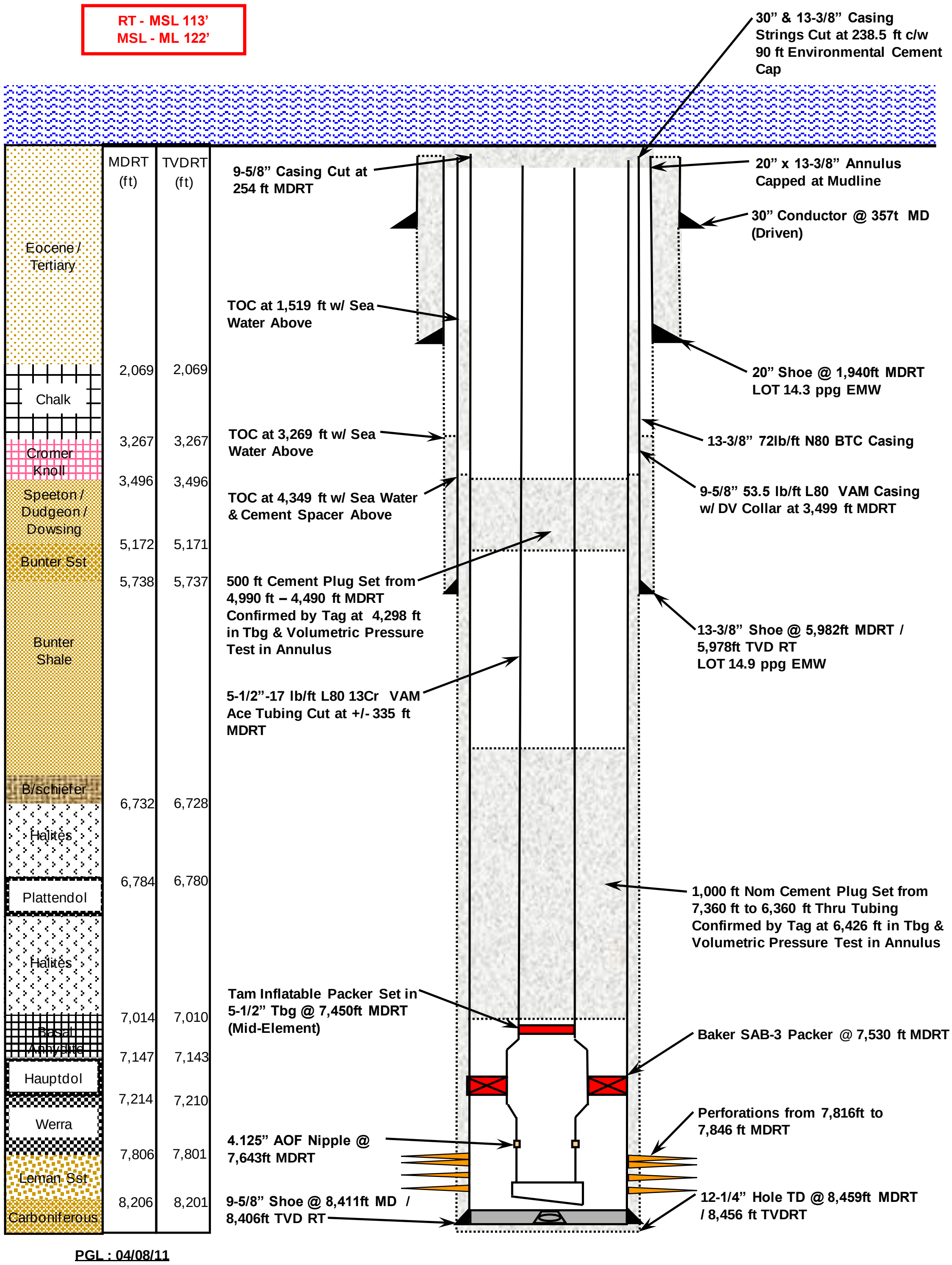


PGL : 30/11/10

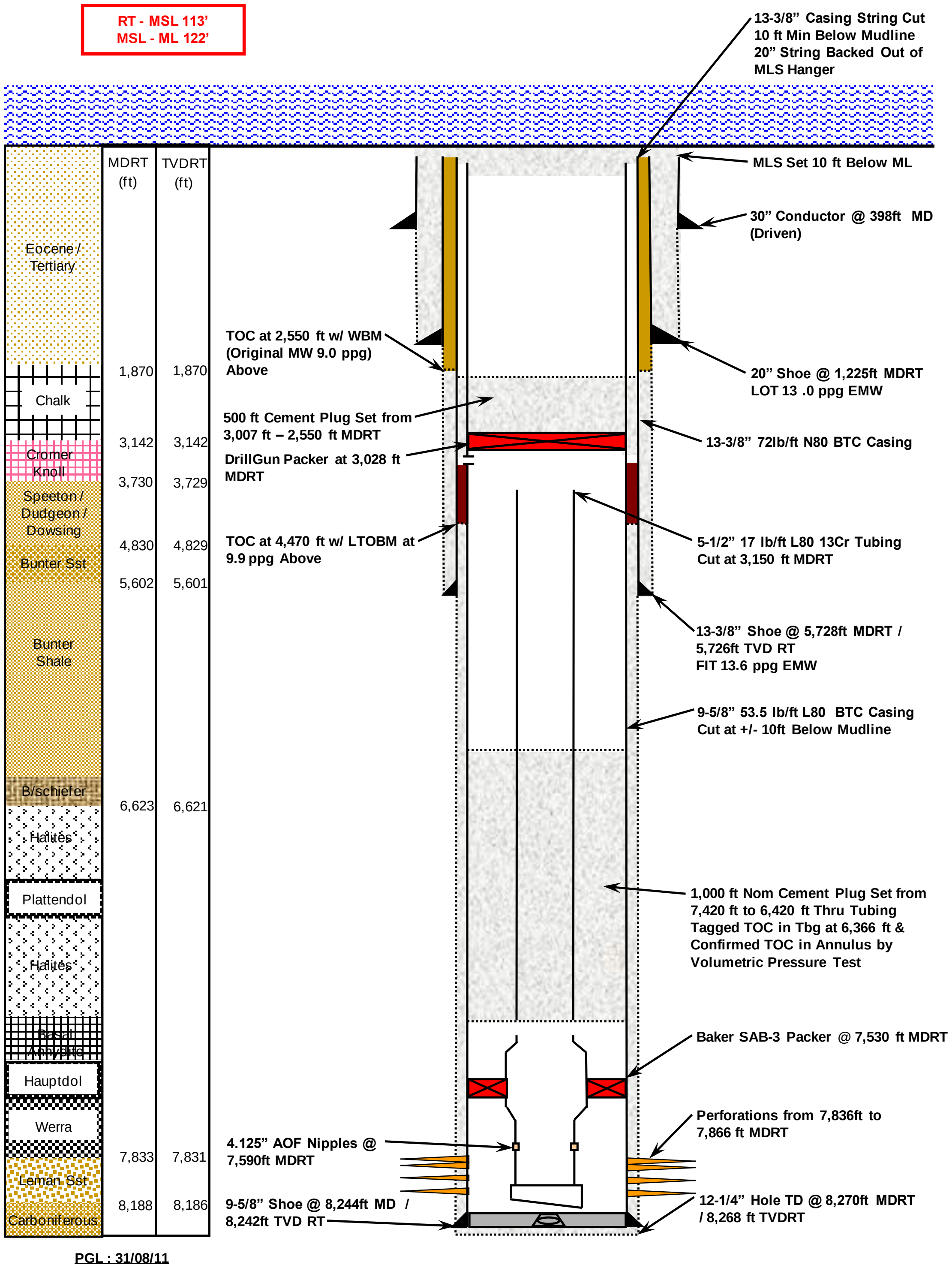
53/4a-5 (WELLAND 2)
FINAL ABANDONMENT SCHEMATIC



49/29b-4 (WELLAND 3)
ABANDONMENT SCHEMATIC



49/29b-6 (WELLAND 4)
ABANDONMENT SCHEMATIC



6.2 Clearance Certificates

National Federation of Fishermen's Organisations.

30 Monkgate
York
YO31 7PF

Tel: 01904 635 432
Fax: 01904 635 431
e-mail: apiggott@nffo.org.uk
Web: www.nffoservices.com

24th June 2016

To whom it may concern

Welland to Thames Pipe Line

CLEAN SEABED CERTIFICATE

The Whitby based Trawler **Advance WY** operating under NFFO membership conducted the following activities at the Decommissioned **Welland to Thames decommissioned pipe line.**

1. A series of sweeps along the known **Welland To Thames Pipe line** has been conducted with the objective of safe future over trawlerbility around the de commissioned pipe line..

A significant number of tows along the length of the pipe. (Individual plotter data has been supplied) using Standard Southern North Sea trawl equipment with a series of chains suspended across the mouth of the trawl was used to conduct the tows.
Chains were attached to the trawl to ensure continuous contact with the seabed to determine whether there were any major obstructions which might present a major snagging hazard for future fishing activities. The trawl net was also seen as a means of gathering any items of debris located in the area. **No debris or obstructions were encountered.**

Following completion of the sweep programme the skipper of **Advance WY** has reported to NFFO the following:

a) No major snag was experienced during any of the tows.
b) On no occasion did the winch pressure showed any increase.
c) The skipper of the Advance is happy that as a result of the sweeps and the absence of any debris or snagging points on the above named decommissioned pipe line suggest that the areas will not pose any significant problem for future fishing operations.

Based upon feedback provided by the skipper, the Federation accepts that the decommissioned **Welland to Thames pipe line** was found to be clear of debris or obstruction and posed no significant problem for future fishing operations.

Signed

Alan Piggott

A Piggott
General Manager

National Federation of Fishermen's Organisations.

30 Monkgate
York
YO31 7PF

Tel: 01904 635 432
Fax: 01904 635 431
e-mail: apiggott@nffo.org.uk
Web: www.nffoservices.com

24th June 2016

To whom it may concern

Welland Field

CLEAN SEABED CERTIFICATE

The Whitby based Trawler **Advance WY** operating under NFFO membership conducted the following activities at the Decommissioned **Welland Platform & W2, W3 W4 Well heads and associated mattress areas**

1. A series of intense bi-directional sweeps over known **Welland Field** 5oo metre Zones and associated areas have been conducted with the objective of safe future over trawlerbility within the said zones.

A significant number of passes has been made across each area. (Individual plotter data has been supplied)
Standard Southern North Sea trawl equipment with a series of chains suspended across the mouth of the trawl was used to conduct the sweeps.
Chains were attached to the trawl to ensure continuous contact with the seabed to determine whether there were any major obstructions which might present a major snagging hazard for future fishing activities. The trawl net was also seen as a means of gathering any items of debris located in the area. **No debris or obstructions were encountered.**

Following completion of the sweep programme the skipper of **Advance WY** has reported to NFFO the following:

a) No major snag was experienced during any of the sweeps.
b) On no occasion did the winch pressure showed any increase.
c) The skipper of the Advance is happy that as a result of the sweeps and the absence of any debris or snagging points on any of the above named decommissioned sites suggest that the areas will not pose any significant problem for future fishing operations.

Based upon feedback provided by the skipper, the Federation accepts that the decommissioned **Welland Field** sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.

The Federation would like to thank Perenco for their efforts in ensuring that all significant items of equipment and debris have been recovered.

Signed

Alan Piggott

A Piggott
General Manager

6.3 Welland Post Decommissioning Environmental Survey Summary

Refer to Perenco summary report below.

6.4 Welland Post Decommissioning Inspection Strategy

Refer to Jee report below.

6.5 Re-analysis of Post Decommissioning surveys – Welland field

Refer to Perenco report below.

6.6 Welland Post-decommissioning Benthic Survey Regime

Refer to Perenco report below.

WELLAND POST-DECOMMISIONING ENVIRONMENTAL SURVEY SUMMARY

Perenco UK Ltd contracted Bibby HydroMap Ltd (BHL), supported by Benthic Solutions Ltd (BSL), to conduct a post-decommissioning environmental survey around the Welland platform and its associated flowline and umbilical routes, which run between the Welland platform and its three wells, and the export line that runs to the Thames platform (refer to Appendix 1.1). The Side Scan Sonar and Multibeam Echosounder survey area covered 200m^2 around each of the four wells and platform locations and a corridor along the pipeline and umbilical routes totalling 72.1km of survey lines.

Ground-truthing by camera and environmental sampling was carried out at 57 stations across the survey area. A cruciform sampling strategy was adopted for the decommissioned platform and well locations with additional stations selected along the pipeline and umbilical routes to provide spatial coverage and to target specific features identified during the acoustic survey.

Particle Size Distribution

A review of the data revealed a relatively homogeneous seabed comprising megarippled sand which was further confirmed by the underwater photographic and video footage. The sand-dominated sediments showed varying but generally small amounts of shell material with mega sand ripples evident throughout the survey area. An area of disturbed sediment was identified at each of the three wells and platform location due to the presence of drill cuttings material. These were present in the predominant tidal direction to the north of the drill location. The presence of cuttings appeared to interrupt the overall pattern of megaripples with these areas showing a featureless seabed character. Generally, stations to the north of the platform and the wells seemed to contain more fine sediment which was possibly influenced by the area of drill cuttings and the northerly current direction in the survey area.

A comparison with previous data collected by CMACS in 2013 revealed no significant change in the proportions of fines, sand and gravel between the surveys with only a slight increase in percentage fines (~+5%) and a decrease in the proportion of sand (~-5%) recorded during the current survey (refer to Figure 1).

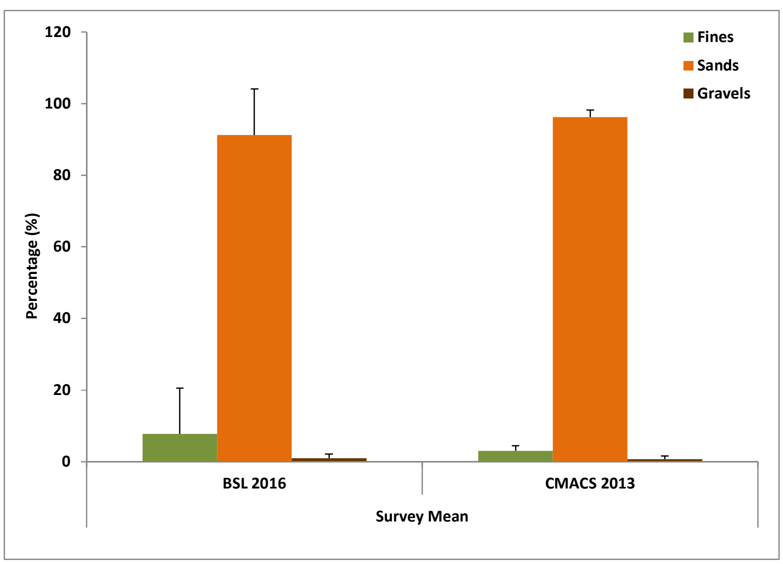


Figure 1 Comparison of Particle Size Distribution with Historical Data

Total Organic Carbon and Moisture Content

Total organic carbon (TOC) results were low and consistent throughout (mean of 0.07±0.06SD), reflecting an organically deprived environment with higher levels recorded at those stations with the highest percentage of fines ($r(57)=0.863$; $p<0.01$) (refer to Appendix 1.2).

TOC concentrations were compared with previous data and remained unchanged between both surveys, showing a consistent mean value of 0.07% (Figure 2). A slightly higher level of 0.13% was recorded at one of the historical stations which coincided with the higher percentage of fines found at this station.

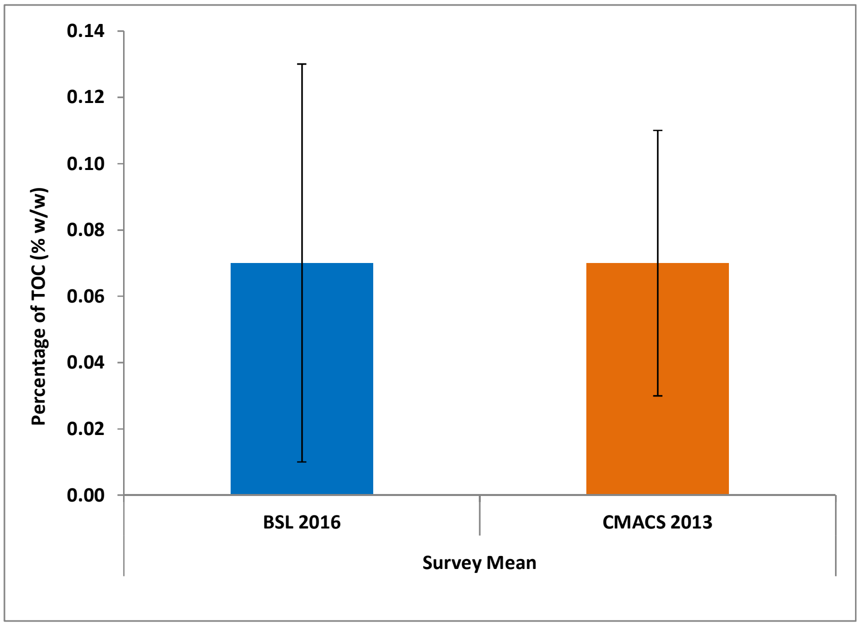


Figure 2 Comparison of Total Organic Carbon with Historical Data

In addition to TOC, the sediments were also analysed for moisture content which was consistent at all sampling stations (mean 21.4%±3.4SD), indicative of similar texture and consolidation throughout. The highest moisture levels were typically found at those stations recording the highest percentages of fines (i.e. Wplat_01, Well2_CTR and Well2_01).

Total Hydrocarbon Concentration

The analysis of total hydrocarbon concentration revealed low levels, ranging from 0.47μg.g^{-1} to 18.75μg.g^{-1}, with only station Wplat_01 recording elevated THC concentrations of 52,577.6μg.g^{-1}. This was likely due to this station's proximity to the decommissioned platform location in combination with the predominantly northerly current direction. The GC-trace for this station showed some indication of weathered mixed hydrocarbon input, dominated by suspected low toxicity oil-based muds used during drilling operations. The calculations of the carbon preference index revealed a general dominance of biogenic compounds, whereas lower CPI values at Wplat_05, Well2_06 and UMB_03 indicated a dominance of petrogenic n-alkanes. Polycyclic aromatic hydrocarbon levels were variable but low giving an average value of 39.9ng.g^{-1} (±65.3SD), excluding the elevated concentration of 9,479ng.g^{-1} measured at station Wplat_01 (refer to Appendix 1.3). This elevated level was not dissimilar to the elevated concentration recorded at station Grab 31 (TOF 31; 4,400ng.g^{-1}) during the 2013 survey operation. A closer inspection of the GC-trace for station Wplat_01 indicated the presence of weathered mixed hydrocarbon input, dominated by suspected low toxicity oil-based muds. Whilst this elevated concentration was above typical background levels for the southern North Sea, it was consistent with expected hydrocarbon levels around offshore platforms.

Total Polyaromatic Hydrocarbons

Hydrocarbon analyses showed, as was to be expected, elevated concentrations of TPH and PAHs at the platform location Wplat_01, with a survey mean below the 95th percentile concentration for stations located over 5km from oil and gas platforms as reported by UKOOA. Drilling related impact was observed in form of potential low toxicity oil-based mud which was identified within the obtained GC traces. Total PAH's were generally found in low levels with a highly elevated concentration of 9,479ng.g^{-1} registered at the platform location Wplat_01. Further analysis confirmed the presence of petrogenic hydrocarbons within the aromatic material for this station as well as mixed to petrogenic PAH sources within the survey area (refer to Appendix 1.4).

Heavy and Trace Metals

Heavy and trace metal concentrations were generally low with the mean concentrations of all metal levels (except arsenic) below their respective ERLs, i.e. below the level where effects on the biota might be seen. Barium levels were found in higher concentrations to the north of the decommissioned platform at stations Wplat_01 and Wplat_02 showing elevated levels of 224mg.kg^{-1} and 777mg.kg^{-1}, respectively (refer to Appendix 1.5). However, mean levels of bioavailable (1,754.7mg.kg^{-1}) and total barium (33,562.1mg.kg^{-1}) within 500m of active platforms (UKOOA, 2001) were both substantially higher than recorded during the environmental decommissioning. This difference in metals concentrations may be due to differences in the sampling/subsampling methods between the two surveys as the 2013 report did not detail the grab type or the method used for subsampling. Overall, heavy and trace metals concentrations were low and consistent with previous results from the 2013 survey.

A comparison of the mean heavy and trace metal concentrations between the current survey and the survey conducted in 2013 (OSIRIS, 2013) is presented in Figure 3. The results for heavy metals were fairly consistent between both survey years with no significant increase or decrease in the concentrations. The majority of metals showed a decrease in the levels recorded, with the exception of chromium and barium where higher concentrations were measured during the current survey.

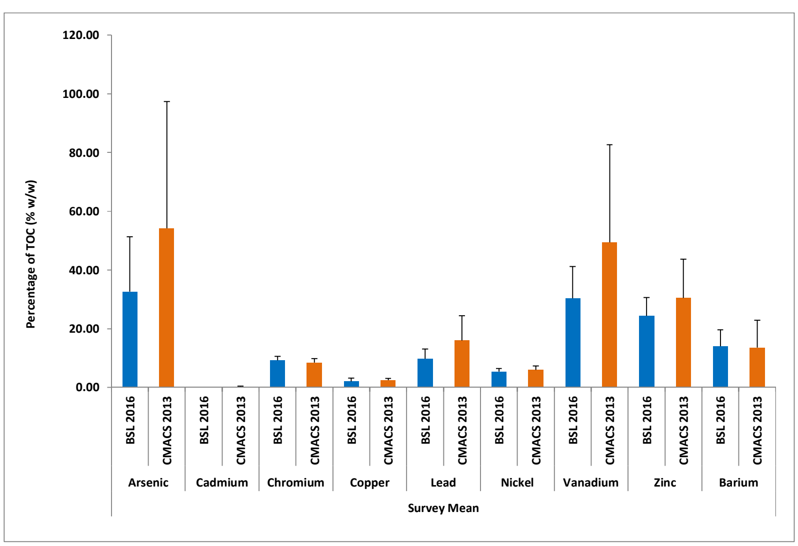


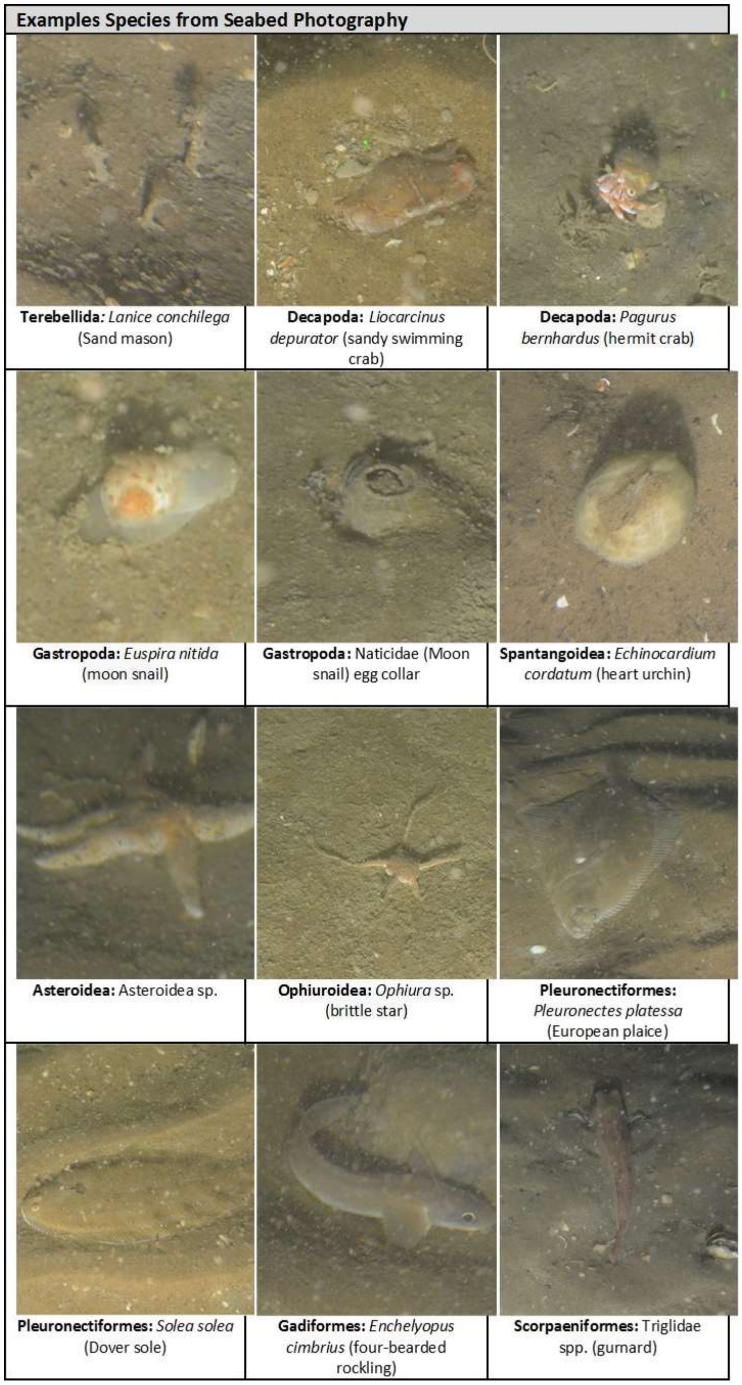
Figure 3 Comparison of Heavy and Trace Metal Concentrations with Historical Data

Macrofauna

The macrofauna community showed minor variation in terms of abundance, richness and species composition as would be expected for a relatively homogeneous seabed, with annelids dominating in terms of abundance and richness, followed by crustaceans for richness and molluscs by individuals (refer to Appendices 6 &7). A total of 4,174 individuals (infauna only) were identified with 77 infaunal and 11 epifaunal species recorded. Annelids were represented by 29 species accounting for over 70% of the total individuals, crustaceans by 24 species (or 5.1% of total individuals), molluscs by 13 species (or 18.8% of total individuals), echinoderms by 5 species (or 4.9% of total individuals) with the remaining groups (i.e. Nemertea, Nematoda, Hydrozoa, Platyhelminthes, Chordata) accounting for 6 species or 1.1% of the total individuals. The Shannon-Wiener Diversity was highly variable throughout all stations due to high numbers of some species at some locations with the lowest value of 0.761 recorded at station Well2_05. This was caused by the polychaete *Lagis koreni* accounting for 236 out of 269 individuals at this location. Further analyses revealed eight significant structural groupings within the Welland infaunal community, however no obvious distributional pattern relating to sediment variation or geographical distribution was found.

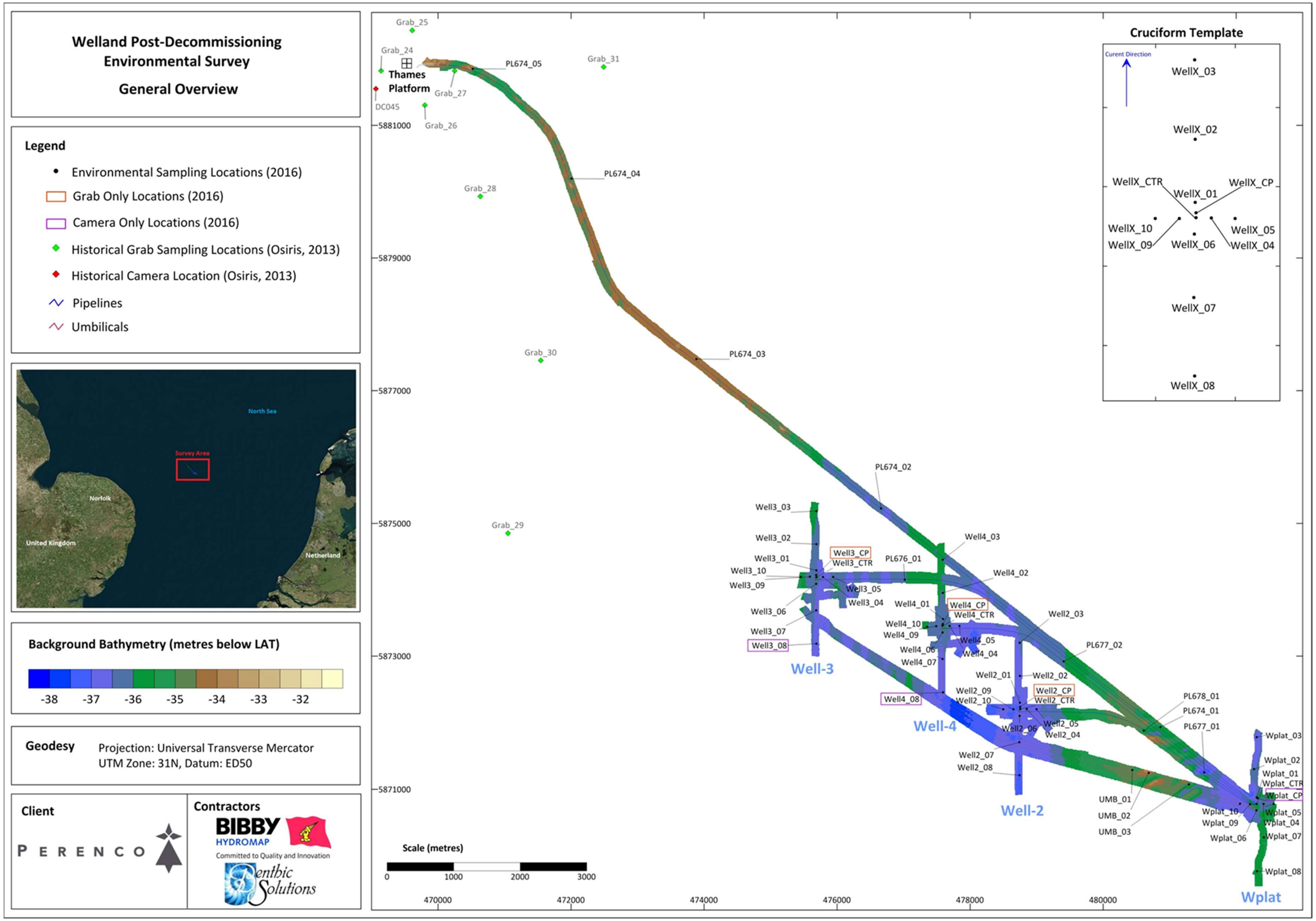
Epifauna was rather scarce and typical of offshore sediment. Due to the sandy sediment they were confined to utilising shell fragments as a settlement surface.

Figure 4 Example species from seabed photography

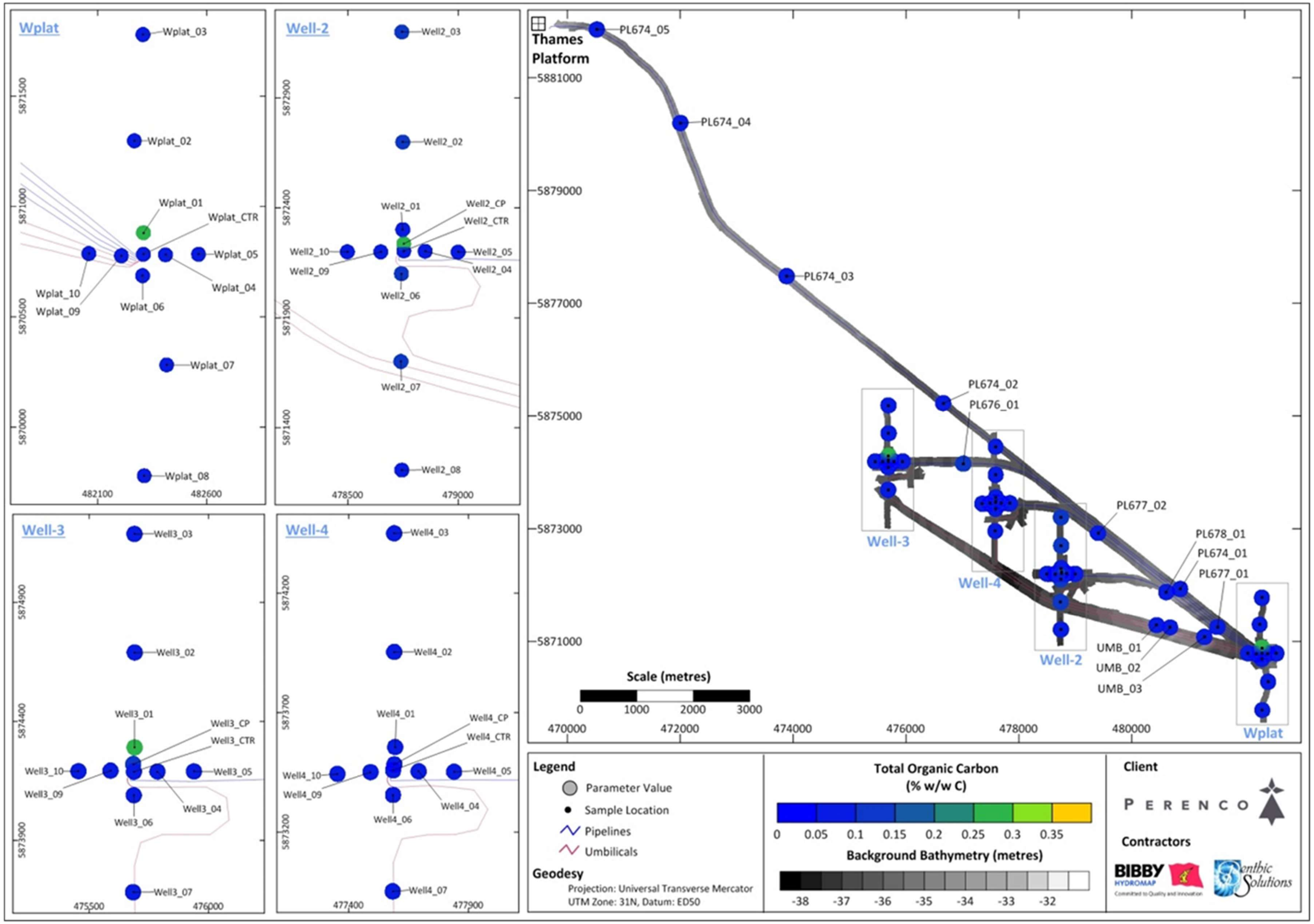


No EC Habitats Directive Annex I habitats or other protected habitats/species were encountered during the post-decommissioning environmental survey. Although several *Sabellaria spinulosa* concretions were recovered at station Wplat_01, these tubes were largely empty with only 30 individuals identified from two replicates. These concretions were not conspicuous in the video data acquired and therefore the presence of *S. spinulosa* here were limited to sparse concretions that do not constitute the protected 'reef' status.

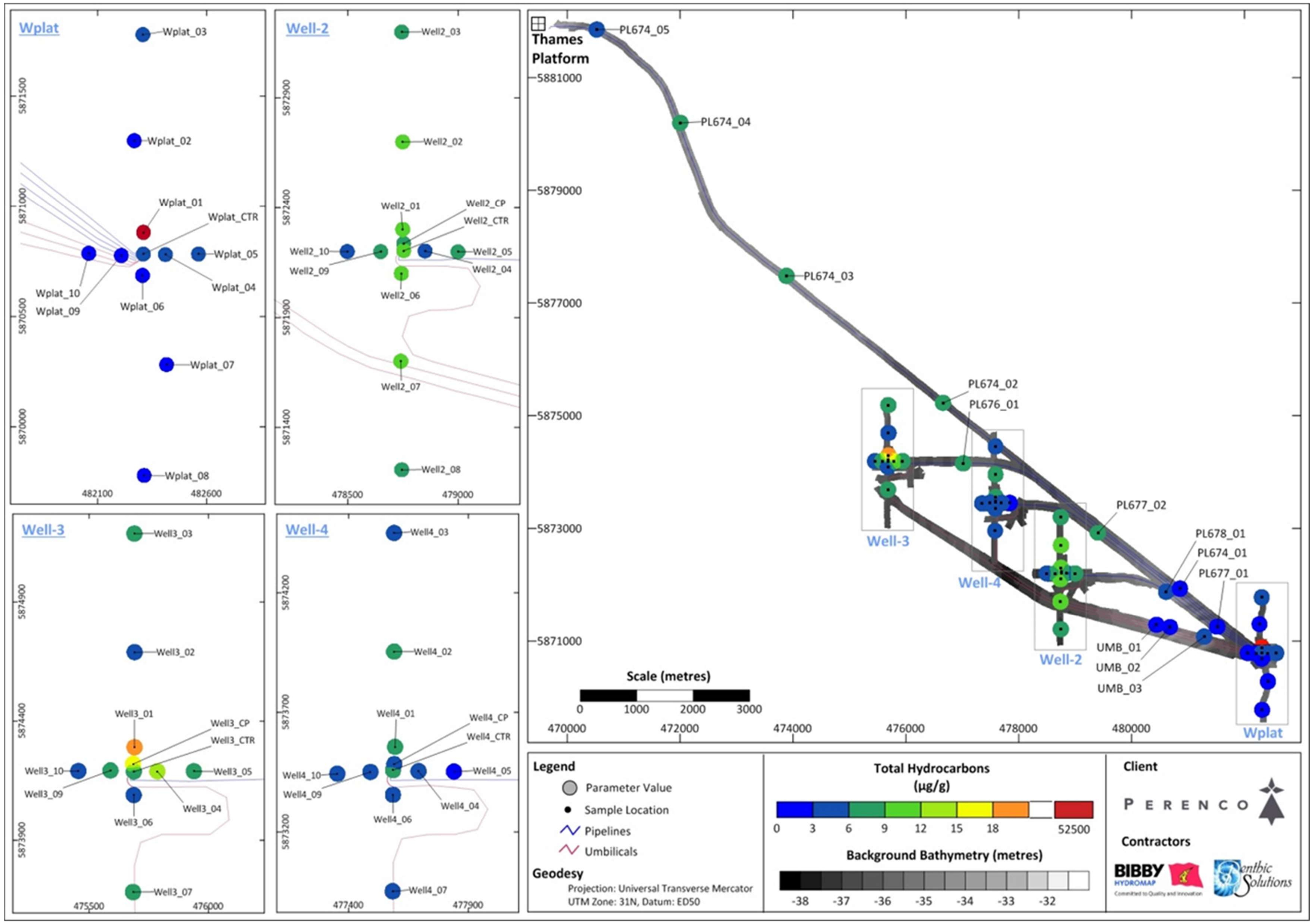
Appendix 1.1 Welland Post Decommisioning Environmental Survey Overview



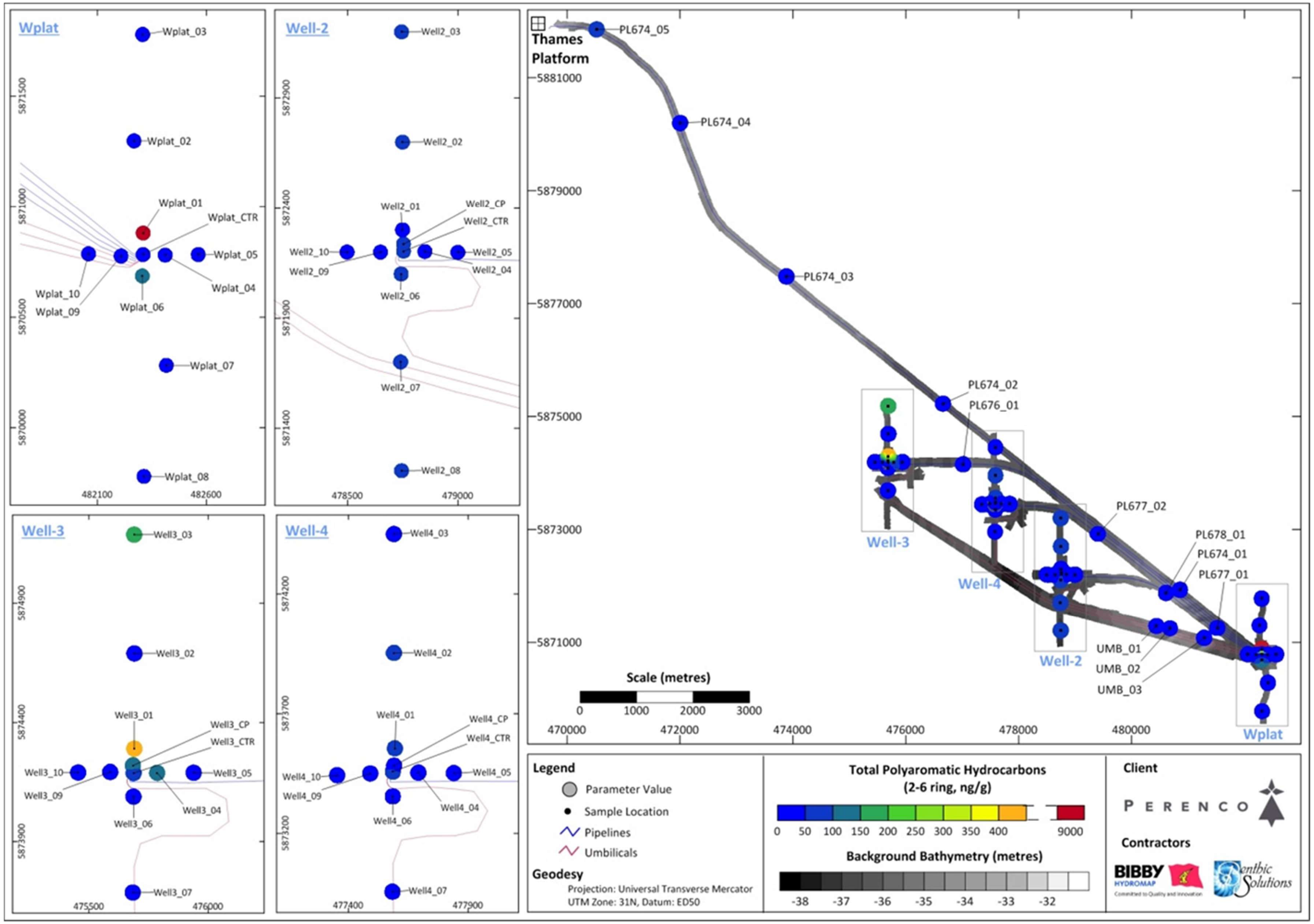
Appendix 1.2 Total Organic Carbon



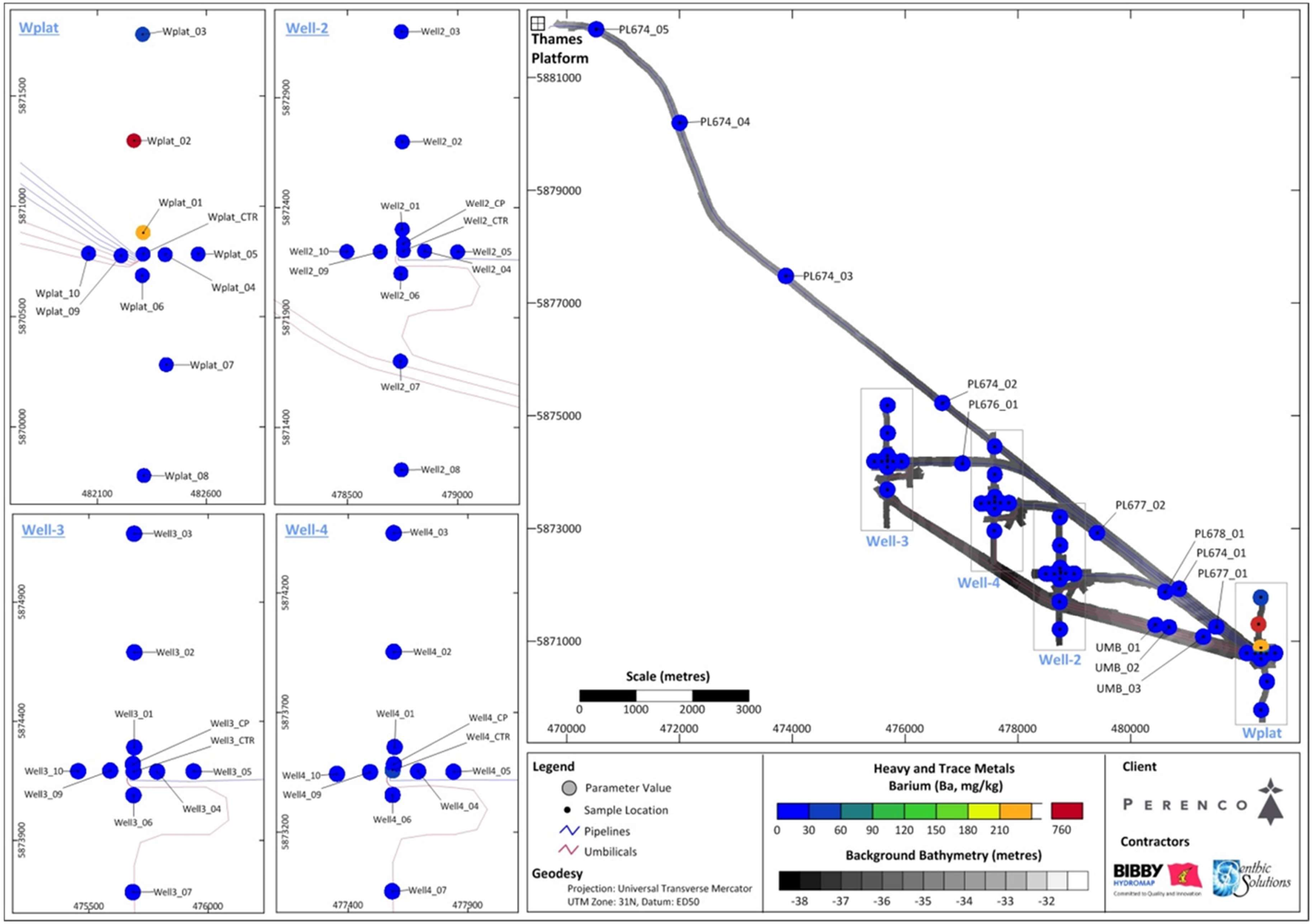
Appendix 1.3 Total Hydrocarbon Concentration



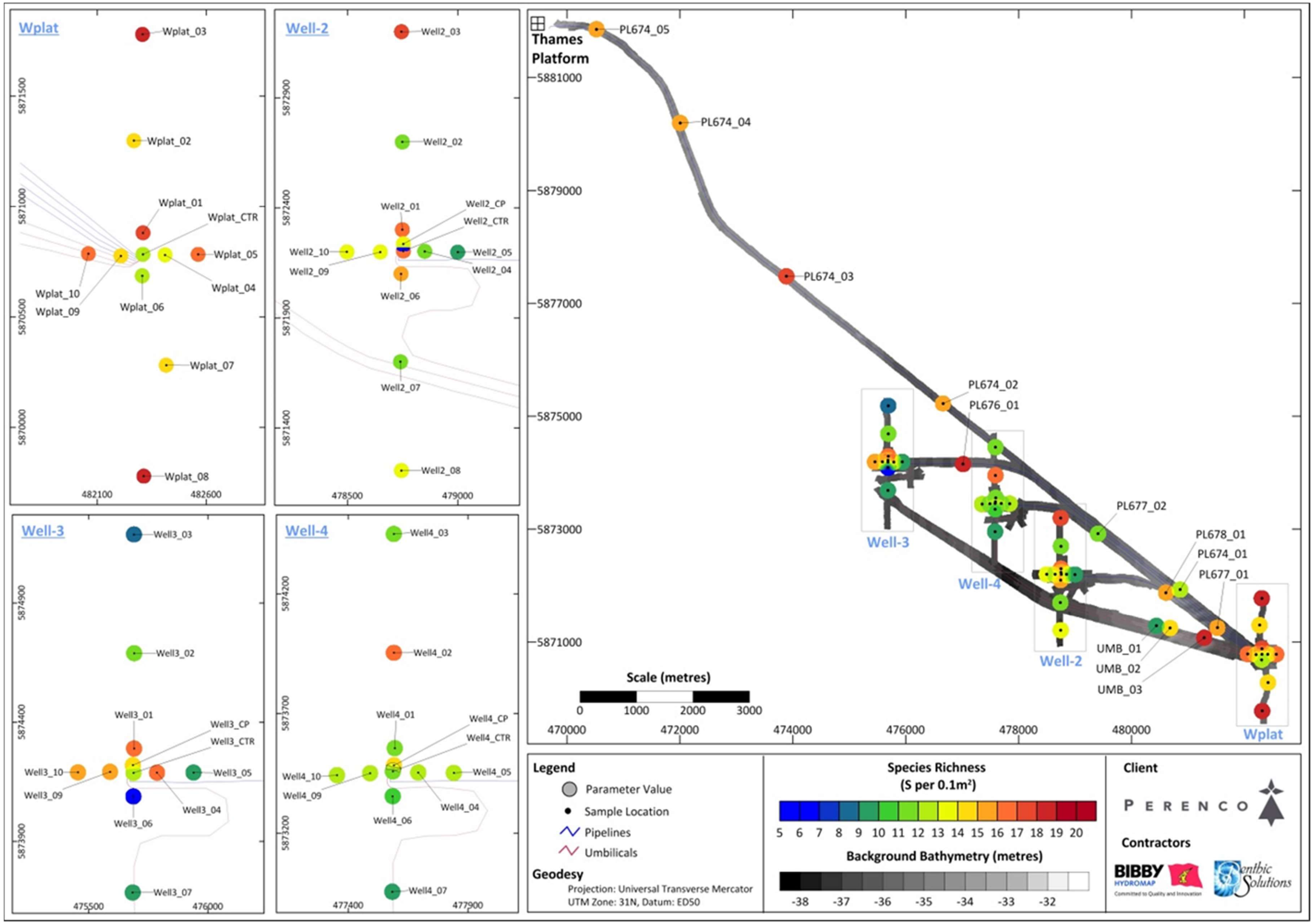
Appendix 1.4 Total Polyaromatic Hydrocarbons



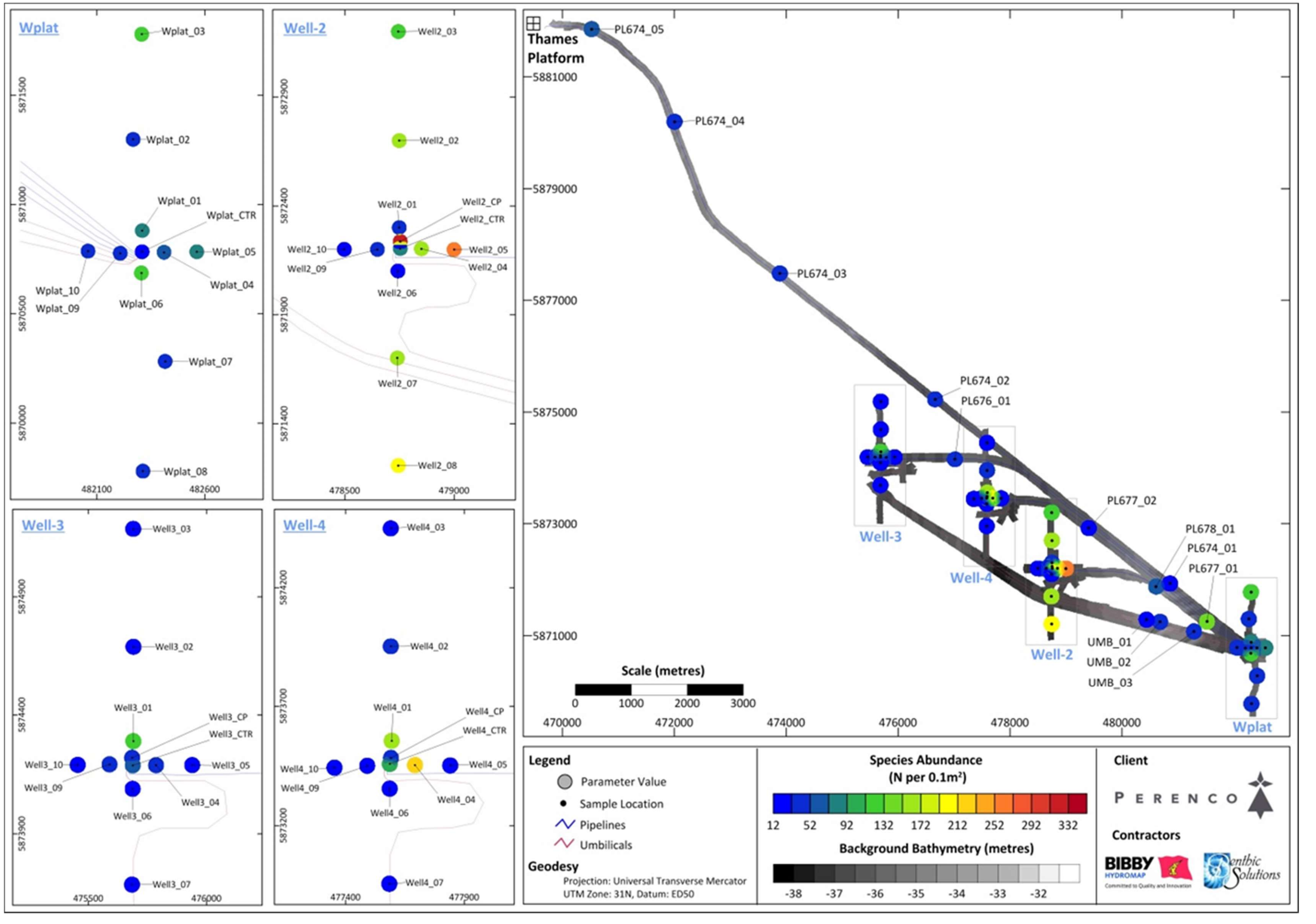
Appendix 1.5 Heavy Metal Concentration for Barium



Appendix 1.6 – Species Richness



Appendix 1.7 Species Abundance



CONFIDENTIAL

Welland decommissioning

Post-decommissioning inspection strategy

Perenco 123 r01d

Document control

Document history

Revision	Date	Description	By	Check	Approved By
A	13/10/2017	Draft issue	GMA	-	-
B	19/10/2017	Seabed hydrocarbon concentration considerations added	GKW	-	-
C	25/10/2017	Client comments incorporated	GMA	MPC	GMA
D	30/10/17	Client comments incorporated	GMA	MDL	MDL

Distribution

Antoine Salzgeber
Perenco

3 Central Avenue
St Andrews Business Park
Norwich
NR7 0HR
United Kingdom

Email: asalzgeber@uk.perenco.com

Issued by

Grant Adam
Head of Intgrity Management

Hildenbrook House
The Slade, Tonbridge
Kent
TN9 1HR

Tel: +44 1732 371378
Email: grant.adam@jee.co.uk

Extent and limitation of use: Perenco has the right to unlimited copying and distribution of this document for their internal business purposes and in accordance with the Extent and Limitation of Use as described herein. This report is specific to this project and the supplied data. Jee Limited accepts no liability for Perenco use of the findings, conclusions and recommendations of this report for any other project or purpose.

Contents

1. Introduction _______ 7
1.1. Overview _______ 7
1.2. Objectives _______ 7
2. Conclusions and recommendations _______ 8
3. System review _______ 9
3.1. Integrity considerations during operating phase _______ 9
3.2. Decommissioning activities and inspection results _______ 9
3.3. Seabed hydrocarbon concentration _______ 11
4. Methodology _______ 13
4.1. Overview _______ 13
4.2. Degradation mechanisms _______ 13
5. Risk based assessment _______ 22
5.1. WSE-Inspection-Review _______ 22
5.2. Asset-Component-Damage-Mechanisms _______ 22
5.3. RBI Results _______ 23
5.4. Discussion of findings _______ 33
6. References _______ 35

1. Introduction

1.1. Overview

Perenco has decommissioned the Welland pipelines and subsea equipment and has achieved clean seabed certification for the sections left in-situ. The pipelines and umbilicals left in-situ are outlined below.

- PL674 16" Interfield line from Welland to Thames AW
- PL675 3" Piggybacked line to 16" (PL674)
- PL676 8" Interfield line from Welland 3 to Welland
- PL677 8" Interfield line from Welland 4 to Welland
- PL678 8" Interfield line from Welland 2 to Welland
- PL679 Umbilical from Welland to Welland 3
- PL680 Umbilical from Welland to Welland 4
- PL681 Umbilical from Welland to Welland 2

Perenco uses risk-based inspection routines for planning of inspections of these pipelines. This document details the risk-based review of these pipelines now that they are fully decommissioned to ensure an appropriate inspection strategy moving forward.

1.2. Objectives

The objective of this document is to present the IMRs for the Perenco Welland pipelines as updated in light of completing decommissioning of the pipelines.

2. Conclusions and recommendations

The following conclusions and recommendations are made as a result of the inspection strategy review:

- The Welland infrastructure decommissioned in-situ should be inspected at a frequency of 10 years with the next inspection due in 2026;
- The inspection should be carried out using a high definition multi-beam echo sounder;
- If significant detrimental changes in the status of the seabed or the infrastructure decommissioned in-situ are observed, a follow-up visual inspection and ultimately remediation may be required.

Furthermore, an additional post-decommissioning hydrocarbon concentration survey is required at sampling location Wplat_01, immediately to the north of the decommissioned platform. This survey should be synchronised with any further environmental survey in the Thames area, if this is feasible, to minimise vessel mobilisations.

3. System review

3.1. Integrity considerations during operating phase

The burial status of the Welland pipelines during the operational life has been reviewed and is documented in the burial analysis document [1]. This report summarises the inspection history to 2009 (when it was issued) and shows that the pipelines were in good condition throughout the period of operation. Pipelines PL676, PL677 and PL678 were found to be fully buried with no exposures or spans. PL674 with PL675 piggybacked had one exposure noted of 7m in length and no spans. The umbilicals were all found to be buried with no exposures or freespans observed in the inspections performed.

3.2. Decommissioning activities and inspection results

3.2.1. 2011

The platform was removed in January 2011 and since then the pipelines have been left in-situ open to the sea.

3.2.2. 2013

The pipelines were subject to a post-decommissioning inspection in June 2013. The pipelines were seen in good condition.

- PL674 with PL675 piggybacked had six exposures totalling 95m in length.
- PL676 was fully buried with no exposures.
- PL677 had one exposure of 44m in length.
- PL678 had two exposures totalling 16m in length

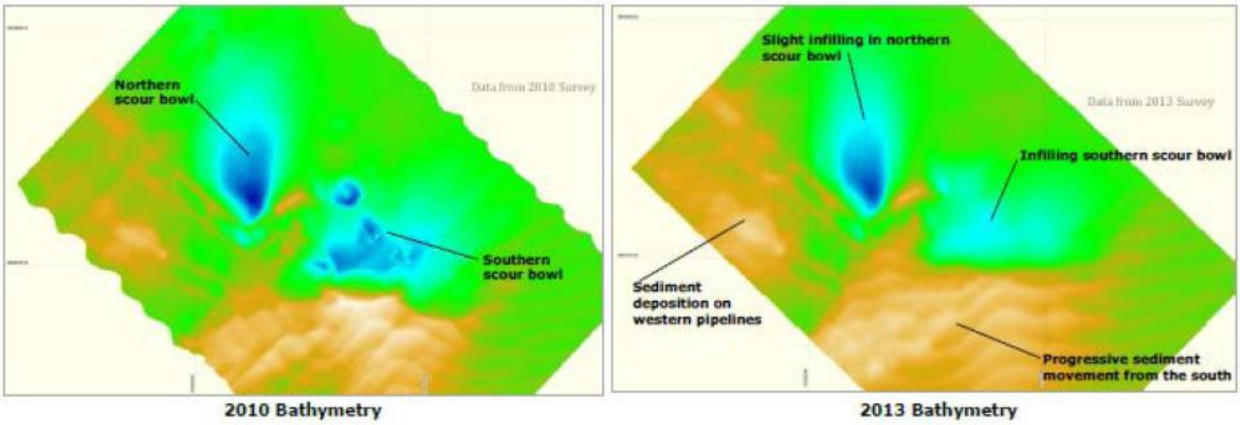
None of the pipelines had freespans.

3.2.3. 2014

In 2014 a survey was carried out to determine the burial status of the mattresses. The findings of this survey are discussed in the UTEC Geomarine assessment of decommissioning options for the Welland field mattresses [2]. From the UTEC report, it can be seen that:

- At the wellsites, mattresses, pipelines and umbilicals are buried to varying degrees and were not considered to present a snagging hazard;
- Based on comparison of the 2010 and 2014 bathymetrical survey data, the level of sediment cover (burial) is increasing and this is likely to continue, especially following removal of the structures (minimising the potential for future scouring);
- Formation of snagging hazards in the wellsite areas in the future is considered very unlikely;

Figure 3-1 Location of scour pits at Welland platform area



- Comparison of the 2010 and 2013 surveys highlights significant infilling of the southern scour pit and the commencement of infilling of the northern pit following removal of the platform (the cause of the southern scour pit);
- As the scour pits infill further, sediment is likely to be deposited around the feature location, mitigating the potential for snagging.

3.2.4. 2016

In June 2016 the National Federation of Fishermen's Organisations issued a Clean Seabed Certificate following the seabed sweep work undertaken by the Advance WY Trawler. Seabed sweeps were carried out on the pipelines, the abandoned platform, wells and mattress areas along with the associated 500m safety zones. These were found to be clear of debris, major obstruction and snagging hazards and posed no significant problem for fishing operations.

In June and July 2016 the pipelines were subject to a second post-decommissioning inspection. Pipeline PL674 with PL675 piggybacked was found to have eighteen exposures totalling 290.8m in length. Whilst the level of exposure has increased since 2013 (when less than 1% of the line was exposed), this is still less than 2% of the overall pipeline length (17.5 km) and is therefore not considered significant. The pipeline was also found to have two spans with lengths of 1.8m and 8.6m. Both had a span height of 0.1 m. These spans are not trawl snagging hazards (spans longer than 10 m in length and greater than 0.8 m in height are classed as trawl snagging hazards) and, as such, are not reportable to FishSAFE.

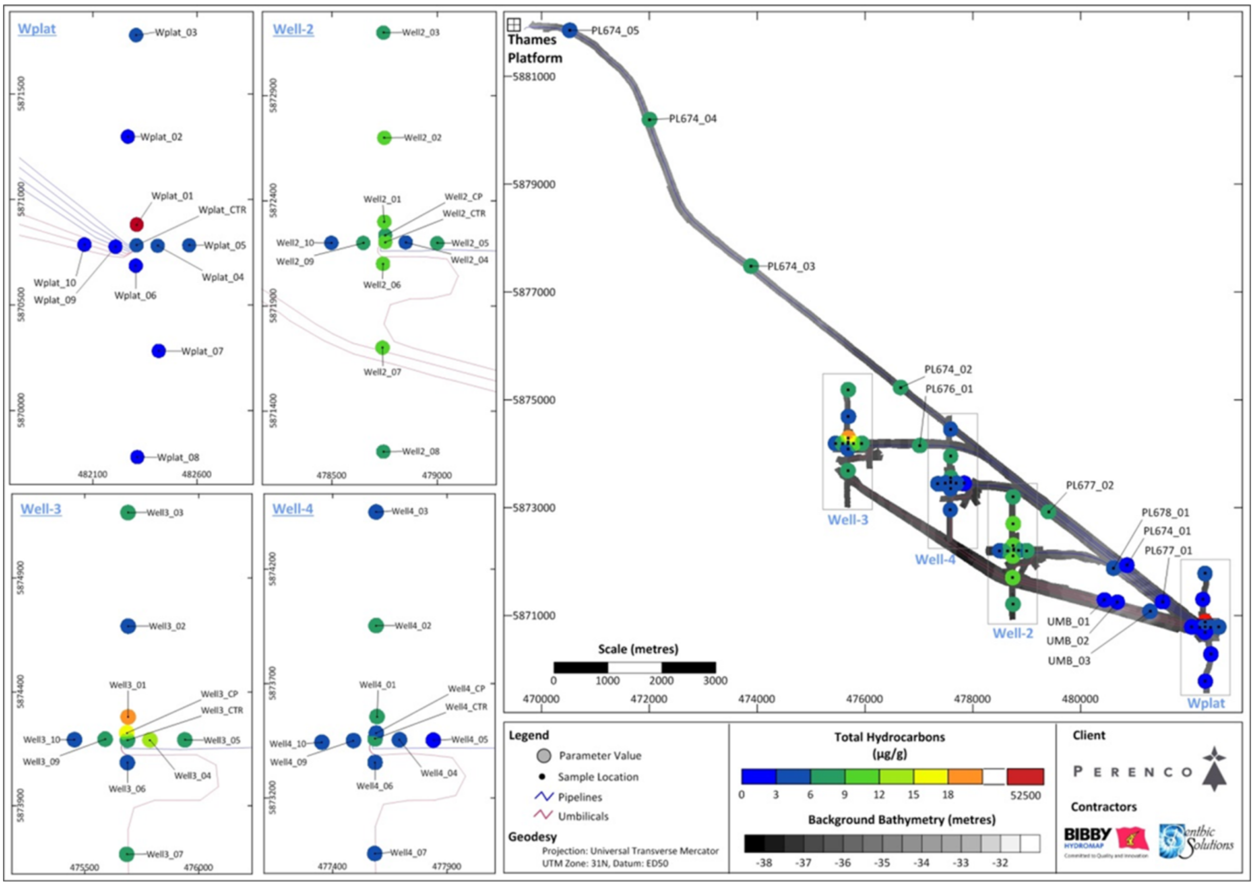
Pipeline PL676 had one exposure of 7m in length. PL677 had thirteen exposures totalling 74m in length. PL678 had six exposures totalling 28.9m in length. None of these pipelines had freespans reported.

During the 2016 inspection the umbilicals were also seen to be in good condition.PL679 had six exposures totalling 36.6m in length and one span of 3.6m in length with no height reported. PL680 had seven exposures totalling 66.5m in length and no spans. PL681 had thirteen exposures totalling 143.6m in length. This umbilical also had two spans reported 5.5m & 3.2m in length with no height reported. This constitutes a minor increase in the level of umbilical exposure over the 7 years since the release of the burial analysis report, with neither of the spans observed being reportable as a snagging hazard. Furthermore, given that no reportable spans have been observed on these assets since installation and that the umbilicals have a lower stiffness compared to the rigid pipelines, a span of reportable height is considered very unlikely on the Welland umbilicals.

3.3. Seabed hydrocarbon concentration

In 2016, Perenco UK Ltd contracted Bibby HydroMap Ltd (BHL), supported by Benthic Solutions Ltd (BSL), to conduct a post-decommissioning environmental survey around the decommissioned Welland platform and well sites. As part of the survey workscope, the total hydrocarbon concentration was measured at each location along a crucifix sampling pattern, designed to capture the possibility of hydrocarbon-rich sediment mobility on the predominantly northerly current. The results of the survey are presented in Figure 3-2 below.

Figure 3-2 Results of the hydrocarbon concentration survey



The analysis of total hydrocarbon concentration revealed generally low levels, ranging from 0.47µg.g^{-1} to 18.75µg.g^{-1}, with only station Wplat_01 recording highly elevated THC concentrations of 52,577.6µg.g^{-1}. This was likely due to this station's location close to the abandoned Welland platform in combination with the predominantly northerly current direction.

The GC-trace for this station showed some indication of weathered mixed hydrocarbon input, dominated by suspected low toxicity oil-based muds used during drilling operations.

Polycyclic aromatic hydrocarbon (PAH) levels were variable but low with an average value of 39.9ng.g^{-1} (±65.3SD), excluding the elevated concentration of 9,479ng.g^{-1} measured at station Wplat_01. This elevated level was not dissimilar to the elevated concentration recorded at station Grab 31 (TOF 31; 4,400ng.g^{-1}) during the 2013 survey operation. A closer inspection of the GC-trace for station Wplat_01 indicated the presence of weathered mixed hydrocarbon input, dominated by suspected low toxicity oil-based muds. Whilst this elevated concentration was above typical background levels for the southern North Sea, it was consistent with expected hydrocarbon levels around offshore platforms.

In order to assess the degradation of the contamination in this location and whether further action is required in accordance with OSPAR, at least one additional survey is required at this location. Given the level of the contamination at Wplat_01 and the expectation that it is likely to degrade over time. Perenco propose undertaking this environmental sampling survey 10 years from the date of 2016's post decommissioning environmental survey.

4. Methodology

4.1. Overview

This assessment has been carried out utilising the RBI approach developed and used by the Perenco pipelines team.

4.2. Degradation mechanisms

The degradation mechanisms identified for decommissioned subsea pipelines and equipment are shown in the list below.

- Formation of trawl snagging span
- Pipeline corrosion at exposures causing snagging
- Mattress snagging
- Hydrocarbon contamination
- Leak at P&A Well
- Protruding casing
- Protruding pile

Each subsea component will be reviewed against the identified degradation mechanisms. The condition of the component with respect to the degradation mechanism will be assessed through review of the historical inspection data. The consequence and likelihood of each event will be assessed against the risk matrix shown in Section 4.3. This will define the inspection interval for each inspection method.

4.3. Modified risk matrix

A modified risk matrix has been developed for inspection of decommissioned infrastructure to reflect the changes in hazards associated with a system that is no longer operational and is hydrocarbon free. The focus of the assessment for decommissioned infrastructure is around the formation of hazards to the environment and other users of the sea.

These are typically much longer term deterioration mechanisms than, for example, corrosion or fatigue concerns leading to a hydrocarbon release from a pipeline during operation. As such, the durations associated with the longer term degradation mechanisms in the risk matrix have been increased from those used in the assessment of operating pipelines. The modified risk matrix is shown below.

The numbers in matrix define maximum recommended interval for inspection planning in years.

The environmental consequences are defined in a separate set of tables within Section 4.3.2. These tables are taken from the Perenco Environmental Risk Assessment procedure [3]

4.3.1. Post decommissioning monitoring matrix

Consequence					Likelihood					
					E	D	C	B	A	
Rating	Safety	Financial	Environmental (see Environmental consequences tables)	Effect on Production	Very Low *Similar scenario never heard of in Oil & gas Industry* Failure expected in >15 years	Low *Similar Scenario heard of in Oil & Gas industry* Failure expected in 9-15 years	Possible *Similar scenario Is known to have occurred within Perenco* Failure expected in 6-9 years	Likely *Similar scenario Is known to have occurred several times per year within Perenco* Failure expected in 3-6 years	Very Likely *Similar scenario Is known to have occurred several times per year at the location* Failure expected in <3 years	Factor of safety
V Very Low	No Injury	≤ £10,000	H	No effect	15	9	6	3	1	1
IV Low	First Aid or Medical Treatment	£10,000 To £100,000	G	Item isolation	13	8	5	2	1	1.125
III Medium	Lost Time Injury	£100,000 To £1,000,000	F	System shutdown	12	7	4	2	1	1.25
II High	Single Fatality or Serious Injury	£1,000,000 To £10,000,000	E	Location shutdown	10	6	4	2	1	1.375
I Very High	Multiple Fatality	>£10,000,000	D	Field/Terminal shutdown	10	6	4	2	1	1.5

4.3.2. Environmental consequences

Environmental Receptor	Consequence - OFFSHORE				
	Lower				Higher
	H	G	F	E	D
Marine water quality	Routine oil in produced water discharges <2 te/yr. Oil and chemical discharges within permit limits for last 12 months. Routine discharge of chemicals with OCNS Gold/Silver Ranking or D/E Grouping, within permit limits.	Routine oil in produced water discharges >2 te/yr. Isolated breach of oil in produced water / drainage concentration limits (100 mg/l instantaneous; 30 mg/l monthly average) within last 12 months. Malfunction or breakdown of discharge abatement equipment, even if still within discharge limits. Routine discharge of chemicals with OCNS White or higher ranking, or A/B/C grouping, or SUB warning, to sea within permit limits.	Regular breaches of oil in produced water / drainage concentration limits (100 mg/l instantaneous; 30 mg/l monthly average) within last 12 months. Isolated breach of chemical permit limits within last 12 months.	Regular breaches of chemical permit limits within last 12 months.	
	For **high sensitivity receptors** (near shore waters and beaches; Marine Protected Areas (MPA), including SACs, SPAs, MCZs, SSSIs, & RAMSAR sites), increase consequence by one category.				

Environmental Receptor	Consequence - OFFSHORE				
	Lower				Higher
	H	G	F	E	D
Marine sediments	No contamination above background &/or national / international quality standards &/or known biological effect concentrations on scale **< 2 km**.	Short term contamination above background &/or national / international quality standards &/or known biological effect concentrations on scale **< 2 km**.	Medium term contamination above background &/or national / international quality standards &/or known biological effect concentrations on scale **< 2 km**.	Long to medium term contamination above background / national / international quality standards &/or known biological effect concentrations on scale **> 2 km**.	Long term/ permanent contamination above background &/or national / international quality standards &/or known biological effect concentrations on scale **> 2 km.**
	For **high sensitivity receptors** (near shore waters and beaches; Marine Protected Areas (MPA), including SACs, SPAs, MCZs, SSSIs, & RAMSAR sites), increase consequence by one category.				
Plankton, benthic communities, fish / shellfish, marine mammals,	No identifiable disruption of population. No identifiable impact on critical habitat or activity.	Localised and /or short term impacts to portion of population. Minor and temporary impact on critical habitat or activities. No threat to overall population viability. Recovery < 1 years.	Medium term impacts to a portion of the population. Minor impacts on critical habitat or activities. No threat to overall population viability. Recovery 1-5 years.	Widespread or long-term disruption to a significant portion of the population. Moderate impacts on critical habitats or activities. Recovery 5-10 years.	Extensive and/or long-term / permanent impact on population(s). Significant impact on critical habitats or activities. Recovery >10 years or permanent.

Environmental Receptor	Consequence - OFFSHORE				
	Lower				Higher
	H	G	F	E	D
seabirds / coastal birds / migratory birds, protected or sensitive habitats	For **high sensitivity receptors** (near shore waters and beaches; Marine Protected Areas (MPA), including SACs, SPAs, MCZs, SSSIs, & RAMSAR sites), increase consequence by one category.				
Climate change	CO_2 emissions <20,000 t/yr Gas venting <200 t/yr F-Gas Inventory of <50 t CO_2e	CO_2 emissions 20,000 - 100,000 t/yr Gas venting 200 - 1,000 t/yr F-Gas Inventory of 50-499 t CO_2e Unplanned F-gas loss of <250 t CO_2e	CO_2 emissions >100,000 t/yr Gas venting >1,000 t/yr F-Gas Inventory of >500 t CO_2e Unplanned F-gas loss of >250 t CO_2e		

Environmental Receptor	Consequence - OFFSHORE				
	Lower				Higher
	H	G	F	E	D
Air quality	NOx emissions < 10 t/yr Atmospheric emissions within PPC permit emission limits for last 12 months.	NOx emissions 10-50t/yr Malfunction or breakdown of emissions abatement equipment, even if still within PPC permit emission limits. Isolated and/or minor breach of PPC permit emission limits within last 12 months.	NOx emissions >50 t/yr Regular and/or moderate breaches of PPC permit emission limits within last 12 months.	Sustained and/or major breaches of PPC permit emission limits within last 12 months.	Continuous and/or severe breach of PPC permit emissions limits within last 12 months.
Landfill / waste treatment & disposal	Disposal of general waste to approved landfill.	Disposal of hazardous or radioactive wastes e.g. sludge, low activity scale to approved landfill Disposal of general waste to unpermitted site.	Disposal of hazardous or radioactive waste to unpermitted site.	n/a	n/a

Environmental Receptor	Consequence - OFFSHORE				
	Lower				Higher
	H	G	F	E	D
Socio-economic (fisheries / oil and gas / shipping & ports / tourism & leisure)	No identifiable impact to stakeholder economic practices.	Localised impact small number of stakeholders that are affected for < 6 months.	Localised impact to a small community of stakeholders. Impact does not affect economic practices. 6 - 12 months.	Impact to regional population and national stakeholders for a period >12 months.	Long term impact to communities including displacement of communities or loss of economic stability of large number of stakeholders. Long term impacts to national stakeholder groups.
Regulatory	Permitted discharges, within permit limits. No notification to Regulatory Authorities required. No regulatory concern.	Isolated and/or minor unplanned release and /or breach of consent limits. Notification to Regulatory Authorities required. Regulatory compliance issue (e.g. verbal warning), which does NOT lead to higher severity level consequence.	Regular and/or moderate unplanned release and/or breach of consent limits. Notification to Regulatory Authorities required. Regulatory compliance issue (e.g. letter / inspection items), which does NOT lead to enforcement or other higher severity level consequences.	Sustained and/or major unplanned release and/or breach of consent limits. Notification to Regulatory Authorities required. Regulatory enforcement / improvement notice. Serial non-compliances which may lead to enforcement action, where return to compliance is unlikely within a year.	Continuous and/or severe unplanned release and/or breach of consent limits. Notification to Regulatory Authorities required. Major regulatory enforcement action (i.e. prohibition / suspension notice).

Environmental Receptor	Consequence - OFFSHORE				
	Lower				Higher
	H	G	F	E	D
Size of spill	No unpermitted release of hydrocarbons or chemicals.	**Hydrocarbons released:** • High sensitivity receptor: <0.1 tonne • Low sensitivity receptor: <1 tonne **Chemicals released:** • High toxicity chemical, high sensitivity receptor: <0.1t • High toxicity, low sensitivity: <0.2t • Low toxicity, high sensitivity: <0.5t • Low toxicity, low sensitivity: <1t	**Hydrocarbons released:** • High: 0.1-1 tonne • Low: 1-10 tonne **Chemicals released:** • High toxicity, high sensitivity: 0.1-1t • High toxicity, low sensitivity: 0.2-2t • Low toxicity, high sensitivity: 0.5-5t • Low toxicity, low sensitivity: 1-10t	**Hydrocarbons released:** • High: 1-10 tonne • Low: 10-100 tonne **Chemicals released:** • High toxicity, high sensitivity: 1-10t • High toxicity, low sensitivity: 2-20t • Low toxicity, high sensitivity: 5-50t • Low toxicity, low sensitivity: 10-100t	**Hydrocarbon released:** • High: >10 tonne • Low: >100 tonne **Chemicals released:** • High toxicity, high sensitivity: >10t • High toxicity, low sensitivity: >20t • Low toxicity, high sensitivity: >50t • Low toxicity, low sensitivity: >100t

Environmental Receptor	Consequence - OFFSHORE				
	Lower				Higher
	H	G	F	E	D
		Low sensitivity receptors: Open sea surface. **High sensitivity receptors:** Near shore waters and beaches; Marine Protected Areas (MPA), including SACs, SPAs, MCZs, SSSIs, & RAMSAR sites. **Low toxicity chemicals:** OCNS Gold/Silver Ranking or D/E Grouping or equivalent. **High toxicity chemicals:** OCNS White or higher ranking, or A/B/C grouping, or SUB warning or equivalent.			
Reputation	Isolated complaint from neighbour. No adverse media coverage.	Regular short term complaints on similar issues from neighbours. Short term adverse local media coverage.	Ongoing unresolved complaint on similar issue from neighbours. Prolonged adverse local media coverage.	Short term adverse national media coverage Damage to relationships with stakeholders of benefit to the asset.	Interventions from Governments in which Perenco has aspirations to operate. Partner / stakeholder outrage in major market. Prolonged adverse national media coverage. Adverse international media coverage

5. Risk based assessment

5.1. WSE-Inspection-Review

A review of the inspection history of the Welland pipelines and subsea equipment has been undertaken and is documented in Table 1 in Section 5.3.

5.2. Asset-Component-Damage-Mechanisms

Based on the review of the inspection history review in Table 1, a risk based assessment has been carried out and documented in Table 2 in Section 5.3.

5.3. RBI Results

Table 1: WSE-Inspection-Review

Equipment No	Inspection/Review	Date	Comments	Type of Inspection
PL674 & PL675	Inspection	24/06/2007	Two exposures totalling 74m in length. KP1.413 to KP1.417 (4m) KP1.765 to KP1.835 (70m) No spans.	GI
PL674 & PL675	Inspection	30/04/2009	One exposure of 7m in length. KP1.775 to KP1.782 No spans.	GI
PL674 & PL675	Inspection	11/06/2013	Six exposures totalling 95m in length. KP1.407 to KP1.433 (26m) KP1.754 to KP1.763 (9m) KP1.767 to KP1.803 (36m) KP1.811 to KP1.822 (11m) KP1.827 to KP1.834 (7m) KP1.840 to KP1.846 (6m). No spans.	GI
PL674 & PL675	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland to Thames pipe line was found to be clear of debris or obstruction and posed no significant problem for future fishing operations.	

Equipment No	Inspection/Review	Date	Comments		Type of Inspection
PL674 & PL675	Inspection	13/07/2016	Eighteen exposures totalling 290.8m in length. KP0.043 to KP0.046 (3.2m) KP0.071 to KP0.08 (46.5m) KP1.468 to KP1.473 (4.3m) KP1.477 to KP1.485 (8m) KP1.492 to KP1.499 (8.3m) KP1.813 to KP1.86 (47.6m) KP1.817 to KP1.827 (10.6m) KP1.868 to KP1.874 (5.7m) KP1.876 to KP1.884 (8.1m) KP1.886 to KP1.894 (7.8m)	KP1.896 to KP1.904 (7.2m) KP1.909 to KP1.916 (6.6m) KP16.43 to KP16.45 (20.5m) KP16.458 to KP16.483 (26.1m) KP16.803 to KP16.82 (17.2m) KP16.831 to KP16.837 (5.9m) KP16.874 to KP16.902 (29.1m) KP16.909 to KP16.937 (28.1m) Two spans reported KP1.859 to KP1.860 (1.8m x 0.1m) KP1.864 to KP1.872 (8.6 x 0.1m)	GI
PL676	Inspection	30/04/2009	No exposures. No spans.		GI
PL676	Inspection	10/06/2013	No exposures. No spans.		GI
PL676	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.		
PL676	Inspection	14/07/2016	One exposure of 7m in length KP7.697 to KP7.705 No spans.		GI
PL677	Inspection	30/04/2009	No exposures. No spans.		GI

Equipment No	Inspection/Review	Date	Comments	Type of Inspection
PL677	Inspection	10/06/2013	One exposure of 44m in length KP1.969 to KP2.013 (44m) No spans.	GI
PL677	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.	
PL677	Inspection	13/07/2016	Thirteen exposures totalling 74m in length KP1.223 to KP1.228 (5.2m) KP1.924 to KP1.929 (5.2m) KP1.933 to KP1.938 (4.5m) KP1.942 to KP1.944 (2.2m) KP1.956 to KP1.959 (3.1m) KP1.966 to KP1.971 (5.5m) KP1.973 to KP1.978 (4.8m) KP1.985 to KP1.992 (6.8m) KP1.999 to KP2.004 (4.7m) KP2.011 to KP2.021 (11.5m) KP2.033 to KP2.041(8.9m) KP2.043 to KP2.05 (6.5m) KP2.054 to KP2.06 (5.1m) No spans.	GI
PL678	Inspection	30/04/2009	No exposures. No spans.	GI
PL678	Inspection	25/06/2013	Two exposures totalling 16m in length KP2.005 to KP2.009 (4m) KP3.892 to KP3.904 (12m) No spans.	GI

Equipment No	Inspection/Review	Date	Comments		Type of Inspection
PL678	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.		
PL678	Inspection	13/07/2016	Six exposures totalling 28.9m in length KP2.02 to KP2.024 (4.2m) KP2.032 to KP2.034 (2.5m) KP2.044 to KP2.049 (4.7m) KP2.056 to KP2.069 (13.4m)	KP2.105 to KP2.108 (2.7m) KP3.672 to KP3.673 (1.4) No spans.	GI
PL679	Inspection	30/04/2009	No exposures. No spans.		GI
PL679	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.		
PL679	Inspection	15/07/2016	Six exposures totalling 36.6m in length KP0.109 to KP0.111 (2.7m) KP0.115 to KP0.119 (3.6m) KP1.726 to KP1.73 (3.6m) KP1.743 to KP1.756 (11.9m)	KP1.78 to KP1.788 (8.1m) KP1.811 to KP1.818 (6.7m) One span reported: KP0.115 to KP0.119 (3.6m in length, no height reported.)	GI
PL680	Inspection	30/04/2009	No exposures. No spans.		GI

Equipment No	Inspection/Review	Date	Comments	Type of Inspection
PL680	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.	
PL680	Inspection	15/07/2016	Seven exposures totalling 66.5m in length KP1.155 to KP1.166 (10.2m) KP1.656 to KP1.662 (5.5m) KP1.685 to KP1.692 (7m) KP1.702 to KP1.708 (6m) KP1.728 to KP1.746 (18.1m) KP2.286 to KP2.301 (14.1m) KP6.628 to KP6.634 (5.6m) No spans.	GI
PL681	Inspection	30/04/2009	No exposures. No spans.	GI
PL681	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.	

Equipment No	Inspection/Review	Date	Comments		Type of Inspection
PL681	Inspection	15/07/2016	Thirteen exposures totalling 143.6m in length KP0.078 to KP0.083 (4.5m) KP0.968 to KP0.98 (12m) KP1.007 to KP1.014 (6.9m) KP1.04 to KP1.047 (7.3m) KP1.079 to KP1.094 (15.7m) KP1.11 to KP1.122 (12.5m) KP1.553 to KP1.558 (4.7m)	KP1.574 to KP1.585 (10.3m) KP1.598 to KP1.608 (9.7m) KP1.619 to KP1.621 (2.5m) KP1.625 to KP1.636 (12.8m) KP1.647 to KP1.662 (15.7m) KP1.669 to KP1.698 (29m) Two spans reported KP1.014 to KP1.020 (5.5m long) KP1.621 to KP1.625 (3.2m long) No heights reported.	GI
Well 2	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.		
Well 2	Inspection	12/07/2016	No exposed equipment. Scour pit 8.5m radius x 0.9m deep.		GI
Well 3	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.		
Well 3	Inspection	14/07/2016	No exposed equipment. Scour pit 8.9m radius x 0.7m deep.		GI

Equipment No	Inspection/Review	Date	Comments	Type of Inspection
Well 4	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.	
Well 4	Inspection	13/07/2016	No exposed equipment. Scour pit 9m radius x 0.5m deep.	GI
Welland platform	Overtrawl operation	24/06/2016	Clean Seabed Certificate Welland Field sites the abandoned wells and mattress areas along with the associated 500m safety zones were found to be clear of debris or major obstruction and posed no significant problem for future fishing operations.	
Welland platform	Inspection	14/07/2016	Scour pits 60m x 34m & 50m x 20m, deepest extent 1.4m.	GI

Table 2: Asset-Component-Damage-Mechanisms

Damage Mechanism	Probability Rating	Probability Comment	Consequence Rating	Consequence Comment	Risk Priority	Type of Inspection	Interval Awarded (years)	Inspection Due
Formation of trawl snagging span	E	Low probability of a span developing that constitutes a snagging hazard and the low probability of a vessel snagging and sinking. In order to sink a trawler would have to make many errors to the standard method of freeing itself from a snag	I	A trawl snagging incident could lead to the trawler sinking during recovery of its fishing equipment; therefore the consequence rating of "E Multiple Fatality"	3	Subsea MBES	10	2026
Pipeline corrosion at exposures causing snagging	E	Due to, the low probability of a hazard being sufficiently exposed to form a snag, the long time necessary for a snag hazard to develop and the low probability of a vessel snagging and sinking. In order to sink a trawler would have to make many errors to the standard method of freeing itself from a snag	I	A trawl snagging incident can lead to the trawler sinking during recovery of its fishing equipment; therefore the consequence rating of "E Multiple Fatality"	3	Subsea MBES	10	2026

Damage Mechanism	Probability Rating	Probability Comment	Consequence Rating	Consequence Comment	Risk Priority	Type of Inspection	Interval Awarded (years)	Inspection Due
Mattress snagging	E	This is due to the configuration of the mattress required to cause a snagging hazard being unlikely. In order to sink a trawler would have to make many errors to the standard method of freeing itself from a snag	I	A trawl snagging incident can lead to the trawler sinking during recovery of its fishing equipment; therefore the consequence rating of "E Multiple Fatality"	3	Subsea MBES	10	2026
Hydrocarbon contamination	E	The pipeline could exchange fluid with the sea allowing very small amounts of residual hydrocarbon liquids to leach out of the pipeline and hence a "H" in the Environmental consequences has been assigned. This equates to "V - Very Low" in the risk matrix	V	"Very Low" likelihood event as the pipeline was cleaned to a very high standard before disconnection, approx 20ppm oil-in-water.	4	None required	N/A	N/A
Leak at P&A Well	E	Any leak from the P&A Well will be a very small quantity of gas and hence This equates to "V - Very Low"	V	This is considered to be a "Very Low" likelihood event as P&A Wells do not commonly leak	4	None required	N/A	N/A

Damage Mechanism	Probability Rating	Probability Comment	Consequence Rating	Consequence Comment	Risk Priority	Type of Inspection	Interval Awarded (years)	Inspection Due
Protruding casing	E	This is due to the very low likelihood of a casing being exposed for a snag hazard to develop and the low probability of a vessel snagging and sinking. In order to sink a trawler would have to make many errors to the standard method of freeing itself from a snag	I	A trawl snagging incident can lead to the trawler sinking during recovery of its fishing equipment; therefore the consequence rating of "E Multiple Fatality"	3	Subsea MBES	120	2026
Protruding pile	E	This is due to the low probability of a pile becoming exposed above the seabed for a snag hazard to develop and the low probability of a vessel snagging and sinking. In order to sink a trawler would have to make many errors to the standard method of freeing itself from a snag	I	A trawl snagging incident can lead to the trawler sinking during recovery of its fishing equipment; therefore the consequence rating of "E Multiple Fatality"	3	Subsea MBES	120	2026

5.4. Discussion of findings

5.4.1. Pipelines and umbilicals

This post-decommissioning report has found that the pipelines were in good condition throughout their operational life. Following decommissioning the pipelines have remained in good condition with only short lengths of exposure observed.

The ongoing risks that a decommissioned pipeline poses relate primarily to the hazard that it presents to other seabed users. In order to pose a hazard, it must provide an opportunity for a seabed user like a trawler to snag the pipeline. Snagging the pipeline on its own does not induce a serious risk; however if the trawler crew deviate from the standard practice undertaken by fishermen to free their fishing gear from a snag, this could result in a fatal accident.

The mechanisms that could result in a snag are outlined in Section 4.2 and risk assessed in Section 5.3. However, their occurrence is considered very unlikely. This is due, in part, to the fact that reportable spans have never occurred on the pipelines or umbilicals associated with the Welland field, in either their operating or decommissioned state. Furthermore, any spans that have been reported have only had heights in the region of 0.1 m.

It is unlikely that any mechanism will result in the formation and persistence of a span of significant height. This is predominantly due to two reasons:

- the lack of scouring sources following structure removal (with the remaining infrastructure at the wellsites predicted to be subject to sediment deposition);
- the ripple-like sandwaves in the area rather than the larger sandwaves elsewhere in the region (meaning significant exposure and spanning at the troughs is less likely given the lower wave height).

This is especially true for the umbilicals, which are less stiff than the pipelines and would therefore sag further into any developing seabed depression, minimising the likelihood of high span formation.

Similarly, the formation of a snagging hazard through pipeline corrosion is also considered very unlikely. This would require material loss through corrosion over the pipe circumference, which would compromise the structural strength of the remaining pipe steel to such a level that it would be insufficient hold a snagging load. The degradation period necessary to develop this level of corrosion would also be significant. Following depletion of the CP system, corrosion at any local coating holidays would typically be of the order of 0.2 mm/year, meaning that over a 10 year period (the proposed inspection frequency), only 2 mm of wall loss would be anticipated. Given the original pipeline wall thicknesses of 14.7 mm, in excess of 70 years would be required to achieve a through wall defect and, considering the sporadic degradation of the coating, significantly more time would be required for sufficient coating degradation and associated pipe steel exposure to lead to the degradation levels required to form a snagging hazard.

5.4.2. Mattresses

For a mattress snagging hazard to form, a mattress would need to be predominantly exposed, with an edge or corner protruding from the seabed into the water column capable of snagging the vessel gear (pipeline stabilisation mattresses are designed to be over trawled). Surveys performed during the operating period and following decommissioning have shown that no mattresses are present in this configuration and the 2016 overtrawling trials performed by the Advance WY Trawler showed the areas to be snag free.

Following removal of the platform and subsea structures, the principal sources of scour that could lead to the development of the mattress snagging hazard discussed have been eliminated. Coupled with the findings of the UTEC Geomarine study, which indicate that further burial of the mattresses would be expected rather than exposure as discussed in section 3.2.3, the formation of a snagging hazard at a mattress location is considered very unlikely.

5.4.3. Hydrocarbon contamination

The pipeline could exchange fluid with the sea allowing very small amounts of residual hydrocarbon liquids to leach out of the pipeline. However the pipeline was cleaned to a very high standard prior to disconnection, the cleaning resulted in an oil-in-water concentration of approximately 20ppm. Therefore the likelihood of contamination is considered very low.

5.4.4. Protruding piles or casings

Piles and casings have been removed to depths of circa 3 m below seabed. This would require significant scour or a large sandwave (wave height of 6 m from trough to crest) to lead to exposure. Given the fact that the primary sources of scouring at these locations (the structures) have been removed and that sandwaves are of the much smaller ripple form, generation of a snagging hazard at these locations is considered very unlikely.

5.4.5. Leaking well

Whilst any significant leak at the wellsite would be detected by the inspection methods considered in this report, the level of deterioration required to lead to a leak at a well that has been abandoned, tested and certified in line with industry requirements has not been heard of in this geologically benign region. As such, its occurrence is considered extremely unlikely.

5.4.6. Inspection approach

Considering the above arguments, the survey history (including multiple post decommissioning surveys) to date and the clean seabed certificate issued in 2016, the most onerous risk identified by the risk assessment is at the EI level. This is based on the potential for multiple fatalities if a fishing vessel is compromised (a very high consequence) but a very low likelihood. This results in an inspection frequency of 10 years, with the next inspection scheduled for 2026.

All of the threats identified can be detected using mutlibeam echo sounder and therefore that is the recommended technology for carrying out the inspection. The location of the sample Wplat 1, where hydrocarbons above background levels were detected, should be sampled and tested at the same time to confirm that the hydrocarbons are gradually degrading in situ as expected without having a detrimental effect on the surrounding environment. If significant detrimental changes in the status of the seabed or the infrastructure decommissioned in-situ are observed, a follow up visual inspection and ultimately remediation may be required.

6. References

[1] Perenco, "Welland Pipeline Infrastructure Burial Analysis," BXX-ST-L-1000, Rev 02, 2009.

[2] UTEC Geomarine, "Welland Decommissioning Assessment of options for removal of concrete mattresses," GM-PER0002-001-P1, Rev P1, 2014.

[3] Perenco, "Environmental Risk Assessment," PUK-SMS-COM-004, Rev 01, 2017.

Subsea engineering and training experts

Jee provides high-calibre engineering services and professional training on subsea systems to the oil, gas and renewables industries.

HEAD OFFICE

ABERDEEN OFFICE

Jee Limited
Hildenbrook House
The Slade
Tonbridge
Kent TN9 1HR
United Kingdom

Tel: +44 1732 371 371

Jee Limited
31 Abercrombie Court
Arnhall Business Park
Prospect Road, Westhill
Aberdeen AB32 6FE
United Kingdom

Tel: +44 1224 392 040

Jee Limited Registered in England and Wales No. 3579143

www.jee.co.uk

2019

Welland Field

Re-analysis of post-decommissioning surveys

PERENCO

3 Central Avenue | St Andrews Business Park

Norwich | Norfolk | NR7 0HR

Document Control Page

Revision Record

DATE	REV NO.	DESCRIPTION	PREPARED	CHECKED	APPROVED
27/09/19	V01	Issued to OPRED	G.Thomson	J.Summerell	A.Salzgeber

Table of Content

Document Control Page **2**
Table of Content **3**
Abbreviations **4**
1 Executive Summary **5**
2 Introduction **6**
2.1 Background 6
2.2 Pipeline Surveys 6
3 Methodology for re-analysis of survey data **7**
3.1 Requirement for the re-analysis of the survey data 7
3.2 Re-analysis activities 7
3.3 Positioning errors 8
3.4 Pipeline Anomaly Criteria 8
3.5 On-bottom stability review 8
4 Results post re-analysis **8**
4.1 Areas of Exposure 8
4.2 Area A - KP 0.03 - 0.08 (Welland 500m Safety Zone) 9
4.3 Area B – KP 1.46 - 1.5 10
4.4 Area C - KP 1.8 - 1.92 10
4.5 Area D - KP 16.42 - 16.95 11
5 Overview of Survey Results **12**
6 Stability Review **17**
7 Conclusions **17**
8 References **18**

Abbreviations

CoP	Cessation of Production
KP	Kilometre Post
MBES	Multi-beam echo sounder
NFFO	National Federation of Fishermen's Organisations
OPRED	Offshore Petroleum Regulator for Environment & Decommissioning
PL	Pipeline
PUK	Perenco UK Limited
SIMOPS	Simultaneous Operations
SSS	Side-scan sonar
UKCS	United Kingdom Continental Shelf

1 Executive Summary

The Welland Close Out report (Ref. 1), submitted to OPRED for consultation, provided details of the previous pipeline surveys carried out on the Welland pipelines in order to support the proposed pipeline monitoring regime put forward by Perenco UK Limited (PUK).

When presenting the past survey data, the report used KP position reference locations without recognising the use of two distinct position reference data for pipelines PL674 and PL675; this inconsistency gave rise to an apparent movement of the pipeline exposures for these pipelines in 2016. Further, the report failed to recognise the change in terminology used to describe the exposures in the 2007 and 2013 “general inspection” pipeline surveys and the 2016 “geophysical” survey. This incorrectly resulted in an apparent increase in exposure number and exposure length.

On OPRED’s request, the 2007, 2009, 2013 and 2016 pipeline seabed survey multi-beam echo sounder (MBES) and side-scan sonar (SSS) datasets, measurement methodologies and operational reports were re-processed to support a more accurate and precise understanding of the history of pipeline exposures along the length of PL674 and PL675.

This report details the outputs from this re-analysis. Furthermore, it incorporates the results of an as-left survey conducted using divers within the Welland 500m zone in 2014.

Four separate regions of exposures and a number of pipeline spans were detected on PL674/675. The results of the re-analysis indicate that contrary to the information provided in the Close Out Report, there has been no significant increase in the exposures identified over the period of the survey history presented in the Close-out Report for these areas, (reference Table 1 below).

Table 1: Summary of outputs from the re-analysis of the survey data and comparison with the information provided in the Close Out Report

Area	Original Close Out Report Analysis				Re-analysis of datasets		
	Exposure length (m) 2013	Exposure length (m) 2016	Difference in exposure length (m) from 2013 to 2016		Exposure length (m) 2013	Exposure length (m) 2016	Difference in exposure length (m) from 2013 to 2016
Area A KP 0.04 - 0.08	-	50	+50		-	3	+3
Area B KP 1.48 - 1.5	26	21	-5		14	21	+7
Area C KP 1.8 - 1.92	69	94	+25		69	79	+10
Area D KP 16.8-17.0	- [1]	127	+127		-	127	N/A
TOTAL	**95**	**291**	**196**		**95**	**228**	**19**

[1] It should be noted, that the Welland pipeline length near the Thames Complex (Area D) will be surveyed as part of the post-decommissioning survey requirements for the Thames Complex Close Out Report planned to be submitted in 2022.

Taking into account that the pipeline length near the Thames Platform (Area D) was not surveyed in the 2013 survey, the re-analysed survey data indicates a difference in exposure length of **19m** from 2013 to 2016, compared to the Close Out Report survey data which had erroneously indicated a difference in exposure length of **196m** from 2013 to 2016.

The identified exposures and pipeline spans were subjected to review by PUK's pipeline integrity department, and were found to be stable for the largest exposure (Ref. 6) and not generally prone to instability for the shorter exposures.

In summary, a re-analysis and review of the post-decommissioning survey data for the Welland pipelines (PL674/675), indicate that the exposures identified have not increased significantly since decommissioning and are considered stable. In addition, the spans identified are not reportable spans i.e. they do not satisfy the Kingfisher Information System criteria for a 'significant' pipeline span. And the 2016 survey performed by the NFFO noted no adverse pulls, debris or obstructions within the 500m zone or along the length of pipelines PL674 and PL675.

2 Introduction

2.1 Background

The Welland field is located in United Kingdom Continental Shelf (UKCS) Blocks 49/29b and 53/4a of the southern North Sea, approximately 72 km from the coast of Norfolk in licence blocks P39 and P105.

The last production from the Welland platform and subsea wells was 2003. Following a review of all the options it was decided to decommission the field and the formal Cessation of Production (CoP) was approved in 2004.

In 2004, the 17 km length Welland export pipelines (16 inch PL 674 and 3 inch PL675) connecting the Welland platform to the Thames platform were all cleaned, flushed and physically isolated from the Thames and Welland platforms. Since 2004 the pipelines have been in a decommissioned state; i.e. flooded and left in situ. The preferred decommissioning option for the buried subsea pipelines, as detailed in the comparative assessment section of the approved Decommissioning Programme, was to leave them buried in situ.

The Welland platform was decommissioned in January 2011.

2.2 Pipeline Surveys

Prior to the decommissioning of the Welland platform in 2011, a 'general inspection' pipeline survey was completed in 2007. In 2009 a 'detailed' pipeline survey was completed as part of a pre-decommissioning geophysical survey; depth of burial, sidescan sonar (SSS) and multibeam bathmetry survey (MBES) data was collected.

Post-decommissioning of the Welland platform, the pipelines were extensively surveyed twice. A 'general inspection' pipeline survey was completed in 2013 and a post-decommissioning 'geophysical survey' was carried out in 2016 (Ref. 4).

The 2013 survey did not cover the pipeline length near the Thames Complex due to a SIMOPS clash, with diving operations within the 500m zone carrying out decommissioning activities around the Thames Complex. The 2016 survey covered the area near the Thames platform.

In addition to the surveys detailed above, the path of the PL674/PL675 pipeline and expansion spool-piece was surveyed as part of a diving as-left survey in 2014.

In 2016 a survey was performed by the NFFO using a trawler vessel equipped a standard otter trawl and the addition of scraper chains prior to the ground gear. No adverse pulls, debris or obstructions were noted within the 500m zone or along the length of pipelines PL674 and PL675. A Clean Seabed certificate (Ref. 2) was issued by the National Federation of Fisherman's organisations (NFFO) over the Welland 500m Safety Zone and the PL674/PL675 pipeline route up to the Thames 500m Safety Zone.

In summary, four MBES-SSS pipeline surveys, one as-left diving survey and one NFFO survey have been carried out since the pipelines were decommissioned in 2004; as shown in Table 2 below.

Table 2: List of surveys carried out on Welland pipelines pre and post-decommissioning

Year	Survey
2007	General inspection (MBES-SSS)
2009	Pre-decommissioning survey (MBES-SSS)
2013	General inspection (MBES-SSS)
2014	Diving as-left survey
2016	Post-decommissioning geophysical survey (MBES-SSS) NFFO Overtrawl survey

3 Methodology for re-analysis of survey data

3.1 Requirement for the re-analysis of the survey data

The Welland Close Out report (Ref. 1), submitted to OPRED for consultation, provided details of the previous pipeline surveys carried out on the Welland pipelines in order to support the proposed pipeline monitoring regime put forward by Perenco UK Limited (PUK).

When presenting the past survey data, the report used KP position reference locations without recognising the use of two distinct position reference data for pipelines PL674 and PL675; this inconsistency incorrectly gave rise to an apparent movement of the pipeline exposures for these pipelines in 2016. Further, the report failed to recognise the change in terminology used to describe the exposures in the 2007 and 2013 'general inspection' pipeline surveys and the 2016 'geophysical' survey. This incorrectly resulted in an apparent increase in exposure number and exposure length.

On OPRED's request, the 2007, 2009, 2013 and 2016 pipeline seabed survey multi-beam echo sounder (MBES) and side-scan sonar (SSS) datasets, measurement methodologies and operational reports were re-processed to support a more accurate and precise understanding of the history of pipeline exposures along the length of PL674 and PL675.

3.2 Re-analysis activities

The 2007, 2009, 2013 and 2016 pipeline seabed survey multi-beam echo sounder (MBES) and side-scan sonar (SSS) datasets, measurement methodologies and operational reports were re-processed to support a more accurate and precise understanding of the history of pipeline exposures along the length of PL674 and PL675. Further, this report incorporates the results of an as-left survey conducted using divers within the Welland 500m zone in 2014. The re-analysis was achieved by:

- Reviewing the survey operational reports;
- Re-referencing the start and end location of exposures and free spans in 2007, 2009 and 2013 using the route position list (RPL) used for the 2016 geophysical survey;
- Reviewing the survey-specific definitions used to describe an exposure;
- Re-measuring the length of exposures detected in the side-scan sonar data using a consistently applied definition for exposure start and end locations. Specifically, for regions of 'intermittent' pipeline exposure, the total length of exposure is now consistently presented as the sum of the intermittent exposures.

3.3 Positioning errors

For the purpose of this report, a conservative positioning error of +/- 2m has been assumed in the detection of exposure start and end locations when located using side-scan sonar data. This expresses the uncertainty associated with the performance of all instrumentation used during surveying.

3.4 Pipeline Anomaly Criteria

The following criteria was used to determine what should be considered a pipeline anomaly for the pipeline PL674 (Ref. 5).

Table 2 Welland Pipeline Anomaly Criteria

Pipeline No.	Description	Span criteria		Exposure criteria		
		KP's	Limit	Status	KP's	Limit
674	16" Welland to Thames	All	17m	Buried	All	Continuous exposure < 0.5D average embedment and length > 81m Intermittent exposure with total exposed length > 0.5 total length and < 0.5D average embedment and total length > 81m

3.5 On-bottom stability review

Pipeline exposures and spans exceeding the parameters in table 2 (Ref. 5) were subjected to an additional on-bottom stability review by an independent pipeline integrity management company using:

- Generalised lateral stability of exposed pipelines method (DNV-GL recommended practise F109)
- Absolute lateral stability of pipelines embedded to 50% of diameter method (DNV-GL recommended practise F109)
- Analysis of 'maximum pipeline freespan length' to satisfy DNV-GL RP-F105 screening criteria (Ref. 5).

4 Results post re-analysis

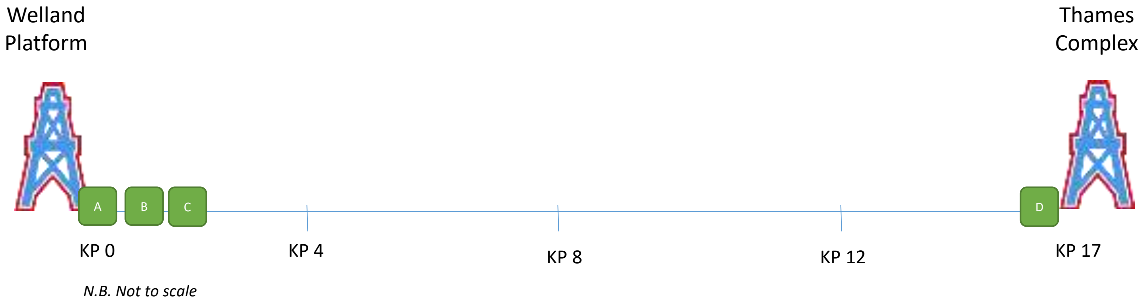
4.1 Areas of Exposure

Four separate regions of exposures and a number of pipeline spans were detected on PL674/675 and are illustrated in Figure 1. None of the pipeline spans meet the criteria for 'significant' pipeline span for reporting to the Kingfisher Information System. The criteria for reporting used therein is a span height of 0.8m AND SIMULTANEOUSLY a minimum span length exceeding 10m.

These four regions are:

- Area A – KP 0.03 - 0.08 (Within the Welland 500m safety zone).
- Area B – KP 1.46 - 1.5
- Area C – KP 1.8 - 1.92 (Region in proximity to a sand wave)
- Area D – KP 16.42 - 16.95 (Approaches the limit of the Thames 500m safety zone)

Figure 1 Location of Areas of Exposures identified in relation to the Installations



The historical survey data in these four areas are reviewed separately herein. The exposures are listed in table 3.

4.2 Area A - KP 0.03 - 0.08 (Welland 500m Safety Zone)

In 2014, an as-left survey (Ref. 3) was performed along the length of the expansion spool piece and pipeline prior to entry into the first pipeline stabilisation rock deposit using divers. The survey detailed precisely the configuration of the concrete mattresses; the elevation of free spans and exposures were confirmed using pneumo-derived depth measurements. The spans and exposures were noted following reprocessing of the survey data were:

- 2014 Survey results:
  - KP 0.040 – KP 0.047 - pipeline span length = 7m.
    The 'span' was recorded as 1.8m above the mud line at KP 0.047 and 1.0m above the mud line at KP 0.040. This region corresponds to the location of the western-most dog leg of the expansion spool piece. This section is not covered by mattress.

  - KP 0.060 – KP 0.063 - exposure length = 3m

The initial analysis of the 2016 survey dataset identified a pair of exposures along the PL674/675 pipeline route commencing from the west of the expansion spool piece / pipeline connection. These were not previously identified in the "general inspection" or detailed pre-decommissioning surveys in 2007, 2009 or 2013. These were:

- 2016 Survey results:
  - KP 0.043 - KP 0.046 - exposure length = 3m
  - KP 0.071 to KP 0.08 - exposure length = 47 m). [N.B. Likely erroneous KP reported – see below]

In 2019, the 2014 divers' as-left survey report was provided to the 2016 post-decommissioning survey contractor to provide additional context to the survey data recorded. This was necessary as multiple interim interpretations of the survey results by different geophysical specialists had produced different results.

As a result of the review of the 2014 divers' as-left survey, the 2016 survey was amended to show that the pipeline is substantially covered by mattresses and the following region of potential pipeline exposure was identified.

- 2016 Survey results (updated post 2019 review of 2014 diving as-left survey)
  - KP 0.060 - KP 0.063 - possible 'crowning' exposure but not conclusive, length = 3m

Based on the 2019 review of the 2014 divers' as-left survey report, it is believed that the 47m exposure identified in 2016 (KP 0.071 to KP 0.08) was an error, likely due to an erroneous KP reported. There was also no further evidence of the pipeline span (KP 0.040 – KP 0.047) observed in the 2014 survey (Ref. 4).

4.3 Area B – KP 1.46 - 1.5

This region of pipeline exposure along PL674/675 was noted in 2007 and both the 2013 and 2016 pipeline surveys; no occurrences of pipeline spans have been identified. These exposures occur within the extent of mega rippled sands; the ripples running north-north-west to south-south-east with a wavelength of 10m and an amplitude <0.5m.

The Close Out report (Ref. 1) originally submitted to BEIS used KP position reference locations without recognising the use of two distinct position reference data; this inconsistency incorrectly gave rise to an apparent movement of the pipeline exposures in 2016. Further, the report failed to recognise the change in terminology used to describe the exposures in the 2007 and 2013 'general inspection' pipeline surveys and the 2016 'geophysical' survey. This incorrectly resulted in an apparent increase in exposure number and exposure length.

Once reprocessed, the compound total lengths and locations of the exposures identified are:

- 2007 Survey results:
  - KP 1.474 to KP1.477 - single exposure length = 4m
- 2009 Survey results:
  - No exposure recorded
- 2013 Survey results:
  - KP 1.466 - KP 1.493- intermittent exposure length = 14m
- 2016 Survey results:
  - KP 1.468 - KP 1.499 - intermittent exposure length = 21m

An increase of 7m in the intermittent exposure length occurred between 2013 and 2016. The variation in position of the exposure start point between 2013 and 2016 is within the accuracy of the survey system measurement used.

4.4 Area C - KP 1.8 - 1.92

This region of exposure along the PL674/675 pipeline route was observed in the 2007, 2009, 2013 and 2016 surveys. These exposures occur within the extent of mega rippled sands, running north-north-west to south-south-east with a wavelength of 10m and an amplitude <0.5m (2013). The sand mega-ripples have recorded in 2009, 2013 and 2016 survey datasets. The exposure lies 82m to the north of the crest of a sand wave with wavelength 200-400m and amplitude 2.0 to 2.3m. Within this region, the piggy-backed MEG pipeline PL675 appears to have detached from the export pipeline PL674.

The report originally submitted (Ref. 1) to BEIS used KP position reference locations without recognising the use of two distinct position reference data; this gave rise to an exaggeration of the apparent movement of the pipeline exposures and an increase in the number of exposures. The report also incorrectly summed the length of exposures along PL674 and PL675 separately; ignoring the fact that detachments of the PL675 pipeline occurred within the extent of an adjacent exposure of the PL674 pipeline.

Once reprocessed, the corrected compound lengths and positions of this exposure identified were:

- 2007 Survey results
  - KP 1.821 – KP 1.890 - intermittent exposure length = 70m
- 2009 Survey results
  - KP 1.830 – KP 1.838 - intermittent exposure length = 8m
- 2013 Survey results
  - KP 1.809 - KP 1.900 - intermittent exposure length = 69m
- 2016 Survey results
  - KP1.813 - KP 1.916 - intermittent exposure length = 79m

Two spans, both approximately 0.1m in height, were identified in the 2016 survey within this region; neither meet the criteria specified for a 'significant' pipeline span as defined by the Kingfisher Information System and have not been reported in the FishSAFE database. These include:

- 2016 Survey results
  - KP 1.864 - KP 1.872 - PL674 span = 9m
  - KP 1.859 - KP 1.860 - PL675 span = 2m

The exposures and pipeline spans were subjected to review by the pipeline integrity department at Perenco using the anomaly criteria limits specified within the Decommissioned Pipelines – Anomaly Limits document, (Ref. 8).

4.5 Area D - KP 16.42 - 16.95

A review of the 2009 survey dataset, identified an exposure along the PL674/675 pipeline route of 32m length from KP 16.463 to KP 16.495. This feature was not recorded at the time and has been discovered as part of this review.

This area was not surveyed in 2013 due to a SIMOPS clash with diving operations within 500m zone carrying out decommissioning activities around the Thames Complex.

Six exposures were detected in the 2016 survey dataset. The exposure detected in 2009 remains visible in this survey. These exposures occur within the extent of mega rippled sands; the ripples running east-north-east to west-south-west with a wavelength of 8.1m and an amplitude <0.5m. The exposures include:

- 2009 Survey results
  - KP 16.463 - KP 16.495 - exposure length = 32m
- 2016 Survey results
  - KP 16.427 - KP 16.458 - exposure length = 21m
  - KP 16.457 - KP 16.483 - exposure length = 27m
  - KP 16.803 - KP 16.819 - exposure length = 15m
  - KP 16.830 - KP 16.836 - exposure length = 6m
  - KP 16.871 - KP 16.899 - exposure length = 28m
  - KP 16.905 - KP 16.933 - exposure length = 28m

The initial Welland close out report failed to account for the reduced area surveyed in 2013. As a result, that initial report incorrectly shows 6 additional exposures and an increase in overall exposure length of approximately 127m.

5 Overview of Survey Results

Table 3 summarises the comparison of the exposure lengths from the 2013 and 2016 surveys; firstly from the analysis carried out for the initial Welland close-out report and secondly from the results of this re-analysis.

Table 4 details the recorded exposures from all the post-decommissioning surveys using a consistent frame of reference and correcting errors/misinterpretations from the previous surveys.

Table 3 – Summary of recorded increase in exposure lengths from 2013 to 2016 surveys – Close Out Report vs Re-analysis

Area	**Original Close Out Report Analysis**				**Re-analysis of datasets**			**Comments**
	Exposure length (m) 2013	**Exposure length (m) 2016**	**Difference in exposure length (m) from 2013 to 2016**		**Exposure length (m) 2013**	**Exposure length (m) 2016**	**Difference in exposure length (m) from 2013 to 2016**	
Area A KP 0.04 - 0.08	-	50	+49.7		-	3	+3	Datasets were realigned using the 2016 position reference. 'Possible crown exposure, but not conclusive' noted.
Area B KP 1.48 - 1.5	26	21	-5.4		14	21	+7	Datasets were realigned using the 2016 position reference.
Area C KP 1.8 - 1.92	69	94	+24.6		69	79	+10	Datasets were realigned using the 2016 position reference.
Area D KP 16.8-17.0	-	127	+126.9		-	127	N/A	2013 inspection failed to survey this region in its entirety.
TOTAL	**95**	**291**	**196**		**95**	**228**	**19**	Comparing areas which were surveyed in 2013 and 2016.

Table 4.1– Recorded exposures using 2016 RPL. (Area A and Area B)

Area	KP Ref.	KP Start and End for Individual Exposure				KP Start and End for Pipeline Span				Total Intermittent Exposure length (m)			
		2007	2009	2013	2016	2007	2009	2013	2016	2007	2009	2013	2016
A	0.060-0.063				0.060-0.063 Length 3								3
B	1.46 – 1.47			1.466 - 1.493 length – 14m	1.468 – 1.473 length - 4m							14	21
	1.47 – 1.48	1.474-1.477 length - 4m			1.477 – 1.485 length - 8m					4			
	1.48 – 1.49												
	1.49 – 1.50				1.492 – 1.499 length - 8m								

Table 4.2 – Recorded exposures using 2016 RPL. (Area C)

<table>
<tr><th rowspan="2">Area</th><th rowspan="2">KP Ref.</th><th colspan="4">KP Start and End for Individual Exposure</th><th colspan="4">KP Start and End for Pipeline Span</th><th colspan="4">Intermittent Exposure length (m)</th></tr>
<tr><th>2007</th><th>2009</th><th>2013</th><th>2016</th><th>2007</th><th>2009</th><th>2013</th><th>2016</th><th>2007</th><th>2009</th><th>2013</th><th>2016</th></tr>
<tr><td rowspan="11">C</td><td>1.80 – 1.81</td><td></td><td></td><td rowspan="2">1.809 – 1.818
length - 9m</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="10">69</td><td></td></tr>
<tr><td>1.81 – 1.82</td><td></td><td></td><td rowspan="5">1.813 – 1.860
length - 48m</td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="10">77</td></tr>
<tr><td>1.82 – 1.83</td><td rowspan="8">1.821 – 1.890
length – 70m</td><td></td><td rowspan="4">1.823 – 1.858
length - 36m</td><td></td><td></td><td></td><td></td><td rowspan="8">70</td><td></td></tr>
<tr><td>1.83 – 1.84</td><td>1.830- 1.838
length – 8m</td><td></td><td></td><td></td><td></td><td>7</td></tr>
<tr><td>1.84 – 1.85</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1.85 – 1.86</td><td></td><td></td><td></td><td></td><td>1.859 -1.860
length - 1.8m
height – 0.1m</td><td></td></tr>
<tr><td>1.86 – 1.87</td><td></td><td rowspan="2">1.866 - 1.877
length - 11m</td><td>1.868 – 1.874
length - 2m

(PL675 outside span section)</td><td></td><td></td><td></td><td>1.864 - 1.872
length -8.64m
height – 0.1m</td><td></td></tr>
<tr><td>1.87 – 1.88</td><td></td><td>1.876 - 1.884
length - 8m</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1.88 – 1.89</td><td></td><td>1.882 - 1.889
length - 7m</td><td>1.886 - 1.894
length - 8m</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1.89 – 1.90</td><td></td><td>1.894 - 1.900
length - 6m</td><td>1.896 – 1.904
length - 7m</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1.90 – 1.91</td><td></td><td></td><td></td><td>1.909 – 1.916
length - 7m</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 4.3 – Recorded exposures using 2016 RPL. (Area D)

Area	KP Ref.	KP Start and End for Individual Exposure				KP Start and End for Pipeline Span				Intermittent Exposure length (m)			
		2007	2009	2013	2016	2007	2009	2013	2016	2007	2009	2013	2016
D	16.43 – 16.44				16.430 – 16.450 length – 21m								47
	16.44 – 16.45												
	16.45 – 16.46												
	16.46 – 16.47		16.463 – 16.495 length – 32m		16.458 – 16.483 length – 26m						32		
	16.47 – 16.48												
	16.48- 16.49												
	16.80-16.81												
	16.81-16.82												
	16.82-16.83												
	16.83-16.84				16.831 - 16.837 length – 6m								80
	16.84-16.85												
	16.85-16.86												
	16.86-16.87												
	16.87-16.88				16.874 - 16.902 length – 29m								
	16.88-16.89												
	16.89-16.90												
	16.90-16.91				16.909 - 16.937 length – 28m								
	16.91-16.92												
	16.92-16.92												
	16.93-16.94												

6 Stability Review

The exposures and pipeline spans were subjected to review by the pipeline integrity department at PUK using the anomaly criteria limits specified within the Decommissioned Pipelines – Anomaly Limits document (Ref. 5).

The 48m exposure between KP 1.813 and KP1.860 (part of the 77m intermittent exposure within Area C), which is in exceedance of an initial 30m exposure limit, was reviewed and found to be stable (Ref. 6). This was in accordance with the conservative absolute stability method presented in DNVGL-RP-F109, with loading associated with the 100 year wave and 10 year current applied perpendicularly.

It was noted within that assessment that "short lengths of exposed pipeline are not generally considered to be at risk of instability when subject to extreme environmental loadings. This is due to the resistance to lateral displacement offered by the buried pipe on either side of the exposure (which would need to be pulled out of burial to allow displacement of the exposed pipe section) coupled with the stiffness of the pipeline itself." (Ref. 6).

7 Conclusions

Four separate regions of exposures and a number of pipeline spans were detected on PL674/675. The results of the re-analysis indicate that contrary to the information provided in the Close Out Report, there has been no significant increase in the exposures identified over the period of the survey history presented in the Close-out Report for these areas.

Taking into account that the pipeline length near the Thames Platform (Area D) was not surveyed in the 2013 survey, the re-analysed survey data indicates a difference in exposure length of **19m** from 2013 to 2016, compared to the Close Out Report survey data which had erroneously indicated a difference in exposure length of **196m** from 2013 to 2016.

The spans identified are not reportable spans i.e. they do not satisfy the Kingfisher Information System criteria for a 'significant' pipeline span. And the 2016 survey performed by the NFFO noted no adverse pulls, debris or obstructions within the 500m zone or along the length of pipelines PL674 and PL675.

The identified exposures and pipeline spans were subjected to review by PUK's pipeline integrity department, and were found to be stable for the largest exposure (Ref. 6) and not generally prone to instability for the shorter exposures.

8 References

1. Perenco UK Limited, Welland Decommissioning Programmes Close Out Report

2. Response via letter from Alan Piggott, General Manager, NFFO, 24th June 2016.

3. 2101480005 Welland Decommissioning – Offshore Field Report-001 Issue 2014.10.06/D, Boskalis.

4. 2016-033 Bibby HydroMap Project, Welland Post-Decommissioning Environmental Survey, September 2016.

5. Decommissioned Pipelines – Anomaly Limits – Perenco 128 r03a.

6. Pipeline exposure assessment: PL674 stability review – Perenco 128 tn08a.

2019

Welland Field

Post-decommissioning Benthic Survey Regime

PERENCO

3 Central Avenue | St Andrews Business Park

Norwich | Norfolk | NR7 0HR

Document Control Page

Revision Record

DATE	REV NO.	DESCRIPTION	PREPARED	CHECKED	APPROVED
16/09/19	D01	Draft for internal review	DH	JHS	
26/09/19	V01	Final Version	DH	MB	JHS

Table of Content

Document Control Page **2**
Table of Content **3**
Abbreviations **4**
1 Executive Summary **5**
2 Introduction **7**
2.1 Background 7
2.2 Current Situation 7
3 Review of 2016 Survey Wplat_01 and Wplat_02 sample station analyses **1**
4 Body of evidence on effect of muds and drill cuttings **3**
4.1 Drill cuttings dispersion 3
4.2 Contaminant concentrations 3
4.3 Persistence of Contaminants 4
4.4 Evidence of Recovery 5
4.5 Disturbance and Remobilisation of Contaminants 6
4.6 Survey monitoring frequency 6
4.7 Case Study: NW Hutton Drill Cuttings Pile 7
5 Comparison of levels of contaminants for Welland and other North Sea Installations **9**
5.1 Elevated Hydrocarbon Levels 9
5.1.1 Total Hydrocarbon Concentrations **9**
5.1.2 Polycyclic Aromatic Hydrocarbons **9**
5.2 Heavy and Trace Metal Concentrations 11
5.3 Macrofauna 12
6 Conclusion **14**
7 References **16**

Abbreviations

CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CoP	Cessation of Production
ERL	Effect Range Low
OBM	Oil Based Mud
OPRED	Offshore Petroleum Regulator for Environment & Decommissioning
PAH	Polycyclic Aromatic Hydrocarbons
PLONOR	Pose Little or No Risk to the Environment
PUK	Perenco UK Limited
THC	Total Hydrocarbon Concentrations
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association

1 Executive Summary

Since 2004 the Welland export pipelines connecting the Welland platform to the Thames platform have been in a decommissioned state; i.e. flooded and left in situ. The Welland platform was decommissioned in January 2011.

Post-decommissioning of the Welland platform, two environmental surveys were completed in 2013 and 2016. Based on the results of these surveys, Perenco UK Limited (PUK) proposed a 10 year survey review. However, the Offshore Petroleum Regulator for Environment & Decommissioning (OPRED) requested a 5 year survey review due to concerns of:

- Elevated levels of Total Hydrocarbon Concentrations (THC) and Polycyclic Aromatic Hydrocarbons (PAH) near the Welland platform;
- Elevated levels of Heavy Metal concentrations near the Welland platform;
- Insufficient evidence that areas with elevated levels of THC, PHA and heavy metal concentrations are recovering as expected.

In response to this request, PUK agreed to review the data from the two surveys (2013, 2016) presented in the Welland Close out Report and revert back to OPRED; this report presents the results of this review, with a summary of the results and conclusions presented below.

Wplat_01 and Wplat_02 sample stations

Based on a closer inspection of the GC-trace for station Wplat_01, the elevated hydrocarbon and metal levels at Wplat_01 and Wplat_02 are considered to be from the remains of the drill cuttings pile, due to the stations' proximities to the decommissioned platform location, in combination with the predominantly northerly sea current direction. The levels are well within the OSPAR Recommendation 2006/5 thresholds.

Elevated Levels of THC and PAH

The review of the Welland data for the two surveys included a comparison of the levels of contaminants from drill cuttings for Welland to other North Sea Installations using a body of evidence from industry and academia. The review concluded that the levels of THC and PAH indicated for Welland are as expected when compared to UKOOA data on dispersion of drill cuttings for stations close to and within 5km of a platform in the southern North Sea.

Elevated Levels of Heavy Metal Concentrations

The review of the Welland data for the two surveys included a comparison of the high metal levels observed at Wplat_01 and Wplat_02 with standard advisory levels (i.e. from CEFAS, ERL, OSPAR, PLONOR).

Heavy and trace metal concentrations were generally low (with the exception of arsenic), with the mean concentrations below the level where effects on the biota might occur (Long et al., 1995). And although the arsenic levels were elevated, they were still within the range where 'discharge' may be permitted (Cefas).

Barium and chromium levels were elevated to the North of the Welland platform; however, barium has a low bioavailability and therefore a low toxicity to marine organisms, and the chromium levels were below background concentrations reported for the southern North Sea.

Evidence that areas with elevated levels of THC, PHA and heavy metal concentrations are recovering

A review of THC and PAH from the 2013 and 2016 surveys indicate that the levels are consistently low.

Sample results from the 2013 survey indicate an elevated PAH level (4,400 $ng.g^{-1}$) at station Grab 31 near the Thames platform, and the sample results from the 2016 survey indicate an elevated PAH level (9,479 $ng.g^{-1}$) at station Wplat_01 near the Welland platform. However, the two sample locations are not directly comparable, as the 2013 sample point (Grab 31) is located 2,836 m from the Thames platform, and the 2016 sample point (Wplat_01) is located 141.5 m from the Welland platform.

In addition, three samples were taken at each survey station at less than 8m apart; two of these were assessed for Biology and one for Petrochemical. The results of the Biology analyses showing a high variability between samples in relation to species abundance, which demonstrates a very dynamic environment. Therefore it would be incorrect to make a direct comparison between sample stations from the 2013 survey and the 2016 survey even for sample stations in the same vicinity.

A comparison of the mean heavy and trace metal concentrations between the surveys conducted in 2013 and 2016 indicates that the results for heavy metals were fairly consistent between both survey years with no significant increase or decrease in concentrations. The majority of metals showed a decrease in the levels recorded, with the exception of chromium and barium where higher concentrations were measured during the 2016 survey. Barium levels are considered low toxicity to marine organisms and the chromium levels are below background concentrations reported for the southern North Sea.

An assessment of the current state of recovery for the Welland area, based on species associated with highly contaminated sites and recovered/recovering sites in the North Sea, was carried out using a body of evidence from industry and academia. The Welland samples did not identify any of the key opportunistic species associated with highly contaminated sites in the North Sea. However, they did identify the abundant presence of the echinoderm *Echinoderm cordatum,* a key sensitive species associated with recovered/recovering sites in the North Sea. In addition, the presence of the polychaete *Lagis koreni* suggests bioturbation has taken place, allowing a higher species diversity to develop, further indicating that Welland is in an advanced stage of recovery.

Conclusions

Henry et al. (2017) recommend that the benthos in the northern and central North Sea are monitored for at least the first 8 years post drilling/decommissioning. Whereas, benthos in the southern North Sea should be monitored for at least one year post-drilling/decommissioning.

Drilling operations on Welland ceased with the commencement of gas production in 1990, the platform ceased operation in 2003 and was decommissioned in 2011. Taking into consideration the recommended survey intervals for the southern North Sea and the evidence from the 2013 and 2016 surveys that the levels of contaminants are low and/or as expected, and that the Welland area is in fact in an advanced state of recovery; PUK do not consider a 5 year survey review fit for purpose for the Welland area.

PUK therefore propose that no further additional benthic surveys be carried out on the Welland area.

An additional survey is unlikely to provide new information over what has already been identified from the 2013 and 2016 surveys and what can be predicted from other industry and academic studies. In addition, disturbance events to the seabed can reset the recovery trajectory; therefore any additional seabed surveys (grab sampling) could contribute to the remobilisation of contaminants.

2 Introduction

2.1 Background

The Welland field is located in United Kingdom Continental Shelf (UKCS) Blocks 49/29b and 53/4a of the southern North Sea, approximately 72km from the coast of Norfolk in licence blocks P39 and P105. The Welland field consists of three reservoirs; West, North and South. Additionally, the Tristan formation was drilled from the Welland platform. Two platform wells and three subsea wells accessed these various reservoirs with production starting in 1990.

The last production from the Welland platform and subsea wells was in 2003. Following a review of all the options, it was decided to decommission the field and the formal Cessation of Production (CoP) was approved in 2004.

In 2004, the 17km length Welland export pipelines (16 inch PL 674 and 3 inch PL675) connecting the Welland platform to the Thames platform were all cleaned, flushed and physically isolated from the Thames and Welland platforms. Since 2004 the pipelines have been in a decommissioned state; i.e. flooded and left in situ. The Welland platform was decommissioned in January 2011. Post-decommissioning of the Welland platform, two environmental surveys were completed in 2013 and 2016.

2.2 Current Situation

PUK proposed a 10 year survey review (with the next survey scheduled in 2026) in the Welland Decommissioning Close out Report. OPRED requested a 5 year survey review (with the next survey scheduled in 2021) due to the following:

- Elevated levels of Total Hydrocarbon Concentrations (THC) and Polycyclic Aromatic Hydrocarbons (PAH) near the Welland platform at sample station location ‘Wplat1’ identified during the 2016 survey;
- Heavy metal concentrations near Welland platform at sample stations ‘Wplat1’ and ‘Wplat2’ identified during the 2016 survey;
- Insufficient evidence that areas with elevated levels of THC, PHA and heavy metal concentrations are recovering as expected.

OPRED requested a further environmental survey be undertaken in 2021, the results of which would be used to determine if further surveys will be required.

In response to this request, PUK agreed to review the data presented in the Welland Close out Report and revert back to OPRED. This review included:

- Review of all 2016 survey sample analyses at stations at Wplat_01 and Wplat_01 where elevated levels of THC, PAH and Heavy Metals were observed;
- Comparison of levels of contaminants for Welland with other North Sea Installations using a body of evidence from industry and academia;
- Comparison of high metal levels observed at Wplat_01 and Wplat_02 with standard advisory levels;
- Assessment of the current state of recovery based on indicator species present and expected rates of recovery of ecosystems using a body of evidence from industry and academia.

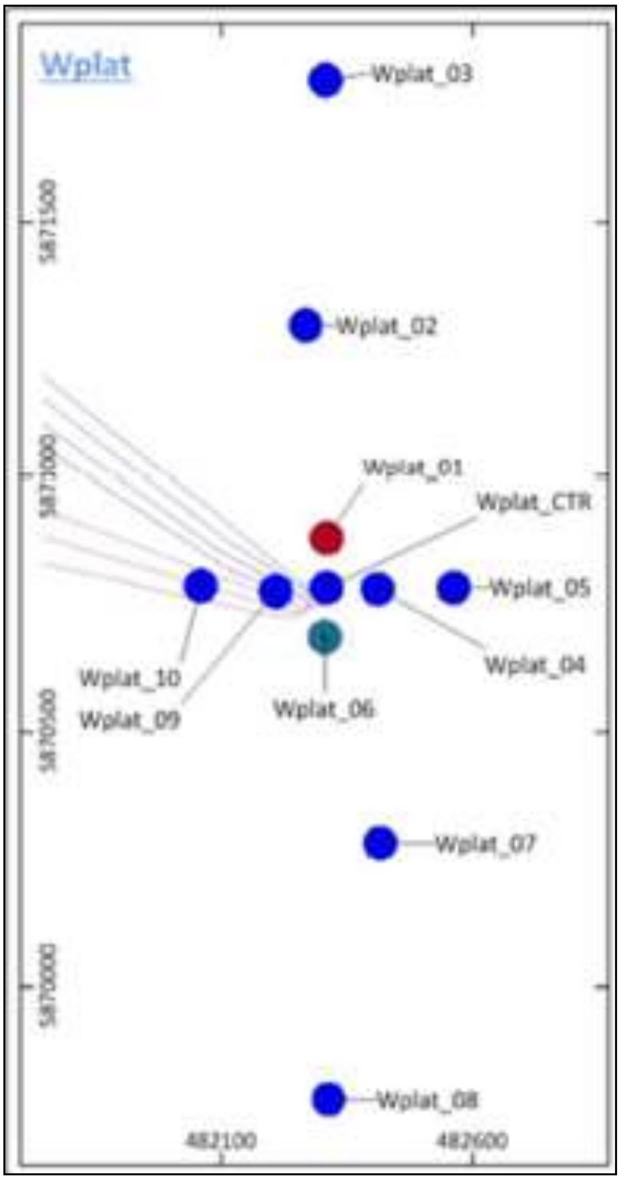
3 Review of 2016 Survey Wplat_01 and Wplat_02 sample station analyses

The analysis of THC for the 2016 survey samples revealed low levels, ranging from 0.47 µg.g^{-1} to 18.75 µg.$^{g-1}$, with only station Wplat_01 recording elevated THC concentrations of 52,577.6 µg.g^{-1}.

The analysis of Total PAHs for the 2016 survey samples revealed low levels with a mean level of 39.9 ng.g^{-1}, and only station Wplat_01 recording elevated PAH concentrations of 9,479 ng.g^{-1}.

Sample station locations Wplat_01 and Wplat_02 are located 142m and c.1000m to the north of the Welland platform respectively, as shown in Figure 1 below.

Figure 1 - Welland 2016 Survey – Sample Station locations



A closer inspection of the GC-trace for station Wplat_01 has indicated the presence of weathered mixed hydrocarbon input, dominated by suspected low toxicity oil based muds (OBM) most likely from dispersed drill cuttings in the area. The elevated hydrocarbon and metal levels at Wplat_01 and Wplat_02 are therefore considered to be from the remains of the drill cuttings pile, due to the stations' proximity to the decommissioned platform location, in combination with the predominantly northerly sea current direction.

The OSPAR (Oslo-Paris) Convention seeks to protect the marine environment of the North-East Atlantic. In 2006, OSPAR published Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles. The purpose of the Recommendation is to reduce to a level that is not significant, the impacts of pollution by oil and/or other substances from drill cuttings piles.

Two thresholds were defined for assessing potential impacts:

- Persistence over the area of seabed contamination in excess of 500km2 per year;
- Rate of loss of oil to the water column of greater than 10 tonnes per year.

OSPAR Recommendation 2006/5 states that if the calculated values for a cuttings pile are below either of these thresholds then no further action is required with regards to treatment of the cuttings pile. The level of contaminants observed at the Welland Area are indicative that the potential impact of the remaining drill cuttings would be significantly below the OSPAR Recommendation 2006/5 thresholds; therefore, no further action is required with regards to the treatment of cuttings.

4 Body of evidence on effect of muds and drill cuttings

Decades of industry environmental survey data from the North Sea is held in the UK Benthos database, an archive of macrobenthos, geology and chemistry dating back to 1975. The data include information on drilling history, station locations, macrobenthic species diversity and composition, sediment granulometry, and a range of geochemical data including hydrocarbon content and heavy metal concentrations.

The UK Benthos database and extensive environmental monitoring in the Norwegian Continental Shelf and in the Dutch and UK regions of the North Sea, coupled with control and field experiments, have given a comprehensive and mostly coherent picture of the spatial effects of muds and cuttings on sediment macrofauna community structure and on the rate of community recovery from past cuttings discharges.

An analysis of UK offshore oil and gas environmental surveys from 1975-95 was carried out by Heriot-University at the request of The United Kingdom Offshore Operators Association (UKOOA, 2001). The analyses of the data focussed principally on potential changes at “background” sites beyond the known zone of gross contamination in the vicinity of platforms and wells (i.e. 5km away from the platform/well). The study also analysed the relationship between sediment type and bathymetry, with contaminant levels and macrofaunal community composition being examined.

In addition to this body of evidence, the NW Hutton field in the northern North Sea provides a good case study for the recovery of the environment surrounding drill cuttings in the North Sea. Five seabed surveys were carried out between 1992 and 2013, and the outputs were used to monitor hydrocarbon contamination and the recovery of macrofaunal community (Gardline, 2016).

Given the location of the NW Hutton field (northern North Sea), it is anticipated that the recovery trend demonstrated for NW Hutton represents a worst case scenario for the Welland site, which is located in the southern North Sea.

The key findings from a review of the body of evidence and the NW Hutton case study are detailed in the sub-sections below.

4.1 Drill cuttings dispersion

Large cutting piles are still present in the northern and central North Sea. Whereas, in the southern North Sea the cuttings have not formed extensive deposits due to strong tidal and storm driven currents.

It has been widely established that mud and cuttings discharges in shallow waters (<50 m) of the southern North Sea do not result in significant accumulation of material in a cuttings pile. This is primarily a reflection of the strong tidal and storm currents of the area (Hartley et al., 2003). Recorded effects on benthic macrofauna are most often confined to within a 250 m radius and seldom detected beyond 500 m from the cutting pile locations (Bakke et al., 2013).

4.2 Contaminant concentrations

Total Hydrocarbon Concentrations

THC concentrations, for samples taken from 14 UKCS drill cuttings piles varied from 1% to 60% (10,000-600,000 $\mu g.g^{-1}$), although 20% (20,000 $\mu g.g^{-1}$) is a more typical maximum concentration (Hartley et al., 2003).

The mean level of THC concentration levels within 500m of active platforms in the North Sea is 11,049 $\mu g.g^{-1}$, (UKOOA, 2001).

The 2001 UKOOA study looked at the range of contaminant concentrations occurring at background sites, i.e. stations over 5km from the nearest installation and/or data from pre-operational surveys, for the entire North Sea and for the separate sectors.

Table 1 below provides the arithmetic mean, and 50th and 95th percentiles (i.e. 95% of the stations examined were below this concentration) of THC at the background stations for the southern North Sea (UKOOA, 2001).

Table 1 - Total hydrocarbons (THC) at the background stations for the southern North Sea (UKOOA, 2001)

	Mean $\mu g.g^{-1}$	50th percentile $\mu g.g^{-1}$	95th percentile $\mu g.g^{-1}$
Total Hydrocarbons (THC)	**4.34**	**3.2**	**11.39**

[NB. 1 $\mu g.g^{-1}$ = 1 ppm]

PAH Concentrations

In cuttings samples from 14 UKCS piles, total PAH varied from 0 - 130,000 $ng.g^{-1}$, with mean values varying from 1000 – 13,000 $ng.g^{-1}$ (Hartley et al., 2003).

The mean of total PAH concentration levels within 500 m of active platforms in the North Sea is 1,730 $ng.g^{-1}$ (UKOOA, 2001).

Table 2 below provides the arithmetic mean, and 50th and 95th percentiles (i.e. 95% of the stations examined were below this concentration) of PAH at the background stations for the southern North Sea (UKOOA, 2001).

Table 2 - Total Polycyclic Aromatic Hydrocarbons (PAH) at the background stations for the southern North Sea (UKOOA, 2001)

	Mean $ng.g^{-1}$	50th percentile $ng.g^{-1}$	95th percentile $ng.g^{-1}$
PAH (MW 202)	40	23	108
PAH (MW 228)	21	15	60
PAH (MW 252)	34	20	131
PAH (MW 276)	16	8	67
Total Polycyclic Aromatic Hydrocarbons (PAH)	**111**	**66**	**366**

[NB. 1 $ng.g^{-1}$ = 0.001 ppm]

4.3 Persistence of Contaminants

The physical and chemical persistence of drill cuttings on the seabed depends on the energy of bottom waters and the drilling substance reactivity and biodegradability. Most minerals in drill cuttings are stable and insoluble in seawater.

Barite, the most abundant particulate solid in most drilling fluids, has a very low solubility in natural seawater and is resistant to dissolution (Sanzone et al., 2016). Barite particles in acidic, anoxic layers of sediment are slightly more soluble and dissolved barium and other metals associated may leach slowly out of an anoxic cuttings pile (Neff, 2008). Nearly all the barium in drill mud is derived from the barite added to the mud to increase its density.

The metals of greatest concern, because of their potential toxicity and/or abundance in drill muds, include arsenic, barium, chromium, cadmium, copper, iron, lead, mercury, nickel and zinc (Neff et al., 2000).

Many of the metals associated with cuttings are present as solid sulphide inclusions within the drilling mud barite. These metals are not readily solubilised from the cuttings under either oxidising or reducing conditions, and have a low bioavailability. Therefore, it is doubtful that metals bioaccumulation from cuttings piles, if it occurs, is sufficient to cause harmful effects on marine fauna living on or near cuttings piles (Hartley et al., 2003).

Organic chemicals, including hydrocarbons, are biodegraded by microbial activity; a process which may occur relatively quickly in the presence of oxygen, or very slowly in the deoxygenated interior of a cuttings pile (Hartley et al., 2003).

Sediment excavation and reworking by benthic fauna plays an important role in the ecological recovery of cutting piles through bioturbation and related processes such as metal sequestration and mobilisation, hydrocarbon biodegradation, and sediment oxygenation (Hartley et al., 2003; Sanzone et al., 2016).

4.4 Evidence of Recovery

Community restoration at previously impacted sites has been recorded as complete within 4-10 years. (Bakke et al., 2013).

Henry et al. (2017) have used the UK Benthos database to measure the scale and persistence of the ecological impact at 19 sites across the UK sector of the North Sea. The recovery time varied across the North Sea, with only 6 out of the 19 sites showing no impacts of drill cuttings. Minimum persistence time was zero at the 44/12 well, Amethyst (A1, B and C), Buchan A and Audrey A platforms; all these wells are located in the southern North Sea.

Where strong significant impacts were detected, more than 50% of these sites showed effects of cuttings piles persisting for at least 6 years post-drilling, with most slow-recovery sites being located in the northern and central North Sea. Interestingly, the benthos in the southern North Sea were not altered by drill cuttings except at the Caister platform (UKCS Block 44/23) where benthos were profoundly affected by a mercury gradient up to 895m away.

When OBMs were used, benthos from the northern North Sea were still recovering on average 6.8 years post-drilling, while those in the central North Sea took on average 8.3 years. There were no significant impacts detected in surveys of benthos at sites exposed to OBM in the southern North Sea, at least in communities more than 200m away from the structure/drill site (Henry et al., 2017).

Unlike the thermally stratified waters of the northern and central North Sea, strong tidal mixing and friction in the southern portion of the basin would support a more disturbance-tolerant taxa. The southern North Sea species are therefore probably more resilient to disturbance in this shallow and relatively more hydrodynamic region (Henry et al., 2017).

The results of the correlations of contaminant concentrations against diversity indices show a general pattern of reduced levels of diversity, evenness and species richness associated with increased contaminant concentrations (UKOOA, 2001).

Following a review of the available literature on the recovery patterns in terms of the communities that recolonise the cutting piles and what influences recolonisation timeframes, Dames and Moore and NIOS (Hartley et al., 2003) produced an overview of recolonisation patterns plotted against time; this is depicted in Figure 2 below.

Henry et al. (2017) found that post-drilling contamination gradients were always associated with opportunistic and/or pollution-tolerant indicator taxa.

Taxa most frequently associated with post-drilling contaminant and/or organic enrichment gradients included the polychaetes *Capitella spp*., *Ophryothrocha spp*., and the bivalve *Thyasira spp*., all of which have been recorded associated with cuttings piles in the North Sea and elsewhere (Ugland et al., 2008).

The hydrocarbon intolerant Polychaete worm *Owenia fusiformis* was present at survey stations closest to the NW Hutton platform during the 2013 survey but not during the earlier 1992 survey. These indicator species demonstrate that recovery is taking place (Gardline, 2016).

The presence of the indicator species *Echinocardium cordatum,* which is sensitive to oil contamination, is an indication of recovery taking place (Daan et al., 1990).

Figure 2 - Overview of recolonisation patterns plotted against time

	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4
Activity	Cuttings discharge				
Impact	Smothering/introduction of toxic compounds to benthic life	Leaching of contaminants Physical change to the sediment	Continued leaching of contaminants Physical change of sediments	Continued leaching of contaminants Physical change to sediment	Contamination may be degraded Sediment may be physically changed
Benthic fauna present on pile	No benthic life	First opportunistic species appear	Development of opportunistic benthic community	Possible reduction of opportunistic species with corresponding recovery of the original community	Return of species to HC contamination Establishment of new benthic community which may be different from surrounding communities as a result of sediment change
Benthic fauna in the surroundings (20-1000m)	Impoverished benthic community	Impoverished benthic community	Recovery starts at the furthest stations (250 - 1000m)	Continued recovery of benthic community	Full recovery of benthic life may be achieved
Time Scale (years)	0	1	2	5	---

Source: From Dames and Moore and NIOZ, (1999)
Note: Shaded areas represent uncertainty in the process

4.5 Disturbance and Remobilisation of Contaminants

Disturbance events to the seabed can reset the recovery trajectory. Henry et al. (2017) found that an abrupt re-disturbance event, possibly by a cuttings pile re-disturbance, seemed to have occurred at the Murchison platform between 1990 and 1993 after 10 years of observed recovery. This re-established a significant contaminant gradient that spread up to 1,200m away.

The implication of this evidence is that monitoring should evolve in line with changes in usage, which could mean a return to a longer or more frequent monitoring programme.

4.6 Survey monitoring frequency

Most monitoring of offshore hydrocarbon developments in the North Sea has focused on the acute effects of drilling discharges in the immediate vicinity of platforms. In the early years of the development of the North Sea this provided valuable information on the intensity and extent of impact on the benthic environment. However, for at least the last decade such an approach has provided little new information over that which could have been predicted from the earlier studies (Harries et al., 2001).

Henry et al. (2017) recommend that the benthos in the northern and central North Sea are monitored for at least the first 8 years post-drilling/decommissioning. Whereas, benthos in the southern North Sea should be monitored for at least one year post-drilling/decommissioning, but due to the generally more limited footprint of impacts on benthos in this region, monitoring should include stations within a 200m diameter of the drilling location.

4.7 Case Study: NW Hutton Drill Cuttings Pile

The NW Hutton field is located in the northern North Sea 130km north east of the Shetland Islands in UKCS Block 211/27a. Decommissioning of the NW Hutton field was completed in 2009.

There is a single drill cuttings pile of approximately 31,000m^3 (200m x 150m x 5.5m) which falls below the threshold values established in the OSPAR recommendation 2006/5. A comparative assessment of options for the drill cuttings pile was undertaken which concluded that the best environmental option for the management of the pile is to leave it in place undisturbed to degrade naturally.

To date there have been five seabed surveys to monitor hydrocarbon contamination and the recovery of the macrofaunal community between 1992 and 2013.

There has been a significant reduction in surface THC levels between 1992 and 2013 (refer to Figure 3 and Figure 4 below.

At the current rate of recovery, the surface sediments at the NW Hutton field are expected to return to background levels by 2028. This suggests that the recovery of surface sediments can be measured in decades rather than longer time periods (Gardline, 2016).

The macrofaunal communities have responded to the declining THC trend. The opportunistic indicator species Capitella capitata, which is hydrocarbon tolerant, was found in high abundance in the 1992 survey. However, the 2013 survey shows only a low abundance of Capitella capitata located at the closest station to the NW Hutton platform centre (Figure 5).

In addition to this, the hydrocarbon intolerant Polychaete worm Owenia fusiformis is present at survey stations closest to the NW Hutton platform during the 2013 survey, but not during the 1992 survey (Gardline, 2016). These indicator species demonstrate that recovery is taking place (Figure 5).

Figure 3 - Hydrocarbon Contamination at the NW Hutton Field (Gardline, 2016)

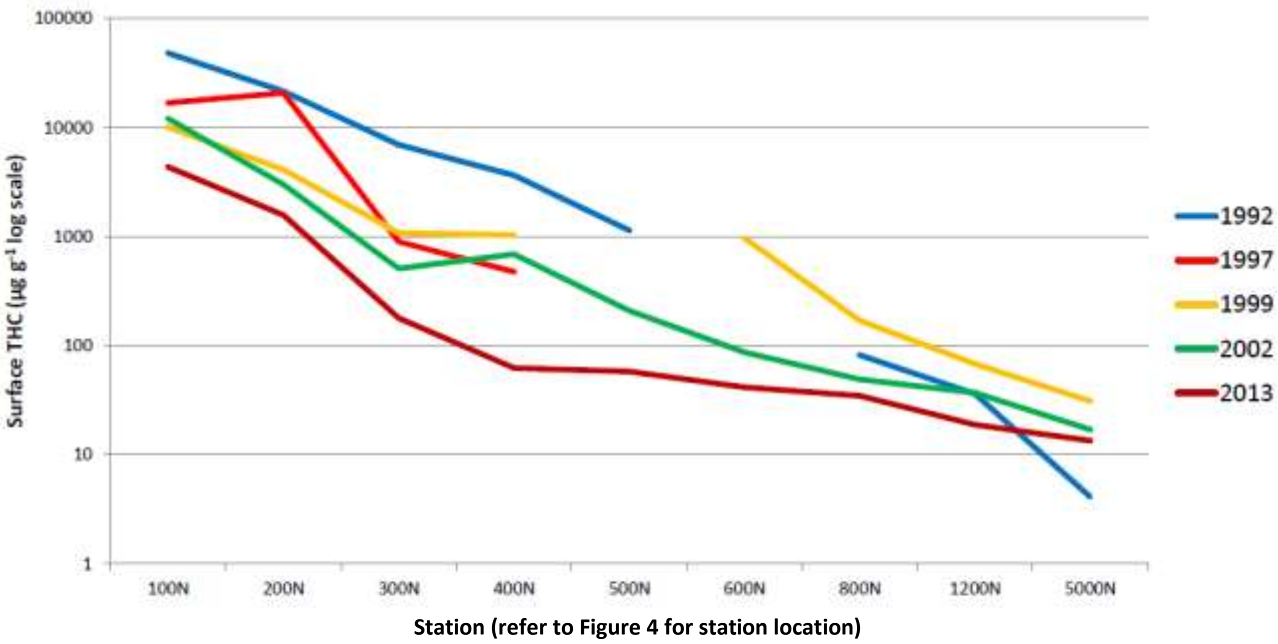


Figure 4 - Survey Station Locations for Hydrocarbon Contamination at the NW Hutton field (Gardline, 2016)

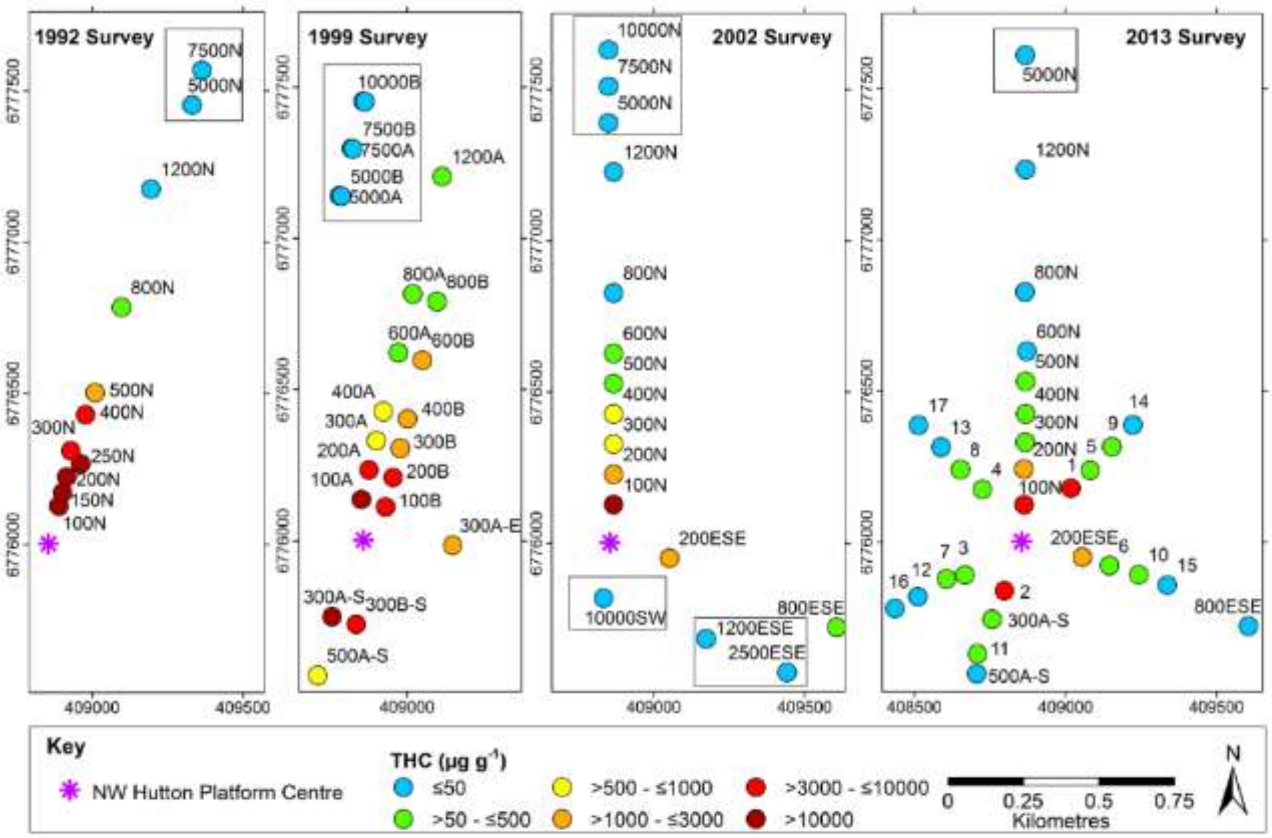
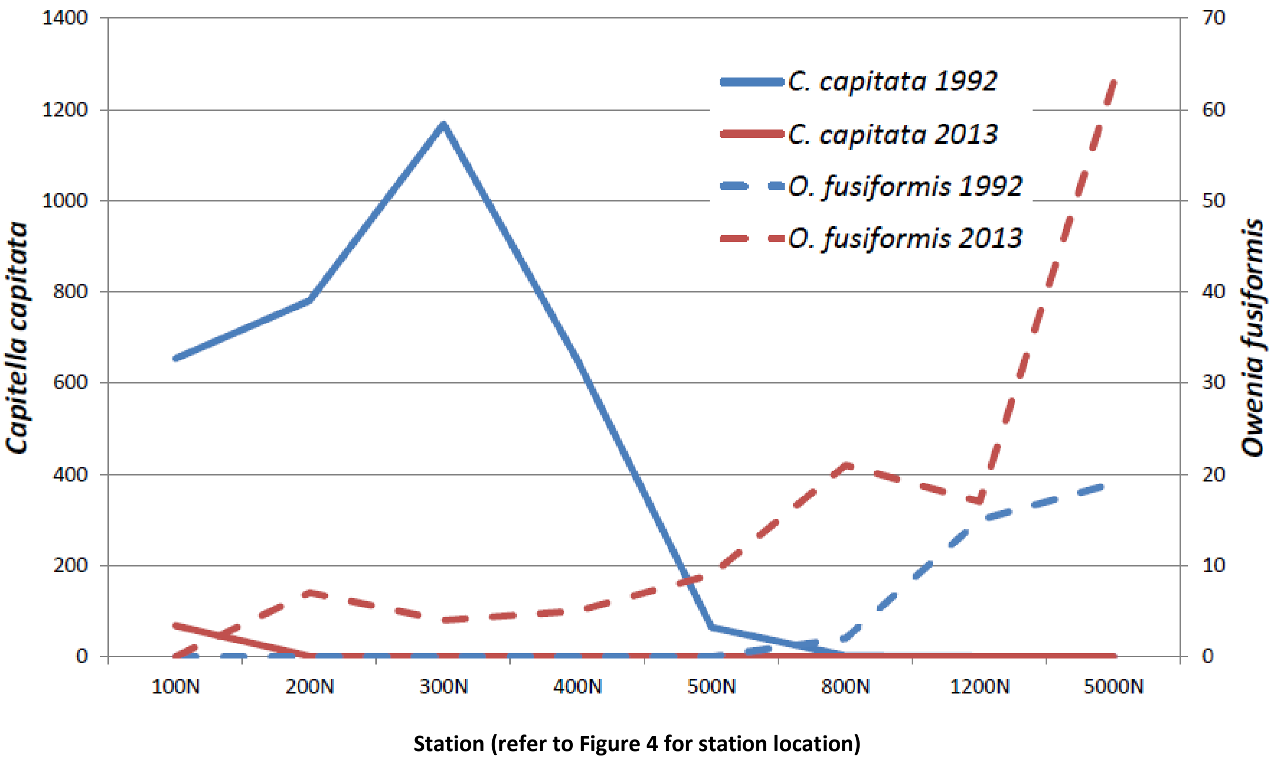


Figure 5 - Indicator Species it the NW Hutton Field (Gardline, 2016)



5 Comparison of levels of contaminants for Welland and other North Sea Installations

5.1 Elevated Hydrocarbon Levels

5.1.1 Total Hydrocarbon Concentrations

An analysis of the 2016 Welland survey samples revealed low level THC concentrations, ranging from 0.47 $\mu g.g^{-1}$ to 18.75 $\mu g.g^{-1}$, which is comparable with THC concentration levels from background stations from oil and gas platforms in the southern North Sea.

Only station Wplat_01 recorded elevated THC concentrations of 52,577.6 $\mu g.g^{-1}$. This station is 142m north of the Welland platform location, and the elevated concentration is due to the presence of OBM from the remaining drill cuttings.

THC concentrations, for samples taken from 14 UKCS drill cutting piles varied from 1% to 60%, i.e. 10,000-600,000 $\mu g.g^{-1}$ (Hartley et al., 2003). Therefore, the Wplat_01 station concentration is as expected for a station located so close to the platform and in a northerly position; (sea currents in the area are predominantly northerly).

Table 3 below compares THC concentrations from the 2016 survey data to results from drill cuttings piles for active platforms, stations within 500 m of an active platform, and background stations within 5km from the nearest platform.

Table 3 - THC Recorded during the 2016 Survey compared to expected levels in the North Sea

Station	Location	Type	THC ($\mu g.g^{-1}$)
Welland – all stations with exception of Wplat_01	< 5km from platform	Range	0.47 - 18.75
Background station levels within southern North Sea*	>5km from platform/well	50 %tile	3.2
		Mean	4.34
		95 %tile	11.39
Welland - Station Wplat_01	Approx. 142m from platform	Single sample	52,578
Station – North Sea cuttings piles **	Platform	Range	10,000-600,000
		Mean	20,000
Stations within 500 m of active platforms within North Sea*	< 500m from platform/well	Mean	11,049

* UKOOA, 2001
** Hartley et al., 2003

5.1.2 Polycyclic Aromatic Hydrocarbons

Total PAH's were generally found in low levels giving an average value of 39.9$ng.g^{-1}$, which is comparable with PAH levels from background stations from oil and gas platforms in the southern North Sea.

Only station Wplat_01 recorded elevated PAH concentrations of 9,479 $ng.g^{-1}$. This station is 142m north of the Welland platform location and the elevated concentration is due to the presence of OBM from the remaining drill cuttings.

In cuttings samples from 14 UKCS piles, Total PAH varied from 0 - 130,000 $ng.g^{-1}$, with mean values varying from 1000 – 13,000 $ng.g^{-1}$ (Hartley et al., 2003). The mean level of total PAH concentration levels within 500 m of active platforms in the North Sea is 1,730 $ng.g^{-1}$ (UKOOA, 2001).

Therefore, the concentration at sample station Wplat_01 is as expected for a station located so close to the platform and at a northerly position; (sea currents in the area are predominantly northerly).

Table 4 compares the PAH concentrations from 2016 survey data in relation to results from drill cuttings piles for active platforms, stations within 500 m of an active platform, and background stations within 5km from the nearest platform.

Table 4 - PAH Recorded during the 2016 Survey compared to expected levels in the North Sea

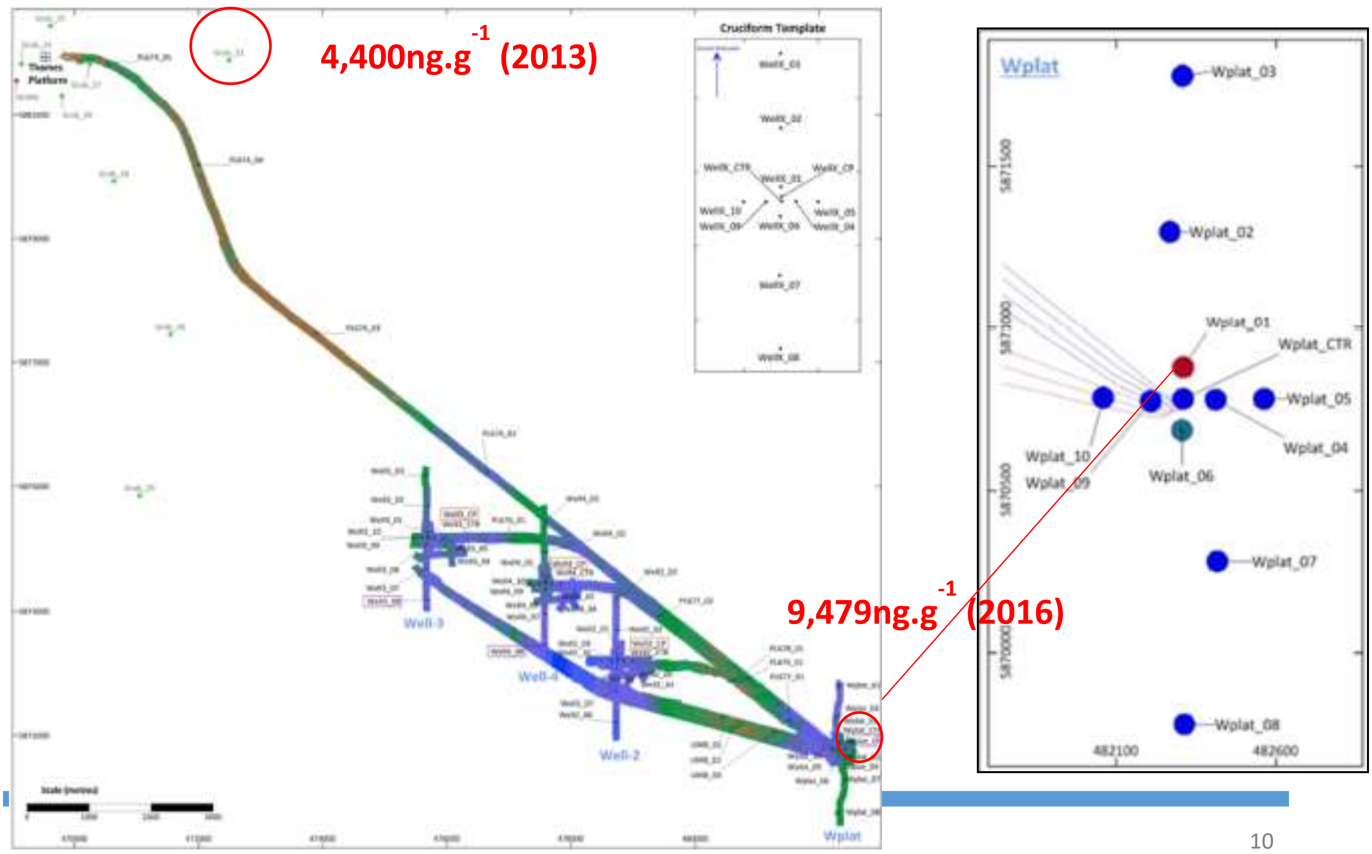
Station	Location	Type	PAH (ng.g^{-1})
Welland – all stations with exception of Wplat_01	< 5km from platform	Mean	39.9
Background Station Total PAH Levels within southern North Sea*	>5km from platform/well	50 %tile	66
		Mean	111
		95 %tile	366
Welland - Station Wplat_01	Approx. 142m from platform	Single sample	9,479
Station – North Sea cuttings piles **	Platform	Range	0 - 130,000
		Mean (Range)	1000 - 13,000
Stations within 500 m of active platform in North Sea*	< 500m from platform/well	Mean	1,100

* *UKOOA, 2001*
** *Hartley et al., 2003*

The sample results from the 2013 survey indicate an elevated PAH level (4,400 ng.g^{-1}) at station Grab 31 near the Thames platform, and the sample results from the 2016 survey indicate an elevated PAH level (9,479 ng.g^{-1}) at station Wplat_01 near the Welland platform.

However, the two sample locations are not directly comparable, as the 2013 sample point (Grab 31) is located 2,836 m from the Thames platform, and the 2016 sample point (Wplat_01) is located 141.5 m from the Welland platform, as shown in Figure 6.

Figure 6 - Location of 2013 and 2016 Survey Stations with elevated PAH concentrations



5.2 Heavy and Trace Metal Concentrations

A comparison of the mean heavy and trace metal concentrations between the 2013 and 2016 surveys is presented in Figure 7. The results for heavy metals were fairly consistent across both survey years with no significant increase or decrease in concentrations. The majority of metals showed a decrease in levels from 2013 to 2016, with the exception of chromium and barium where slightly higher concentrations were measured during the 2016 survey.

Figure 7 - Comparison of Heavy and Trace Metal Concentrations with Historical Data

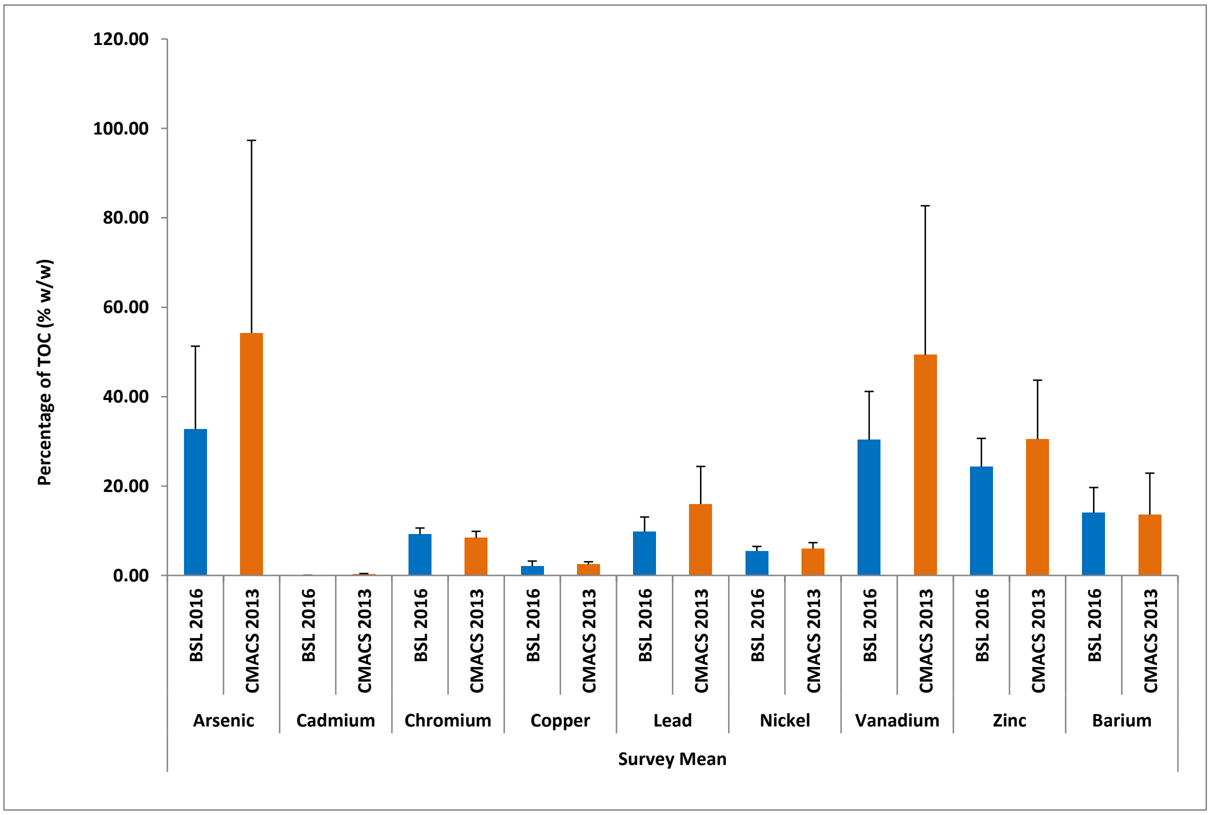


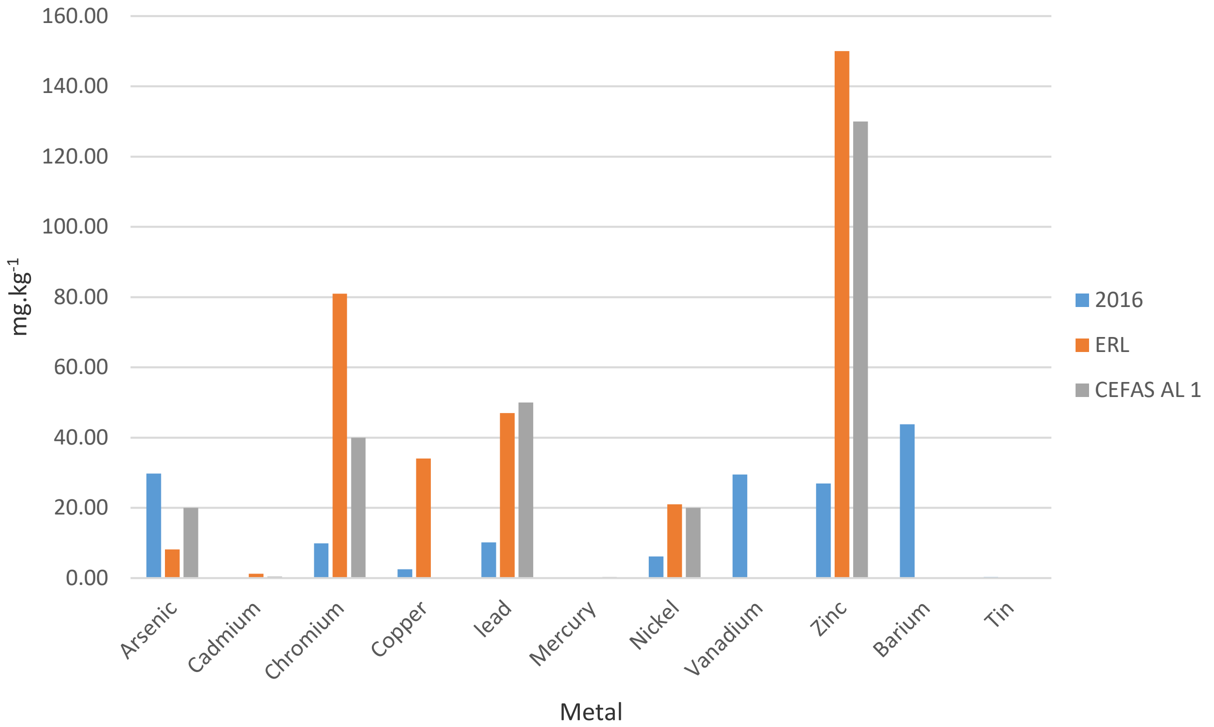
Figure 8 shows heavy and trace metal concentrations from the 2016 survey in relation to the corresponding standard advisory contamination levels (ERL and CEFAS Action Level 1).

The arsenic concentration exceeds the ERL (8.2 mg.kg^{-1}) at sample locations Wplat_01 (12.3 mg.kg^{-1}) and Wplat_02 (29.5 mg.kg^{-1}). In addition, the CEFAS Action level 1 threshold for arsenic is exceeded at sample location Wplat_02.

The greatest concentration for chromium was recorded at sample location Wplat_01 (26.1 mg.kg^{-1}). However, this is below the ERL (81 mg.kg^{-1}) and CEFAS level 1 threshold (40 mg.kg^{-1}). In addition, the Wplat_01 sample is only slightly higher than background concentrations reported for the southern North Sea (24.7 mg.kg^{-1}).

Note that there are no advisory contamination levels for barium which has low bioavailability and toxicity to marine organisms (listed as Pose Little or No Risk to the Environment (PLONOR)).

Figure 8 - Heavy / Trace Metals from the 2016 Survey with Standard Levels



5.3 Macrofauna

For the 2016 survey, there was a high degree of variability observed between grab samples; this was particularly evident at station Wplat_01 where the three grab samples (two for macrofauna and one for physico-chemical analyses) were very different in appearance. Wplat_01_F1 comprised medium sand with shell fragments; Wplat_01_F2 had a very shallow redox layer (1 cm) and significant *Mytilus spp*. shell residue; and Wplat_01_PC1 appeared to be contaminated with drill cuttings.

All samples were taken within 4m of the target location, demonstrating the patchiness and variability at this station, and similar stations within the survey area. This variability was reflected in the biology with one replicate (Wplat_01_F1) having the highest richness recorded and the other (Wplat_01_F2) having the joint second lowest species richness. The relationship between richness and abundance by station is presented in Figure 9.

The Shannon-Wiener diversity index (an index that is commonly used to characterize species diversity in a community) was highly variable throughout all stations due largely to high species numbers at some locations; the lowest value of 0.761 was recorded at station Well2_05 caused by the polychaete *Lagis koreni* accounting for 236 out of 269 individuals.

A couple of small *Sabellaria spinulosa* concretions were observed around station Wplat_01, but not in significant quantities to constitute a protected 'reef' status. Overall, the macrofauna community was composed of species commonly found in this area, with variations attributed to varying levels of sand and shell material and no Annex I habitats or other protected habitats/species recorded.

The 2016 Welland survey results indicate that bioturbation has taken place. Survey stations located near previously drilled wellheads did not appear to have a low diversity, where a gradient of change is expected with distance from the well.

The top 15 species are listed in Table 5 in order of decreasing total rank score. The dominant species throughout the Welland survey area were the bivalve *Fabulina fabula,* followed by the polychaetes

Spiophanes bombyx and *Lagis koreni* (ranked 2nd and 3rd respectively), another bivalve *Abra alba* (ranked 4th), the polychaetes *Nephtys hombergi* and *Nephtys cirrosa* (ranked 5th and 8th respectively), echinoderms *Ophiocten affinis* and *Echinocardium cordatum* (ranked 6th and 7th respectively), the cumacean *Diastylis laevis* (ranked 9th), and the polychaete *Goniada maculate* rounding off the top 10.

The 3rd ranked polychaete *Lagis koreni* was found to be distributed in higher concentrations around wellheads. This polychaete is known to rework and oxygenate the sediment, thus supporting the ecological recovery and allowing a higher diversity to develop.

Typical opportunistic indicator species associated with highly contaminated sites (post-drilling contaminant and/or organic enrichment gradients) include *Capitella spp*., *Pholoe inornata, Thyasaria sarsi, Beggiatoa*, none of which were found or identified in the 2016 Welland survey.

Furthermore, the abundance of 7th ranked echinoderm *Echinocardium cordatum* suggests that is the Welland area is at an advanced stage of recovery.

Figure 9 - Species Abundance and Richness by Station (0.1m^2) (2016 Survey)

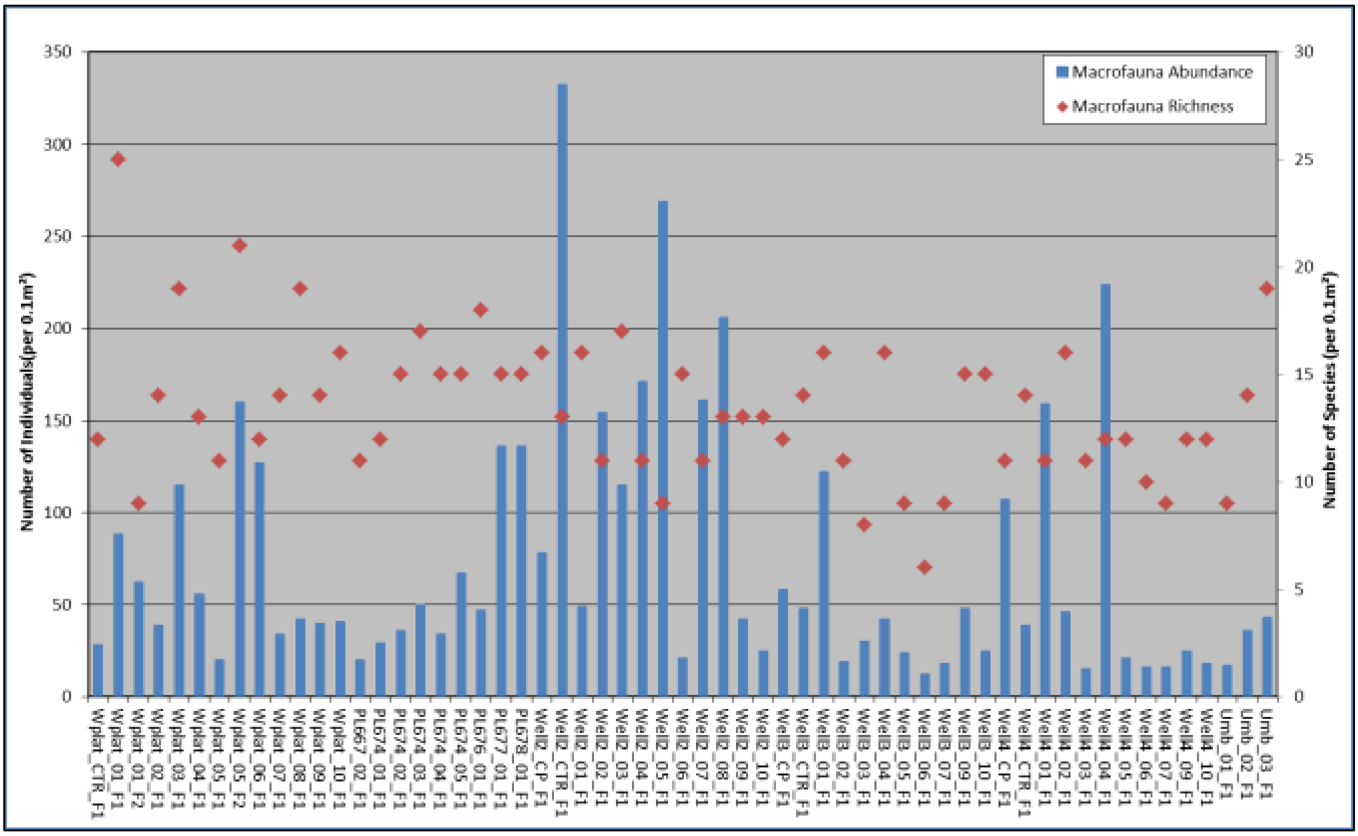


Table 5 - Overall Species Ranking (Top 15 Species)

Overall Top 15 Rank	Species / Taxon	Total Rank Score (out of 590)	Numerical Abundance (59 replicates)	Numerical Top 15 Rank
1	*Fabulina fabula*	444	290	4
2	*Spiophanes bombyx*	409	350	3
3	*Lagis koreni*	382	2108	1
4	*Abra alba*	321	369	2
5	*Nephtys hombergi*	246	104	6
6	*Ophiocten affinis*	233	105	5
7	***Echinocardium cordatum***	**157**	**55**	**8**
8	*Nephtys cirrosa*	151	56	7
9	*Diastylis laevis*	134	49	9
10	*Goniada maculata*	128	44	11
11	*Euspira nitida*	117	44	11
12	*Chaetozone setosa*	116	48	10
13	*Bathyporeia guilliamsonia*	104	37	14
14	*Ophelia limacina*	98	42	13
15	*Urothoe elegans*	91	37	14

6 Conclusion

A 5 year survey cycle approach is not considered to be fit for purpose at the Welland location, and any additional survey is unlikely to provide new information over what has already been identified from the 2013 and 2016 surveys, and what can be predicted from reference to existing industry and academic studies. PUK proposes that no further additional benthic surveys be carried out on the Welland area.

This is supported by the main conclusions from this report, as listed below:

- OSPAR Recommendation 2006/5 thresholds with regards to treatment of cuttings at Welland require no further action;
- The analysis of THC revealed low concentration levels, ranging from 0.47 $\mu g.g^{-1}$ to 18.75 $\mu g.g^{-1}$, with only station Wplat_01 recording anomalous elevated THC concentrations of 52,577.6 $\mu g.g^{-1}$ due to OBM within the remains of a drill cuttings pile near the Welland platform location;
- It has been widely established that mud and cuttings discharges in shallow waters (<50m) of the southern North Sea do not result in significant accumulation of material in a cuttings pile;
- The benthos in the southern North Sea is less sensitive to contaminant gradients than other regions of the North Sea. The southern North Sea species biology are more resilient to disturbance in this shallow and relatively more hydrodynamic region;
- No significant impacts have been detected in surveys of benthos exposed to OBM in the southern North Sea at sites 200m away from the structure/drill location. Henry et al. (2017) recommend that the benthos in the northern and central North Sea are monitored for at least the first 8 years post-drilling/decommissioning, but benthos in the southern North Sea should be monitored for at least one year only post-drilling/decommissioning;
- The NW Hutton field case study (northern North Sea) shows a recovery trend which represents a worst case scenario for the Welland site which is located in the shallower and relatively more hydrodynamic southern North Sea;

- The presence of hydrocarbon intolerant echinoderm *Echinocardium cordatum* at Welland suggests an advanced stage of ecological recovery. In addition, the survey stations located near previously drilled wellheads did not appear to have the low diversity expected in such areas. The presence of the polychaete *Lagis koreni* suggests bioturbation has taken place, allowing a higher species diversity to develop;
- Disturbance events to the seabed can reset the recovery trajectory, including additional seabed surveys (grab sampling) which could contribute to the remobilisation of contaminants.

7 References

Bakke, T., Klungsøyr, J., Sanni., S. (2013) Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry, Marine Environmental Research 92 (2013) 154-169.

Daan, R., Lewis, W.E., Mulder, M. (1990) Biological effects of discharged oil-contaminated drill cuttings in the North Sea. NIOZ-Rapport 1990-5:79pp.

Gardline (2016) Rapid Recovery of the Environment Surrounding the NW Hutton Drill Cuttings Pile.

Harries, D., Kingston, P.F. and Moore, C.G. (2001). An analysis of U.K. offshore oil & gas environmental surveys 1975-95. Draft report of study carried out by Heriot Watt University for UKOOA. 165pp plus appendices.

Hartley, J., Trueman, R., Anderson, S., Neff, J., Dando, P. and Fucik, K. (2003) Report to UKOOA. Drill Cuttings Initiative Food Chain Effects Literature Review, January 2003.

Henry, L-A., Harries, D., Kingston, P., Roberts, J.M. (2017) Historic scale and persistence of drill cuttings impacts on North Sea benthos, Marine Environmental Research (2017), 1-10.

Long, E. R., MacDonald, D. D., Smith, S. L. and Calder, F. D., (1995) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuary sediments. Environmental Management 19: 81-97.

Neff, J.M. (2008) Estimation of bioavailability of metals from drilling mud barite. Integr. Environ. Assess. Manage. 4:184-193.

Neff, J.M., McKelvie, S. & Ayers, R.C. (2000) Environmental Impacts of Synthetic Based Drilling Fluids. U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region. New Orleans: August 2000.

Park, I., Bell, N., Carrol, M. (2001) Assessment of the Actual Present Environmental Impact of Representative OBM and WBM Cuttings Piles. R & D Programme 2B. A report for the UKOOA Drill Cuttings Joint Industry Project, Cordah/UKO016/ 2001. BMT Cordah Limited, Aberdeen.

Sanzone, D.M., Neff, J.M. & Vinhateiro, N. (2016) Environmental Fates and Effects of Ocean Discharge of Drill Cuttings and Associated Drilling Fluids From Offshore Oil and Gas Operations. International Association of Oil & gas Producers, report 543: March 2016.

Ugland, K.I., Bjorgesaeter, A., Bakke, T., Fredheim, B., Gray, J.S., (2008) Assessment of environmental stress with a biological index based on opportunistic species. J. Exp. Mar. Biol. Ecol. 366, 169e174.

UKOOA (2001) An analysis of U.K Offshore Oil & gas Environmental Surveys 1975-95. A study carried out by Heriot-University at the request of The United Kingdom Offshore Operators Association. September 2001.