TECHNICAL REVIEW OF PROJECT-SPECIFIC DRILL CUTTING DISPERSION MODELLING FOR TILT COVE EXPLORATION DRILLING PROJECT ENVIRONMENTAL IMPACT STATEMENT

Context

Suncor Energy (the Proponent) has proposed to carry out exploratory drilling in the Newfoundland Region. Specifically, the Proponent proposes to conduct its work in Tilt Cove, located approximately 325 km east southeast of St. John's, Newfoundland on the eastern edge of the Grand Banks and approximately 100 km west of the Flemish Pass. The Proponent submitted an Environmental Impact Statement (EIS) to the Impact Assessment Agency of Canada (IAAC) for review, who subsequently submitted the document to Fisheries and Oceans Canada (DFO) through the Fish and Fish Habitat Protection Program (FFHPP).

FFHPP is requesting that Science undertake a technical review of the project-specific drill cutting dispersion modelling from the Tilt Cove Exploration Drilling Project, which is appended to the EIS document. In particular, a review of the scientific merit of the information presented and the validity of the Proponent's methodologies and conclusions.

In accordance with the legislative provisions of the *Canadian Environmental Assessment Act* (CEAA 2012), DFO is required to provide specialist or expert information or knowledge, pertaining to the Department's mandate, with respect to a designated project that is subject to an environmental assessment.

The submission consists of the following document: Appendix C – Suncor Energy Offshore Exploration Partnership Tilt Cove Exploration Drilling Project (2019–2028) Drill Release Risk Assessment.

The objective of the Science Response Process is to provide project-specific advice on the following questions:

- Is the information provided in the modelling report complete and based on the most recent information available?
- Are the methods used and assumptions made adequate, do they present the current state of knowledge and are they adequately described and incorporated in the conclusions?

This Science Response Report results from the Regional Peer Review: Technical Review of Project-Specific Drill Cutting Dispersion Modelling for Tilt Cove Exploration Drilling Project Environmental Impact Statement, which was held on March 30, 2023.

Analysis and Response

The comments provided by DFO Science, NL Region as requested by the Fish and Fish Habitat Protection Program (FFHPP) are specifically related to the Drill Release Risk Assessment

Appendix C in Suncor Energy Offshore Exploration Partnership Tilt Cove Exploration Drilling Project (2019–2028) (Suncor Energy 2019).

General Comments

In general, this assessment has unclear and confusing methodological details. There are some assumptions made without clear rationale, or used incorrectly to minimize potential impact of exploration drilling.

The authors hired by the Proponent focus the analysis of HYCOM (Hybrid Coordinate Ocean Model) currents on a 7-year period from 2006 to 2012 to conclude that 2012 is a representative year. However, 7 years is not long enough to characterize the variability of the system which is known fluctuate on decadal time scales (see Han et al. 2014). An assessment of how representative 2012 is for the entire period is not demonstrated. A more appropriate methodology would have been to simulate discharge scenarios using historical data from a longer period (performing tens or hundreds of simulations) and then comparing statistical representations of the different results to highlight the most probable scenarios (e.g., there is X% chance that the area exceeding a certain thickness threshold is less than Y km^2). As a matter of fact, there is a significant difference between the two scenarios modeled (Figures 1 and 2 [Figures 3-1 and 3-2 in Suncor Energy 2019]), which implicitly increases the need for more simulations of all possible scenarios.

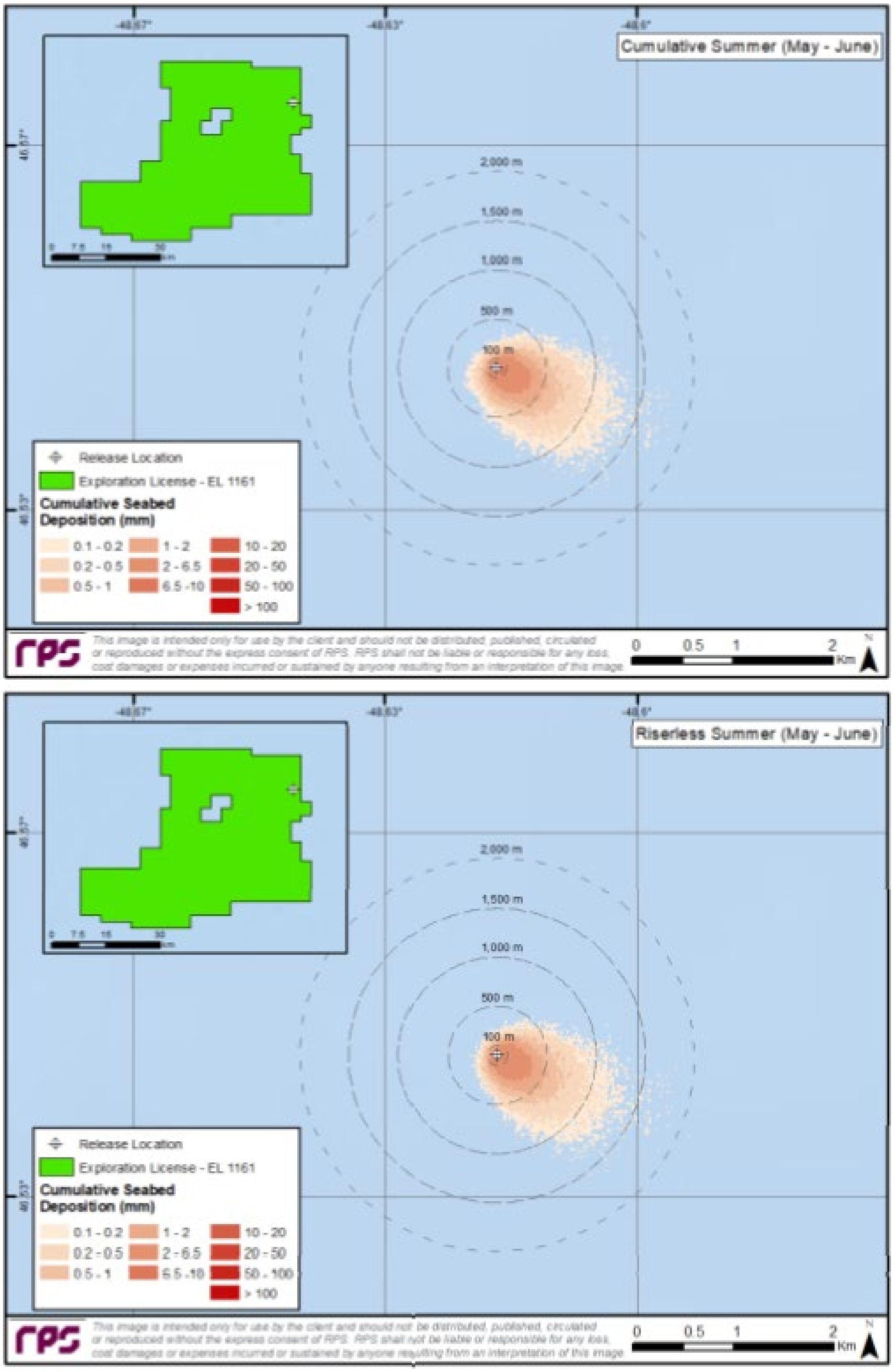

Figure 1. Scenario 1: Predicted thickness of seabed deposition of discharged mud and cuttings resulting from all drilling sections (top) and from only the riserless drilling sections (bottom) during the summer at EL 1161 (Suncor Energy 2019).

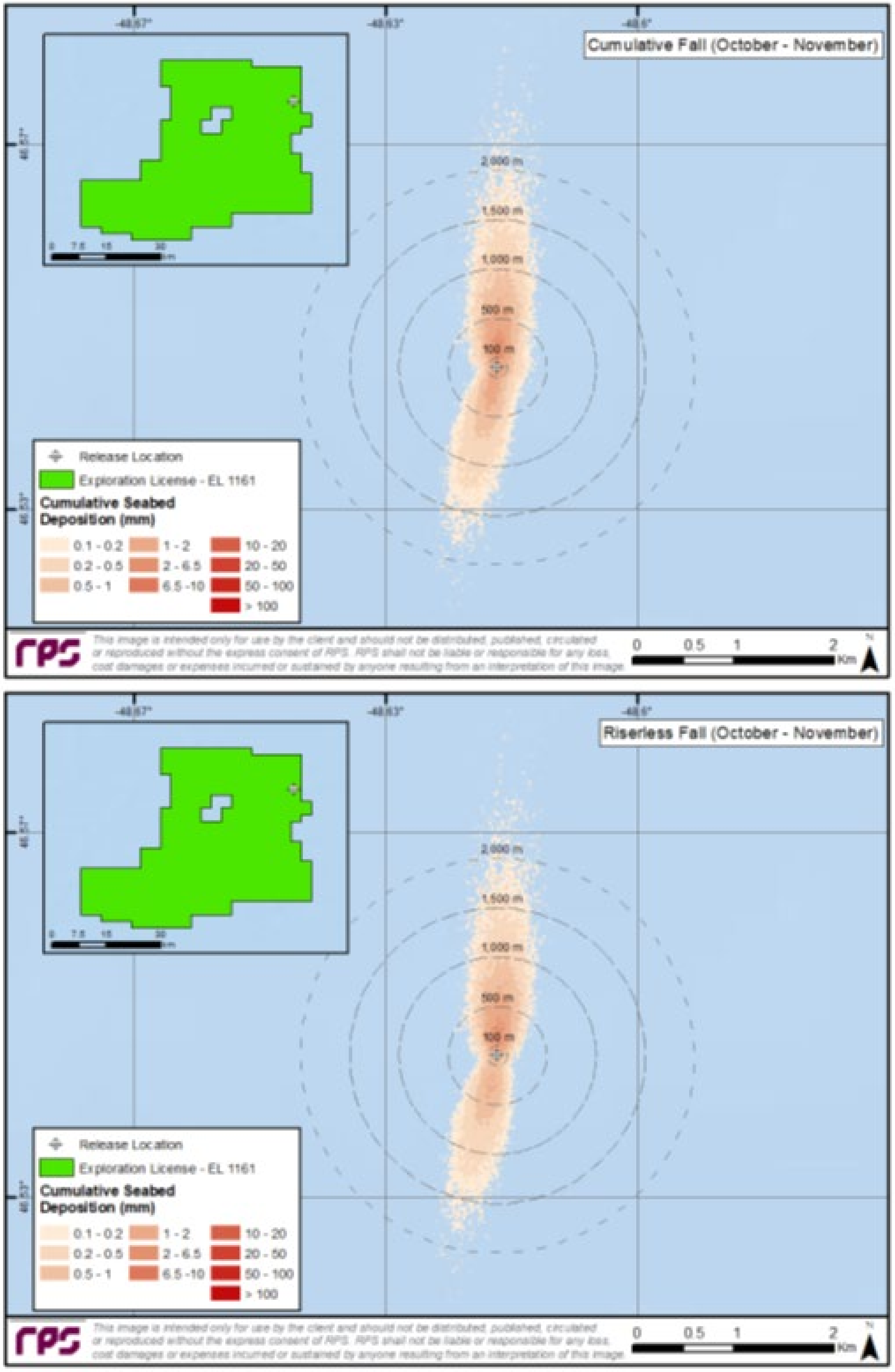

Figure 2. Scenario 2: Predicted thickness of seabed deposition of discharged mud and cuttings resulting from all drilling sections (top) and from only the riserless drilling sections (bottom) during the fall at EL 1161 (Suncor Energy 2019).

Further, given that this report was written in 2019, it can be concluded that the information provided in this report is not based on the most recent information available. Subject matter experts suggested that the quality of the risk assessment would have been improved by extending data analyses to 2019. An assessment of HYCOM would be beneficial (quantification of how well the model represents reality). HYCOM uses Mercator projections between 78°S and 47°N latitude and a bipolar patch for regions north of 47°N to avoid computational problems associated with the convergence of the meridians at the pole. Since the simulations provided by the Proponent are very close to 47°N, it should be considered whether this grid patching/merging has an effect on the quality of the current forcing at this latitude.

It is not clear how the discharge simulations are performed. It would appear that one simulation is done for the summer (May-June) and one for the fall (October-November). For each simulation, the cuttings/muds are released for 16.5 days over the course of 27 days, and then the model is kept running for another month to allow for the particles to settle. The specific dates of the simulations were not provided.

With regards to simulations, page 15 of Suncor Energy (2019) states, *"One deterministic simulation was performed for each of the five (5) drilling sections for both of the seasonal scenarios, totaling twenty (20) individual simulations.*" It is unclear how this equates to 20 simulations (5 stages x 2 seasons should equal 10 simulations).

It causes concern if these individual simulations aim to represent the same scenario (summer or fall), and how cumulative effects are taken into account.

There are few details provided with regards to the MUDMAP dispersion model (a personal computer-based model developed by RPS [formerly Rural Planning Services] to predict the near and far field transport, dispersion and bottom deposition of drill muds and cuttings and produced water). It is said to be based on integral plume theory but no reference and/or equations are provided. The risk assessment also states, "*The equations and solutions in MUDMAP are based on thirty years of research and the model is regularly updated as new scientific research is presented*", but the references are mostly based on industrial reports rather than peer-reviewed literature. The authors do provide examples of validation of the model, but these are either from different environments (e.g., from mangroves; Burns et al. 1999) or from industrial reports (King and McAllister 1997, 1998).

There are issues with the model results. The total deposition during the riserless stages (stage 1 and 2) is more or less identical to the deposition over the 5 stages together (Figures 1 and 2 [Figures 3-1 and 3-2 in Suncor Energy 2019]). This suggests that the sediments from stages 3 to 5 do not deposit at all and that the model loses track of them. This is more or less confirmed on page 16 of Suncor Energy (2019), *"approximately 78% of the total mass of all sections combined are predicted to be discharged near the seabed, where they settle rapidly. During the remaining sections of drilling, where the remaining roughly 22% of mass is discharged near the sea surface, smaller particle size fractions with low settling velocities were transported greater distances as they settled through approximately 100 m of the water column"*. In Table 1 (Table 2-1 in Suncor Energy 2019), the total volume discharges is approximately 10,000 m^3 (480 m^3 cuttings + 9,831 m^3 mud). A simple calculation based on Table 2 ([Table 3-1 in Suncor Energy 2019] deposition thickness x surface area) suggests that the total volume of material deposited in the model varies between 1,350 m^3 (minimum approximation) and 2,800 m^3 (maximum approximation). This appears to imply that only 13.5–28% of the particle volume actually deposits according to the model. The consequences of the model not accounting for this fraction of sediment should be addressed.

Table 1. Proposed drilling program for Tilt Cove (provided by Suncor). Each row defines drilling sections beginning with the sediment-water-interface (1) down to the reservoir (5) (Suncor Energy 2019).

Section	Diameter (mm)	Drilling Period		Drilling Duration (days)	Discharge Duration (days)	Cuttings Discharge			Drilling Fluid (Mud) Discharge[1]			Mud Type	Release Depth[2]
		Scenario 1	Scenario 2			Vol m^3	Solid Mass (tonnes)**	Rate (m^3/d)	Vol (m^3)	Solid Mass (tonnes)**	Rate (m^3/d)		
1	1,067	Summer	Fall	1	0.5	55	143	110	3,271	799	6,541	WBM	Seabed
2	660	Summer	Fall	2	1	150	390	150	6,541	1,599	6,541	WBM	Seabed
3	445	Summer	Fall	7	4	140	385	35	9.7	27	2.4	SBM	Sea Surface
4	311	Summer	Fall	10	7	115	316	16.4	7.9	22	1.1	SBM	Sea Surface
5	216	Summer	Fall	7	4	20	55	5	1.4	4	0.3	SBM	Sea Surface
Total	**-**	**-**	**-**	**27**	**16.5**	**480**	**1,289**	**-**	**9,831**	**2,451**	-	-	-

Notes:

1. Cuttings from sections drilled with SBM were modelled with an additional 6.9% by weight to account for base fluid that was assumed to be adhered to cuttings
2. Releases were simulated at 5 m above seabed or 5 m below the sea surface

**Values used for the drilling simulations; Mass is calculated using volumes of muds and cuttings (Table 2-1), as well as bulk densities of the materials and percent solid by weight (Table 2-2)

Table 2. Areal extent of predicted seabed deposition (by thickness interval) for operational discharge simulations in Summer and Fall (Suncor Energy 2019).

Deposition Thickness(mm)	Cumulative Area Exceeding (km^2)			
	Summer		Fall	
	Cumulative Sections	Riserless Sections	Cumulative Sections	Riserless Sections
≥0.1	1.4349	1.3319	2.1381	2.0186
≥0.2	0.8752	0.8310	1.2438	1.1697
≥0.5	0.4574	0.4338	0.5143	0.4722
≥1	0.2616	0.2494	0.1996	0.1507
≥1.5	0.1752	0.1642	0.0777	0.0700
≥2	0.1289	0.1204	0.0269	0.0216
≥6.5	0.0029	0.0005	0.0000	0.0000
≥10	0.0000	0.0000	0.0000	0.0000
Maximum Thickness (mm)	7.28	6.72	2.64	2.53

Specific Comments

Executive summary, paragraph 2 and Section 2.1, paragraph 2: *"MUDMAP does not account for resuspension and transport of previously discharged solids; therefore, it provides a conservative estimate of the potential seafloor depositions"*. To consider this estimate conservative does not seem appropriate. Re-suspension and further transport can potentially dilute the cuttings and sediment even more, which has the potential to reduce accumulation thickness in some areas, especially near the wellhead. However, it also has the potential to extend the zone of influence (and thus the impact footprint of the project), and potentially accumulate sediment in other areas further from the wellhead. In these circumstances, it does not seem appropriate to consider the neglection of some mechanisms as a conservative approach.

Executive summary, paragraph 3: *"As with any hydrodynamic model, there is the potential that local currents may deviate from predictions based upon grid resolution and small-scale variability in ocean circulation dynamics. However, the data used is sufficient for this type of modelling".* It is not explained how sufficient is assessed. This is not an appropriate assumption. The report provides no detail about the accuracy of HYCOM in the region. Further, details such as the vertical grid spacing are not provided so even expert readers cannot ascertain the model's applicability to this type of study.

Section 1.2, paragraph 1: *"The boundary where these two currents converge produces extremely energetic and variable frontal systems and eddies on smaller scales, on the order of* *kilometers (Volkov 2005). Due to these eddies, local transport may advect parcels of water in nearly any direction"*. The region being extremely energetic does not support the above statement that the data used are sufficient for this type of modeling.

Section 1.2, paragraph 3: Figure 3 (Figure 1-3 in Suncor Energy 2019) *"…illustrates that the site is close to the inshore branch of the Labrador Current near the Flemish Cap".* This is not the definition of the inshore branch, which is usually defined as the current flowing along the NL coast (in contrast with the main branch of the Labrador current that flows on the continental shelf break). The inshore branch further splits north of the Avalon Peninsula with part of the flow merging offshore with the main branch of the Labrador current and the remaining flowing through the Avalon channel near St. John's.

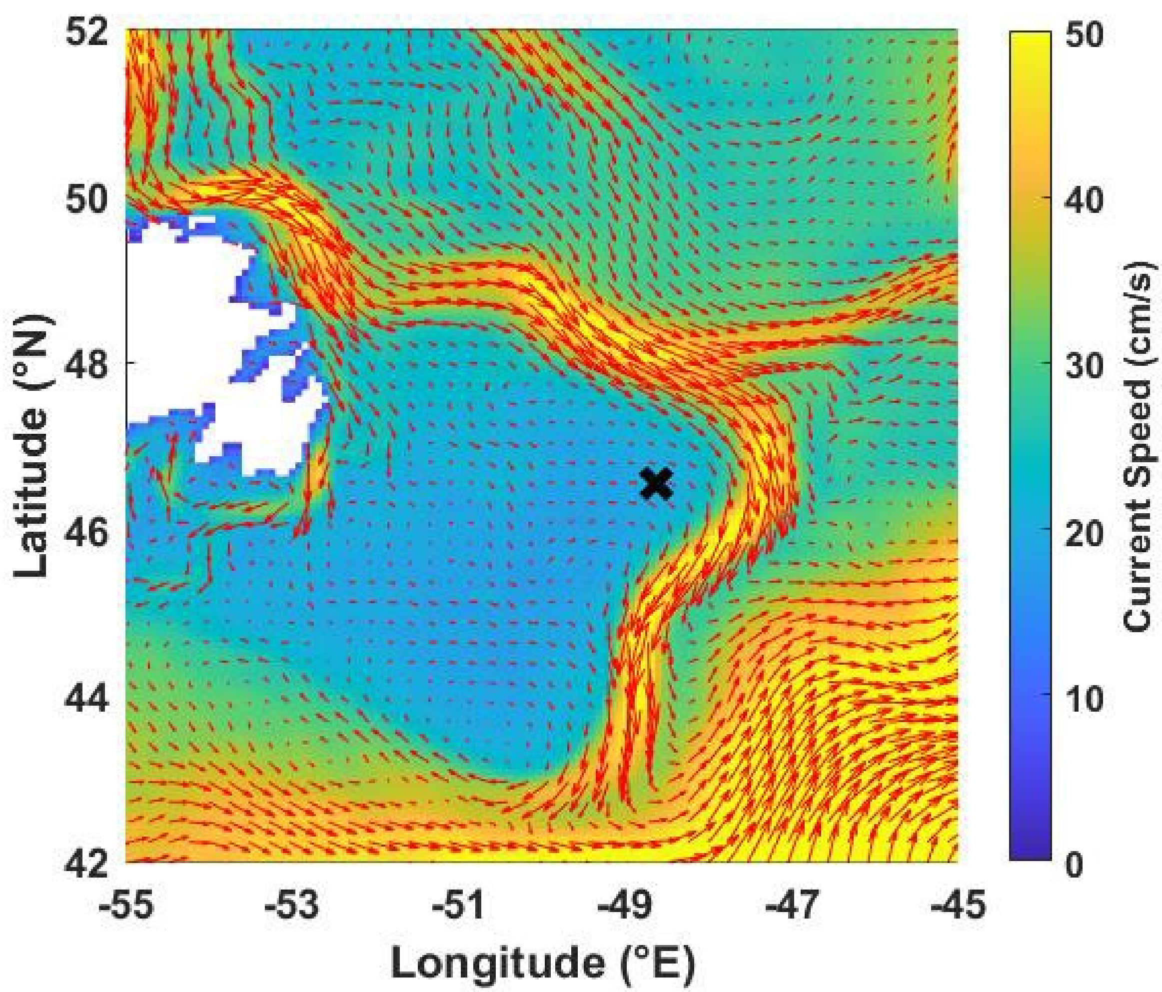

Figure 3. Average surface current speed (cm/s) in color, and speed and direction presented by red vectors offshore Newfoundland from HYCOM (2006–12). The black X represents the EL 1161 drilling site (Suncor Energy 2019).

Figure 4 (Figure 1-5 in Suncor Energy 2019): The authors describe the surface currents in the model, however, the bottom currents and subsurface currents are much more relevant in this study (see page 21, paragraph 2 of Suncor Energy [2019], *"Summer simulations for the EL 1161 site were predicted to have weaker subsurface current regimes with moderate directional* *variability, when compared to the fall simulations")*. As such, using the surface currents to analyze the variability in the environment is not applicable for this study.

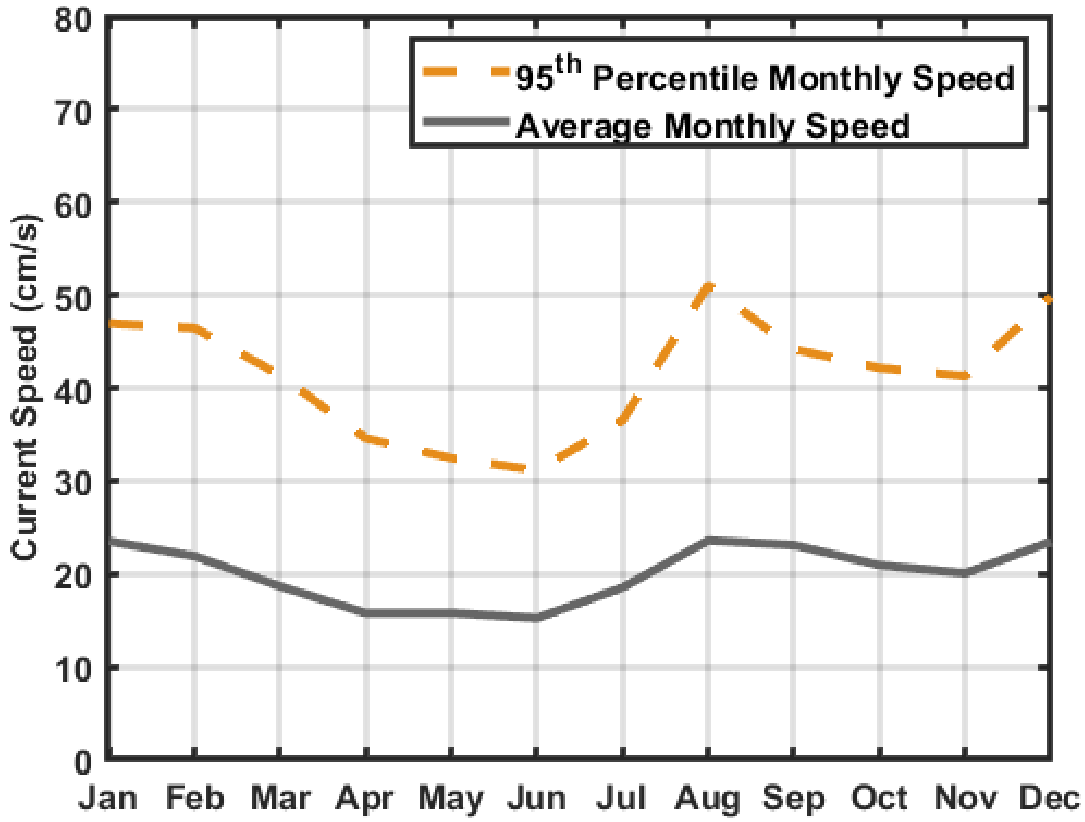

Figure 4. Monthly average (grey solid) and 95th percentile (orange dashed) HYCOM surface current speed (cm/s) statistics at EL 1161 (Suncor Energy 2019).

Figure 5 (Figure 1-6 in Suncor Energy 2019): A subject matter expert commented that the current rose at 90 m is quite different than higher in the water column. This may be important for the simulation. The text says that the proposed drilling site is 100 m deep, however the HYCOM currents displayed in this figure only extend to 90 m. The currents in the bottom 10 m are unknown, however, and important for deposition simulations. This is another situation where it is important to describe the vertical grid spacing so that readers can understand how well the bottom boundary layer is resolved. Also of note, fall data in Figure 2 (Figure 3-2 in Suncor Energy 2019) match with the deep current rose (Figure 5), but summer data in Figure 1 (Figure 3-1 in Suncor 2019) are more similar to the surface rose (Figure 5). Further explanation or investigation for this was not included in the appendix.

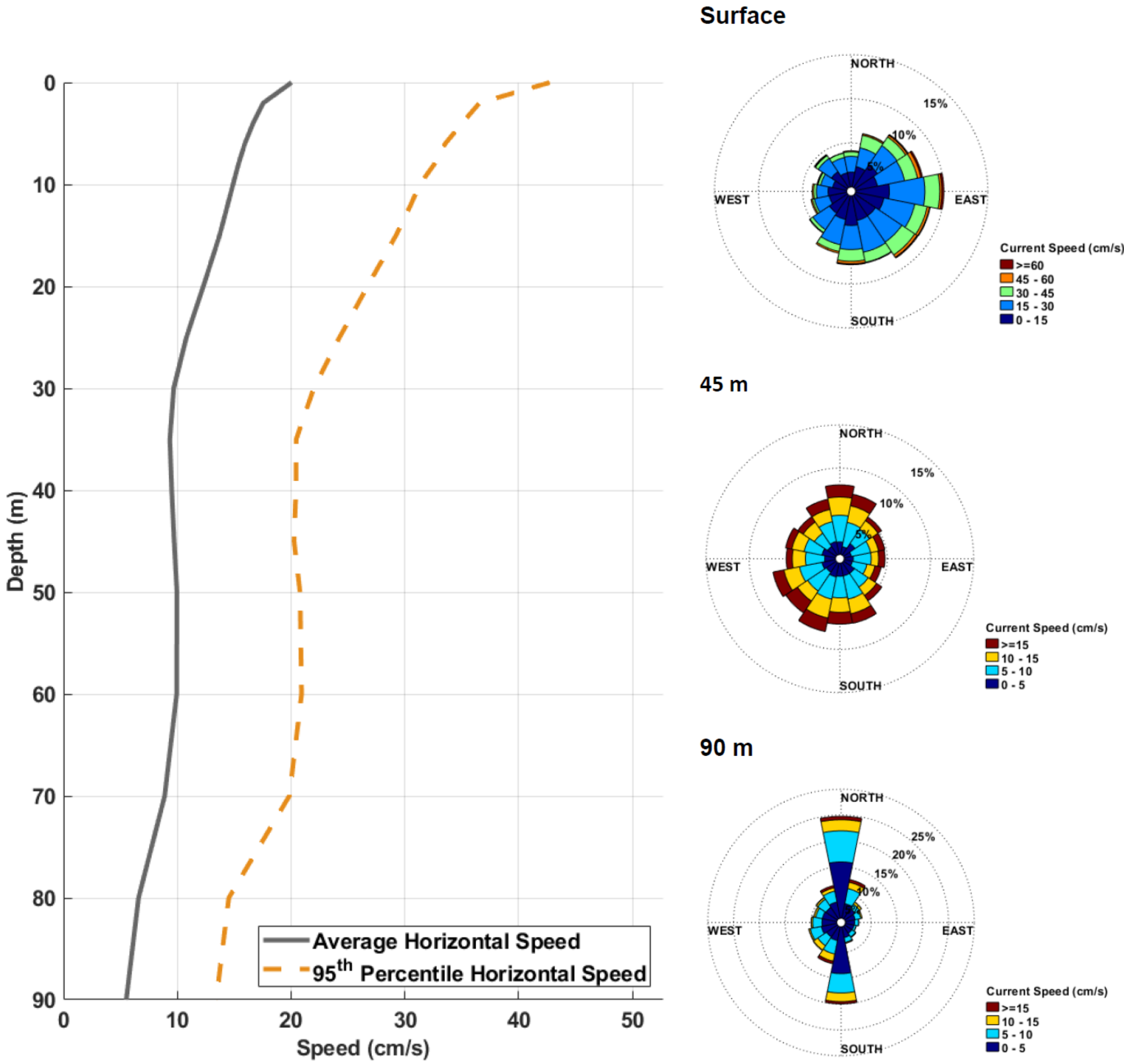

Figure 5. Vertical profile of average and 95th percentile horizontal current speed (cm/s) by depth (m) (left) and current roses at multiple depths presented in oceanographic convention (direction currents are flowing toward) (right) at EL 1161; derived from HYCOM model currents between 2006 and 2012 (Suncor Energy 2019).

Section 2.2: *"For discharges near the sea surface, a horizontal dispersion (i.e., mixing) coefficient of 2.0 m^2/s was used to account for the turbulence of the sediment as it was transported from the release site. A vertical dispersion coefficient of 0.001 m^2/s was used to account for the influence of turbulence within the water column. These values were selected, based upon professional judgment and previous experience, to represent typical conditions of the deep marine environment".* The vertical diffusivity parameter used is two orders of magnitude higher than generally measured in the ocean (Waterhouse et al. 2014). Stronger justification than professional judgement should be given. More detail about how the diffusivity parameters were selected is needed. For example, if the authors ran tests to determine if their results were sensitive to these parameters.

Table 3 (Table 2-2 in Suncor Energy 2019): Experts identified two issues with this table. First, these are "*provided by RPS based on prior drilling discharge studies*", so not only is RPS providing data to itself, but the source of this information is not mentioned. Second, no uncertainties are provided for these numbers, which means no uncertainties are transferred to the results.

Table 3. Bulk density of drilling discharges used for modelling (Suncor Energy 2019).

Discharged material	Bulk density (ppg)	Bulk density (kg/m^3)	Percent solid by weight	Average SG of solid fraction
WBM cuttings	21.7	2,600	100	2.6
WBM fluids	10.2	1,222	20	3.8
SBM cuttings	23.0	2,750	100	2.75

Section 4, paragraph 1: *"Slow settling velocities associated with the fine silts/clays and coarse silts, which make up the largest fractions of the cuttings drilled with WBM (water based mud) and SBM (synthetic based mud), allowed for greater dispersion before settling out"*. It is also stated on page 15 of Suncor Energy (2019) that the simulations were only several days long. These fine silts and clays would require weeks to settle based on the settling velocities reported in Table 4 (Table 2-4 in Suncor Energy 2019). The simulations weren't long enough to state that these materials would settle or be dispersed.

Table 4. Water based mud (WBM) settling velocities (Brandsma and Smith 1999).

Size Class	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
1	7.01	2.74×10^{-3}	2.37
2	7.99	6.10×10^{-3}	5.27
3	5.00	1.48×10^{-2}	12.77
4	10.00	3.00×10^{-2}	25.94
5	13.26	4.36×10^{-2}	37.66
6	13.26	5.12×10^{-2}	44.24
7	19.24	6.40×10^{-2}	55.30
8	19.24	8.23×10^{-2}	71.10
9	4.00	4.27×10^{-1}	368.69
10	1.00	1.12	969.12

Section 4, paragraph 4: "*Together, both drilling periods consist of representative current regimes for the area and the predicted results could be applicable to timeframes outside of the modelled temporal windows*". This is not accurate. The two simulations are drastically different, which highlights the exact opposite: that the dispersion is highly dependent on the time window. This reinforces the need for stochastic maps (running multiple simulation and doing probability statistics). In several places it is stated that the MUDMAP simulations use environmental conditions from the ocean model including currents and density, yet only currents are discussed in any detail. The water column density changes throughout the year. As such statements are not justified, a detailed analysis of the ocean model density structure is needed to support this claim.

Conclusions

The objective of this Science Response Process was to provide project-specific science advice on the following questions:

- Is the information provided in the modelling report comprehensive and based on the most recent information available at the time of report production?
- Are the methods used and assumptions made appropriate, do they present the current state of knowledge, and are they adequately described and incorporated in the conclusions?

In general, methodological details are unclear at times and assumptions are made without clear rationale. If assumptions are to be made, they should be based on peer-reviewed scientific literature.

1. The decision to select HYCOM current data from 2012 only (from an available period of 2006–12) as a representative modelling period is not supportable. There is no assessment or evidence put forward to demonstrate that 2012 is more representative compared to the available time series. Furthermore, using only 2012 data does not demonstrate that the information provided in the modelling report is based on the most recent or complete information available.
2. Simulations are not proven to be representative of the variable conditions in this region, nor were they long enough to determine the outcome of smaller particles in terms of settling versus dispersing.
3. More details regarding the MUDMAP dispersion model are needed. References are not based on peer-reviewed literature and examples of validation of the model are from different environments that do not necessarily apply to the current site.
4. Sensitivity analysis of the different parameters used in the model (e.g., environmental forcing, discharge schedule, discharge solids characteristics, horizontal and vertical diffusivities, grid resolution, number of particles, etc.) should be performed. More detail with regards to how these parameters were selected is also required.

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Sources of Information

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