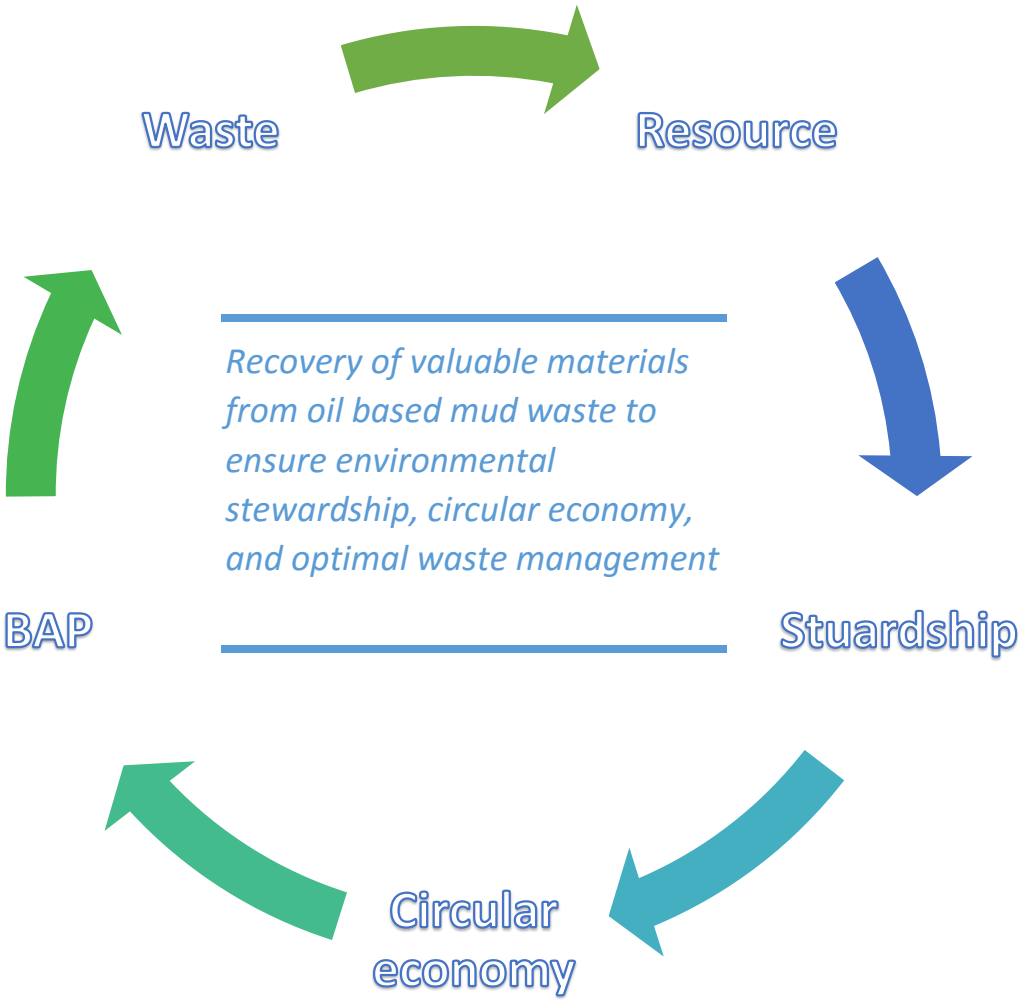
IN CONTROL OF DRILLING WASTE TO ENSURE BEST AVAILABLE PRACTICE

Destabilization and separation of drilling mud



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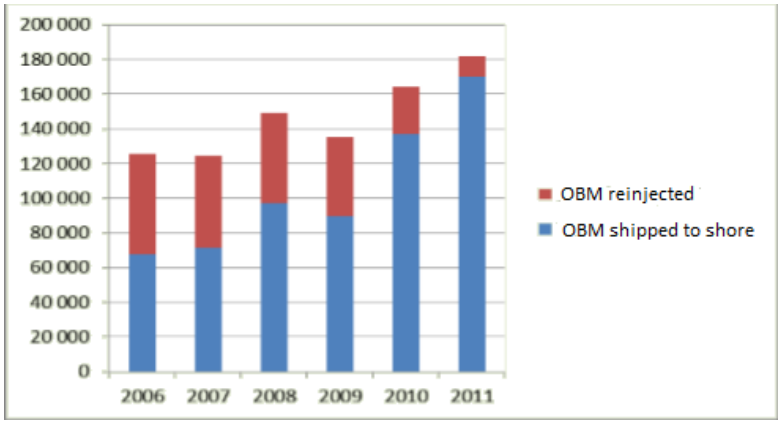
Drilling fluids (Oil based mud and completion fluid) is in general an expensive and is required in several drilling operations. Approximately 180 thousand ton of oil based mud is shipped to shore every year on the Norwegian continental shelf. The drilling mud is initially considered a resource as it can in general be upgraded and reused. However, this practice was often not performed, as the drilling mud did not meet the high performance requirements after upgrading. A substantial amount of mud is therefore considered waste. Handling oil based mud as waste has a cost of around USD $300/ton based on data received by Norsk Gjenvinning. Some drilling fluids are stored in tanks for several years as they contained highly expensive compounds.

Norwegian Technology AS were offered a contract by Baker Hughes to separate 330 m^3 of low solid oil based mud that had been stored in tanks. The mud contained expensive brine (60 percent) and a oil fraction of around 40 percent by volume. The mud was successfully separated into approximately 60 percent brine, 20 percent oil and 20 percent sludge.

Waste generation from drilling operations

During drilling operations with oil based mud (OBM), the drilling mud is reused as a part of the primary treatment (solid control). Here, the drill cuttings are separated from drilling mud. Approximately 70 percent of the OBM is reused, while 30 percent remains on the drill cuttings or in the well. At a certain point, the OBM is considered off specification, and not suitable for reuse. This mud is sent to the drilling waste supplier, which is contracted to upgrade the fluids to make it suitable for reuse. Oil based drilling mud is therefore considered a resource and not waste. However, in many cases the OBM ended up as waste. According to MI-SWACO, drilling fluid upgrading is not performed due to the high specification requirement (Den Norske Veritas, 2013)

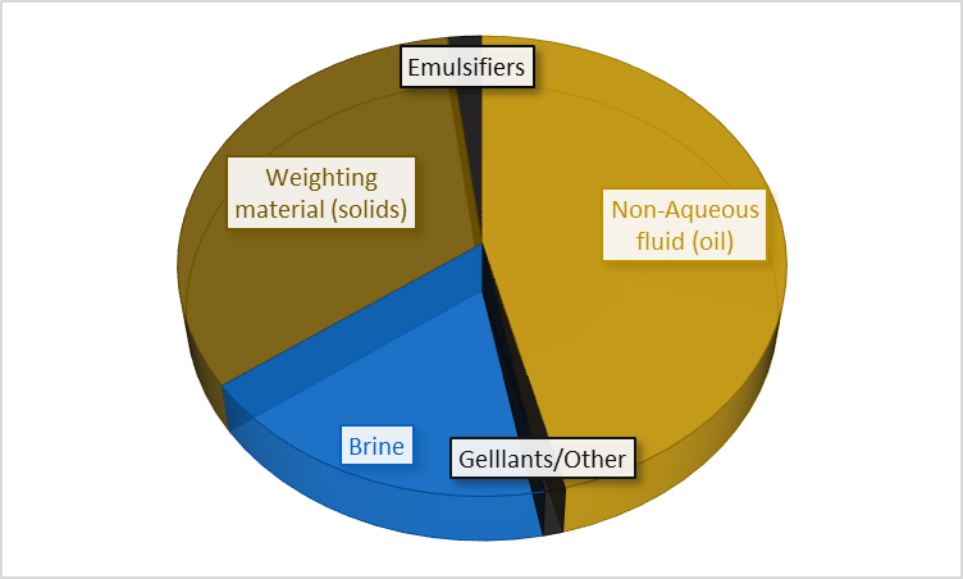
A substantial amount of mud is sent to shore as waste. The Figure below reveals a trend of increase in amount of OBM waste produced. The increase in mud waste is associated with drilling longer and more challenging wells (Svensen & Taugbol, 2011). The graph also illustrates that more mud waste is shipped to shore. This is associated with less mud reinjected due to leakage from injection wells (Den Norske Veritas, 2013).



Quantity of OBM waste generated and waste handling method

Mud as a resource

Oil based mud vary both in price and material composition. A general composition of OBM is illustrated in the Figure below (IPIECA/OGP, 2009)



The compounds in the diagram above are usually present in OBM. However, the quantity of each compound varies significantly. The oil/brine ratio can range between 60/40 to 90/10 (McCosh, Kapila, Dixit, Way, & Phipps, 2009), and the solid weighting material can be almost none existing for some drilling muds. The cost of each component also differs significantly. In general, Oil and Brine is expensive components in OBM.

Reducing cost

Low oil prices, demanding drilling conditions and strict environmental regulations contributes to challenging practice for the oil and gas industry. Optimization of waste management can contribute to significant cost savings. Oil based mud is an expensive drilling fluid which is necessary in many drilling operations. The price of materials used in the base fluids can range from USD $ 250 to 2 500 /m^3 (Melton et al., 2004)

Table 1: *Cost comparison of handling 330 m^3 low solid OBM as waste, compared to separating the mud in order to recover oil and brine.*

	Metric tons	Cubic meters	US$/ton	US$/$m^3$	Total US$
Total disposal	581	330	300		174 300
Cost of treatment	581	330	48		27 888
Recovered Brine	337	198		3 894	771 012
Recovered base oil	53	66		2 427	160 182
Sludge disposal	191	66	300		57 420
Commercial return					845 886

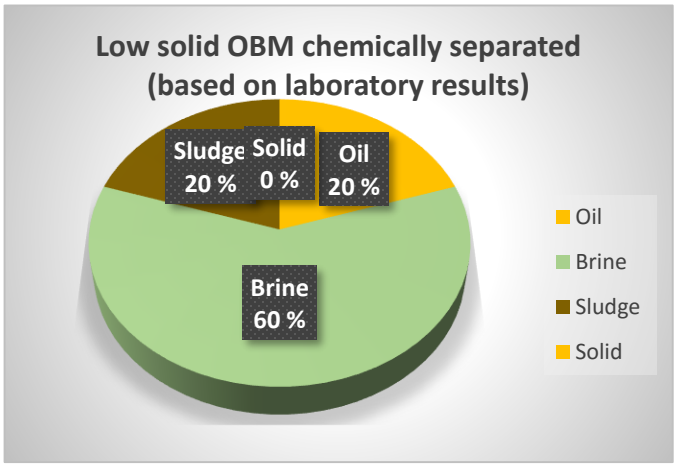
The cash flow calculations are based on 60 and 20 percent brine and oil recovery. The cost does not include transportation. The total cost is calculated based on separating 330 m^3 of low solid OBM with a density of 1,76 ton/m^3.

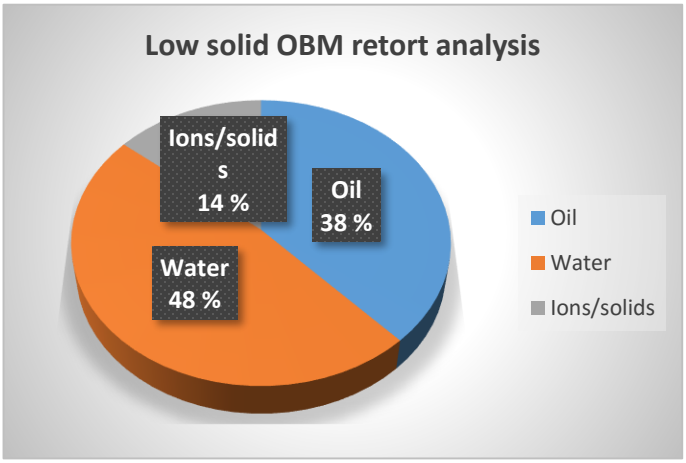
Utilizing the resources in waste, reduce the amount of waste generated and allows for recovery of valuable materials

Low solid OBM destabilization and separation for Baker Hughes at Mongstad

Drilling mud is in general chemically separated into four fractions (Oil, sludge, brine and solids). The type of chemical and quantity utilized to destabilizing mud vary and depends on the mud characteristics. The optimal chemical for destabilization of this low solid OBM was found to be Mudsplit 001 with a dosing in the range of 3-4 l/m^3. The Mudsplit 001 chemical is among other chemicals that Norwegian Technology AS utilizes for separation of OBM.

The low solids OBM was separated into 3 fractions (Oil, sludge and brine). The solid fraction was not quantified during separation as the amount was not detected visually. Both the brine and oil fraction was clear and transparent after destabilization and separation. This is illustrated in the figure to the right. The diagrams below illustrate the volumetric fraction of each component. The volumetric fraction of brine in the full scale separation was measure to be 59 percent. The oil fraction was not detected, but it is assumed to correlate with the laboratory results.





The two graphs illustrate the efficiency of the Mudsplit 001 separation chemical. It is important to notice that in a retort analysis (evaporation), the dissolved ions in the brine fractions remains in the sample container and contributes therefore to a solid fraction. As a result, the chemically separated mud contains more brine than water.

Low solid oil based mud (left) destabilized and separated. The brine fraction (right) was withdrawn from the first 38 m^3 batch of full-scale separation at Mongstad.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