5. TRACKING AND SURVEILLANCE

Knowledge of the present position of spilled oil and an ability to predict its motion are essential components of any oil spill response. This function is known as surveillance and tracking and has three main components:

- *Identifying the location of the oil using visual observation*
- *Identifying the location of the oil using remote sensing techniques*
- *Calculating and predicting the motion of the oil, generally using a computer program*

5.1. Visual Surveillance

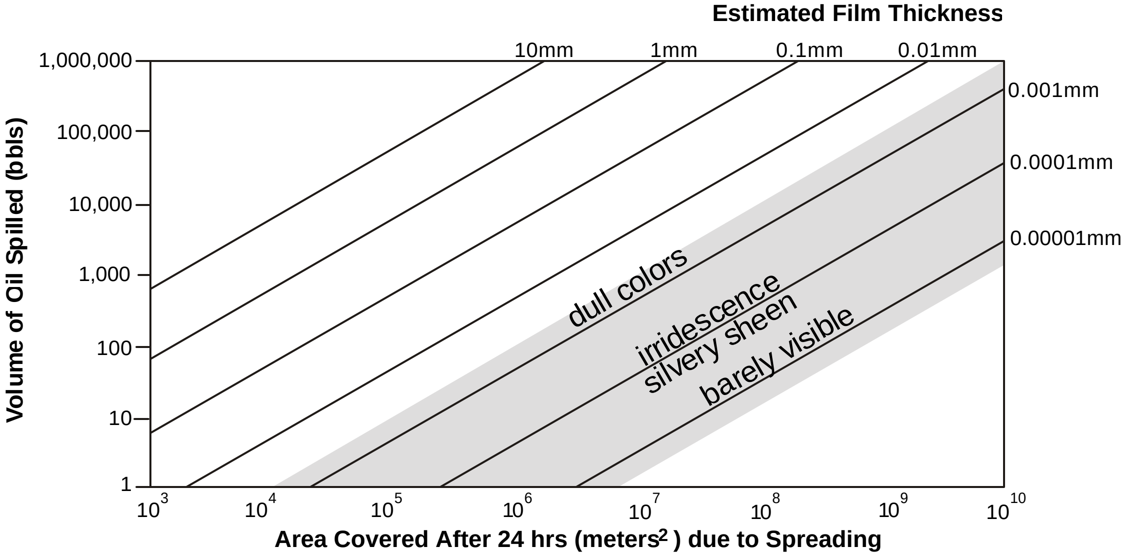
For small spills, visual observation is the best method of locating the oil. This will be done from the spill site or through the use of a helicopter. As visibility decreases, it becomes more difficult to locate the oil. In such conditions, it may be advisable to deploy oil-spill tracking buoys to follow the motion of the oil.

For reliable detection of oil on water, a trained observer will be used, since there are many naturally occurring ocean features that can be confused with oil. These include:

- *Wind slicks*
- *Cloud shadows*
- *Ocean fronts*
- *Surface vegetation*
- *Benthic habitats*
- *Diatom blooms*
- *Wood debris*

Visual observations of oil on water can provide an estimate of the thickness of the oil slick. A thick oil slick appears brown or black, whereas a very thin oil slick has a gray or silver appearance (Figure 5-1). Emulsified oil has a red to brown color, indicating that water has been incorporated into the slick. Table 5-1 can be used as a guideline for estimating oil spill volume; however, it is highly recommended that an experienced spill observer estimate the spill volume.

Figure 5-1 Relationship Between Appearance, Thickness, and Volume of Crude Oil on Water



Note: shaded area indicates the range for which thickness and area covered can be determined by appearance. Any value below the shaded area would not be visible, and any value above would be dark brown or black.

Table 5-1. Guidelines for Estimating Oil Spill Volume (liters)

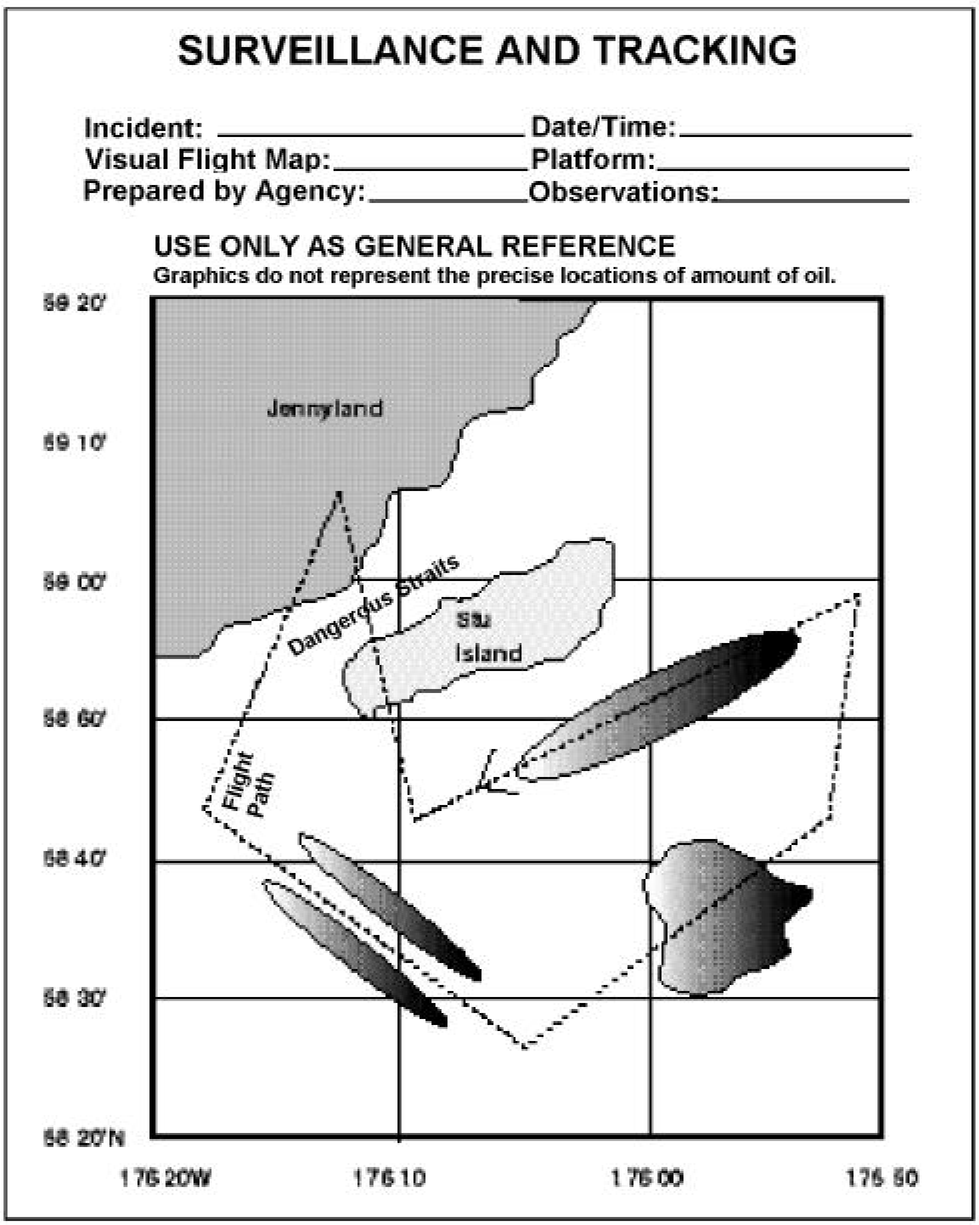
	Visual Color					
	Barely Discernible	**Silvery Sheen**	**Faint Colors**	**Bright Band of Color**	**Dull Colors**	**Light Brown**
Approximate Thickness (mm)	**4×10^{-5}**	**10^{-4}**	**1.5×10^{-4}**	**3×10^{-4}**	**10^{-3}**	**2×10^{-3}**
Area (m^2)						
100	0.004	0.01	0.015	0.03	0.1	0.2
500	0.02	0.05	0.075	0.15	0.5	1.0
1,000	0.04	0.1	0.15	0.3	1.0	2.0
1,500	0.06	0.15	0.225	0.45	1.5	3.0
2,000	0.08	.02	0.3	0.6	2.0	4.0
3,000	0.12	0.3	0.45	0.9	3.0	6.0
5,000	0.2	0.5	0.75	1.5	5.0	10.0
10,000	0.4	1.0	1.5	3.0	10.0	20.0
30,000	1.2	3.0	4.5	9.0	30.0	60.0
60,000	2.4	6.0	9.0	18.0	60.0	120.0
90,000	3.6	9.0	13.5	27.0	90.0	180.0
100,000	4.0	10.0	15.0	30.0	100.0	200.0
125,000	5.0	12.5	18.75	37.5	125.0	250.0
150,000	6.0	15.0	22.5	45.0	150.0	300.0
175,000	7.0	17.5	26.25	52.5	175.0	350.0
200,000	8.0	20.0	30.0	60.0	200.0	400.0
400,000	16.0	40.0	60.0	120.0	400.0	800.0
600,000	24.0	60.0	90.0	180.0	600.0	1,200.0
800,000	32.0	80.0	120.0	240.0	800.0	1,600.0
1,000,000	40.0	100.0	150.0	300.0	1,000.0	2,000.0
1,250,000	50.0	125.0	187.5	375.0	1,250.0	2,500.0
1,500,000	60.0	150.0	225.0	450.0	1,500.0	3,000.0
1,750,000	70.0	175.0	262.5	525.0	1,750.0	3,500.0
2,000,000	80.0	200.0	300.0	600.0	2,000.0	4,000.0
2,250,000	90.0	225.0	337.5	675.0	2,250.0	4,500.0
2,500,000	100.0	250.0	375.0	750.0	2,500.0	5,000.0
2,750,000	110.0	275.0	412.5	825.0	2,750.0	5,500.0

The volume of the oil is in liters. The calculation assumes that the oil is of uniform thickness over the total area. This is rarely the case, especially for large areas.

Visual observations of oil on water will be reported using a standard format on a map. There are many standards used for making this presentation. One standard recently developed by the American Society for Testing and Materials (ASTM) is readily available and is the result of a five-year program to produce a universally accepted reporting standard. Figure 5-2 illustrates a typical map. The base outline of the map is prepared before the survey, and visual observations are hand-recorded on the map using a standard notation.

Oil properties, local winds, and ocean currents determine the motion of spilled oil. Immediately after the oil is spilled, it spreads under the influence of gravity, retarded by the viscosity of the oil. Therefore, heavy oil spreads less than light oil.

Figure 5-2. Sample Flight-path Map for Surveillance and Tracking of Oil Spills

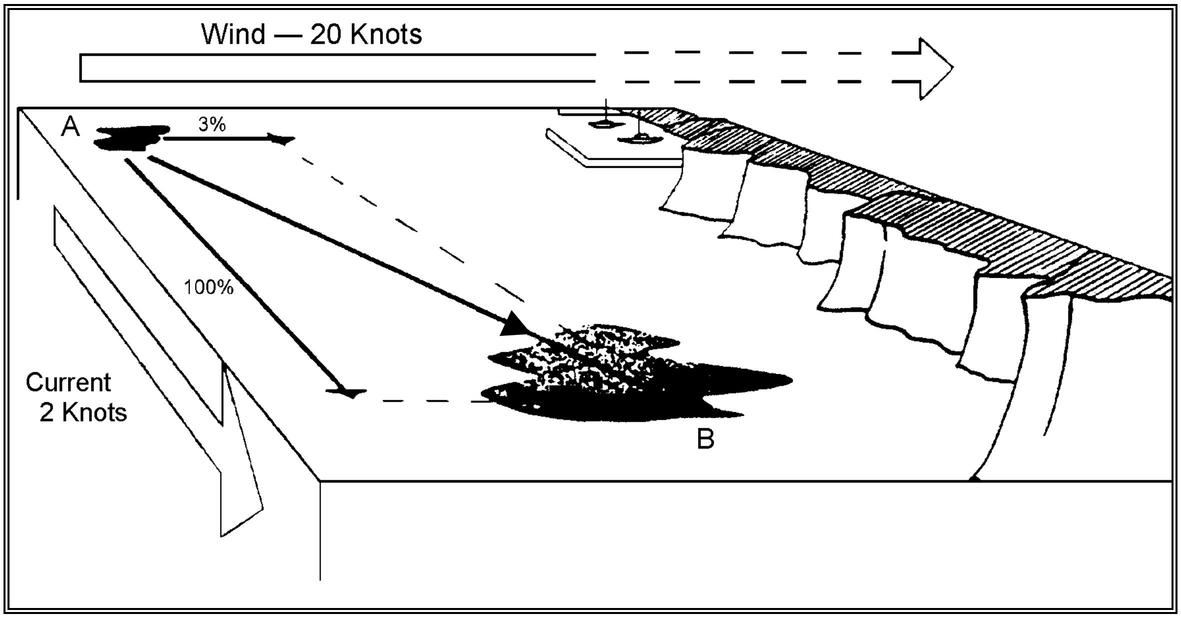


Wind directions are specified as the direction *from which* the wind occurs; that is, a north wind moves oil toward the south. The oil moves at a speed of about 3% of the wind speed; that is, a wind of 10 m/sec moves oil at a speed of 30 cm/sec. Ocean currents are specified as the direction *to which* the water is moving; that is, a north current moves the oil northward. The oil moves at the speed of the ocean currents, with no shear between the oil and water.

In order to calculate the total motion of the oil, the vector sum of the wind and currents must be calculated. This can best be done graphically as shown in Figure 5-3.

For most Tier 1 and 2-size spills, the use of vector addition in combination with local knowledge is an adequate method of predicting the future motion of the oil, since it would require a significant effort to prepare the input for a computer model.

Figure 5-3. Graphical Vector Analysis of the Motion of an Oil Spill



The influence of 3% of the wind speed combined with 100% of the current speed results in the movement of oil from A to B (adapted from ITOPF, 1987).

5.2. Remote Sensing

For Tier 2 and 3 incidents, the same types of surveillance and tracking data are needed as in Tier 1, but the spatial extent of the spill requires some changes in the operational pattern. Because of the size of the slick, visual observations will still play a prominent role in determining the oil location, but the observation platform will probably be an aircraft. Simple remote-sensing systems, such as a UV/IR camera, can provide useful additional information on the location of the slick. IR can be used to differentiate the relative thickness of the oil slick. The response effort will concentrate on the thicker part of the slick. For Tier 2 and 3 incidents, the maps of either visual or remote-sensing observations will become more complex. In some situations, a briefing will be needed on the contents of the map.

- **Radar** — Oil slicks can be detected by high-resolution, side-looking radar over large areas. The radar signal is reduced by the relatively smooth surface of an oil slick as compared to the surrounding water, and the slick appears as a black area in the radar image. The radar used is a specialized system, and conventional search radar cannot be used for this purpose. A dedicated aircraft must be used, because special antennas are required. This type of radar has an all-weather operational capability and will detect oil through cloud cover but cannot be used under high winds. Since it is the effect of the oil on the water surface that is detected, other natural phenomena that smooth the surface of the water, such as wind slicks and cliff shadows, will return the same type of signal as an oil slick. False positive images are common for radar systems. Radar systems are best used in a reconnaissance mode, with the presence of oil being confirmed using other remote sensing or visual observations.
- **Laser fluorosensor** — The laser fluorosensor uses an airborne laser beam to excite the oil. The resulting return signal contains information on the type of oil within a broad classification. The laser fluorosensor is unique in that the physical-chemical properties of the oil are the basis for detection. This means that false signals are uncommon. This instrument is the only remote-sensing system capable of identifying oil on shorelines; however, a specially equipped airplane is required for deploying this equipment.

5.3. Computer Modeling

Computer models of oil spill fate and trajectory can be used successfully to estimate movement and fate of spilled oil under different environmental conditions. One model, OILMAP, was used to predict the motion of the spills in the offshore environment of this Project (see Appendix A). A computer model is valuable for larger spills in which spatial and temporal variability of winds and ocean currents are so complex that a simple vector addition may not be adequate. OILMAP may be used in support of response measures and planning for significant offshore spills related to this Project.

During the response it may take some time to prepare the input for an OILMAP model; the model results for the two credible spill scenarios for the FSO could to be consulted during the early hours of the spill for planning purposes. The OILMAP model results presented in Figures A-5 and A-6 (Appendix A, this GOSRP) show the probability of shoreline oiling for summer and winter spills under prevailing northerly and southerly wind conditions.

Data needed to run the OILMAP model include:

- **Base map covering area of the spill** — A GIS map of the Gulf of Guinea is used, with the FSO location plotted as the potential spill source.
- **Physical properties of the oil** — The physical properties of the oil are used to compute the spread of the slick and to determine its fate in the environment. Processes, including evaporation, dispersion, dissolution, and emulsification, are dependent on the physical properties of the oil. These processes influence the physical nature and quantity of the oil being recovered. The model currently uses a Bunker C with an API of 14.1 (at 60°F).
- **Spatial and temporal wind field** — Winds have a significant influence on the motion of the oil, and accurate wind data and forecasts are essential to a successful oil-spill trajectory prediction. Winds tend to be spatially homogeneous, especially in an ocean

environment, and temporally variable. The ability to predict the future motion of an oil spill is limited by the ability to predict future wind patterns. Typical skilled meteorological predictions are for 48 hours, with an outlook to five days. The effective time limit of a trajectory model is 48 hours, because the quality of the data in longer-range meteorological forecasts is inadequate for oil-spill motion prediction. For predictions beyond this, statistical wind fields within OILMAP will be used to provide a probablistic estimate of the oil motion.

- **Spatial and temporal ocean current fields —** In contrast to wind information, ocean currents are spatially complex and temporally predictable. Tidal currents are quite predictable and, in many cases, they do not contribute to a net motion of the oil. Currents generated by topography and large-scale ocean features change over periods of months and can be assumed to be constant for any spill situation. A hydrodynamic model was developed specifically for the area of the FSO. During an actual response, verification of ocean currents will be obtained from in-situ current meters.
- **Spill-location observations —** OILMAP allows the incorporation of visual and remote-sensing observations into the model. The relocation of the oil in the trajectory model, as the result of observations, improves the predictive capability of the model.

5.4. Sample Collection

Oil samples may be collected during response to a Tier 3 incident. Oil samples should be collected from the source of the spill and from key concentrations of oil in the environment. Source samples should be collected as soon as possible after the incident to help characterize the spilled oil. Field samples should be collected to characterize the oil that has impacted shorelines or sensitive areas. All samples for chemical analysis must be collected in chemically clean jars, sealed, labelled, and kept refrigerated until processed in the laboratory. Chain-of-Custody forms must be initiated by the person collecting the samples and maintained through delivery to the laboratory. Specific lab analyses to be performed will depend on the situation and needs to be established at the time of the incident. Accredited laboratories, to be recommended by Technical Advisors at the time of an incident, would be used for all analyses.