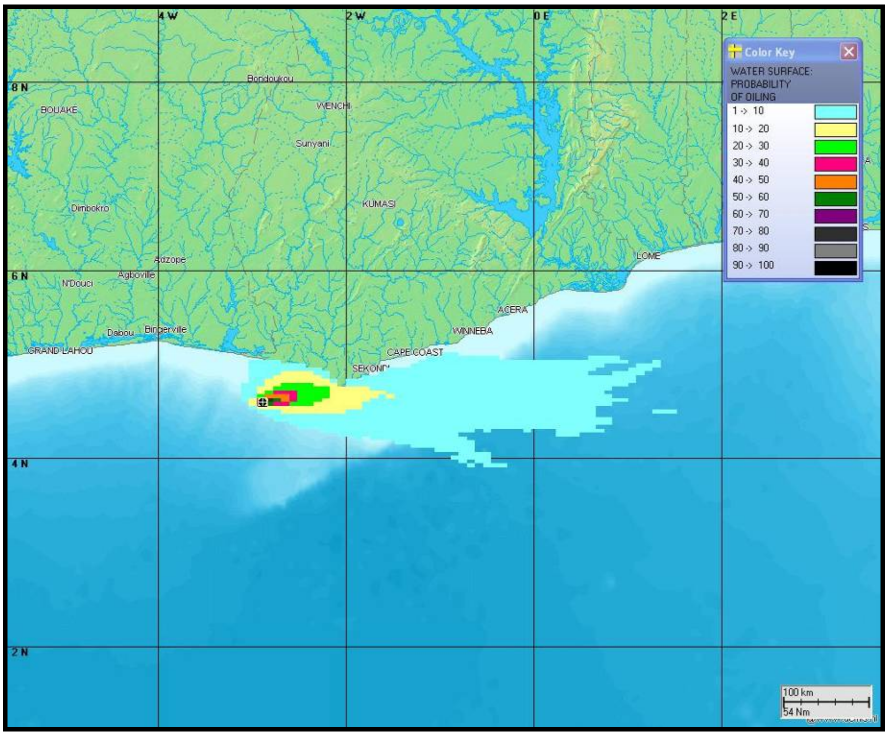
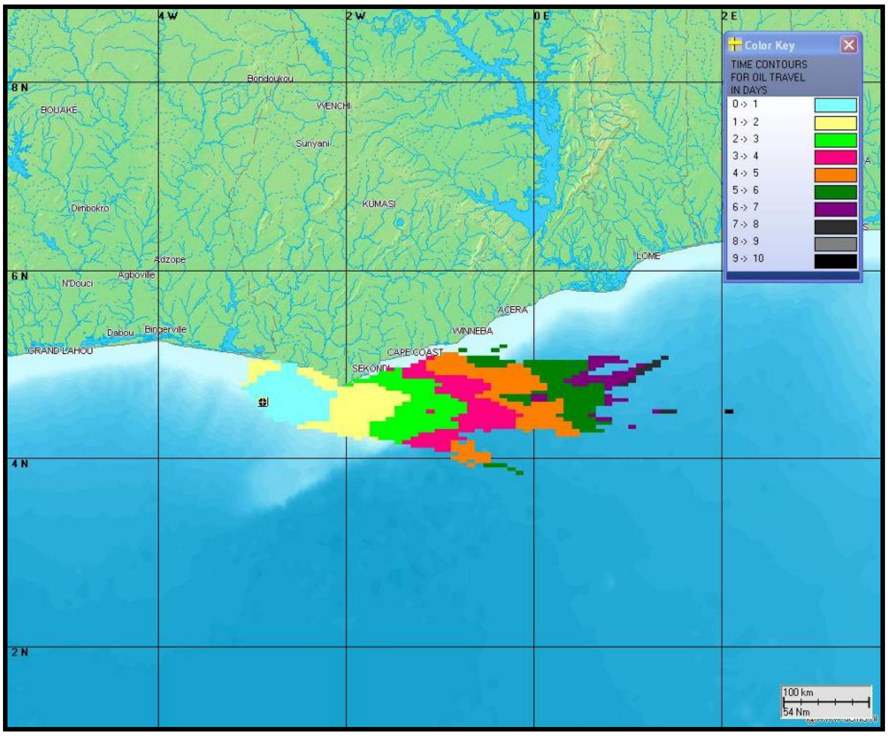
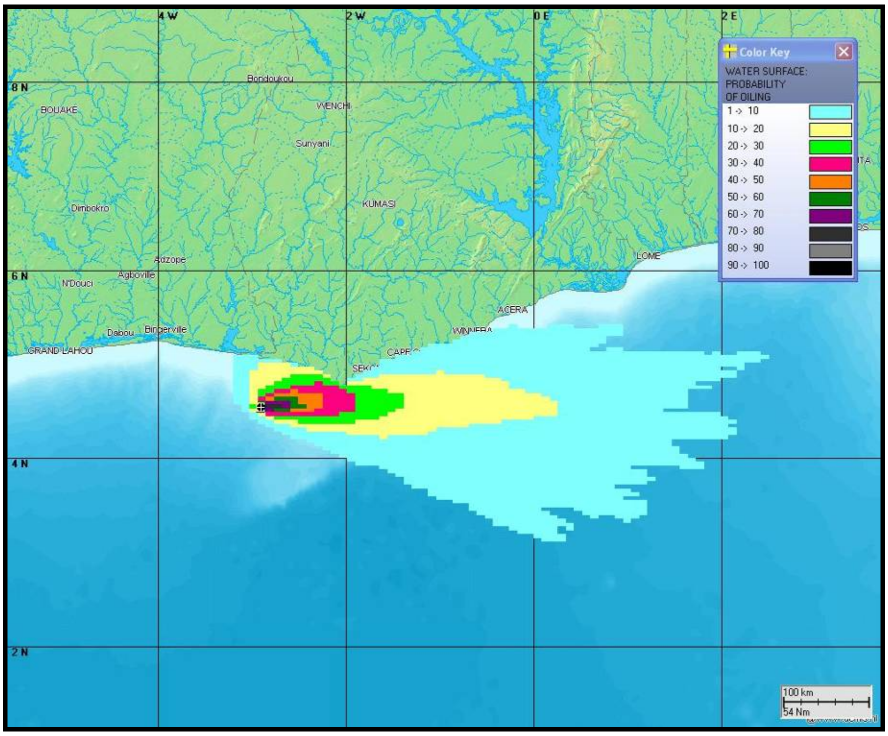


a)

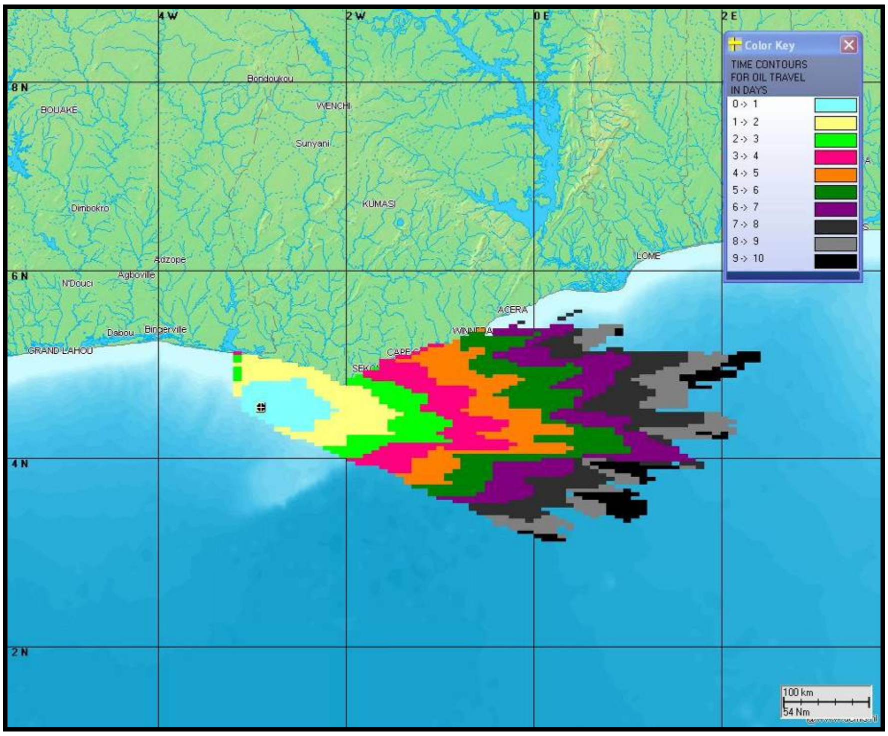


b)

Figure 15. Marine gasoil spill of 100 Tonnes at the FPSO, a) water surface probabilities of oiling; b) travel time contours.

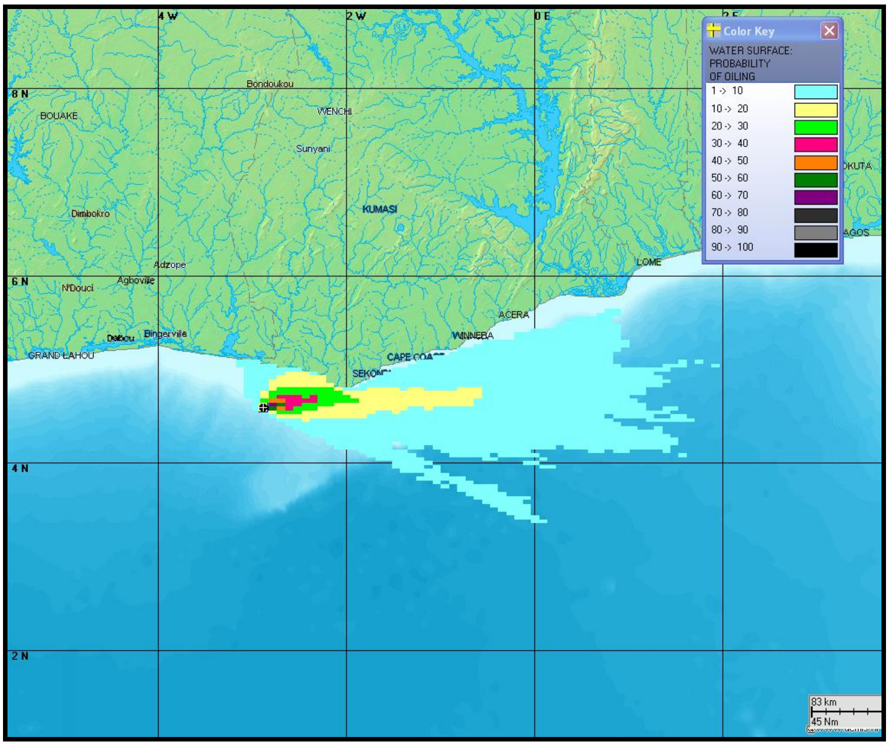


a)

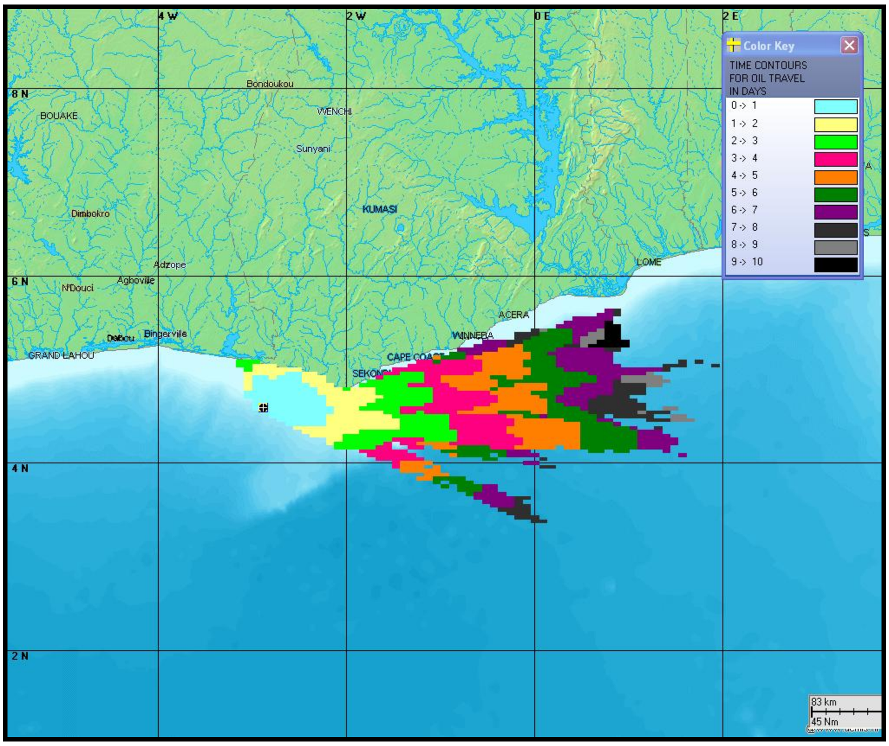


b)

Figure 16. Crude spill of 1000 Tonnes at Well M1, a) water surface probabilities of oiling; b) travel time contours.

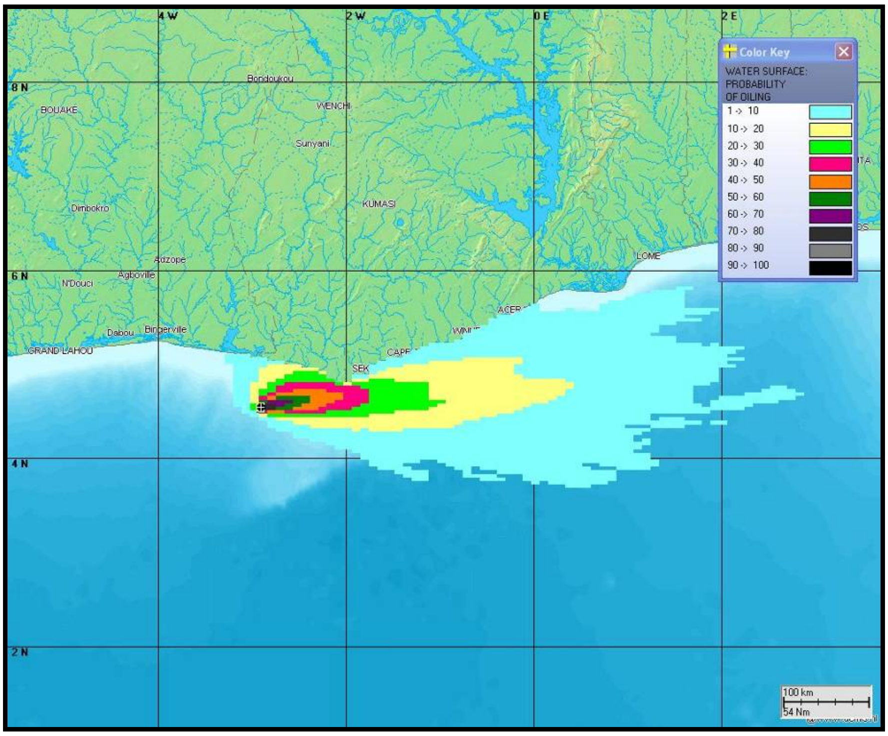


a)

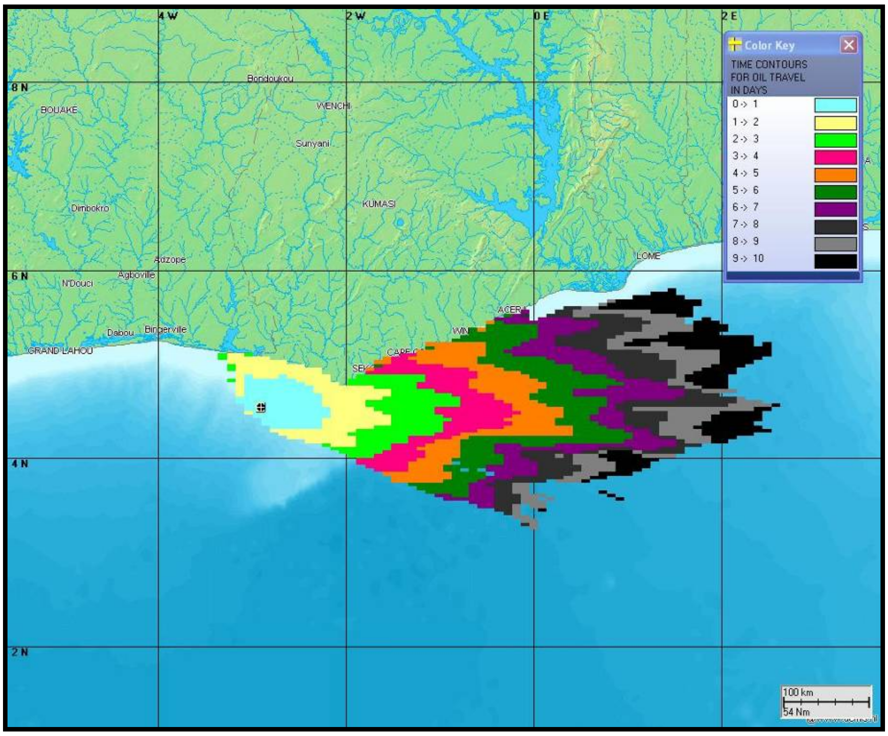


b)

Figure 17. Crude spill of 1000 Tonnes at the FPSO, a) water surface probabilities of oiling; b) travel time contours.

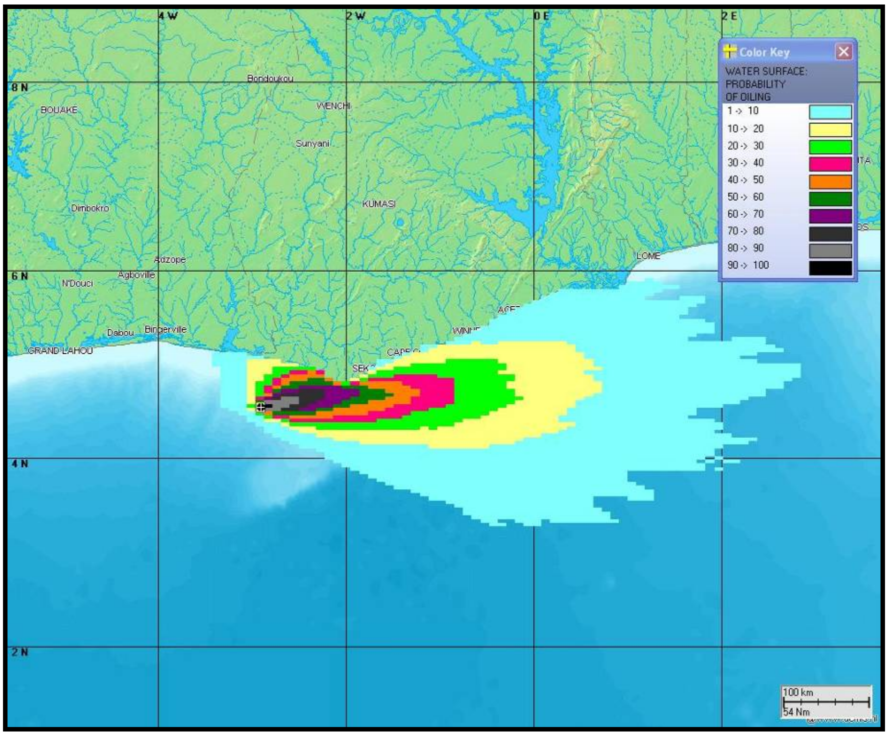


a)

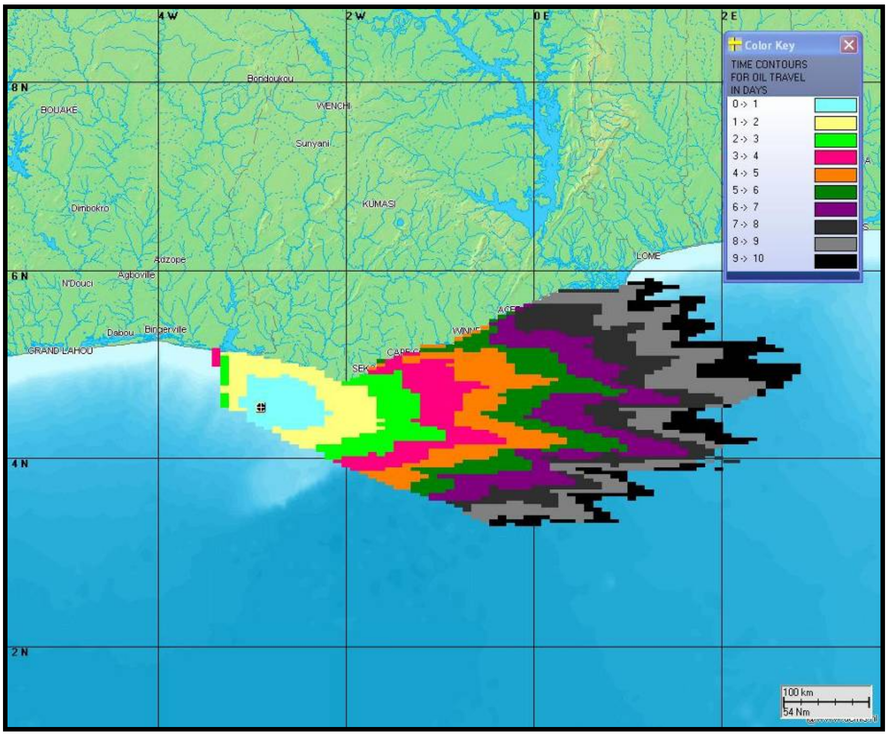


b)

Figure 18. Crude spill of 5000 Tonnes at Well M1, a) water surface probabilities of oiling; b) travel time contours.

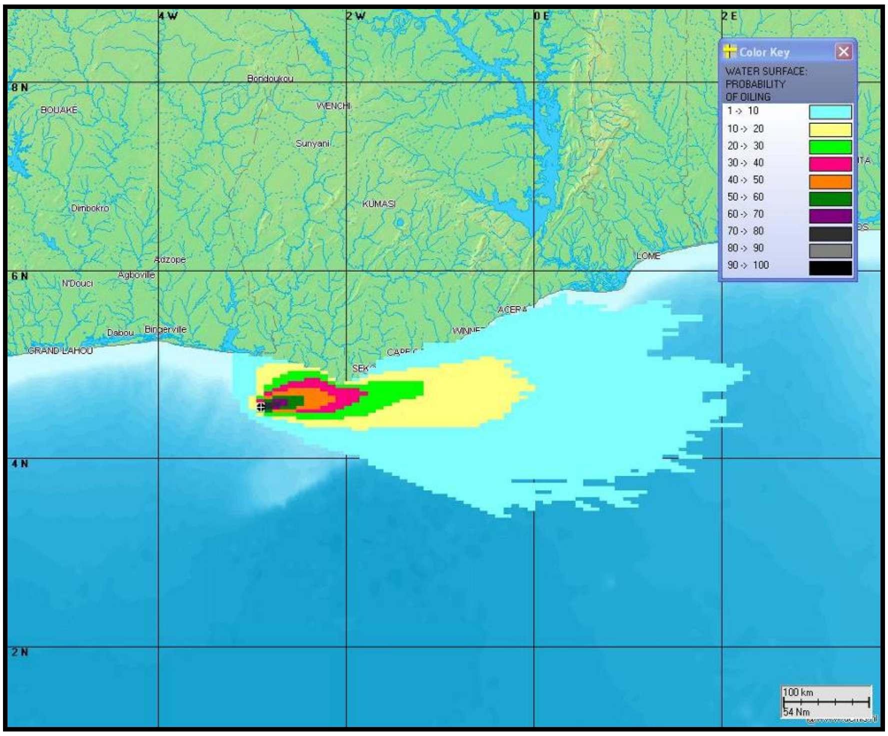


a)

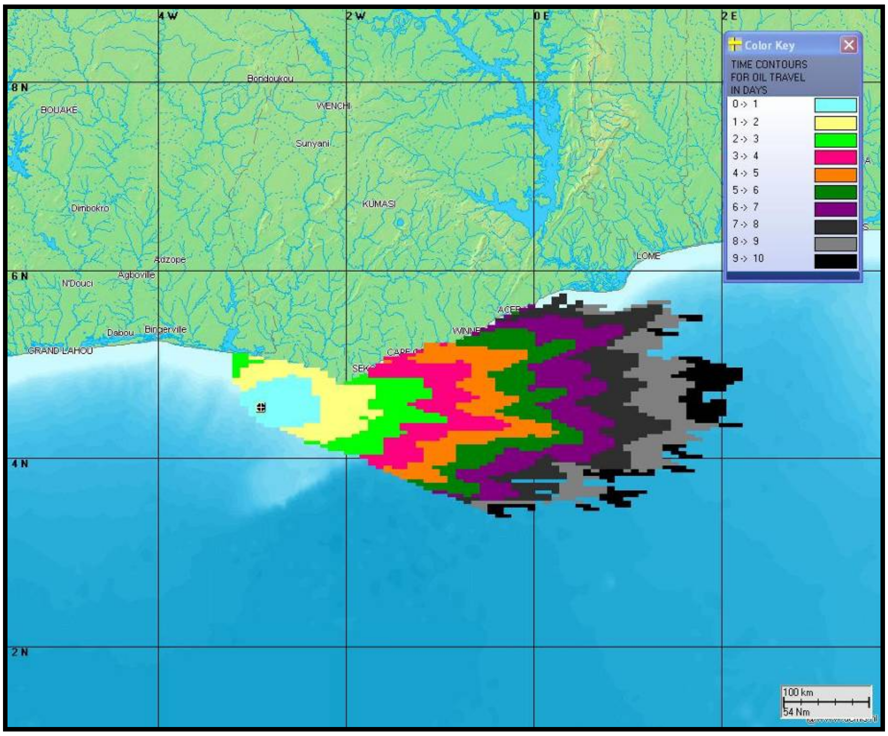


b)

Figure 19. Crude spill of 20,000 Tonnes at Well M1, a) water surface probabilities of oiling; b) travel time contours.

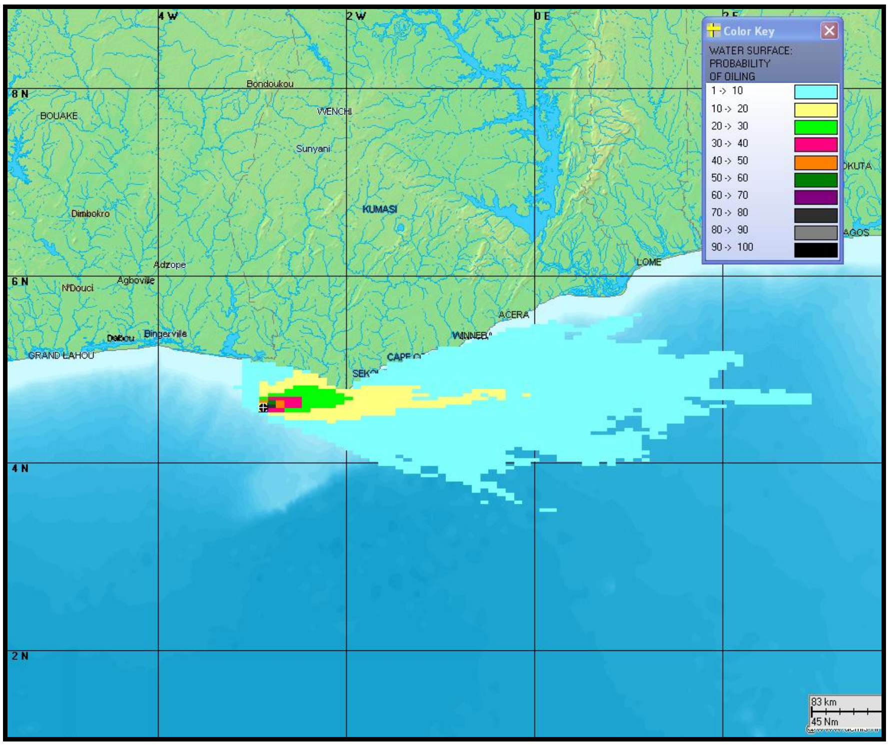


a)

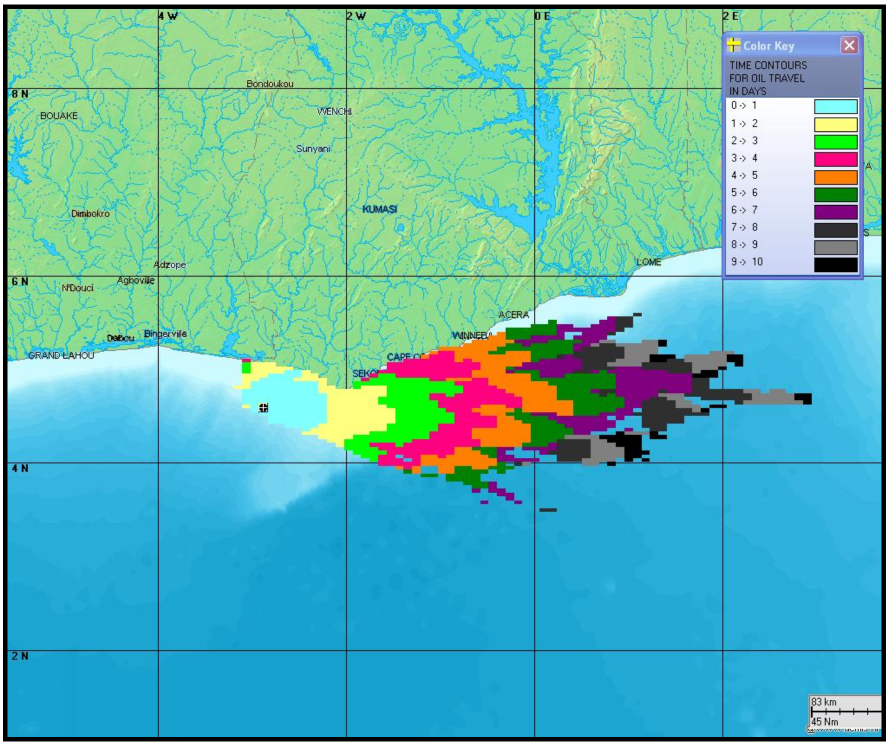


b)

Figure 20. Crude spill of 28,000 Tonnes at Well M1, a) water surface probabilities of oiling; b) travel time contours.



a)



b)

Figure 21. Crude spill of 28000 Tonnes at the FPSO, a) water surface probabilities of oiling; b) travel time contours.

3.4. Deterministic Model Predictions

A deterministic trajectory/fate simulation was performed for a simulation resulting in significant shoreline impacts identified in the stochastic analysis. Deterministic simulations provide a time history of oil weathering over the duration of the simulation, expressed as the percentage of spilled oil on the water surface, on the shore, evaporated, and entrained in the water column.

The simulation with significant impacts can be defined in many ways: as the simulation that predicts the shortest time for oil to reach shore, the simulation with the most oil ashore, the simulation with the greatest length of shoreline oiled, or based on some other criterion. For this study, due to the consistency of the wind record and the similarity of the stochastic predictions for the eleven scenarios considered, a single start time was selected to be used for all trajectory/fate simulations. The simulation time was chosen to encompass a period in which the winds and currents resulted in a greater transport of oil to shore than most other time periods. Winds are primarily from the south, transporting the first oil onshore 45 hours after the spill begins. The time for the first oil to reach shore is approximately half the average time for oil to reach shore determined by the stochastic simulations (see Table 4).

Trajectory/fates simulations were run for all scenarios except the marine gasoil spill of 10 Tonnes at the FPSO. Results are shown in Figures 22-41. Two figures are given for each scenario: the first shows the predicted footprint of the spilled oil (in gray) and the shoreline impacted (in red), the second shows the oil mass balance over time.

The footprint of the instantaneous spills of 10 or 100 Tonnes is almost exactly the same for the crude and marine gasoil spills at Well M1 and the FPSO (Figures 22, 24, 26, and 28) with the same shoreline area being oiled. The mass balance figures show the difference due to the type of oil: due to the lower evaporation rate of the crude, 70-75% of the crude oil is still on the water surface when the spill reaches land (Figures 23, 25 and 27). In contrast, evaporation has removed approximately 60% of the marine gasoil prior to landfall (Figure 29).

Similarly the footprints for the 2-hour duration crude oil spills of 1000 and 28,000 Tonnes (Figures 32 and 40) are nearly identical to those of the instantaneous 100 Tonne spills (Figures 24 and 26) and the trend of the mass balance is also similar (Figures 33 and 41 versus Figures 25 and 27). For the larger spills, there is a slight decrease in the percentage evaporated and correspondingly slight increase in the percentage of oil in the water or on shore throughout the duration of the simulation.

The 48-hour duration spills of 1000, 5000 and 28,000 Tonnes at Well M1 (Figures 30, 34 and 38, respectively) have very similar footprints and extent of shoreline oiling. The effect of a 48-hour spill, compared to an instantaneous spill (Figures 24, 26 and 28), is to spread the oil over a wider area due to the winds shifting while the oil is being released. For these scenarios approximately 75 km of shoreline are oiled. The mass balances (Figures 31, 35, and 39) are also similar for these scenarios, with approximately 80% of the oil on the water surface when oil first reaches shore and oil going ashore over a period of just over two days.

The 168-hour duration spill (Figure 36) shows the largest oiled footprint of all the scenarios due to winds shifting over the long duration of the release. Approximately 125 km of shoreline are impacted by the spill. Oil reaches shore while oil is being released at the well site; the mass balance (Figure 37) shows that roughly 20% of the released oil has evaporated by the time it first reaches shore.

A few generalizations can be made based on the results of the trajectory/fates simulations. Most obvious is that the length of shoreline impacted depends on the duration of the spill release. As oil is released over a longer period, variations in winds and currents carry the spilled oil in different directions so that when it finally reaches shore, it is spread over a wider area. For the short duration spills (instantaneous to 2 hours) 10-12 km of shoreline are impacted. A spill duration of 48 hours results in 75 km of shoreline oiled, while a 168-hour release impacts more than 125 km of shoreline. Note that all these simulations are run under the same environmental conditions.

Also evident from the oil mass balance results is that the amount of oil that strands onshore is reduced by the extent of evaporation that occurs before the oil reaches shore. The longer it takes for oil to reach shore, the more time is available for evaporation to reduce the surface water mass. Evaporation is also affected by oil type, water temperature and wind speed. The typically high water temperatures in the study area increase the rate and amount of evaporation over what would occur in temperate regions.

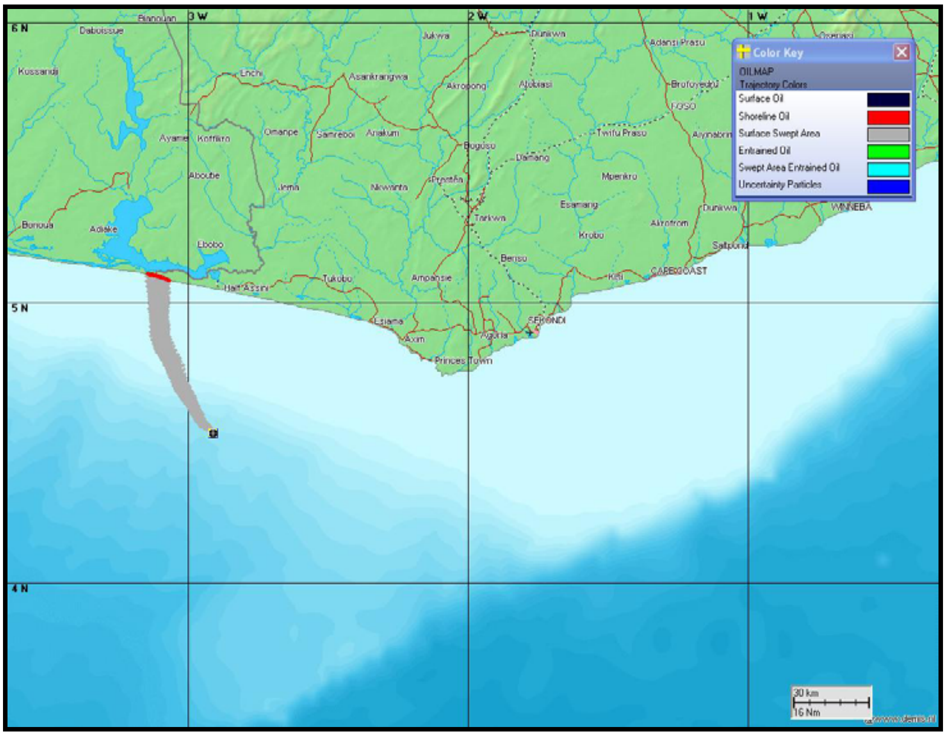


Figure 22. Instantaneous spill of 10 Tonnes crude at Well M1: model predicted water surface signature of the significant impacts spill.

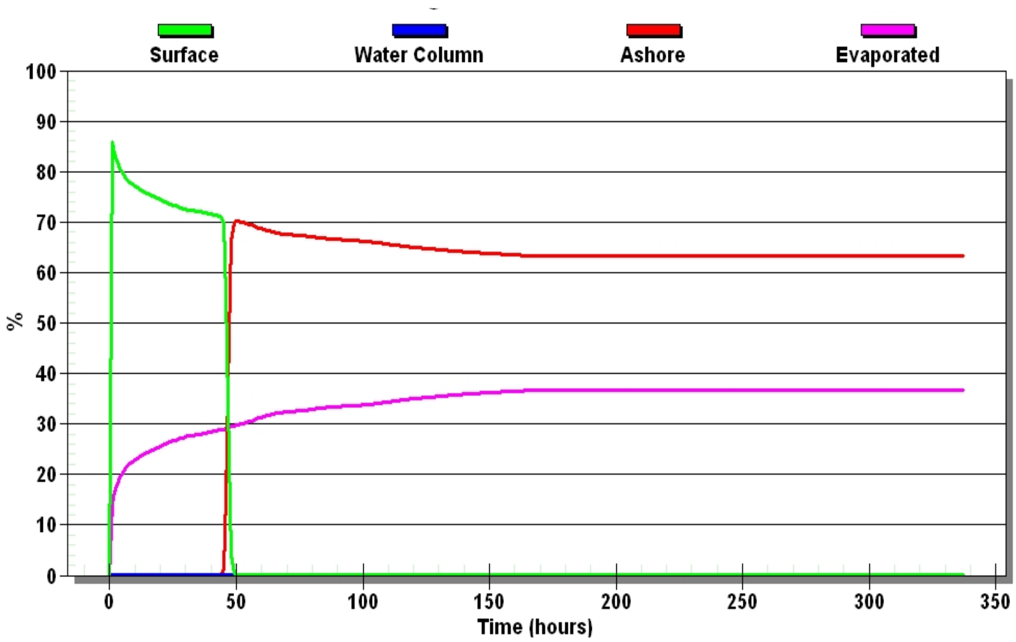


Figure 23. Instantaneous spill of 10 Tonnes crude at Well M1: model predicted mass balance of the significant impacts spill.

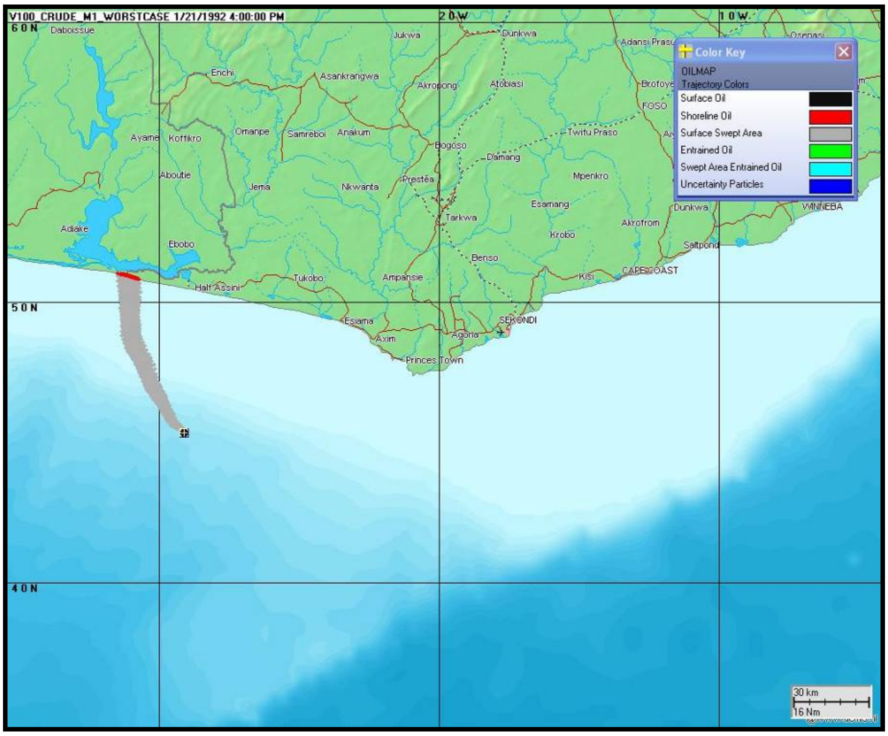


Figure 24. Instantaneous spill of 100 Tonnes crude at Well M1: model predicted water surface signature of the significant impacts spill.

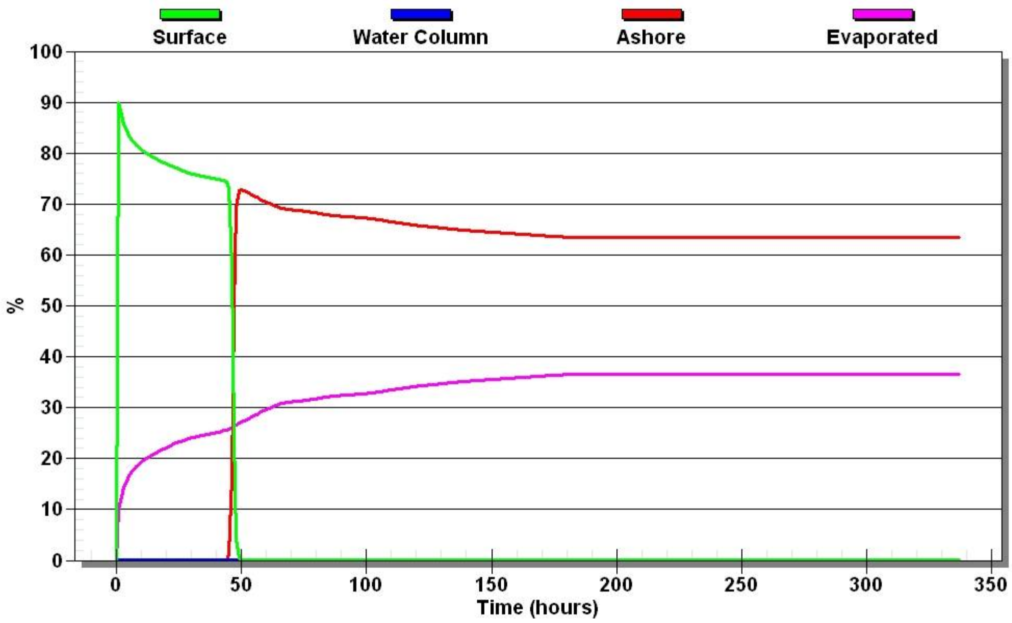


Figure 25. Instantaneous spill of 100 Tonnes crude at Well M1: model predicted mass balance of the significant impacts spill.

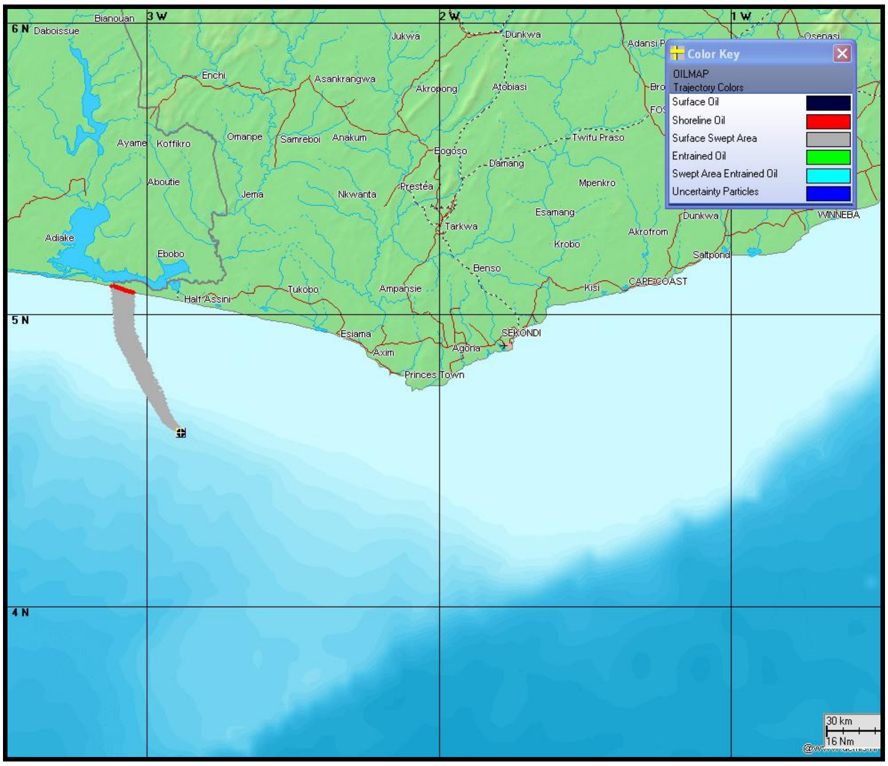


Figure 26. Instantaneous spill of 100 Tonnes crude at the FPSO: model predicted water surface signature of the significant impacts spill.

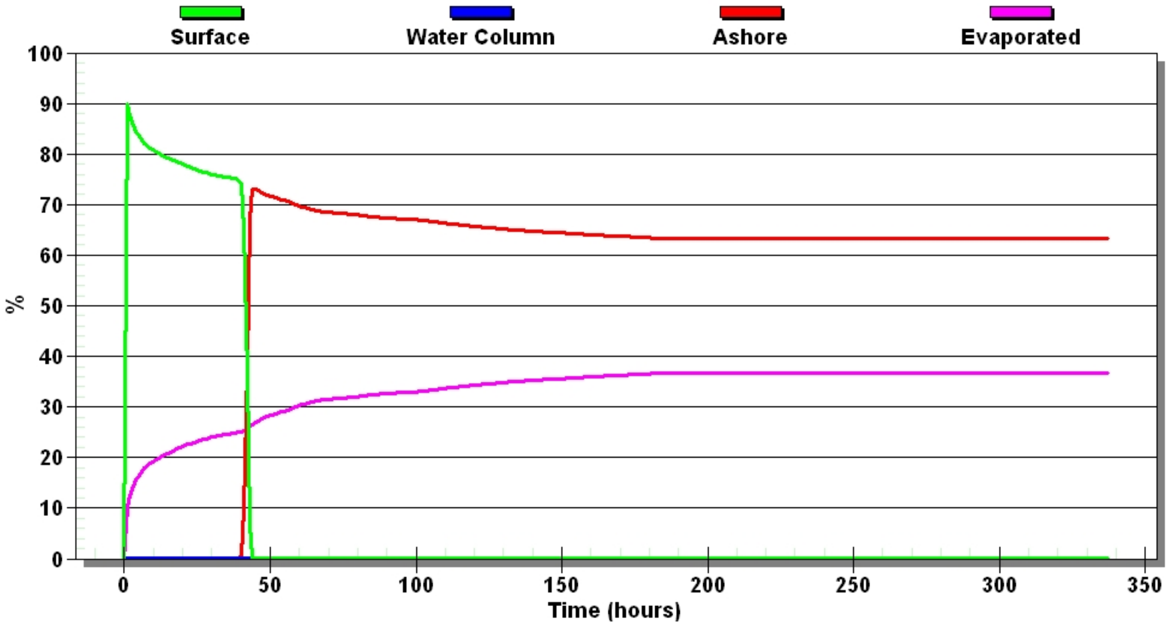


Figure 27. Instantaneous spill of 100 Tonnes crude at the FPSO: model predicted mass balance of the significant impacts spill.

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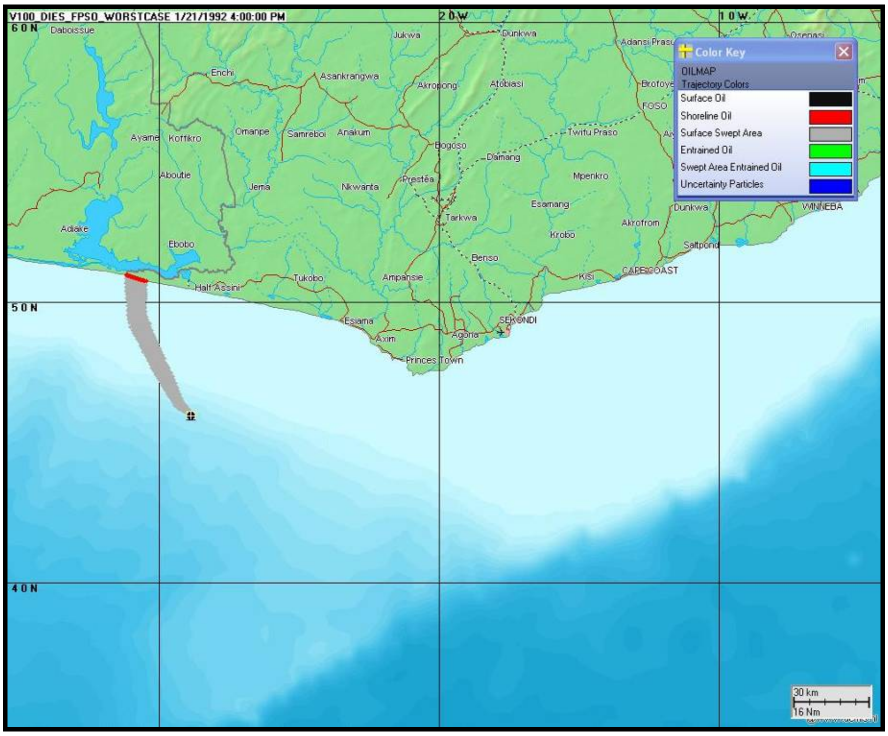

Figure 28. Instantaneous spill of 100 Tonnes marine gasoil at the FPSO: model predicted water surface signature of the significant impacts spill.

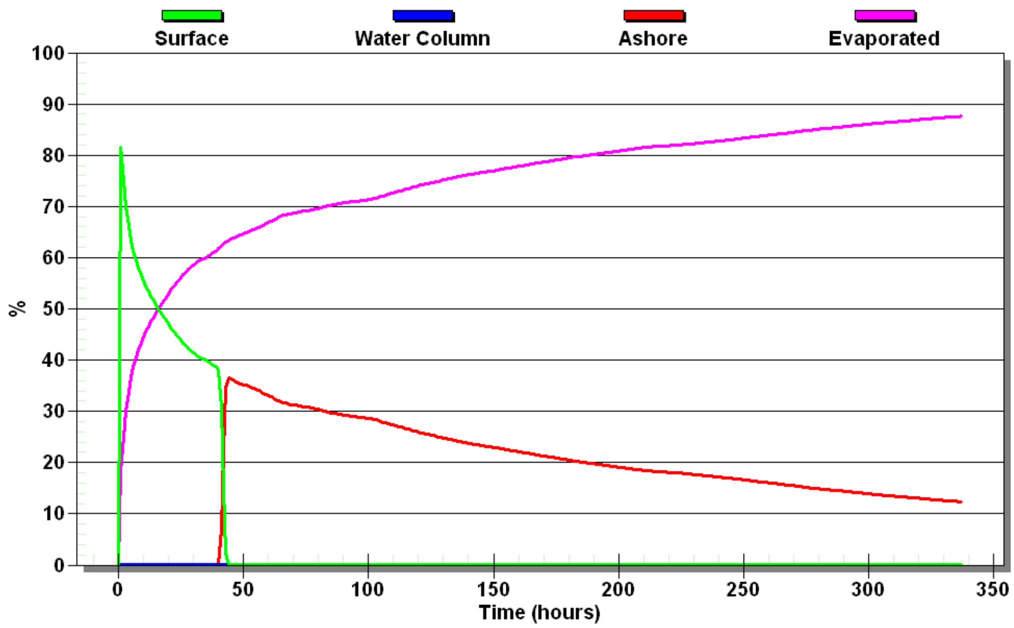

Figure 29. Instantaneous spill of 100 Tonnes marine gasoil at the FPSO: model predicted mass balance of the significant impacts spill.