VALE UMBILICAL DECOMMISSIONING

Comparative Environmental Assessment

Spirit Energy Norway AS

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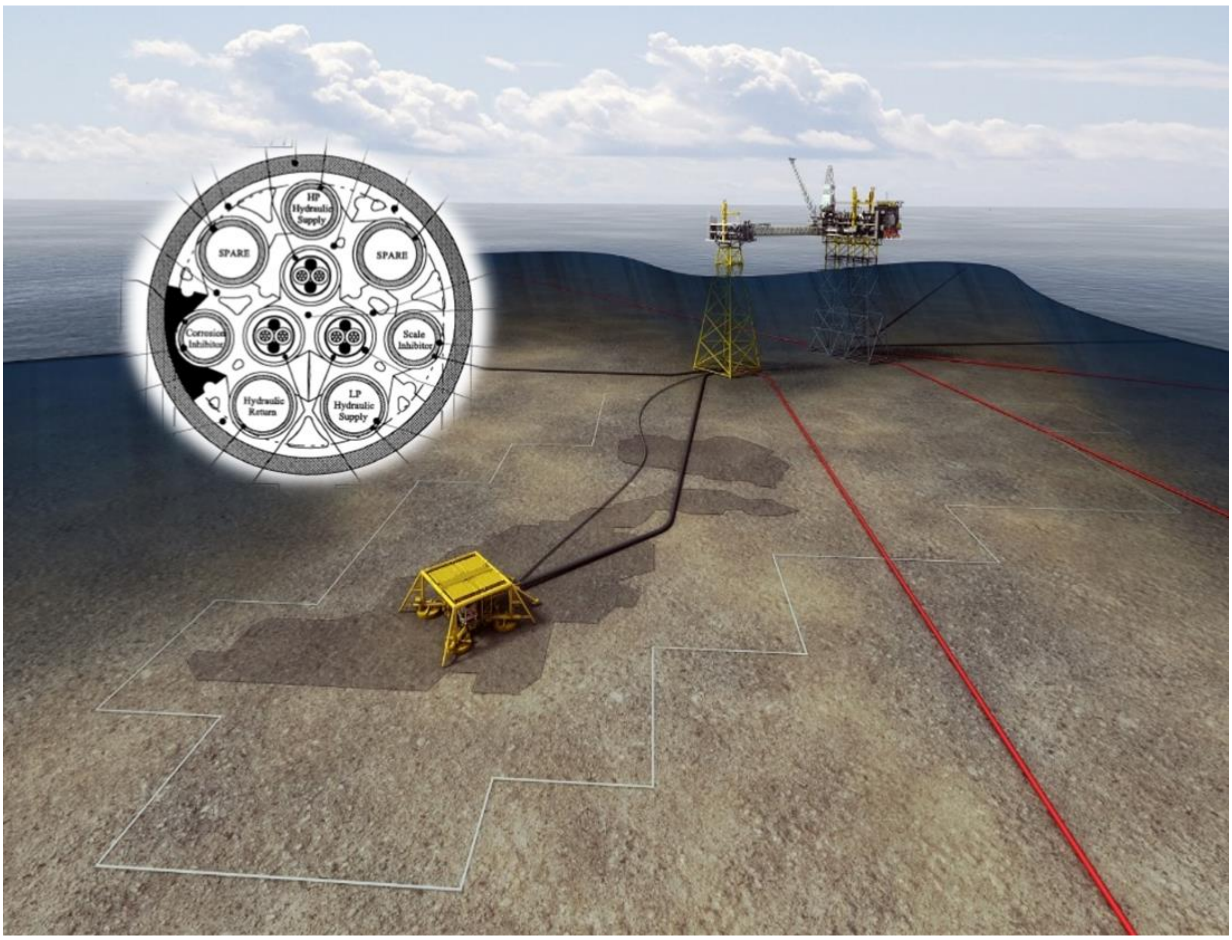

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Objective:

Assessing environmental risk/impact of leaving the Vale umbilical with an uncleaned chemical line and performing an environmental comparative assessment of a retrieval and removal option.

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Table of contents

SUMMARY 1

1 INTRODUCTION 2
1.1 Short description of the Vale field 2
1.2 Vale Cessation Plan 2
1.3 Issue for consideration and study objective 3

2 FACILITIES DESCRIPTION 4
2.1 Umbilical 4
2.2 Service line 4
2.3 Material composition and quantities 5
2.4 Burial and coverage 5

3 SCOPE OF ASSESSMENT 7
3.1 Background 7
3.2 Alternatives for comparison 7

4 ENVIRONMENTAL CONDITIONS AND SENSITIVITY 9

5 COMPARATIVE ENVIRONMENTAL ASSESSMENT 10
5.1 Energy use and emissions to air 10
5.2 Discharge to sea 11
5.3 Physical impacts 12
5.4 Materials management 13
5.5 Summary of comparative environmental assessment 13

6 REFERENCES 15

APPENDIX A. VESSEL ACTIVITY BREAKDOWN 16

SUMMARY

Spirit Energy is planning for decommissioning of the Vale field and a Decommissioning Plan (DP) was submitted to Norwegian authorities in 2020. A disposal decision from the authorities is pending.

Amongst other the DP recommends to leave the umbilical buried in place, following cleaning of the internal lines which have been in use.

In the further planning after having submitted the DP, it has been revealed that one of the umbilical's internal chemical lines (the scale inhibitor line) is clogged and not available for cleaning.

DNV has undertaken a study to assess environmental risk and impacts of leaving the umbilical in place with the scale inhibitor line un-cleaned, and perform a high-level comparative environmental assessment of leaving the umbilical vs. retrieval and removal to shore.

The comparative environmental assessment of the two umbilical decommissioning alternatives has been undertaken addressing environmental risk, energy balance, CO2 footprint, physical impact on the seabed and materials management. The chemical product in the plugged line is considered not to pose any particular environmental risk (it is not toxic but quite persistent), and will generally stay contained inside the pipe being slowly degraded over time. Environmental impacts of leaving the umbilical buried in place with the scale inhibitor line un-cleaned are hence considered negligible, both in the short and long-term perspective. The energy balance suggests that recovery of the umbilical may have net benefits from recycling of material such as plastic and steel. The CO2 footprint of this option is however higher (~900 tonnes of CO2) compared to leaving it in situ. The removal option will further have a physical footprint on the seabed from de-burial of the umbilical including rock relocation, with significant local and mainly temporary negative environmental effects. The physical footprint from leaving the umbilical in situ will be very limited and any micro plastic pollution effects is not considered likely. Removal to shore enables for recycling of the metals and energy recycling of the plastic materials, while leaving in place involves no material recycling.

Table 0-1. Summary of comparative environmental assessment – dark green color illustrating the best performance on the actual environmental aspect. No cross ranking performed.

Environmental aspect	Disposal options	
	Leave in place	Removal to shore
Environmental risk		
Energy balance		
Emissions to air (CO2 footprint)		
Physical impact		
Material management		

The comparative environmental assessment reveals that leaving the umbilical in place has no significant impacts neither in the short nor long-term perspective. Removing the umbilical to shore has however no significant environmental benefit, and will cause some minor negative environmental impacts. Hence, there is no obvious best environmental solution. Spirit Energy will do a holistic evaluation also including factors as cost and risk, which likely will favor the leave in place solution. DNV therefore recommends that an addendum to the decommissioning plan is submitted to the Ministry of Petroleum and Energy, documenting the post decommissioning plan information on the umbilical (scale inhibitor line) cleaning and requesting approval to maintain the proposed plan to clean the umbilical and leave in situ.

1 INTRODUCTION

1.1 Short description of the Vale field

Vale is a single well subsea tie-back to Heimdal, producing gas and condensate. Heimdal is an Equinor operated gas processing and transit hub with Cease of Production planned June 30th, 2023. Hence, decommissioning of Vale is also required.

The field consists of:

- A wellhead system with protection structure
- A buried production pipeline
- A buried umbilical (96mm diameter, 16.7 km)
- A service line (2 inches diameter, 16.7 km) piggybacked to the umbilical
- A few concrete mattresses and GRP covers

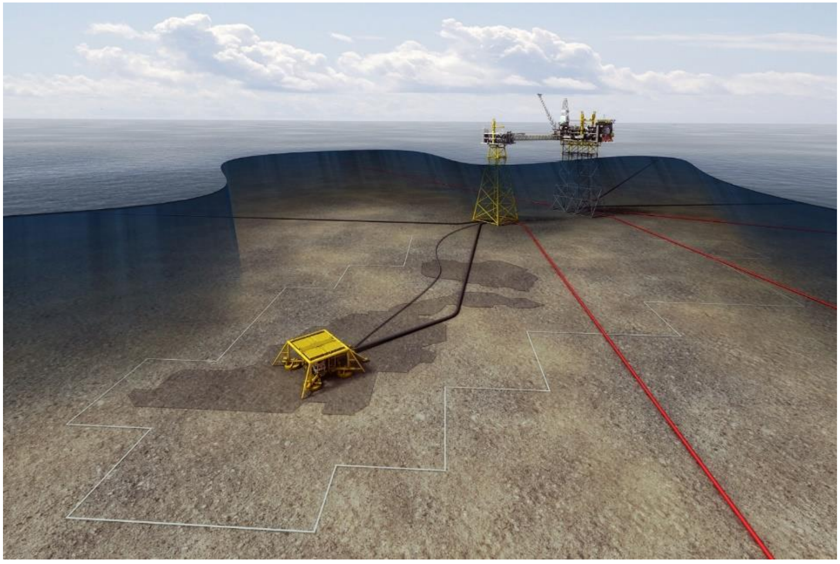

Figure 1-1. Vale field layout.

1.2 Vale Cessation Plan

A Plan for cessation of Vale was submitted to Norwegian authorities in March 2020. A final disposal decision from national authorities (Ministry of Petroleum and Energy) is pending.

The Cessation Plan states that the pipeline and umbilical shall be cleaned prior to end-disposal, which is “leave in place” (ends cut and buried). This is in accordance with NCS practice (MPE, 1999).

Following application from Spirit Energy demonstrating that the disposal work is not expected to have significant effects on commercial and environmental aspects (Spirit Energy, 2019), an exemption for an Impact Assessment has been granted by the Ministry of Petroleum and Energy in a letter dated 3rd July 2019 with reference to the Regulations to the Petroleum Act, Section 45.

The Ministry of Climate and Environment stated during the consultation of the operator’s application for an exemption that the following remarks should be conveyed to the operator:

“all pipelines must be cleaned prior to permanent abandonment on site”

In the Cessation Plan some initial thoughts on cleaning are provided:

“The Vale controls for the subsea production system is a closed loop system and the cleaning of the low-pressure and high-pressure lines are planned to be performed by circling out the fluids back to Heimdal. All chemical lines will be displaced into the Vale well. Spare lines in the umbilical contains MEG and are not planned to be part of the umbilical cleaning.”

1.3 Issue for consideration and study objective

One of the umbilical chemical lines (the scale inhibitor line) has however been clogged for several years, and is not possible to clean prior to disposal. This situation is hence not aligned with the situation described in the Cessation Plan.

The objective of this study is 1) to consider environmental impacts of leaving the umbilical in place without cleaning the clogged line (base case), and 2) to perform a comparative assessment of the base case vs. an alternative solution with retrieval to shore.

2 FACILITIES DESCRIPTION

At installation the service line was piggy-backed to the umbilical. Hence, removal of the umbilical will require simultaneous removal of the service line.

The umbilical will be cut at the ends and a smaller part at each end recovered. This will approximately 254m at the vale tree end and approximately 300m at the Heimdal end. This is valid independent of overall umbilical disposal solution. These parts are hence not included in the current assessment.

Both lines are described in the following sub-sections.

2.1 Umbilical

The umbilical contains electrical, hydraulic and chemical lines, in total seven tubing's and three cables. The umbilical is 16,7km long and trenched with an average depth of 0,5m below seabed. Some exposed areas close to Heimdal are rock dumped. The weight of the umbilical is approximately 160ton.

One of the chemical lines has been used for injection of scale inhibitor.

The umbilical consists of hydraulic lines and three chemical lines with dimensions and characteristics summarized in the table below. The hydraulic and chemical lines (except the scale inhibitor line) will be cleaned prior to disposal. Following cleaning the hydraulic and chemical lines will be filled with seawater (possibly freshwater), the service line with seawater and some remains of MEG in the Vale tree end (last 5% of the line) to prevent seawater entering the tree.

Table 2-1. Overview of lines within the umbilical and the MEG service line.

Line ID	Description	ID (inch)	ID (mm)	WT (mm)	OD (mm)	Length (m)	Volume (m3)	Material
2	LP hydraulic supply	5/8	15.9	1	17.9	16212	3.3	SS
3	HP hydraulic supply	1/2	12.7	1.52	15.74	16212	2.1	SS
4	Hydraulic return	5/8	15.9	1	17.9	16212	3.3	SS
5	Scale inhibitor	1/2	12.7	1.52	15.74	16212	2.1	SS
6	Spare hydraulic fluid	5/8	15.9	1	17.9	16212	3.3	SS
7	Spare chemical injection	5/8	15.9	1	17.9	16212	3.3	SS
8	Corrosion inhibitor	1/2	12.7	1.52	15.74	16212	2.1	SS
	MEG service line	2	45.8	6.35	60.3	16212	27.6	SS

(WT = wall thickness; SS = stainless steel)

2.2 Service line

The 2 inches service line is carbon steel piggy backed to the service umbilical. The function of the service line is to supply MEG to the x-mas tree and as a mean to equalize pressure after integrity testing of the x-mas tree valves. The service line is coated with a 2mm polyethylene layer for protection. The service line weight is approximately 150ton whereof 0,7ton is anodes.

The service line will be inhibited with MEG (5%) prior to cease of production. This inhibited water will be displaced with seawater as part of the cleaning process.

2.3 Material composition and quantities

A cross section of the umbilical is shown in Figure 2-1. The outer umbilical sheeting is 5 mm Polyethylene medium density (MDPE) with Polyvinylchloride (PVC) as filler between the umbilical lines. The tubes are made of stainless steel, the electrical cables of copper.

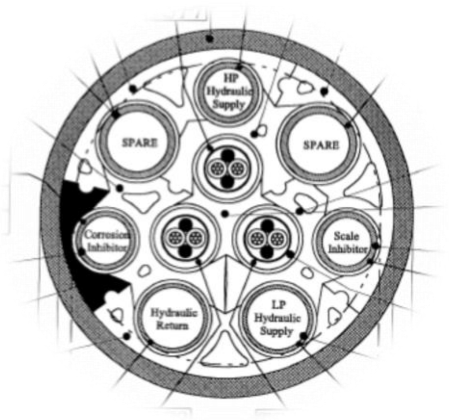

Figure 2-1. Cross section of the umbilical.

Main materials and overall weights are presented in the table below. Details are presented in section 5.

Table 2-2. Umbilical and service line materials and weight (overall, including ends).

Item	Materials	Dry weight (ton)
Umbilical	Combination of steel and plastic materials	156
Service line	Steel with plastic coating	159

2.4 Burial and coverage

(The following information is received from Spirit Energy)

The umbilical was generally trenched between 0.5 m and 1.5 m, but due to the soil conditions not all the umbilical achieved at least 0.5 m depth of cover. Due to this, rock dumping was required on some areas along the line.

The umbilical is also rock dumped at two crossings, with 3 mattresses installed across the 36” Oseberg Gas Transport pipeline and 1 mattress installed over 22" Huldra pipeline. There is protection of the umbilical laydown loop at the Vale template, with minimum 0.5 m rock above top of umbilical. The approximate length of rock berm is 247 m. A total of 9176 tonnes of gravel (1’’-3’’) was installed over the umbilical.

The latest external inspection of the entire umbilical took place in October 2014. The depth of cover is presented in the figure below. It is calculated in relation to the top of the umbilical. The design requirement is to have minimum 0.5 m cover above the umbilical, but the figure below shows that some locations don’t have sufficient cover. After the 2014 inspection, a 20 m section of the umbilical with minimum cover of 0.07m was identified at KP 16.087 (about 300 m from Vale template), between two gravel interventions from installation. The burial status comparison between 2010 and 2014 shows that a similar lack of cover was observed in 2010. This area was rectified in April 2019, by installing 260 tonnes of gravel.

In conclusion, there is no integrity concern regarding the umbilical, despite some minor areas with depth of cover slightly below the recommendation of 0.5 m. It is entirely trenched and buried or covered with rock dump, except the first 11m after the J-tube bellmouth at Heimdal and 8m towards the Vale template.

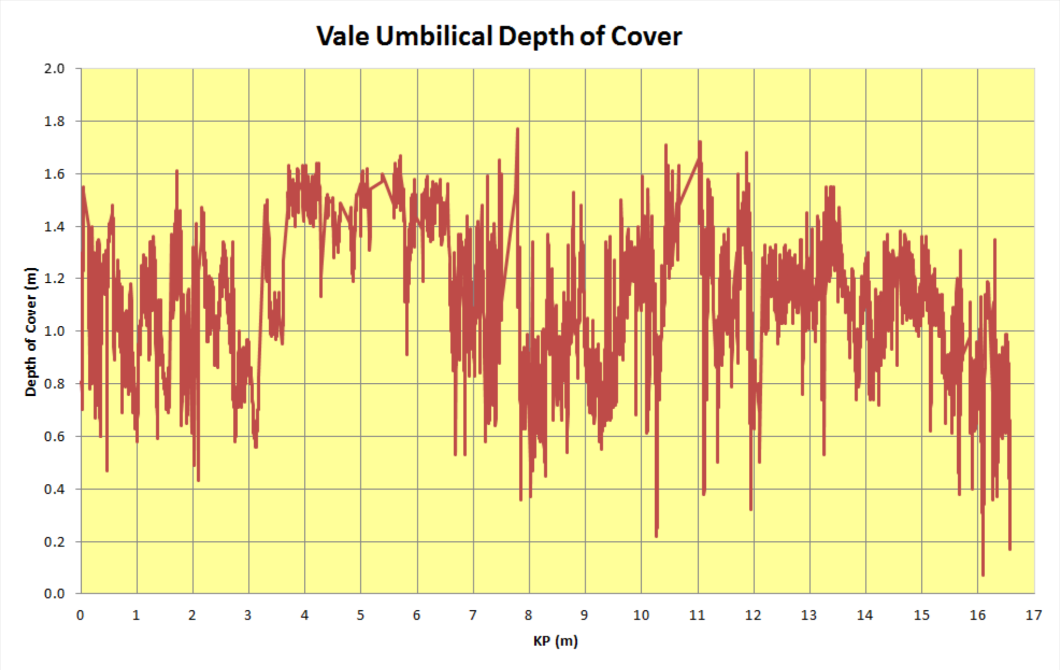

Figure 2-2. Sediment/rock cover above the umbilical.

3 SCOPE OF ASSESSMENT

3.1 Background

(The following information is received from Spirit Energy)

The scale inhibitor line was set-up for downhole injection. A short recap of the history and current status is given below:

- The scale inhibitor line (line 5) was originally filled with MEG. As part of early production phase, it was filled with scale inhibitor SI-4471 a chemical classified as a yellow Y2. Production performance revealed however that scale inhibitor injection was not required. A review of historic records reveals that a total of 5.59 tonnes of scale inhibitor was purchased in 2002. There were no other users of scale inhibitor in this period at Heimdal. Using reported densities of the chemical this corresponds to some 4.6-4.8 m^3 of scale inhibitor. The volume of chemical line (Line 5) is 2.1 m^3. The scale inhibitor line was hence not in use for a number of years, and it is not possible to find documentation that the scale inhibitor was replaced with MEG. It is therefore believed that the scale inhibitor has disintegrated and plugged the line.
- Dialogue with Heimdal offshore Operations in Equinor reveal that the line has been plugged since before 2007.
- Vale had water breakthrough in 2015, and injection of fluid into the scale inhibitor line was attempted without success. Repeated attempts have been made to unplug the line without success during 2015-2017. An Operational Risk Assessment in June 2016 recommended to close the ROV-operated subsea safety valve for the scale inhibitor line on the next offshore survey. This operation was done in September 2018.

Hence, no cleaning of the scale inhibitor line is planned as it is confirmed plugged and not achievable.

3.2 Alternatives for comparison

As described above, an updated and improved understanding of the content and status umbilical has been established since submission of the decommissioning plan. Since it is not possible to clean the scale inhibitor line, it is required to undertake a comparative assessment of maintaining the recommended disposal solution of leaving it in place versus a retrieval option. A high-level description of the two alternatives is outlined below.

The alternative to leaving the umbilical in place is to retrieve it for transport to shore, Table 3-1.

Table 3-1. Alternative disposal options for assessment

Base case (A)	Alternative (B)
Umbilical and service line left buried in situ. (The non-trenched sections will be uncovered, cut and recovered, not part of this CA.) All lines except the scale inhibitor line are cleaned prior to end-disposal.	Umbilical and service line retrieved and taken to shore for material recycling /waste disposal. All lines except the scale inhibitor line are cleaned prior to retrieval.* Unburial and removal of rock cover necessary prior to retrieval.

* Cleaning of the individual lines prior to removal is considered necessary as to prevent possible chemical spills during the removal operations (cutting, retrieval, transport, off-loading to shore, onshore handling).

Since the cleaning activities will be the same between option A and B, this part will not be included in the comparative environmental assessment.

3.2.1 Retrieval activities

The base case alternative has no additional vessel activity when cleaning is completed, ends cut and buried/covered.

Recovery of the lines requires the use of vessels with ROV support.

The following assumptions are made:

- Recovery of the complete line from Vale to Heimdal (avoid cutting at the 500m zone).
- The recover technique must retain the umbilical integrity to contain chemicals, i.e.. not cut into sections.
- Overstressing the product during de-burial is not acceptable due to integrity concerns when recovering.
- De-burial of a piggybacked line is possible.
- The j-tube seal can be released by ROV.
- The umbilical has been trenched and rock dumped approximately 1m below surface.
- GRP covers will be accounted for in other decommissioning activities.

Different options have been considered for removal[1], and a solution with de-burial followed by recovery (two campaigns) is recommended. The de-burial activity is suggested applying the “hydro blower/digger” technique; it is suspended above the seabed and blast water downwards and clear away rock and soil very effectively. Volume of de-burial activity is assumed to 400 m3/hour.

Table 3-2. Vessel activity for the removal option (vessel days) – detailed breakdown in Appendix A.

Option	Light Construction Vessel, LCV	Medium Construction Vessel, MCV
De-burial and recovery	4.9	8

3.2.2 Disposal activities

Retrieved umbilical and service line will be lifted to shore for further management. It is assumed that the service line can be sent directly to the smelter without removing the outer plastic sheet. The umbilical will however likely be grained and the materials sorted; steel and copper being sent for material recycling, the plastics for energy recycling.

Onshore handling and transport have energy consumption, the same for material recycling – however in a material life cycle analysis perspective with a positive footprint as it requires less energy than producing metals from ore. The plastics energy recycling will generate energy (i.e. positive contribution to the energy balance).

[1] Umbilical recovery without de-burial (i.e. pull the umbilical through the backfill and recover) is not recommended as it is considered possibly violating the assumption of overstressing – with some risk of the umbilical breaking (which will be both a safety concern and having a cost impact associated with more vessel days).

4 ENVIRONMENTAL CONDITIONS AND SENSITIVITY

Environmental baseline conditions were measured prior to production drilling at Vale and regular environmental monitoring has since been undertaken at the field.

The seabed sediment generally consists of silt, clay and some sand.

No unique or particularly vulnerable benthic fauna has been identified.

Total hydrocarbons (THC) measured in sediments over time are in the range of 4-5 mg/kg, which is generally low and well below the limit for significant contamination (effects generally expected above 50 mg/kg). Hence, the contamination situation is characterised as uncontaminated and the benthic fauna as undisturbed and generally with even distribution/normal diversity.

There are no areas of particular environmental value or sensitivity (SVO) in the Vale area, the nearest area being more than 60 km to the north.

Some fish species may spawn in this area, e.g. haddock, saithe, whiting, mackerel and Norwegian pout, however these species have widely distributed spawning areas and the Vale area is not of particular importance.

5 COMPARATIVE ENVIRONMENTAL ASSESSMENT

The comparative environmental assessment focus on environmental aspects considered relevant to the actual scope and of significance based on industry practice and experience from previous decommissioning projects (Norsk olje og gass, 2020; Nesse & Moltu, 2012).

The following aspects are addressed in the comparative assessment:

- Energy use
- CO2 emission to air
- Discharge to sea
- Physical impact
- Material management

5.1 Energy use and emissions to air

In an energy balance context, leaving recyclable materials in place has an energy penalty equal to the energy required to produce the same amount of new materials (Institute of Petroleum, 2000) – an approach widely used in decommissioning comparative assessments. This is applied for the metals for the "Leave in place"/base case option. The energy penalty is calculated to about 9 440 GJ (steel materials in umbilical and service line). No penalty is allocated to the plastic materials, as material recycling of such in the actual context is questionable.

The removal option (B) requires energy for retrieval, transport to shore, onshore handling and transport, and recycling. The energy required is calculated to about 9475 GJ. The plastics will however have a positive energy contribution through energy recycling, estimated to 6260 GJ, giving a net energy use at 3200 GJ.

Hence, the overall (comparative) energy balance is about 6 245 GJ in favour of the removal option. There is however significant uncertainty to the vessel duration for retrieval and moreover related to the energy benefit of plastics energy recycling, which may be considered too optimistic[2].

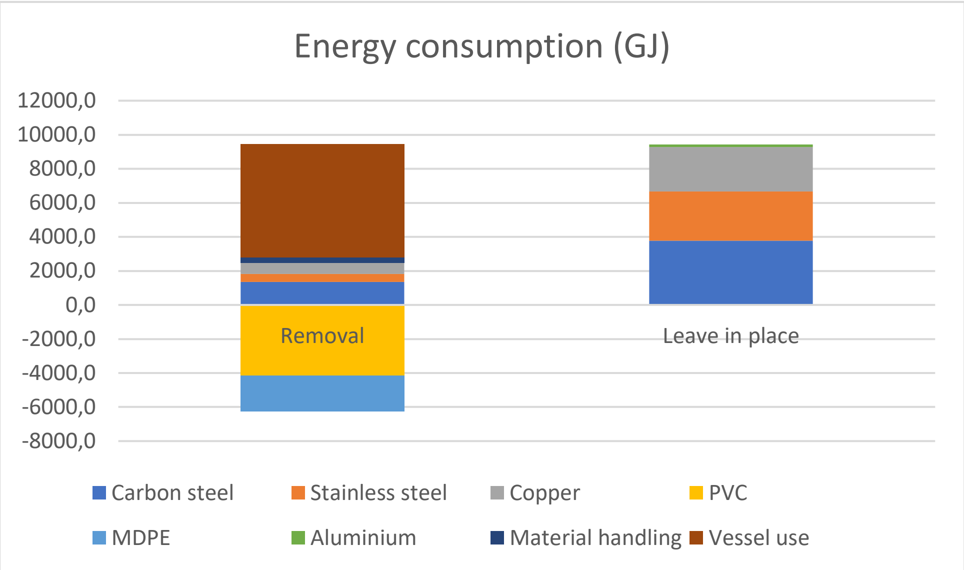

Figure 5-1. Energy balance for the two options.

[2] A reduced energy recovery rate to 70% will reduce the overall energy balance to 4370 GJ.

To avoid double-dipping to that of the energy balance, emissions to air are often considering the direct emissions only – not looking into the LCA perspective. With this approach the reference case has no emissions to air while the removal option (B) will have a CO2 footprint in the order of 895 tonnes. Obviously, this will highly depend on the energy source of metal processing plants etc. (which are out of study scope, hence generic data applied cf. Institute of Petroleum (2000)) and actual vessels being applied. CO2 emissions break-down per activity/metal processing are shown in Figure 5-2. The difference between the two removal options studied (de-burial and retrieval vs. pull out and retrieval) will be about 50-60 tonnes of CO2, however the “pull out” option is considered not applicable (ref section 3.2.2).

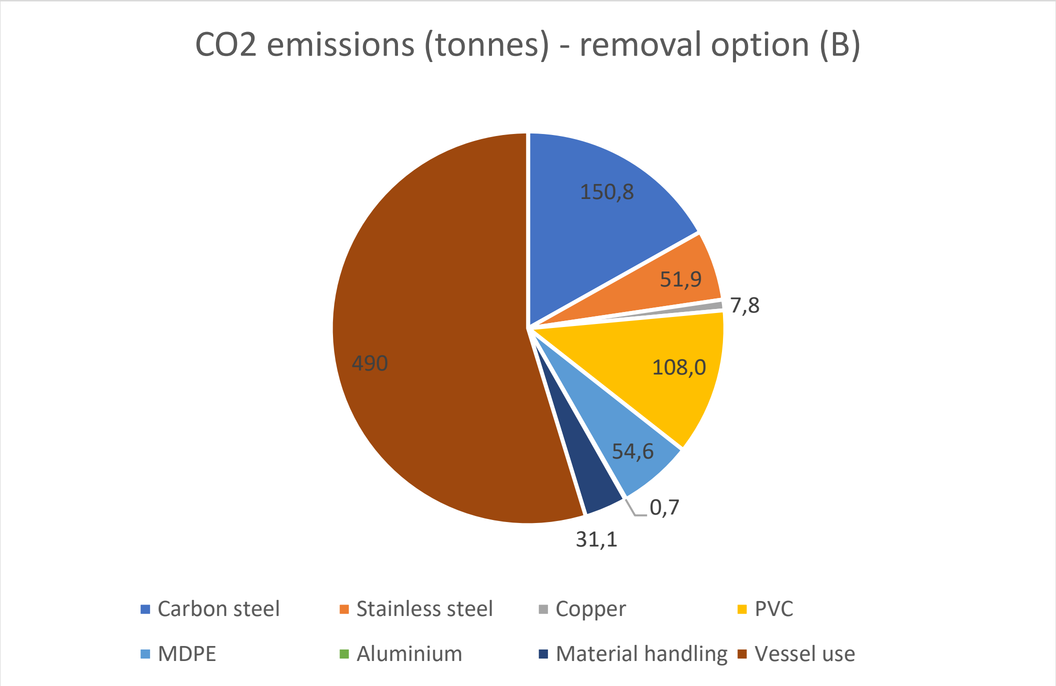

Figure 5-2. CO2 emissions for Option B with material and activity specific contribution.

5.2 Discharge to sea

Both the short and long-term perspective are considered of relevance.

The basis for the disposal work is that all lines are being cleaned except for the clogged scale inhibitor line.

An assessment of the chemical was given by Schlumberger to Spirit Energy which confirmed that the chemical is classified as Y2, yellow. The product is 10% active (polymer), remaining part water and MEG. The polymer is not easily degradable and will not have changed significantly since it was pumped into the line. The persistent part of the polymer is known, and it does not have any bioaccumulation potential, and it is not toxic to the environment in case of leakage. The degree of toxicity of the active component is EC50>600 mg/l. SI-4471 is a chemical still in use and updated documentation is available on all components and the product is approved for use in drinking water offshore.

Another issue being high on the environmental/society agenda is macro plastics pollution. This has been considered for the leave in place option.

5.2.1 Base case – leave in place (A)

When the umbilical is disconnected at the ends, the cable ends being buried and covered, the liquids within the individual lines will generally be stagnant as there is no flow through the system, nor any pressure or significant density differences. Only limited liquid migration at the ends of the scale inhibitor line can be expected, considered negligible due to the mentioned factors – and also the clogged pipe situation - ensuring an approximate liquid equilibrium. This stable situation will further prevent oxygen to enter the liquid phase from the ends (very little oxygen available ~0.5-1 m into the sediment), preventing natural degradation.

Degradation of the umbilical materials will be extremely slow as the materials are very persistent (plastics and stainless steel) and since the umbilical is buried and covered, buried stable in the seabed sediments. Previous studies have estimated pipeline/cable degradation time in the order of several hundreds to above a thousand of years (Jakobsen et al., 1998; DNV 1998). Since the chemical/hydraulic lines are made of stainless steel, corrosion will be very limited and slow under the prevailing environmental conditions.

The scale inhibitor is persistent however will degrade slowly in the very long-term perspective. No environmental effects are expected from these processes, as the liquid is contained and not toxic.

Secondary micro plastic pollution is related to physically eroded or chemically degraded plastic particles, with size generally less than 5mm. The small size of such plastic fragments gets them easily available for ingestion by different marine species, causing adverse effects on their health (Chatterjee & Sharma, 2019; de Sa et al., 2018). The Vale umbilical is buried, generally deep into the sediments. The plastics are persistent and their degradation into micro plastic particles will likely take centuries, especially considering the limited physical action in this sediment environment. The degradation will further take place generally in a sediment depth with no or limited biological activity. The risk of micro plastics from the degraded Vale umbilical becoming an environmental problem is considered very unlikely.

5.2.2 Removal option (B)

During retrieval some of the chemical inside the line may drain out and be released to sea. The total line volume is estimated to about 2.1 m^3 (Table 2-1), however as the line is both long and clogged, only the last part of the line being retrieved is expected drained out (0.1 litre/m). Based on the exo-toxicological information provided by Schlumberger, no measurable environmental effects are expected from such a minor release. The situation will, however, be subjected to an application and prior permit from the Norwegian Environment Agency.

5.3 Physical impacts

This aspect is relevant for the removal option (B) only.

De-burial of the umbilical including removal of natural overlying sediments and sections with rock fill will be performed along the entire route. Different methods exist for dredging seabed materials, most of which will apply suction or blow (water jetting) techniques - the removed sediments being suspended into the surrounding water masses before settling back on the seabed. The assumed technique is the “hydro digger/blower” which remove underlaying sediments/rock by jetting water downwards. It will generally spread sediment particles quite significantly in the water masses. It is expected that particles may be spread some tens of meters upward in the water masses and up to some hundreds of meters laterally (DNV GL 2018[3]; NOROG 2019).

Majority of the particles well re-settle in the vicinity (fines may spread widely), often expected to impact (>1mm sedimentation) at least an area of 5-10 m at each side of the trench (Intertek, 2017). The activity will leave a plough mark (suppression) but due to the jetting likely not with pronounced berms along the sides of the trench. The rock filling material will similarly be relocated locally, generally deposited closer to the trench (due to weight). Immediate environmental effects are increased turbidity in the water column, and smothering effects from re-settled sediments, terminating local immobile/slowly mobile organisms. However, natural fauna will re-establish within relatively short time, more rapid in a sandy environment compared with muddy environments (Dernie et al., 2003). In a silty-sandy environment as for Vale the seabed will gradually level out and stabilise within a few years’ time.

[3] Environmental monitoring during dredging (suction dredging) at Ekofisk and Valhall has documented sedimentation beyond 260 m, visually observed particle plume within about 50-100 m. For a blowing/jetting technique the spreading is likely more extensive.

5.4 Materials management

This aspect is relevant for the removal option (B) only.

It is assumed that the majority of the materials (all metals) can be material recycled (~75%), while plastics (~25%) generally will go to energy recycling as there may be a mix between different qualities/impurities preventing plastic recycling. It is further assumed that the plastic coating on the service line follows the steel pipe to the smelter, energy being released in the process. The amount of waste generated is considered limited and not quantified, will include removed concrete mattresses etc.

Table 5-1. Material inventory (tonnes dry weight in air).

Item	Material	Disposal solution	
		Recycling	**Energy recycling**
Umbilical	Stainless steel	51.9	
	Copper	26.1	
	Plastics		75.8
Service line	Steel with plastic sheet	150.8	5.5
	Aluminium	0.7	
Overall		229.5 (73.8%)	81.3 (26.2%)

5.5 Summary of comparative environmental assessment

The comparative environmental assessment of the two umbilical decommissioning alternatives has been undertaken addressing environmental risk, energy balance, CO_2 footprint, physical impact on the seabed and materials management. The chemical product in the plugged line is considered not to pose any particular environmental risk (it is not toxic but quite persistent), and will generally stay contained inside the pipe being slowly degraded over time. Environmental impacts of leaving the umbilical buried in place with the scale inhibitor line un-cleaned are hence considered negligible, both in the short and long-term perspective. The energy balance suggests that recovery of the umbilical may have net benefits from recycling of material such as plastic and steel. The CO_2 footprint of this option is however higher (~900 tonnes of CO_2) compared to leaving it in situ. The removal option will further have a physical footprint on the seabed from de-burial of the umbilical including rock relocation, with significant local and mainly temporary negative environmental effects. The physical footprint from leaving the umbilical in situ will be very limited and any micro plastic pollution effects is not considered likely. Removal to shore enables for recycling of the metals and energy recycling of the plastic materials, while leaving in place involves no material recycling.

The comparative environmental assessment reveals that leaving the umbilical in place has no significant impacts neither in the short nor long-term perspective. Removing the umbilical to shore has no obvious environmental benefit. Hence, there is no obvious best environmental solution (Table 5-2) and environmental aspects will thus not be the key factor in making a decision. Spirit Energy will do a holistic evaluation which will also include other factors as cost and risk in reaching a decision.

Table 5-2. Summary of comparative environmental assessment – green color illustrating the best performance on the actual environmental aspect. No cross ranking performed.

Environmental aspect	Disposal options	
	Leave in place	**Removal to shore**
Environmental risk	Low environmental risk in bort short and long-term	Low short -term environmental risk
Energy balance		Best energy balance however with uncertainties to actual performance
Emissions to air (CO2 footprint)	No emissions	~900 tonnes of CO2 emissions
Physical impact	No impact	Significant local impacts
Material management	No material recycling	High percentage material recycling

6 REFERENCES

Chatterjee, S. and S. Sharma, 2019. Microplastics in our oceans and marine health. The journal of field actions, special issue 19/2019: Reinventing plastics.

De Sa, L.C., M. Oliveira, F. Ribeiro, T. L. Rocha, M. N. Futter, 2018. Studies of the effects of microplastics on aquatic organisms: What do we know and where should we focus our efforts in the future? Science of The Total Environment, Volume 645, 15 December 2018, Pages 1029-1039

DERNIE, K. M., M. J. KAISER and R. M. WARWICK, 2003. Recovery rates of benthic communities following physical Disturbance. Journal of Animal Ecology, 2003, 72, 1043–1056.

DNV 1998. Leaving Ekofisk I pipelines in place. Disintegration hypothesis and impact assessment. DNV report No. 98-4040.

DNV GL 2018. ENVIRONMENTAL MONITORING AT EKOFISK 2/4 A. Results from environmental monitoring of drill cuttings relocation. Report No.: 2018-4086.

Institute of Petroleum (London), 2000. Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in Removal & Disposal of Offshore Structures, ISBN 0 85293 255 3.

Intertek 2017. Modelling of Sediment Disturbance During Trenching of the Proposed Viking Link Interconnector.

Jacobsen M., Egelund M, Hovdan H and J.P Aabel, 1998. Nedbrytning av rørledninger over tid. Report from Dames & Moore to the Ministry of petroleum and Energy.

Ministry of Petroleum and Energy, 1999. Disposal of discarded pipelines and cables on the Norwegian continental shelf.

Nesse and Moltu, 2012. “Frigg cessation project. Environmental footprint and EIA comparison”. SPE 157361 (rev 1).

Norsk Olje og Gass, 2019. Handbook. Species and Habitats of Environmental Concern. Mapping, Risk Assessment, Mitigation and Monitoring – In relation to Oil and Gas Activities. Report Nr.: 2019-007.

Norsk Olje og Gass, 2020. Handbook. Impact assessment for offshore decommissioning. Decommissioning and final disposal of redundant offshore oil and gas facilities.

Spirit Energy, 2019. Vedlegg til søknad om fritak for konsekvensutredning i forbindelse med avslutning av Vale. Vurdering av eventuelle virkninger for nærings- og miljømessige forhold.

APPENDIX A. VESSEL ACTIVITY BREAKDOWN

(data provided by Spirit Energy)

Option 1 - Campaign 1 - De-Burial - Light Construction Vessel					
No.	**Description**	**Productivity**	**Unit**	**Time (hr)**	
1	Mobilisation & Transit			34	
2	Deployment of hydro digger / blower			6	
3	De-burial of the umbilical	400	m/hr	41,9	
4	Transit and demob			28	
5	Waiting on weather (15%)	15	%	7,2	
			Total	**117**	4,9

Option 1 - Campaign 2 - Umbilical Recovery - Medium Construction Vessel					
No.	**Description**	**Productivity**		**Time**	
1	Mobilisation & Transit			46	
2	Survey the line	1200	m/hr	13,95417	
3	Disconnect the umbilical at the XMT and cap it.	12	pc	24	
4	Recover 1st end to the vessel and secure to the reel(s)			12	
5	Recover the 16.5 km of umbilical and service line	600	m/hr	27,9	
6	Pay out from the topside and			12	
7	Recover 2nd end to the vessel and secure to the reels(s)			12	
8	Transit and demob			28	
9	Waiting on weather (15%)	15	%	15,3	
			Total	**191**	8,0

LCV Fuel Consumption - Port 3 mt/day. Transit 20 mt/day. DP Operations 7 mt / day.

MCV Fuel Consumption - Port 4 mt/day. Transit 35 mt/day. DP Operations 15 mt / day.

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