Development Plan Amendment

Use of Stand-Alone Subsea Trees in the White Rose and North Amethyst Fields

Volume 2 – Environmental Assessment Overview

September 2023

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Table of Contents

1.0 Introduction 3
2.0 Project Description 4
2.1 Stand-alone XMT Well Design 4
2.2 Well Construction and Abandonment Operations 5
3.0 Environmental Assessment Overview 6
3.1 Accidental Event Scenarios Associated with Development Drilling, Workovers and Production 9
4.0 Summary of the Assessment of Environmental Risk Criteria and Reliability Targets 10
5.0 References 14

List of Figures

Figure 1 EDC Well Completion Design and Concept SA XMT Well Completion 4

List of Tables

Table 1 Potential Environmental Effects Assessment Summary for Fish and Fish Habitat – Potential Future Activities * 8
Table 2 Predicted Probabilities of Production Blowouts (from WREP EA Table 3-60) 9
Table 3 - Annual Target Reliability and Calculated Reliability of EDC and SA XMT Developments 12

1.0 Introduction

The original White Rose field underwent an environmental assessment in 2000 pursuant to the *Canadian Environmental Assessment Act* (S.C. 1992, C.37) as a comprehensive study (White Rose EA). The original project assessed the construction and operational activities associated with three drill centres and up to 25 wells. In 2007, a further environmental assessment was undertaken on activities associated with drilling of up to 54 wells, construction of up to five additional drill centres and associated flowlines under Husky White Rose Development Project: New Drill Centre Construction and Operations Program Environmental Assessment (New Drill Centres EA: LGL 2006 and 2007). To date, 45 of those 79 wells have been completed within five drill centres.

On May 28, 2012, Husky Energy submitted a Project Description to initiate the White Rose Extension Project Environmental Assessment (WREP EA) to the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB). The C-NLOPB was the Responsible Authority, and the EA was completed in 2013 under *CEA Act* (S.C. 1992, c. 37) as a screening level of assessment pursuant to subsections 124(2) and 14(2) of CEAA 2012. In addition to development of West White Rose, the WREP EA assessed potential future activities including excavating and installing up to two additional drill centres (note these had been previously assessed under the New Drill Centres EA), geotechnical and geohazard surveys.

As a condition of approval for environmental assessments, the C-NLOPB requires that Cenovus Energy provide an outline of proposed activities, confirm that the proposed program activities fall within the scope of the previously assessed program, and whether the EA predictions remain valid.

This EA summary demonstrates the assessment of all activities associated with drilling and operation of a Stand-Alone Christmas Tree (SA XMT).

Following the approval of this Development Plan Amendment, Cenovus will submit a separate application for specific program authorizations within which a review of EA predictions will be conducted and updated as required to assess if they remain valid. Cenovus will provide information regarding the adaptive management of requirements in the *Species at Risk Act* into program activities (e.g., introduction of new species or critical habitat to Schedule 1; additional mitigations; implementation of recovery strategies and/or monitoring plans).

2.0 Project Description

2.1 Stand-alone XMT Well Design

The SA XMT well design is proposed as an alternative means of field development in lieu of excavated drill centres (EDCs), whilst providing an equivalent level of environmental protection.

Drilling and completion of SA XMT wells will be carried out using the existing White Rose and North Amethyst procedures and standards. However, an enhanced completion barrier design can achieve the same reliability target as the existing subsea well system placed in EDCs. Maintaining placement of the components critical to integrity at a depth below the natural seabed is necessary to ensure that iceberg contact loading does not compromise the integrity of the barriers in the enhanced downhole completion (Figure 1).

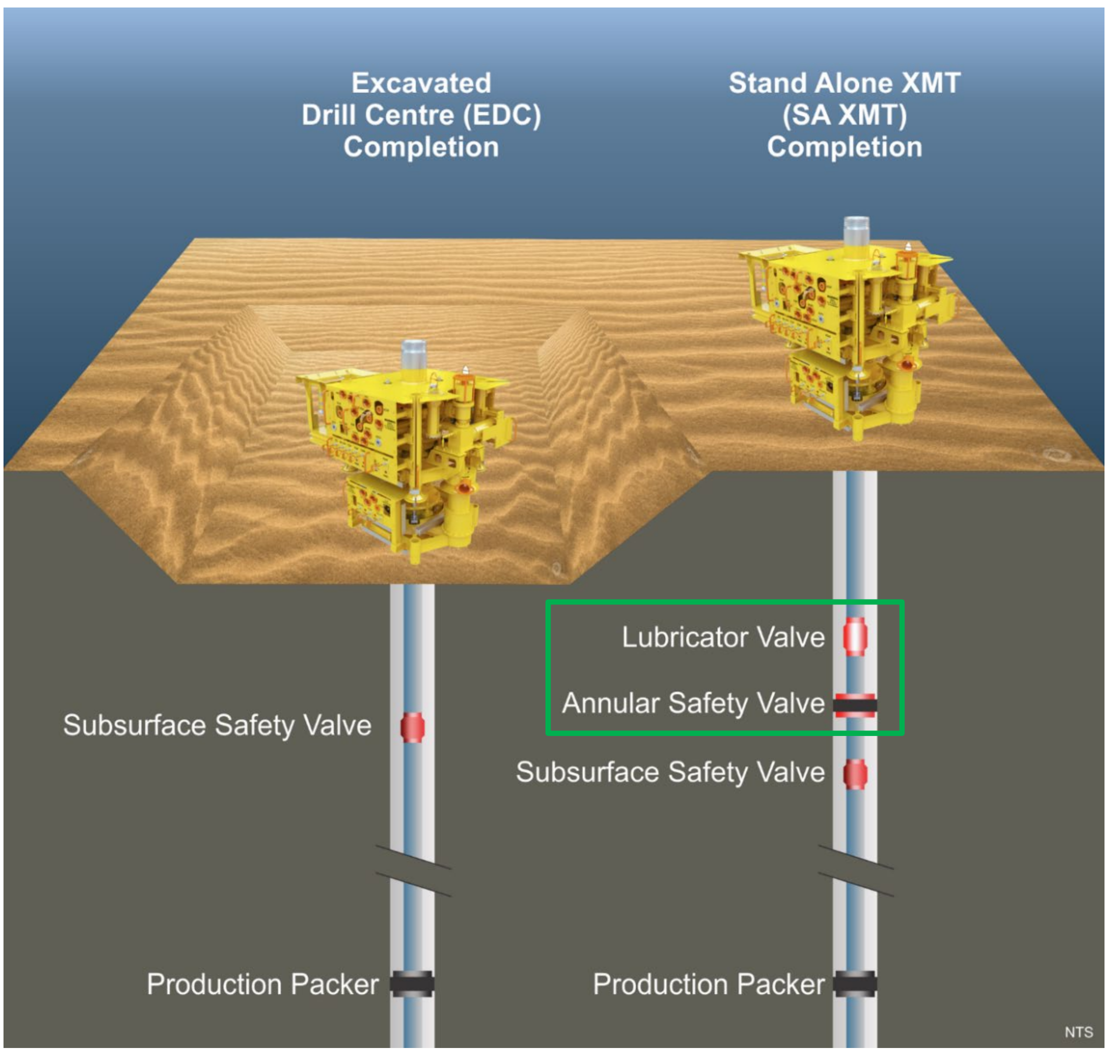

Figure 1 EDC Well Completion Design and Concept SA XMT Well Completion

Most components in the completion design shown above are similar to those used in White Rose EDC wells. The key enhancements of the SA XMT well are achieved by using the following additional equipment in the well completion:

- A lubricator valve, and
- An annular safety valve.

In the unlikely event that wellhead integrity is compromised by iceberg impact, the well will remain isolated by the additional downhole barriers deep below the seabed.

The SA XMT well completion design has been assessed to demonstrate that an equivalent reliability target in terms of environmental protection from oil spills can be achieved using either EDCs or enhanced downhole barriers in the SA XMT wells.

2.2 Well Construction and Abandonment Operations

Activities associated with drilling an SA XMT well are the same as drilling a well in an EDC, except for the down-hole completion, as outlined above. SA XMT wells will be drilled by a Mobile Offshore Drilling Unit (MODU) using accepted drilling methods and technologies. There are no changes to previously assessed emissions and discharges. Water-Based Mud (WBM) and Synthetic-Based Mud (SBM) cuttings will be released from the MODU per Cenovus's Environmental Protection and Compliance Monitoring Plan (EPCMP). MODU deck drainage, bilge and ballast water will be treated and discharged in accordance with the EPCMP.

Requirements for geophysical surveys (e.g., wellsite/vertical seismic profile (VSP) surveys) have not changed from those assessed within the White Rose Field. Well testing will be conducted in accordance with the C-NLOPB's *Drilling and Production Regulations*, as previously assessed.

Cenovus maintains logistical support to its offshore installations; the *SeaRose Floating Production, Storage, and Offloading (FPSO)* vessel and chartered Mobile Offshore Drilling Unit (MODUs). Key areas of support during operation and maintenance of both development options include shore-based marine logistics, warehouse services, personnel transportation, supply and standby vessels, communications, ice management services, marine fuel supply, waste management, medical services, and weather forecasting.

In the unlikely event of direct iceberg impact on a SA XMT well, the well would likely be abandoned. If required, the XMT and existing wellhead can be removed via a Remotely Operated Vehicles (ROVs) cutters and retrieved by crane from a vessel once the area around the wellhead has been cleared by an ROV dredger. The casing can then be prepared, and a remediation wellhead installed. The remediation wellhead will interface with pressure control equipment and allow for well abandonment by pumping down the annulus to kill the well, setting of cement plugs and pulling tubing as per current industry regulations. If the depth of casing deformation is too deep for dredging to be practical, a relief well will be drilled. Relief well plans will be developed, and dynamic kill analyses will be performed at the design phase of the well per the current standards for Cenovus well design.

3.0 Environmental Assessment Overview

The physical activities associated with drilling and completing a SA XMT well are the same as those required for a well located within an EDC. The assumptions and predictions made within the above referenced EAs remain valid. Each of the environmental assessments within the White Rose field considered the following drilling activities:

- Presence and operation of a MODU (presence of structure; safety zone; lighting; drilling; air emissions; noise emissions; chemical use and management; operation of seawater systems; water management, well testing; cementing and completing wells).
- Drilling-associated surveys (VSP and wellsite surveys; geotechnical / geophysical / environmental surveys; diving surveys; ROV surveys).
- Waste management (WBM and SBM cuttings discharge; domestic waste; sanitary waste; oily water treatment; cooling water; deck drainage; bilge water; BOP (Blow Out Preventors) fluid; cement; vent and flare system).
- Supply and servicing (operation of helicopters and supply / support / standby / tow vessels within the Project Area).
- Well abandonment (plugging, suspending, and abandoning of wells).

The potential environmental effects of these activities were evaluated for each of the selected Valued Ecosystem Components (VECs). The VECs within the WREP EA include Air Quality, Fish and Fish Habitat, Fisheries, Marine Birds, Marine Mammals and Sea Turtles, Species at Risk and Sensitive Areas. The purpose of an environmental assessment is to determine if the activities are likely to result in a significant adverse residual environmental effect, as considered through the VECs.

The WREP EA assessed potential activities outside the development of West White Rose, including up to two additional drill centres with 16 wells each, the installation of associated infrastructure and associated surveys. Potential future assessed within the WREP EA include:

- Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving).
- Excavation of drill centres (including disposal of dredge spoils).
- Noise from drilling from MODU at potential future subsea drill centres.
- Water-based mud and synthetic-based mud drill cuttings.
- Installation of pipeline(s)/flowline(s) and testing from drill centres to FPSO, including flowline protection; and
- Chemical use and management (e.g., BOP fluids, well treatment fluids, corrosion inhibitors).

The WREP EA also assessed future activities within each of the VEC (Valued Ecosystem Components) chapters. As an example, Table 1 is the assessment summary table for the Fish and Fish Habitat VEC. This list of activities would apply to the SA XMT concept, and the conclusion of the assessment would not change, except for excavation/dredging activities associated with an EDC well. The dredging interactions assessed within the WREP EA include:

- Dredge spoil discharge.
- Air emissions.
- Bilge/ballast water.
- Storm water, potable water, fire water and industrial water.
- Noise (including underwater noise); and
- Solid, construction, hazardous, domestic, and sanitary waste disposal.

The decommissioning and abandonment of any wells drilled in a SA XMT development mode will be in accordance with the approved White Rose Decommissioning and Abandonment Plan.

Table 1 Potential Environmental Effects Assessment Summary for Fish and Fish Habitat – Potential Future Activities *

WREP Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation Measure	Evaluation Criteria for Assessing Environmental Effects [(A)]						Significance Rating	Level of Confidence
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological / Socio-cultural / Economic Significance		
Excavation of drill centres (including disposal of dredge spoils)	Change in habitat quality (N) Change in habitat quantity (N) Potential mortality (benthos) (N)	• Use of industry best practices and improvement programs • Compliance with terms of Section 32 *Fisheries Act* Authorization	L	2	1	2	R	3	NS	H
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	Change in habitat quality (N)	• Adherence to the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2012d)	L	1	2	2	R	3	NS	M
Noise from drilling operations from MODU at potential future subsea drill centres	Change in habitat quality (N)	• Use of industry best practices and improvement programs	L	2-3	6	5	R	3	NS	H
WBM and SBM cuttings	Change in habitat quality (N) Change in habitat quantity (N) Potential mortality (benthos) (N)	• Use of industry best practices and improvement programs • Adhere to OWTG • Compliance with terms of Section 32 *Fisheries Act* Authorization	L	2	6	5	R	3	NS	H
Installation of pipelines/ flowlines and testing from drill centres to FPSO including flowline protection	Change in habitat quality (N) Change in habitat quantity (N)	• Use of industry best practices and improvement programs • Minimize seabed disturbance	L	3	1	2	R	3	NS	H
Chemical use and management	Change in habitat quality (N)	• Use of industry best practices and improvement programs • Adhere to OWTG	N	1	6	5	R	3	NS	H

KEY:

Magnitude:
N = Negligible (essentially no effect)
L = Low: <10 percent of the population or habitat in the Study Area will be affected
M = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
H = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km radius
2 = 1 to 10 km radius
3 = 11 to 100 km radius
4 = 101 to 1,000 km radius
5 = 1,001 to 10,000 km radius
6 = >10,000 km radius

Frequency:
1 = <11 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/year
4 = 101 to 200 events/year
5 = >200 events/year
6 = continuous

Duration:
1 = <1 month
2 = 1 to 12 months
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Reversibility (population level):
R = Reversible
I = Irreversible

Ecological/Socio-cultural/Economic Significance:
1 = Relatively pristine area not affected by human activity
2 = Evidence of existing adverse activity
3 = High level of existing adverse activity

Significance Rating:
S = Significant
NS = Not Significant
P = Positive

Level of Confidence:
L = Low level of confidence
M = Medium level of confidence
H = High level of confidence

(A) Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

* Example - Table 8-11 (p. 8-74) from Husky Oil Operations Limited White Rose Extension Project Environmental Assessment, CEAR No. 12-01-68249 (https://www.cnlopb.ca/wp-content/uploads/whiterose/wrepea_p3.pdf)

3.1 Accidental Event Scenarios Associated with Development Drilling, Workovers and Production

The WREP EA assessed two types of accidental events during drilling and production operations: blowouts and "batch" spills. Blowouts are continuous spills that can last hours, days or weeks. These spills involve the discharge of large volumes of associated gas into the atmosphere and discharge of crude oil and gas condensate (a very low viscosity, highly volatile type of liquid petroleum oil) into surrounding waters. Batch spills are instantaneous or short-duration discharges that could occur from accidents on the production platforms where hydrocarbon are stored and handled.

Based on global data, it was concluded that blowouts associated with development drilling operations that resulted in extremely large spills (>150,000 bbl.) occurred at a frequency of 1.16×10^{-5} (1/85,796 development wells drilled), and blowouts resulting in very large spills (>10,000 bbl.) occurred at a frequency of 4.66×10^{-5} (4/85,796 development wells drilled). Similarly, blowouts associated with production and workover activities that resulted in extremely large spills occurred at a frequency of 5.71×10^{-6} blowouts/well-year (2/350,000 well-years), and for very large spills, at a frequency of 1.71×10^{-5} (6/350,000 well-years)(Table 2).

Table 2 Predicted Probabilities of Production Blowouts (from WREP EA Table 3-60)

Event (Numbering per WREP EA Table 3-60/Consolidated Responses Table 7)	**Historical Frequency**
2. *Blowout during production involving some hydrocarbon discharge >1 bbl.*	2.8×10^{-5} / yr.
5. *Production / workover blowout with hydrocarbon spill >10,000 bbl.*[1]	1.71×10^{-5} / yr.
6. *Production / workover blowout with hydrocarbon spill >150,000 bbl.*	5.71×10^{-6} / yr.

[1] Frequency revised from 1.4×10^{-5}/yr in WREP EA Table 3-60 to 1.71×10^{-5}/yr in Table 7 of WREP EA Report Addendum – Response to comments

Similarly, as the physical activities associated with drilling and completing a SA XMT well are the same as those required for a well located within an EDC, the accidental event scenarios assessed within the WREP EA apply to a SA XMT well design.

4.0 Summary of the Assessment of Environmental Risk Criteria and Reliability Targets

Subsea wells on the Grand Banks are at potential risk to freely floating and scouring icebergs. Prior to development of the Terra Nova and White Rose fields, the iceberg risk and associated minimum acceptance criteria for the deployment of subsea wells was evaluated. The Canadian Standards Association S471-92 risk criteria and design strategies were followed, and any contact of a wellhead from an ice scour was considered as a Safety Class 1 event, i.e., great risk to life or high potential for environmental pollution or damage requiring an annual target reliability of 10^{-5} (Note: Within the frequency range of a very large spill described above).

The original White Rose Development Plan applied CAN/CSA-S473-92 Safety Class 1 as the design criteria for the protection against iceberg scour and included the functional criteria that:

> "Subsea wellheads will be located in glory holes [EDCs] to protect them from iceberg scour. Equipment within the glory hole will be designed such that the top is a minimum of 2 to 3 m below the mudline".

The White Rose Development Plan Vol. 5 (Concept Safety Analysis) established the environmental risk criteria that must be adhered to in the project and stated:

> "The environmental risk associated with iceberg scour of the subsea wells and pipelines is considered insignificant based on the following:
>
> - subsea wells will be submerged below the seabed in glory holes and therefore, any iceberg scour will pass over the top of the wellheads.
> - subsea pipelines are assumed to be trenched below the seabed so that the pipelines will also be protected against any iceberg scour; and
> - in the event that pipelines are not buried to be free from the risk of scour damage (for example, due to trenching difficulties), then a policy of isolating and purging the pipelines will be adopted, should an iceberg of potential scouring draft approach."

It was concluded that "the environmental risk associated with iceberg scour of subsea wells and pipelines was insignificant based on the subsea wellheads will being submerged below the seabed in glory holes and any iceberg scour will pass over the top of the wellheads… with the top of the equipment a minimum of 2 to 3m below the mudline".

The CAN/CSA-S470 series of standards was superseded by the CSA ISO 19900 series of standards as the relevant standard for design considerations in ice prone environments. CSA ISO 19906 references ice gouging, operational procedures to reduce ice actions, such as ice management, and risk reduction for subsea system components using downhole safety valves, which were not considered as mitigating factors in the original assessment as CSA S471 Safety Class 1. For subsea wellhead systems, which are unmanned, the consequence category can be C1 (High), C2 (Medium) or C3 (Low), with the respective exposure levels L1, L2 and L3 having annual target reliabilities of 10^{-5}, 10^{-4}, or 10^{-3}. The exposure level L1 is selected based on the previously assumed high consequence category and aligns with the CSA S471 Safety Class 1 designation for the original Development Application.

The Development Plan Amendment process for SA XMTs has evaluated design performance against the original assumptions to determine if an annual reliability target of 10^{-5} can be achieved, by assessing:

- Up-to-date iceberg patterns and contact frequencies – Based on the data available at the time used in the EDC development (e.g.: International Ice Patrol / Shipping data), conservative assumptions on contact rates were used. Using industry specific ice data from over 25 years of operations, iceberg contact frequency analyses have shown a reduction in expected contact rates. Further information can be found in section 8.1 (Iceberg Contact Rates) of Volume 1 of this application.

- Ice Management Programs – Ice Management was not accounted for as a mitigation in the assessment of iceberg contact rates for EDC developments. Using the results of actual ice management activities over the last 30 years, the ice management success rates have been incorporated into the analysis in accordance with CSA ISO 19906. Further information can be found in section 8.2 (Effectiveness of Ice Management in Mitigating Ice Contact) of Volume 1 of this application.

- Iceberg loads on stand-alone trees and downhole stresses on completion components – For EDC developments, the original conservative assumption was that any iceberg contact would compromise all well barriers required to isolate the well. Analysis of the downhole stresses transferred to the downhole barriers following iceberg contact, show that the downhole barriers will maintain their integrity. Further information can be found in section 8.3 (Effects on Downhole Completion Following Iceberg Contact) of Volume 1 of this application."

- Reliability of additional downhole barriers – The reliability of the downhole barriers to isolate the well in the event of iceberg contact was determined to be 92.2%, which meets the L1 criteria for development scenarios assessed. Further information can be found in section 8.4 (Barrier Reliability in Isolating the Well Downhole) of Volume 1 of this application.

Analysis of the SA XMT enhanced well design demonstrates that this approach to iceberg protection achieves the same annual target reliability as the placement of wells below the seabed in EDCs.

The annual reliability of 10^{-5} for the SA XMT well completions design expressed the number of failures resulting environmental release following iceberg contact is below the historic frequencies of blowout during production involving some hydrocarbon discharge. This is outlined in section 3.6.6 (Summary of Blowout and Spill Frequencies) of the WREP EA and Table 10 of the Consolidated Response to Review Comments on the White Rose Extension Project Environmental Assessment and Addendum.

Table 3 - Annual Target Reliability and Calculated Reliability of EDC and SA XMT Developments

Design Criteria / Development Mode	Annual Reliability (yr^{-1})	Return Period
CSA S471 Safety Class 1 / CAN ISO 19906 Exposure Level 1 Target	$< 1.0 \times 10^{-5}$	< once in 100,000 years
EDC Average (excl. NDC) (70m x 45m footprint @120m water depth)	3.1×10^{-6}	Once in 322,581 years
16 Well SA XMT Development (75m x 40m footprint @ 120m water depth)	3.2×10^{-6}	Once in 312,500 years
16 Well SA XMT Development (75m x 40m footprint @ min. WRF water depth)	3.9×10^{-6}	Once in 256,410 years
1 Well SA XMT Development (5m x 10m footprint @ max. WRF water depth)	7.9×10^{-7}	Once in 1,265,823 years

The frequency of a leak path developing due to completion failure (e.g. probability of downhole completion barrier failure in the well) was combined with the mitigated iceberg contact rates (e.g. with ice management) to determine the overall frequency of environmental release (Kent 2023) presented in Table 3.

The fault tree assessment (Kent 2023) shows that the probability of successful isolation of the well is expected to be 92.1% for the SA XMT wells. Combining this probability of successful isolation with the lowest frequency of iceberg contact (1 well SA XMT development at the maximum White Rose Field (WRF) water depth) and the highest frequency of iceberg contact (16 SA XMT well development at the minimum WRF water depth) gives a range of environmental release frequencies of between 7.92×10^{-7} and 3.88×10^{-6} per annum respectively. These frequencies are much lower than the L1 criterion.

Historically, the downhole barriers (i.e. TRSCSSV and production packer) in EDC wells was assumed to have been compromised following contact with an iceberg. To provide a more direct performance comparison between the EDC well and the SA XMT well, the reliabilities of current EDC well design and the SA XMT well design were analyzed using the same methodology.

The most comparable cases would be the average of the EDCs (excluding NDC due to its much smaller size than the other EDCs) and the 16 well SA XMT development (75m x 40m at 120m water depth) with annual frequencies of environmental releases of 3.1×10^{-6} vs. 3.2×10^{-6} respectively. The release rates for these comparison cases are an order of magnitude below the L1 criteria $<10^{-5}$, with the differences in the cases being considered insignificant in the range of 10^{-7}.

Based on the most up-to-date iceberg data collected from decades of continuous offshore operations, and using thorough engineering analysis, the SA XMT concept has been evaluated for use in a variety of development sizes and water depths in the White Rose area. Based on these evaluations, the SA XMT concept has demonstrated that it can achieve the same level of environmental protection, with the chances of environmental release ranging from 3.9×10^{-6} per annum to 7.9×10^{-7} per annum (Kent 2023).

The SA XMT design utilizes proven equipment and builds on the most up-to-date data to establish an alternate development concept that broadens the available options as the industry evolves while maintaining environmental safety standards.

The approval of this Development Plan Amendment establishes the SA XMT design as an acceptable development concept within the Field. Application for the use of SA XMT in the development of specific resources would be subject to additional approval through a separate Development Plan or Development Plan Amendment. The analysis of SA XMT concept in this application provides a basis for the evaluation of the future use of this subsea development approach.

The proposed use of SA XMTs would not result in any changes in the original environmental effects predictions, required mitigation or associated determinations related to environmental effects significance for any component of the environment.

5.0 References

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