DNV

SURVEY AT ALVE NORD, SHREK, RONDESLOTTET AND ØRN

SeaFAN Rondeslottet

DeepOcean AS

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1 INTRODUCTION

DNV has on behalf of Aker BP AS performed discharge modelling and following environmental impact assessment for the planned drilling campaign at Rondeslottet (PL1005) located in the Norwegian Sea (Figure 1-1). The drilling is for exploration purposes and drill cuttings and water-based mud from the sections 9 7/8", 36"/42" and 26" for are planned discharged to sea. Proposed well location has been selected to increase the distance of the deposition area from nearby clay outcrops identified in the area. The discharge will take place at the sea floor. This report presents the results for Rondeslottet. The discharge has been modelled from the planned drilling location:

Geodetic Parameters: ED50, UTM Zone 32N, 09° E			
Latitude	64° 15' 59.405" N	Northing [m]	7 132 215
Longitude	05° 15' 36.986" E	Easting [m]	318 897

Rondeslottet is in the area of the Ellida discovery (6405/7-1) in the Norwegian Sea. The discovery is located in blocks 6405/7 and 6405/10, approximately 100km west of the Njord field (Equinor) and approximately 80km North of Ormen Lange (Shell). The water depth is approximately 1100m. Ellida was discovered in 2003, by an exploration well encountering a 52m high oil column in the Late Cretacous Nise Formation. Ellida was never developed due to tight reservoirs and in addition it is located in very deep waters (1200m). However, due to technological progress in later years, Aker BP now wants to revisit the discovery.

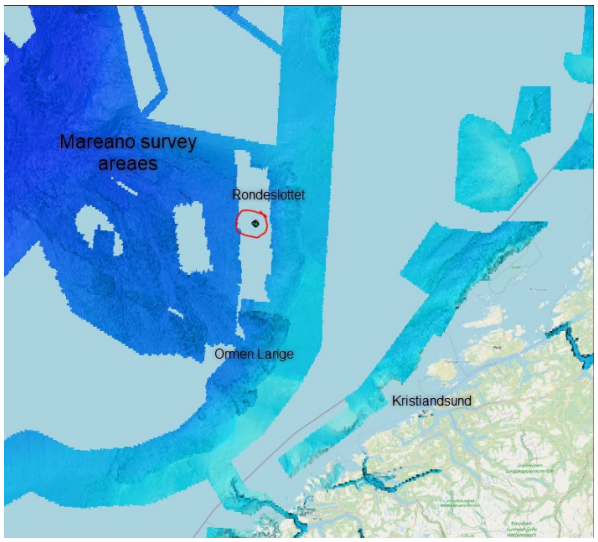

Figure 1-1 The Rondeslottet location in the Norwegian Sea

A site survey was performed in 2021 and the seafloor was surveyed with multibeam echo sounder (MBES), and side scan sonar (SSS) mounted on the ROV (DNV, 2022). Interpretations of SSS data in combinations with the MBES data collected during the high-fly survey, was used to identify targets, seabed features and changes in reflectivity which could be subject for further visual survey. In general, most of the seabed consisted of mud flats, but there were also identified numerous large clay mounds and clay-blocks in the north-eastern part of the site area, corresponding to the high reflectivity areas detected with MBES. These were classified as two distinct habitats: "continental slope mud flats" and "clay outcrops areas". The "clay-outcrop" areas may qualify as a habitat that could require mitigation to minimize disturbance from planned activities in the area. Given the distinctive shape and reflection characteristics of the clay blocks it was decided that all conspicuous targets delineated from multibeam data would, in a first assessment, be treated as vulnerable clay outcrop habitats.

The risk assessment methodology and derived thresholds for sediment deposition on corals applied are used and as outlined in the "Handbook Species and habitats of environmental concern: Mapping, Risk Assessment, Mitigation and Monitoring. - In relation to Oil and Gas activities" (NOROG, 2019).

The project used the model DREAM MEMW 13.0, and DNV's internal SeaFAN tool for statistical analysis and presentation of modelling results. In each of the cases, a total of 48 parallel simulations using different high-resolution hind cast modelled current data (NORKYST800 – met.no) were applied in the modelling to create variance in the output results.

2 MODELLING METHODOLOGY AND RISK ASSESSMENT

2.1 Discharge characteristic and methodology

The project used the model DREAM MEMW 13.0, and DNV's internal SeaFAN tool for statistical analysis and presentation of modelling results. A total of 48 parallel simulations using different high-resolution hind cast modelled current data (NORKYST800 – met.no) were applied in the modelling to create variance in the output results. Modelling was performed using flat seabed. The results have been compiled statistically in discharge footprint maps for sea floor deposition expressed as mm thickness layer. Drilling discharges (barite, bentonite, and cuttings) and durations for each section is modelled. All discharges were modelled with a release 1 m above sea floor for the base case. Model parameters and planned discharge durations and amounts are presented in Table 2-1 and Table 2-2 respectively

Table 2-1 Area and model specific elements.

Element	Item	Specification
Site specific	**Current**	Norkyst800 (Hourly, 800*800m) (met.no)
	Bathymetry	High resolution measured data
	PSU	35 no halocline
	Temp	0 °C no thermocline
Model specific	**Number of particles**	3000
	Output interval	30 min
	Time step	10s
	Concentration z cell	10m (200-300m)
	Model grid	25*25m cells, 2*2km
	Output files	NETCDF4 (water column conc and sediment thickness)

Table 2-2 Overview of activity, discharge amounts (tons) and total duration for the planned discharges at Rondeslottet.

	To seabed					
Drilling section	**9 7/8"**	**pause**	**36"x42"**	**pause**	**26"**	**pause**
Start of discharge, (month) 48 simulations	March – August					
Section length, m:	740		90		740	
Drilling rate, m/h	100		20		50	
Duration of Discharge, hrs	7,4		4,5		14,8	
Discharge depth, (m above seabed)	0		0		0	
Cuttings (MT sg2,6)	95,1		209,2		659,0	
Bentonite (MT sg2,5)	14		7		28	
Barite (MT sg 4,1)	29		95		226	
Water (MT)	276		377		1000	
sum mud (bentonite, barite, water)						

2.2 Environmental risk assessment methodology

The risk assessment methodology and derived thresholds for effects from sediment deposition on corals applied are described in the "Handbook Species and habitats of environmental concern: Mapping, Risk Assessment, Mitigation and Monitoring. - In relation to Oil and Gas activities" (NOROG, 2019).

2.2.1 Environmental Resources

Multiple clay outcrop areas have been identified in the area (DNV 2022). These areas arise up from the seabed and constitutes of harder substrate and could have its origin from the Storegga Slide. In some parts, the clay outcrops could create small cliffs with sharp edges reaching up to 5-10m height from the surrounding sea floor. Consequently, it creates a habitat for sessile hard bottom species and other species utilizing the slightly higher water transport. Common seen on the ridges were the glass sponge cf. *Farrae*, soft coral *Gersemia*, hydroids, sea spider cf. *Collossendeis*, and the basket star *Gorgonocephalus* sp (Figure 2-1). In accordance with OSPAR and M300, Deep Sea Sponge aggregation and the single coral species such as Gersemia are addressed and could qualify as an especially vulnerable habitat. The clay outcrops closest to the well are summarised in Table 2-3

Figure 2-1 Examples of fauna identified on a clay outcrop; In the centre, a Gorgons head (*Gorgonocephalus* sp), left a sea spider (cf. *Collossendeis*) and scattered across are glass sponges cf. *Farraea occa* and soft corals (*Gersemia sp.)*

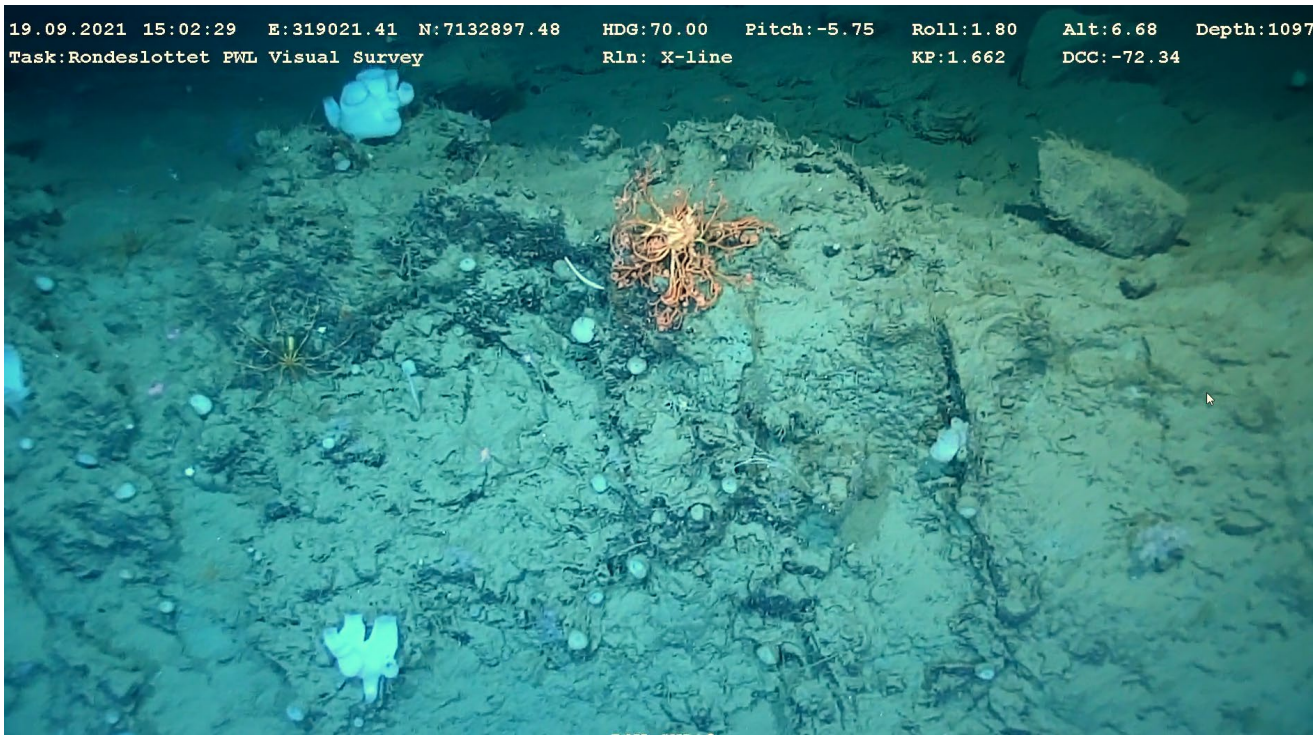

Table 2-3 Overview of the clay outcrops closest to the Alt.PWL.

ObjectID	Type	Area (m^2)	Distance from Alt. PWL (m)	X (ED 50, UTM 32N)	Y (ED 50, UTM 32N)
8	Clay outcrop	5766	249	319042	7132485
27	Clay outcrop	380	248	319150	7132264
29	Un-surveyed feature	270	350	319247	7132274
34	Clay outcrop	182	358	319260	7132220
40	Clay outcrop	107	322	319212	7132276
47	Clay outcrop	68	309	318990	7132508
50	Clay outcrop	62	359	319258	7132246

All clay outcrops have in the impact assessment been valued to “excellent/DD”.

2.2.2 Threshold values for deposition of particles

The applied threshold values for consequences of particle deposition arising from drilling discharges on cold-water corals are presented in Table 2-3 (same intervals as in the footprint maps). A modified Impact matrix based on condition of SHEC and expected impact sediment deposition (NOROG, 2019) is presented in Table 2-4. The modifications are colouring from “risk” colours to shades of grey and change of name from “risk” to “impact” matrix.

Table 2-4 Threshold values for consequences of deposition thicknesses of particle discharges (NOROG, 2019).

Deposition thickness	Consequences
0.1-1 mm	No detectable influence
1-3 mm	Minor smothering. Good ability to shed sediments, but might start to aggregate
3-10 mm	Moderate smothering. Reduced ability to shed sediments. Some polyp mortalities of sponge necrosis can occur
>10 mm	Considerable smothering. Potential suffocation. Polyp mortality or sponge necrosis expected. Potential for depletion of energy reserves

Table 2-5 Modified Impact matrix based on condition of SHEC and expected impact sediment deposition (NOROG, 2019). The modifications are colouring from "risk" colours to shades of grey and change of name from "risk" to "impact".

		Identified SHEC value			
		Poor	**Fair**	**Good**	**Excellent/DD**
Degree of impact	0.1-1 mm	Low	Low	Low	Low
	1-3 mm	Low	Moderate	Moderate	Considerable
	3-10 mm	Low	Moderate	Considerable	Large
	>10 mm	Low	Considerable	Large	Large

*DD – Data deficit

2.2.3

Modelling results are extracted at the locations and presented in box whisker plot and further compared with threshold in mm (NOROG, 2019). Explanation of the box whisker plot is presented in Figure 2-1

- 10% probability: The upper whisker (90 percentile) crosses a given deposition value (y-axis), which more than 10 % of the simulations are above this value and 90% below this value
- 25% probability: The 75-percentile indicated by where the upper box crosses a given deposition value, which more than 25 % of the simulations are above this value and 75% is below this value.

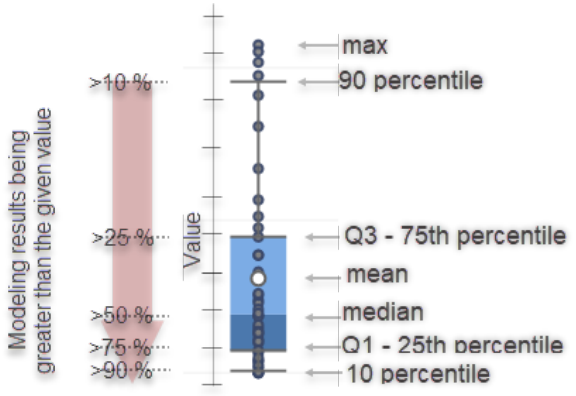

Figure 2-2 Explanation of the box whiskers and relation the probability (%) of the simulations that are equal to or greater than the given value.

3 MODELLING RESULTS AND IMPACT ASSESSMENT

Drilling discharge footprint map has been generated based on the modelling results using a semi-stochastic approach (48 simulations) and presented as sedimentation in mm for the intervals 1-3mm, 3-10mm and >10mm based on current data for the period 2020 (Figure 3-1). The footprint map is compiled from “hit probability maps” for different thickness intervals where 90% of the modelling results are within the respective interval (meaning that <10 % are outside).

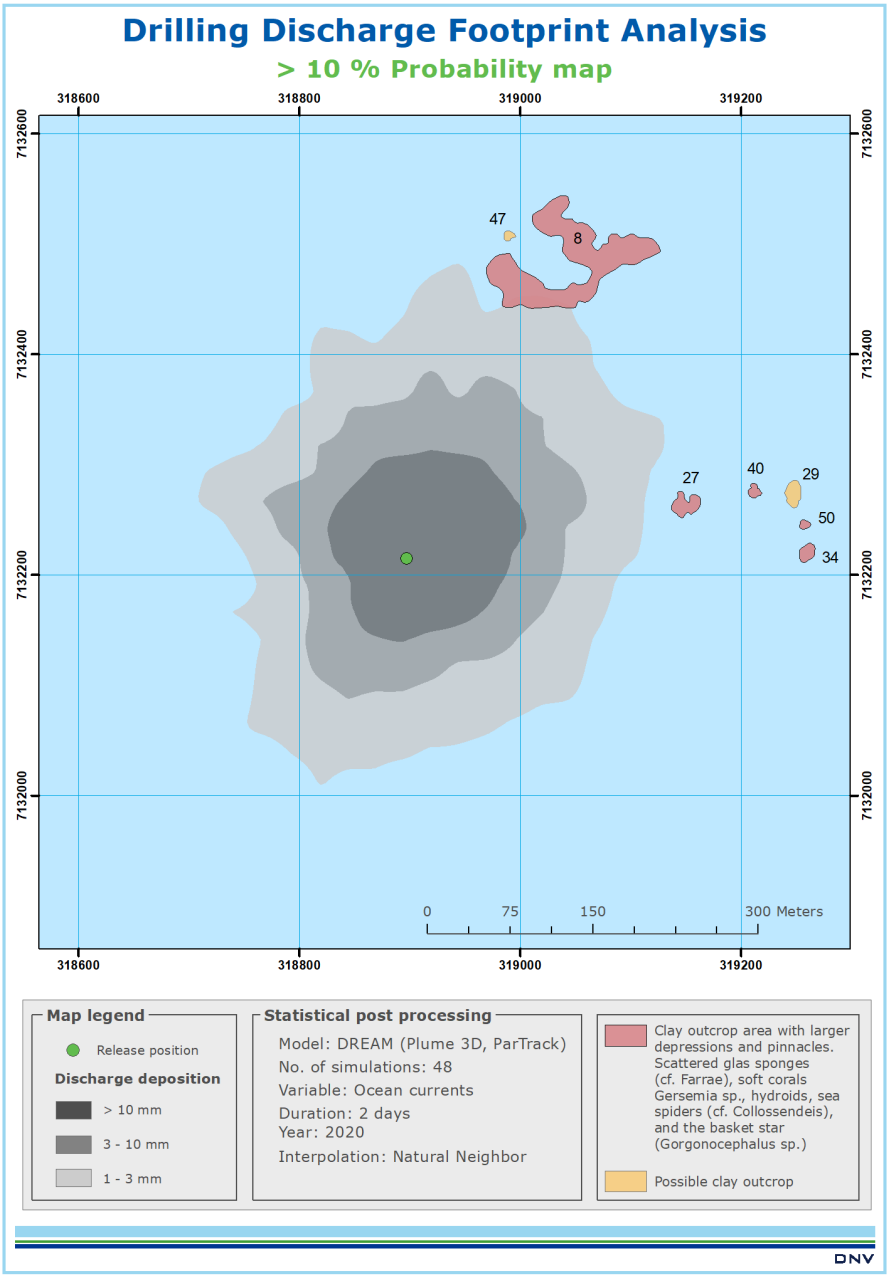

Figure 3-1 Drilling discharge footprint map for the planned drilling campaign at Rondeslottet for the base case.

The results from the modelling have been assessed for >10 % probability for a given clay outcrop exceeding threshold deposition values, 1mm (representing interval 1-3mm) shown in Figure 3-1 and Figure 3-2 and Table 3-1. In the overall assessment none of the outcrops will exceed the threshold of 1mm with a **probability >10 %.** The outcrops are at "low" impact of being negatively influenced by the discharge deposition at PWL location.

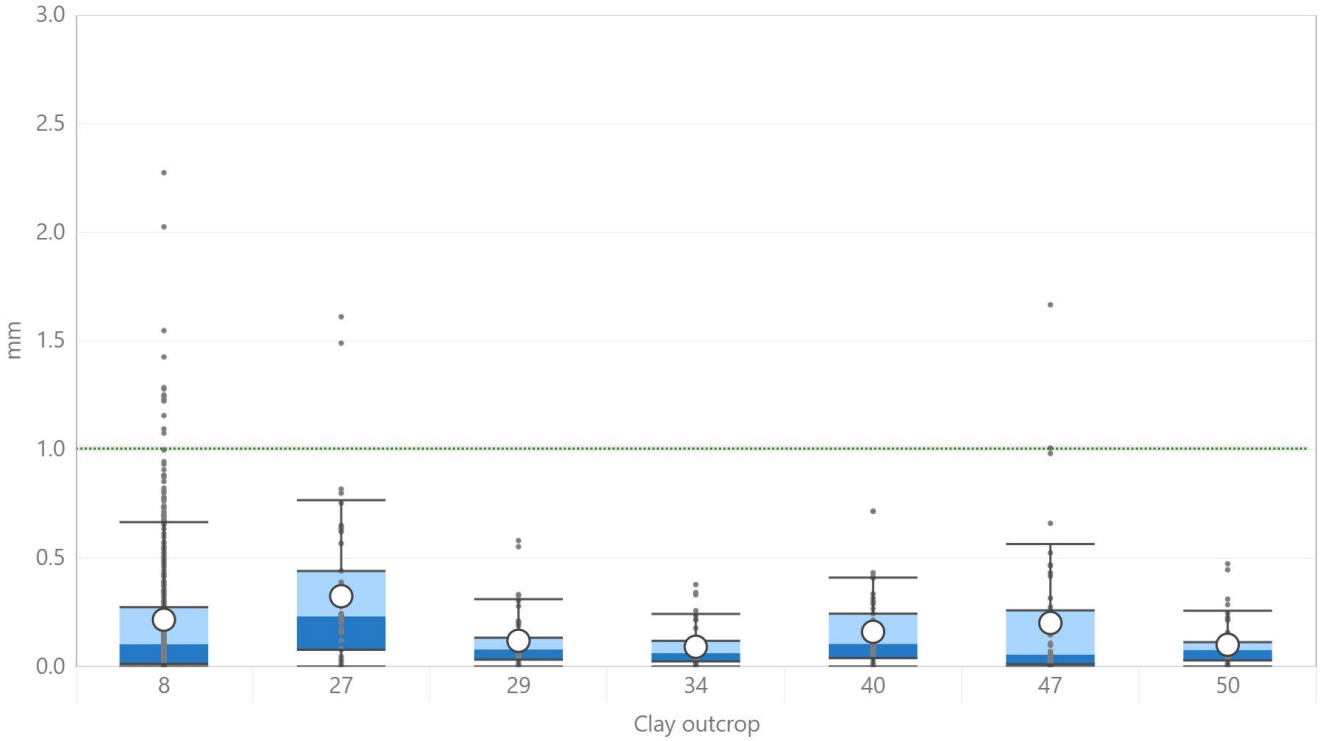

Figure 3-2 Box whisker plot for deposition of discharges at the coral locations from 48 modelling simulations for base case at Rondeslottet. Dotted horizontal lines indicate thresholds in mm (1 mm) (NOROG, 2019).

Table 3-1 Impact assessment (>10%) for the clay outcrops and discharge deposition in mm from planned drilling at Rondeslottet. The impact categories are low (●), moderate (●), Considerable (●) and Large (●).

		Identified SHEC value			
		Poor	**Fair**	**Good**	**Excellent/DD**
Degree of impact	0.1-1 mm	Low	Low	Low	**multiple** Low
	1-3 mm	Low	Moderate	Moderate	Considerable
	3-10 mm	Low	Moderate	Considerable	Large
	>10 mm	Low	Considerable	Large	Large

4 CONCLUSIVE SUMMARY

DNV has on behalf of Aker BP AS performed discharge modelling and following environmental impact assessment for the planned drilling campaign at Rondeslottet (PL1005) located in the Norwegian Sea. The drilling is for exploration purposes and drill cuttings and water-based mud from the sections 9 7/8", 36"/42" and 26" are planned discharged to sea.

Multiple clay outcrop areas have been identified in the area. These areas arise up from the seabed and constitutes of harder substrate. In some parts, the clay outcrops could create small cliffs with sharp edges reaching up to 5-10 m height from the surrounding sea floor. Consequently, it creates a habitat for sessile hard bottom species and other species utilizing the slightly higher water transport. Common seen on the ridges were the glass sponge cf. *Farrae*, soft coral *Gersemia*, hydroids, sea spider cf. *Collossendeis*, and the basket star *Gorgonocephalus* sp). In accordance with OSPAR and M300, Deep Sea Sponge aggregation and the single coral species such as *Gersemia* are addressed and could qualify as an especially vulnerable habitat.

Based on this, the planned well location was moved to increase the distance of the deposition area to nearby clay outcrops identified in the area, the closest ones being ~250m north and northeast of PWL.

Dispersion modelling and impact assessment has been performed revealing relatively small particle loads at the outcrops (average <0.5mm). In the overall assessment none of the outcrops will exceed the threshold of 1mm with a **probability >10 %.** The outcrops are at "low" impact of being negatively influenced by the discharge deposition at PWL location (utilizing the NOROG thresholds (2019)).

5 REFERENCES

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