MEMO

TO: Olivia Allen, Helen Crosby

FROM: Roy van Ballegooyen

SUBJECT: Final Review of the draft DHI Oil Spill Modelling Study

DATE: September 14, 2023

1 INTRODUCTION

I have undertaken a final review of the view of the DHI Report:

- DHI (2023). Offshore Production Right and Environmental Authorisation Applications for Block 11B/12B: Oil Spill Modelling Technical Report[1] , Report no: 42803622 (Rev. Final 05), 65pp + 75 pp Appendices, (Approval date : 12-09-2023)

This final review is the culmination of a review process comprising a reviewer comment and response cycle within which a number of issues have been addressed (see Section 4 of this memo).

TotalEnergies EP South Africa B.V. (TEEPSA), has specific requirements as to the content and presentation of the model results in the reporting. Initially, the primarily goal was to ensure consistency with the reporting for similar studies most recently undertaken in South African waters. However, as two prior oil spill modelling studies (HES, 2021a, 2021b) also form part of the oil spill modelling reporting for the present ESIA, the focus now is on ensuring consistency between the three oil spill modelling reports (HES, 2021a, 2021b and DHI, 2023) informing the present ESIA.

The context within which the review needs to take place is provided in Section 2 (Reporting Requirements), which outlines the "*high-level", best practise reporting requirements* for the ESIA.

The *detailed scope of work* and reporting requirements for the oil spill study is contained in the service level request forms:

- 221202_ZA_11B-12B_Disch5_OSCAR_service_Request_Form.pdf (2 Dec 2022)
- 230320_ZA_11B-12B_Pipe_OSCAR_service_Request_Form_Signed.pdf (28 Mar 2023).

The above documents have been reviewed to ensure that the DHI Oil Spill modelling report meets the stated requirements.

The review comprises "high-level" comment in Section 3 (Review Summary) as well as a more detailed review of specific aspects of the study as outlined in Section 4 (Detailed Review).

The marine ecologist specialist, the primary user of the oil spill modelling reports, has also been consulted to ensure that the DHI Oil Spill Modelling report (DHI, 2023) meets the information requirements of the marine ecology specialist study being undertaken for the ESIA.

[1] File name: 120923_TEEPSA_Block11B12B_ESIA_OS_Modelling_230530_ComPTA__rev01.pdf/docx

2 REPORT REQUIREMENTS

The reporting of the DHI Oil Spill modelling undertaken needs to both:

- be accessible to a wide range of readership and yet;
- contain sufficient detail to withstand a technical specialist review.

This requires that it is written simply, yet contain all core technical information relevant to the study. Whilst sufficient information should be included for the general reader, there are additional reporting requirements for more the specialist reader / technical reviewer. Thus, some more deeply technical information (*e.g.*, validation of the metocean study, model parameterisations, *etc*.) may need to be included in the reporting, ideally as appendices or, if more substantive, as referenced material. An added complexity is that *a sufficient degree of consistency is required with the earlier reporting for Oil Spill modelling undertaken for oil spill releases at discharge Locations 1 and Location 2 (HES (2021a, b).*

This necessarily is the context within which the present reporting for i) a blow-out discharge at Location 5 and ii) an accidental release due to a pipeline rupture, needs to take place.

Generic requirements for DHI Oil Spill modelling reporting:

- **Modelling software:** The modelling software utilised needs to include all of the relevant processes that determine the transport and fate of the oil spills under investigation. The model capabilities need to be clearly described in the report, including any assumptions and limitations of relevance to the study.
- **Metocean Data:** The robustness of the metocean conditions used in the study needs to be demonstrated. This typically would require evidence of adequate calibration and validation of the metocean database used in the study.
- **Model scenarios – Environmental conditions:** The approach to developing the environmental conditions need to be consistent with the earlier Oil Spill studies for location 1 and 2 (HES, 2021a, 2021b) and should include all relevant variability in currents, water quality and associated water column mixing processes. It should be noted that, whilst the Agulhas Current shows little evidence of seasonality, it is subject to substantive episodic perturbations.
- **Discharge Location(s):** There needs to be adequate motivation for the selection of the discharge location(s) used in the modelling. The selection of spill locations needs to provide a sufficiently conservative assessment of the oil spill risk for the components of the proposed project under assessment. The previous studies HES (2021a, 2021b) selected the discharge locations on the following basis:
    - The need to assess different (rather shallower) water depths,
    - Proximity (shorter distance) to the shoreline,
    - Proximity to sensitive areas.
- **Model scenarios – Spill scenarios**: The modelled scenarios need to be motivated in terms of the type of oil, discharge rates and duration of the spill, based on the proposed project infrastructure and operations. Where “worst case” deterministic simulations are selected for presentation, the basis for their selection needs to be provided. The earlier Phase 1 EIA (HES, 2021a, 2021b) used a criterion of the largest quantity (mass) of oil (hydrocarbon mass) reaching the shoreline.
- **Consistency with prior reporting:** There needs to be adequate degree of consistency with earlier reporting to facilitate the reading and interpretation of the component Oil Spill modelling specialist studies included in the present ESIA study.

The earlier modelling presented model outputs as follows:

– *Probabilistic modelling:*
  1. The minimum thresholds for reporting the occurrence of oiling at the sea surface: Ideally these should be consistent between the present reporting and the earlier Phase 1 EIA Oil Spill modelling reports (HES, 2021a, 2021b) that used reported a minimum probability of 1% above a >5 µm surface oil thickness threshold.
  2. Minimum arrival time at the surface: The smallest contour plotted was 1 day for oil above a 5 µm surface oil thickness threshold.
  3. Occurrence of oiling at the shoreline: The study reported presence probability <10% for a shoreline concentration threshold > 10 g/m^2).
  4. Minimum arrival time at the shoreline: The smallest range plotted was for 0 to 1 day for oil reaching the shoreline at a concentration > 10 g/m^2.

– *Deterministic modelling:*
  1. Concentration of oiling through the water column and at the sea surface: Ideally the thresholds used should be consistent between the present reporting and the earlier Phase 1 EIA Oil Spill modelling (HES, 2021a, 2021b) that reported a minimum concentration of 0.001 ppm in snapshots of the oil at the surface.
  2. Oil drift trajectories at the sea surface: Oil spill trajectories for oil above a 5 µm thickness threshold were presented for 1, 3, 5, and 6 days in the earlier Phase 1 Oil Spill modelling reports (HES, 2021a, 2021b).
  3. Concentration of oil reaching the shoreline: The earlier Oil Spill modelling studies (HES, 2021a, 2021b) reported shoreline oiling for concentration exceeding 0.01 kg/m^2 (*i.e.*, 10 g/m^2).

3 REVIEW SUMMARY

High level review comments on the DHI Oil Spill Modelling Study (DHI, 2023) are summarised below.

3.1 MODELLING SOFTWARE

The model capabilities are clearly described in the report, including assumptions and limitations of relevance to the study.

The DHI model, although different to the model used in several previous studies (OSCAR), is adequate for the present study. Sufficient detail of the model capabilities has been provided by the inclusion of Appendix A. Of particular relevance, is the schematic of the weathering process and typical time scales associated with these processes.

The modelling study was undertaken using a Lagrangian approach. The assumptions and limitations around the parameterisations and processes included in the model are deemed appropriate, as is the spatial resolution in the model. The following observations were made:

- Given the nature of the spill (*i.e.*, condensate), *evaporation is by far the most important process*.
- Conversely, *photooxidation is considered to contribute less than 1% of the total removal and therefore is not included in modelling setup*. This is an inherently conservative approach.
- DHI states that at maximum, removal due to biodegradation of 10-20% of the remaining oil (after evaporation, dissolution) within a 120-day window is expected.

However, for very thin oil sheens (likely to be the case for condensate) and when oil droplets are dispersed in the water for a long period), then the biodegradation becomes a more dominating process (*e.g.*, Sørheim and Pettersen (2021). *Biodegradation is included in the model, however the mass balance calculation for the deterministic drift trajectories show the effects of such processes to be minimal.*

- If the density of the oil exceeds the density of the ambient water, the settling of the oil needs to be included in the model simulations. However, condensate has a very low density with limited heavy components, even after significant evaporation. Furthermore, sedimentation due to the uptake of heavier particles is only considered relevant for oil close to the coastlines, where adsorption to sediment followed by sedimentation may be of relevance. *Consequently, the absorption of sediments is not included in the model under the assumption that sinking of oil is not relevant for the condensate spills being simulated in this projec*t.
- Overall, biodegradation, sedimentation and photooxidation within a considered 120-day-window are assessed to contribute less than 10% of the total mass balance of the oil spill and for maximum 10-20% of the remaining oil (after evaporation and dissolution).

Based on the above, the assumptions around the processed included and excluded from the modelling study are deemed appropriate.

3.2 METOCEAN DATA

It is important that reporting demonstrates that:

- the Metocean data base used in the modelling study are both appropriate and sufficiently accurate, and ;
- the environmental conditions considered in the oil spill modelling study are sufficiently representative of the prevailing conditions in the area of interest.

The environmental conditions have been summarised in the report based on the Appendix containing the Metocean data summary and the validation study for the SATOCEAN data that have been used in the oil spill modelling study. The appendix contains a reference to Russo *et al*. (2022) that provides a detailed validation of global models in South African waters, albeit focussed on large-scale oceanographic features. *The information contained in the Appendix to the DHI Oil Spill modelling report under review, provides adequate confirmation that the SATOCEAN data comprises a sufficiently accurate hydrodynamic database for the execution of the oil spill modelling study.*

DHI has supplemented these data with i) water level and water quality data from the HYCOM global model (upon which the SATOCEAN data are based) and ii) wave data from DHI's Global Wave Model (that uses ERA5 wind data for forcing). These additional data allow for more detailed process modelling in the oil spill model simulations that, in many cases, is not included in other oil spill studies. *These additional data are internationally recognised as being suitable for modelling studies undertaken at the scales of the present DHI Oil Spill modelling study. Therefore, these data are deemed adequate and appropriate to inform the Oil Spill modelling study (DHI, 2023) under review*.

3.3 ENVIRONMENTAL SCENARIOS MODELLED

It is important that the oil spill scenarios are simulated for a representative range of environmental conditions.

The SATOCEAN hydrodynamic database covers a 5-year period (2012 to 2016) that is of sufficient duration to include a good degree of the interannual variability in the offshore environmental conditions. While evidence of seasonality in the Agulhas Current is equivocal and somewhat limited, the Agulhas Current is subject to substantive episodic perturbations that will influence the trajectory and fate of oil spills. Furthermore, the simulation of oil spills at the sea surface are strongly influenced by seasonable variability in winds and surface wind-driven currents. Given the ensemble approach used in the oil spill study, the environmental scenarios modelled are inherently appropriate as all seasonal conditions and major perturbations of the Agulhas Current are included in the model scenarios.

Given the seasonality of the winds and wind-driven (particularly over the shallow shelf regions) it is appropriate that the model results are presented as both seasonal and annual simulations. Also, the approach of identifying the worst-case ensemble run and then providing detailed deterministic simulation of these worst-case conditions is both robust and informative.

Thus, it can be concluded that the oil spill simulations have been undertaken in a manner that is representative of the environmental conditions at both the spill locations and further afield.

3.4 DISCHARGE LOCATIONS

Two modelling scenarios were analysed, namely:

- *Block 11B/12B well blow-out with condensate LOC 'Discharge 5' at the wellhead*. Discharge location 5 was selected as a representative location for drilling occurring both to the east and the west of this location, *i.e.,* a central location within the proposed production development area. The Discharge 5 location is in close proximity to the previously drilled explorations well, Luiperd-1X, upon which the oil spill characteristics for the study are based.
- *Block 11B/12B full pipeline rupture of condensate in the middle of the Critical Biodiversity Area*. The discharge also is located in shallower water where it is not only closer to the shoreline but also located where the influence of wind-driven flows over the shelf results in a greater distribution the oil being released at this location.

The motivation for the oil spill locations seemingly is well- chosen and adequate to characterise the risks of potential oil spill associated with the proposed project.

3.5 OIL SPILL SCENARIOS

The oil type modelled is condensate, the oil type encountered when drilling the Luiperd (and Brulpadda) exploration wells in close proximity to the deep Discharge Location 5.

The motivation for the oil type seems well motivated based on a better knowledge base than the Location 1 and 2 oil spill modelling undertaken for the eastern side of the block, where both condensates and crude oil were simulated due to the uncertainties prevailing at the time that these studies were undertaken.

The spill quantities seem reasonable, particularly for the loss of containment discharge based on the rupture of the pipeline which has a clearly defined mode of failure that informs the proposed spill quantities and spill durations. The well blow-out scenario assumes a discharge duration of 20 days (18 350 bbl/day), while the full pipeline rupture discharge duration of 24 hours (19 320 bbl/day for first two hours decreasing to 10 728 bbl/day for the remainder of the period).

Given that the oil released comprises a condensate having a high evaporation rate, the 30-day simulation period for the well blow-out discharge and a 20 day simulation period for the pipeline rupture discharge are deemed reasonable. This observation is supported by the results of the deterministic drift trajectory and associated mass balance results.

3.6 MODEL RESULTS

The model results are largely reported in a manner similar to those reported for the earlier Location 1 and Location 2 Oil Spill modelling studies (HES, 2021a, 2021b). However, for the deterministic modelling results the concentration of oil along the shoreline is not plotted in the DHI Oil Spill Modelling report under review. The shoreline oiling results are only graphically reported as a probability of shoreline oiling for the stochastic modelling results. However, the actual mass of condensate reaching the shoreline, the length of shoreline oil, *etc*. are reported in summary tables for both the well blow-out and pipeline rupture spill scenarios.

While the reporting is not exactly the same as for the Location 1 and Location 2 Oil spill modelling studies, the decision on how to present the results is logical. *Given that the oil spill comprises condensates, none of the omissions (e.g., plots of shoreline oiling concentrations which are very low and mostly below thresholds of concern), are deemed material.*

When presenting the results, the same thresholds have been used for the earlier Location 1 and Location 2 Oil Spill modelling studies (HES, 2021a, 2021b). Slightly different contour intervals have been used for some plots (*e.g*., minimum time to shoreline plots that are plotted for 0.5 days and upwards rather than 1 day and upwards. This seemingly is to ensure appropriate granularity of the results for a condensate being discharge closer inshore, compared to the offshore discharges of crude simulated for the earlier HES (2021a, 2021b) studies.

In particular, the reader needs to be cognisant of the thresholds used when generating the plots for the oil spill modelling simulations and the reporting of the results in the summary Tables 5.2 and 5.4. The threshold adopted for the DHI Oil Spill modelling study under review are the same as those recommended by the earlier HES (2021a, 2021b) studies where the thresholds were well motivated.

Based on the above, the thresholds utilised, and the nature of the plots used to present the DHI Oil Spill modelling results (DHI, 2023) are deemed appropriate and "fit for purpose".

4. SPECIFIC ISSUES ADDRESSED DURING THE REVIEW

The following specific issues were addressed during the review process.

- The report is focussed on the surface results as the subsurface dissolved oil is only a very small fraction of the oil released. The use of a third party hydrodynamic database (*i.e.,* the SATOCEAN data) also complicates the presentation of such results.
- The shoreline oiling is based on a threshold of 10 mg/m^2. Thus, although oil may reach the shoreline, in the shoreline oiling probability plots the shoreline will not be indicated to be oiled if the shoreline oiling occurs at a threshold < 10 g/m^2 . This is true even should the probability of oil reaching the shoreline be greater than a 1% probability threshold (i.e., the oil reaches the shoreline but not in concentrations exceeding a 10g/m^2 threshold).
- The use percentiles in reporting the minimum time to oiling is invoked to avoid outliers. However, this does risk providing a slightly less conservative minimum time to oiling, but nothing that could be deemed material or change the conclusions of the study.
- The "actual oil" for the domain reported in the mass balance results comprises the surface oil (slick), any dispersed oil (likely to remain close to the sea surface) and any sedimented oil (when such processes are included).
- It should be noted that the deterministic oil spill drift trajectory plots only provide an indication of the location of oil where a surface oil thickness 5 µm is exceeded.

- Initially there were a number of issues around the reporting of the summary results in Tables 5.2 and 5.4. These were related to a lack of clarity as to whether the results being reported were for probabilistic simulations, deterministic simulations, the "worst case" deterministic simulations (selected based on greatest length of shoreline oiling) and whether thresholds were involved. This resulted in a number of comments and explanatory notes being added below the tables. It should be noted that, at times, the general area encompassing some of the selected sensitive locations are indicated as being affected by oil. However, this does not necessarily translate into oiling of the selected sensitive sites themselves which each only represent a 500m stretch of coastline.
- The results in Tables 5.2 and 5.4 may be difficult to interpret due to the fact that both probabilistic and deterministic results are being presented. Furthermore, the result presented generally include the application of thresholds (such as a < 10 g/m2 or > 5µm oil thickness), however this is not always the case (*e.g.*, the mass of oil reaching the coastline). The reader should thus take care in interpreting the summary of the results in these tables. In doing so, particular attention should be paid to the explanatory notes below the table.

CONCLUSION

The Oil Spill modelling study undertaken by DHI (2023) is sufficiently comprehensive and has sufficient rigour to address the risk issues associated with oil spill for the specific component of the proposed project being addressed (*i.e.*, the drilling to be undertaken in the Project Development Area targeted for production wells). The HES (2021a, 2021b) Oil Spill modelling reports address the risks in the Exploratory Priority Area of Block 11B/12B.

Roy van Ballegooyen, Principal Associate

Transport and Infrastructure, WSP Group Africa

REFERENCES

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HES (2021a). TEP South Africa Block11B/12B – Discharge Point 1 Oil Spill Drift Modelling Technical Report, Report No: DG/PSR/HSE/EP/ENV/OPS Nº 2020_31, 136pp.

HES (2021b). TEP South Africa Block11B/12B – Discharge Point 2 Oil Spill Drift Modelling Technical Report, Report No: DG/PSR/HSE/EP/ENV/OPS Nº 2020_38, 140pp.

Russo, C.S., J. Veitch, M. Carr, G. Fearon and C. Whittle (2022) An Intercomparison of Global Reanalysis Products for Southern Africa's Major Oceanographic Features, Frontiers in Marine Science, 9, Article 829706, 27 pp. doi: 10.3389/fmars.2022.837906

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[2] File name: 120923_TEEPSA_Block11B12B_ESIA_OS_Modelling_230530_ComPTA__rev01.pdf/docx