Reference MCA website – STOp notices:
http://www.mcga.gov.uk/c4mca/mcga-environmental/mcga-dops_cp_environmental-counter-pollution.htm

This chapter covers various types of equipment used to restrict the movement of oil. The aim may be to:

- Prevent a spillage spreading;
- Reduce the area and increase the thickness of an oil layer, thus enhancing recovery;
- Deflect the path of oil towards a recovery point; and
- Deflect the path of oil to protect particular sections of coastline.

The success of such operations will depend on adequate planning prior to an incident taking place. Therefore, after reading this section, local authorities should identify those areas of coastline where booms or barriers could be used and include within their contingency plans details such as current strengths and appropriate boom configurations. In addition, fixed boom mooring points should be installed and their position noted in the plan. Having established sites where booms can be deployed successfully, regular boom deployment exercises should be carried out in order that response personnel become fully familiar with operational procedures.

5.1 Floating Booms

An oil boom is a floating barrier designed to stop the spread of oil on water. In calm conditions almost any floating solid will work as a barrier to oil. However, in waves or currents, booms require freeboard (height above the water) to prevent splash-over of oil by wave chop and sufficient depth to stop oil passing beneath. Therefore boom design incorporates a flotation chamber providing freeboard and buoyancy, and a sub-surface skirt to prevent escape of oil under the boom. The boom is held in place by mooring chains or ropes. Floating booms fall broadly into two categories:

- Skirt booms

  These consist of a flexible buoyancy chamber (usually an air-inflated plastic tube) supporting a skirt with an integral ballast chain or tension wire to provide the boom with longitudinal tensile strength as shown in Figure 4 and deployment of a skirt boom is shown in Figure 5.

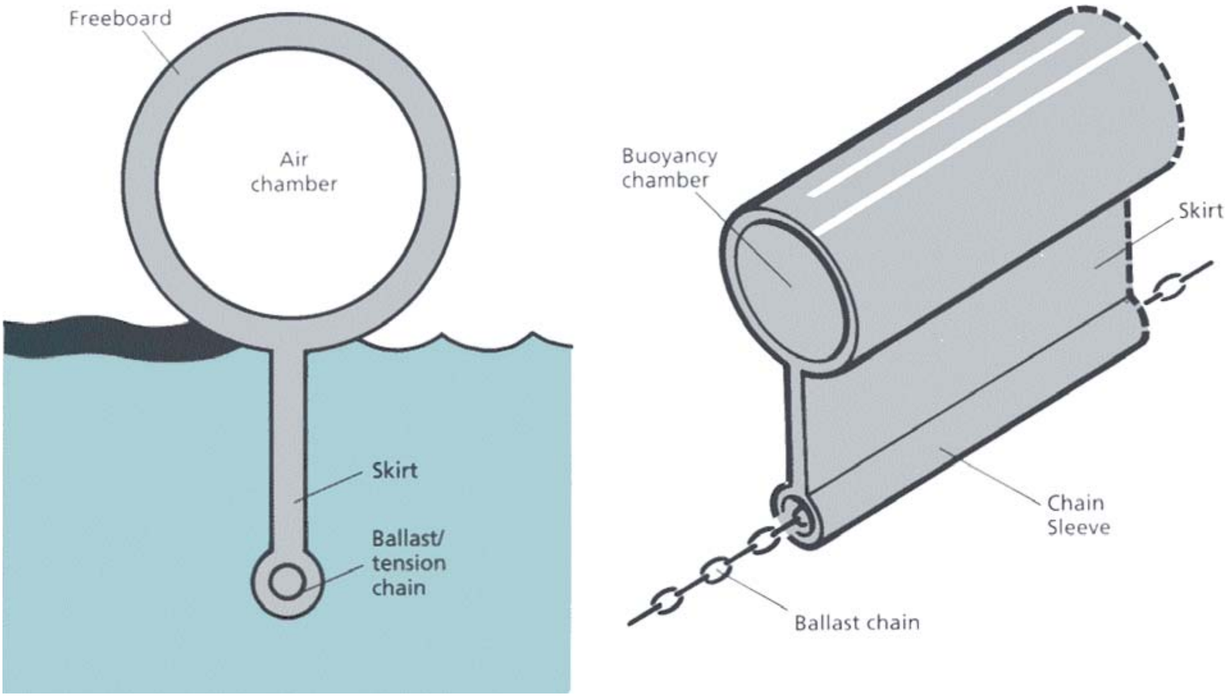


Figure 4 Skirt boom

Figure 5 Deployment of a skirt boom

- <u>Fence booms</u>
  These consist of a rigid fence-like structure with solid flotation chambers and ballast weights fitted at intervals along the skirt as shown in Figure 6. Fence booms are quick to deploy but can be bulky to store. Curtain booms, however, although they have to be inflated before use, have good wave-following capabilities and require less storage space.

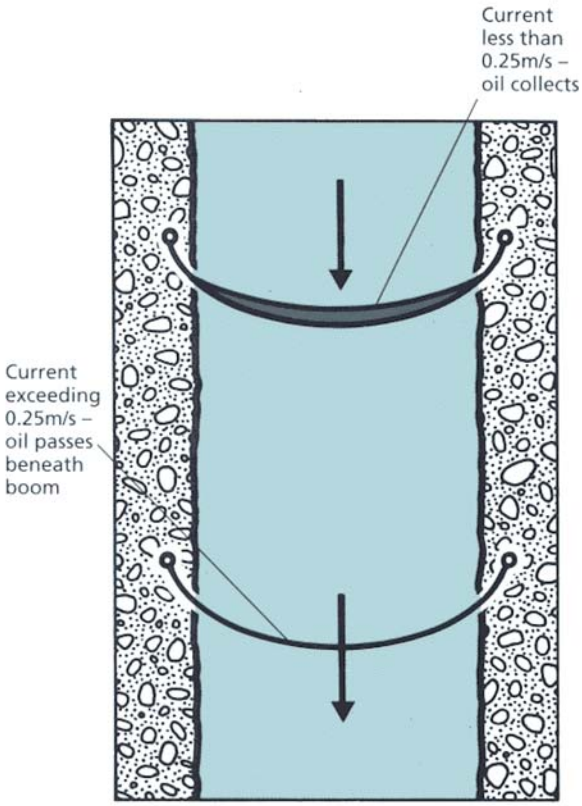
Figure 6 Deployment of a fence boom

Lengths of boom are available from the MCA stockpile, or from oil clean-up contractors or equipment manufacturers.

5.1.1 Limitations of floating booms

The main limitation on the use of booms is the velocity of the current. If a barrier is placed at right angles to a current, oil will begin to dive beneath it when the velocity exceeds 0.25m/s (0.5 knot). This is because water flows under the boom and shears oil from the oil / water interface (Figs. 7 and 8). The faster the flow, the more oil is lost. However, by securing the boom at an angle to the current, it may he possible to divert oil from faster flowing water to calmer water where the oil can be collected.

The other limiting factor is the required strength of mooring. This too depends on the flow rate of water as well as the size of the boom and is calculated.



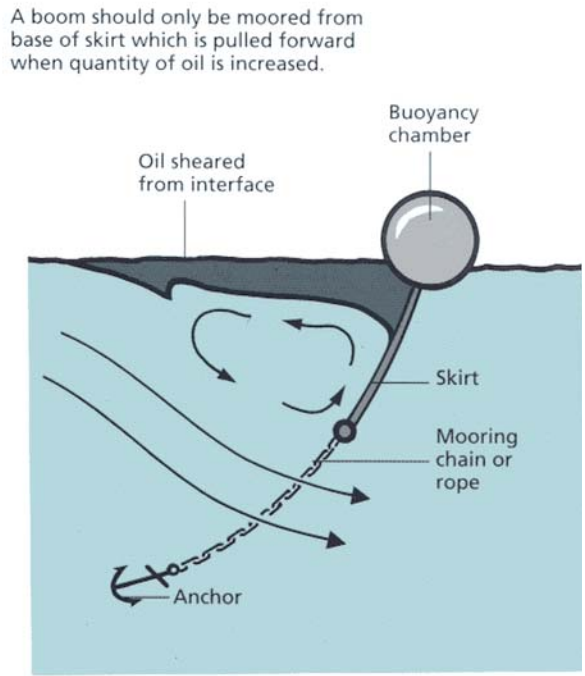


Figure 7 *Oil passing under boom* *Figure 8* *Flow beneath a boom*

5.1.2 Using floating booms

The selection of a ballast chain or tension wire to suit a particular site will depend on the flow conditions and the strength required. A light wire or chain will be sufficient in calm water but cordage or synthetic fibre rope are unsuitable for booms as their elasticity is greater than that of the boom, causing mooring loads to be transmitted to the boom fabric. Table 1 indicates sizes of chain or wire likely to be required, and it is important to ensure that there is sufficient tensile strength in reserve.

Table 1. *Load and chain cable size*

Anticipated max. load (tonnes force)	Chain cable size (mm)
0.3	3.2
0.7	4.8
1-2	7.9
3-4	12.7
5-8	15.9
9-12	18.8

It is necessary to establish the flow velocity in the river or stream, either by current metering or by using a stop watch with suitable floating objects – **this should be done at the contingency planning stage and not at the time of a spill.** The forces exerted on a boom moored in a current can then be calculated from the following formula:

$$F = \frac{CdApV^2}{2g}$$

where:

F = Force (N or kgf)
Cd = Drag coefficient (a value of 2 is realistic)
A = Immersed aspect area of the boom (m2)
p = Density of water (1000kglml)
V = Mean current velocity near the water surface (m/s)
g = gravity (10mlsl)

As an example, if a boom with a skirt depth of 30cm is placed across a river 50m wide in which the surface current is 0.5m/s, the drag would be:

$$\frac{2 \times 50m \times 0.3m \times 1000\ Kg / m^3\ 0.5\ m/s \times 0.5\ m/s}{2 \times 10\ m/s^2} = 375N$$

As the load is proportional to V squared, if the current flow is doubled, the force increases by a factor of four.

Mooring arrangements for floating booms

The type of mooring arrangement will be dictated by the area in which the boom is deployed. For a water channel not exceeding about 100 m in width, the form of mooring in Figure 9 is the simplest to arrange and no anchors are required.

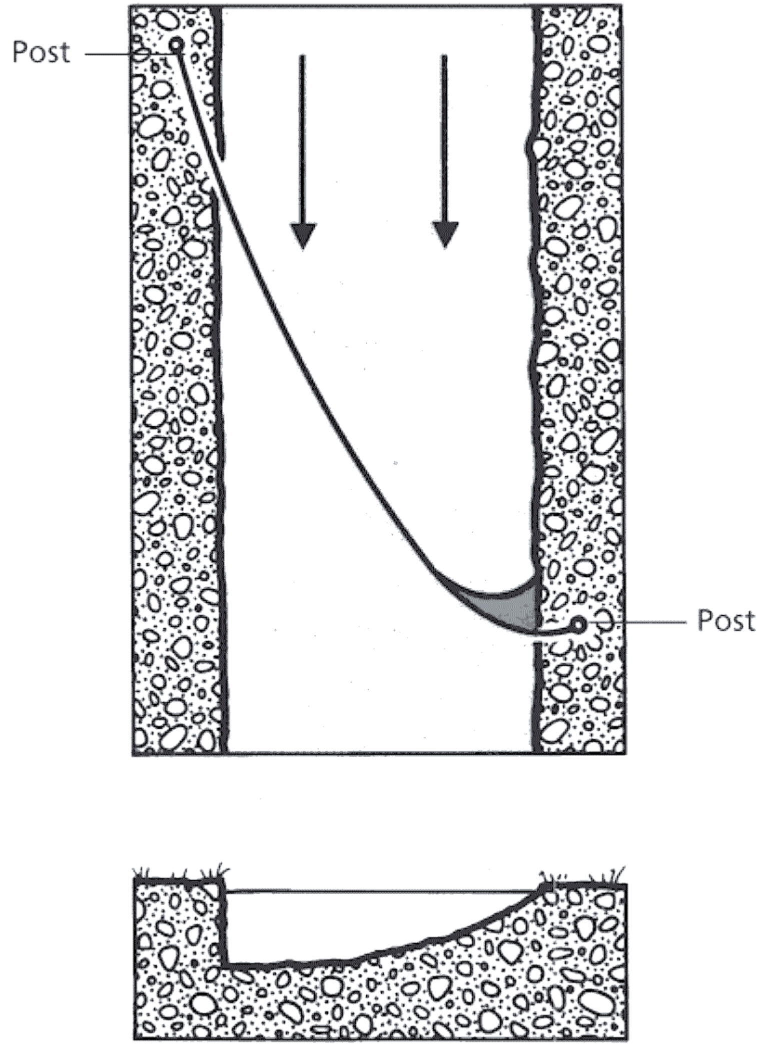


Figure 9 Simple boom mooring in a water channel

Bank moorings can take several forms. For light work, an anchor or post may be used but where high loads are anticipated, a buried sleeper wrapped in steel chain forms an economical and easily arranged terminal mooring (Figure 10). In some areas, particularly those where pollution occurs more frequently, permanent moorings should be set up at points where access is good and where local conditions are known to be suitable for the operation of booms. In general, such sites will have lower flow velocities than elsewhere, and road and river access will be feasible.

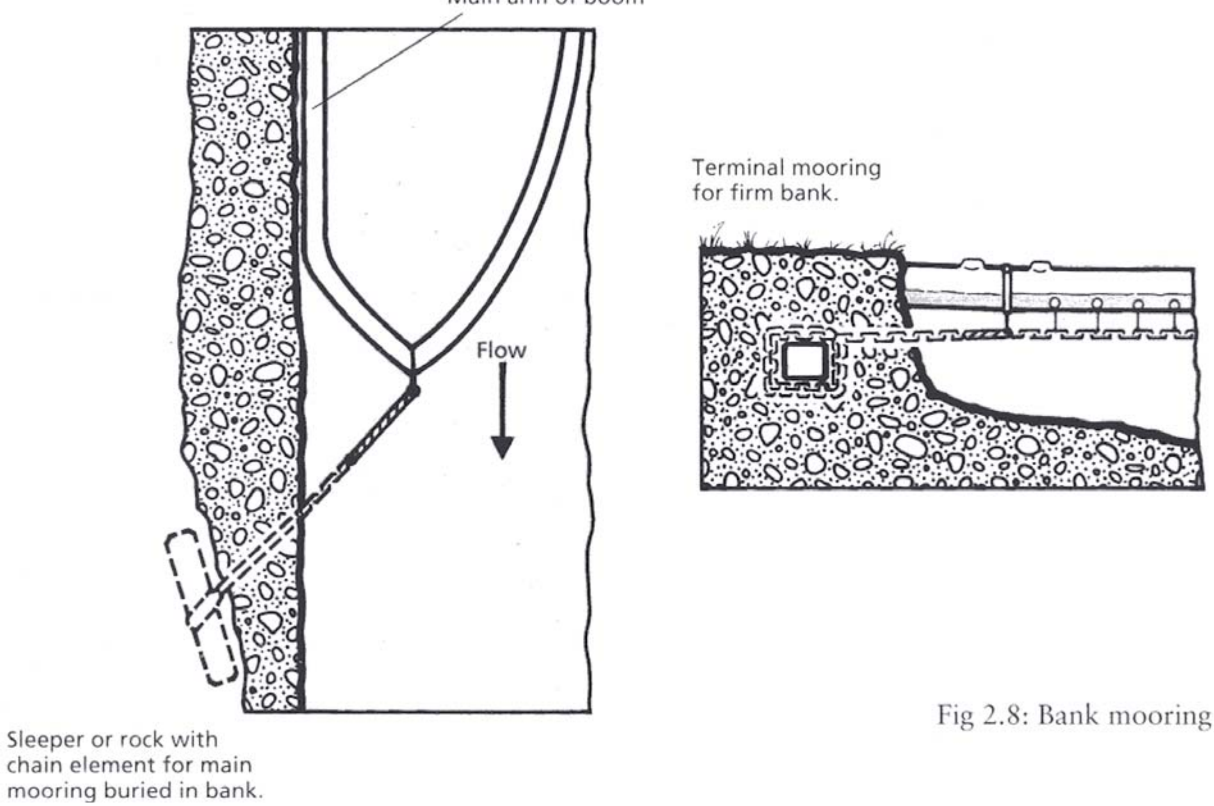


Fig 2.8: Bank mooring

Figure 10 Bank mooring

Anchors of the Danforth or Fisherman's type form the best means of mooring in flowing waters. Heavy clumps of cast iron (sinkers) and concrete blocks also make convenient and reliable mooring points, but their weight in air must be at least three times the expected load, to compensate for their reduced weight in sea water. The exact holding power of anchors is difficult to calculate; in general terms the Fisherman's type anchor works better on rocky bottoms and the Danforth is more effective on sand and mud substrates. The approximate holding power of Danforth type anchors in various sediment types is given in Table 2 below.

Anchor weight (kg)	**Holding Strength (kg force)**		
	Mud	Sand	Clay
15	200	250	300
25	350	400	500
35	600	700	700

Table 2. Holding strength of Danforth type anchors in loose mud, sand or gravel, and clay

The length of mooring between boom and anchor should be five times the maximum water depth. In tidal waters, the depth of water at high tide should be taken into account. Clearly, if the mooring is too short the boom may be dragged beneath the water surface or the anchor may be 'tripped' out. If the mooring rope is too long, its elasticity may allow the boom too much movement, so that in current flow the drag forces cause the boom to form a deep cusp (Figure 11), the centre of which is located away from the shoreline.

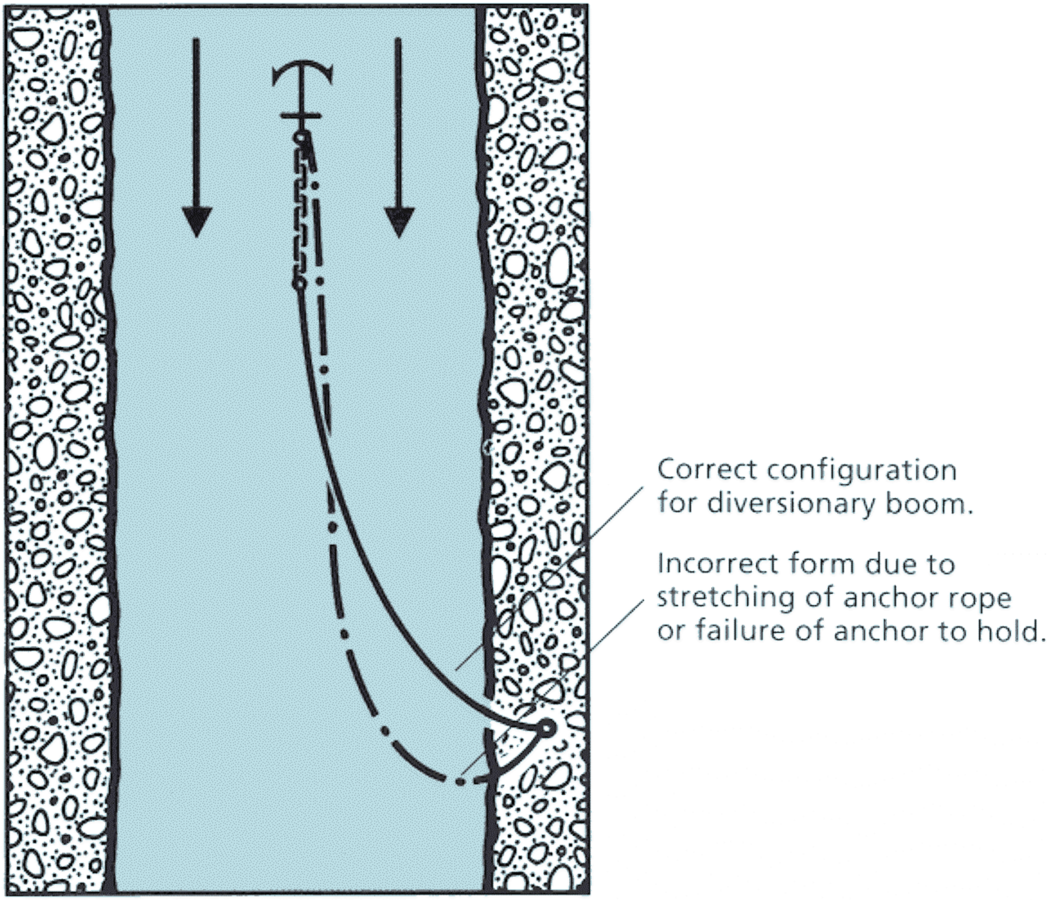


Figure 11 Cusp in diversionary boom due to mooring failure

The insertion of a buoy in a leading mooring helps to maintain a more or less horizontal pull on the boom, thereby reducing the tendency to submerge the leading boom module. The distance between boom and buoy should be about a quarter of the water depth. Figure 12 shows the general arrangement of this type of mooring.

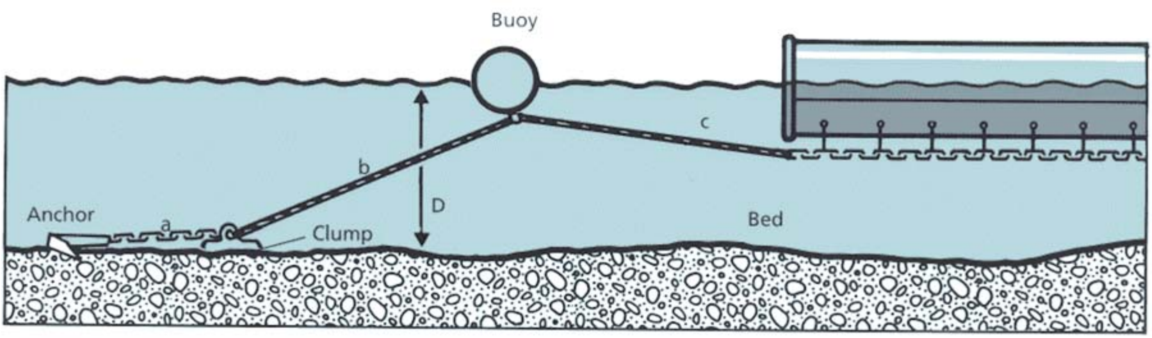


Figure 12 Length of mooring chains relative to water depth

Boom layout

A boom moored at right angles to the flow of water (Figure 7) is the simplest arrangement, but as explained earlier, if the current exceeds 0.5 knot, oil will inevitably be lost under the boom. However, if the boom is placed obliquely at an angle to the direction of flow, floating oil may be diverted to a region of calmer water (Figure9). This may also make recovery of the oil more convenient. The maximum velocity of water past the boom at any given point is still limited but depends on the angle between the current and the boom. However, this angle becomes more acute as the current flow velocity increases - see Table 3 below. Above 1.5 m/s (3 knots), the acute angle and the excessive length of boom required makes boom deployment impractical.

Current strength (knots)	(m/S)	Maximum angle (degrees)
0.7	0.35	90
1.0	0.5	45
1.5	0.75	28
2.0	1.0	20
2.5	1.25	16
3.0	1.5	13

Table 3. Maximum boom deployment angles at different current strengths to prevent escape of oil

Many rivers have a cross-section that is saucer- shaped (Figure 13). In rivers of this type, the flow at the centre of the channel may be much greater than at the sides because, as the water shallows towards the banks, the bed creates added friction which reduces the velocity. Under these conditions, the chevron-shaped boom layout is suitable. Oil is diverted to the banks where it may be conveniently collected.

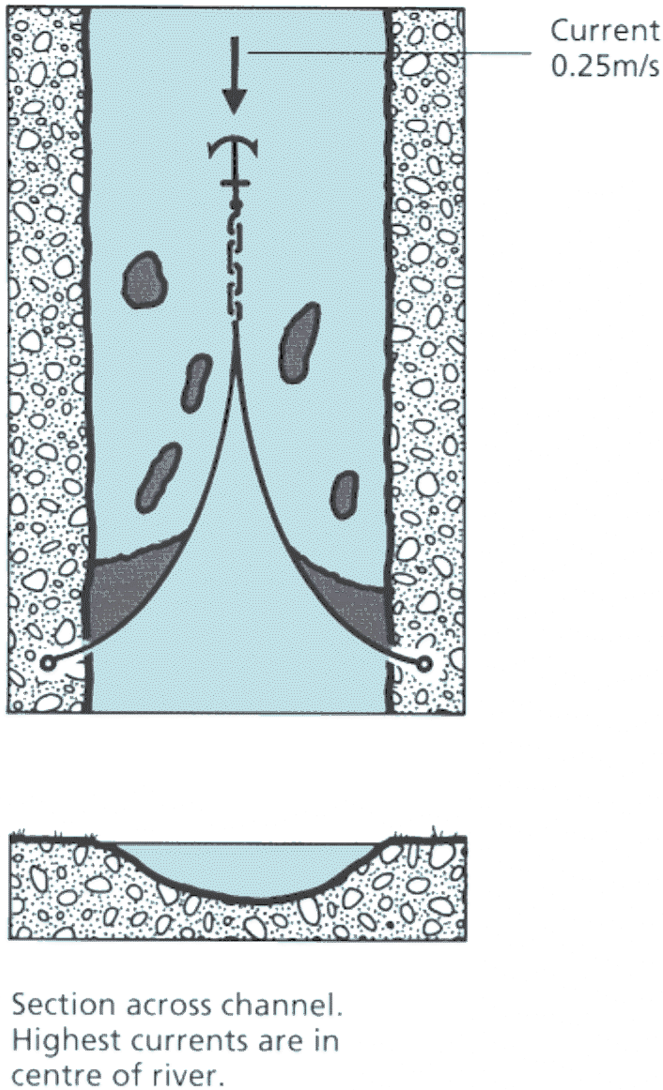


Figure 13 Effect of cross-section on current

However, in rivers with steep banks (Figure 14) high velocities may persist to both sides, thereby eliminating any chance of containment.

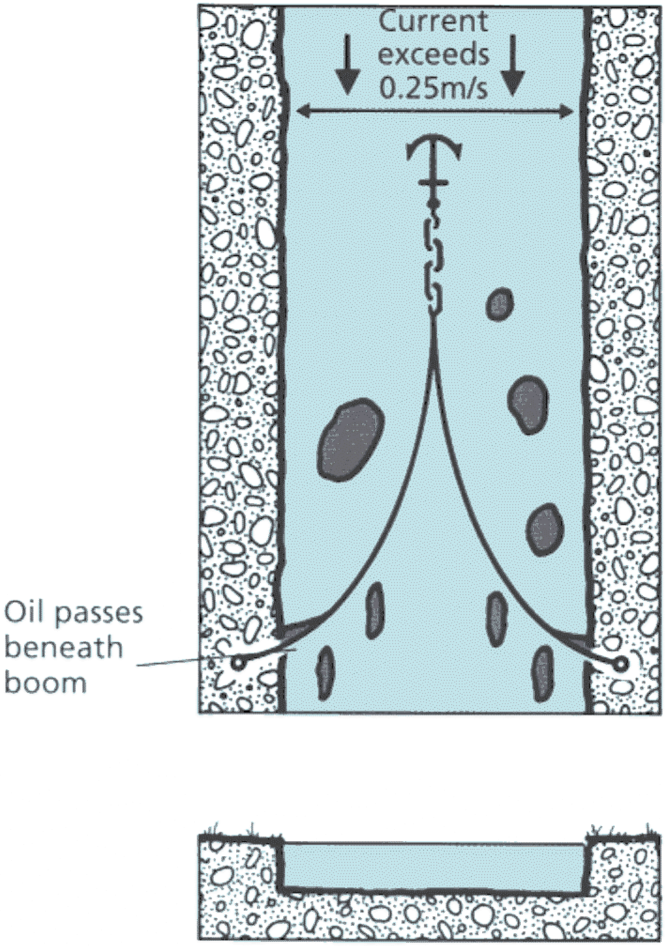


Figure 14 Effect of cross-section on current

If the channel is asymmetric in section, a single boom diagonally placed will be satisfactory, the oil being diverted from a high flow region (deep water) to the shallower side where current velocities are likely to be lower (Figure 9).

Spur booms (Figure 15) are sometimes useful where pollution is limited to only one side of a river (e.g. due to a ruptured storage tank or tanker leak). These layouts should take the form of a half-chevron and particular care should be taken in choosing an anchor of adequate holding power.

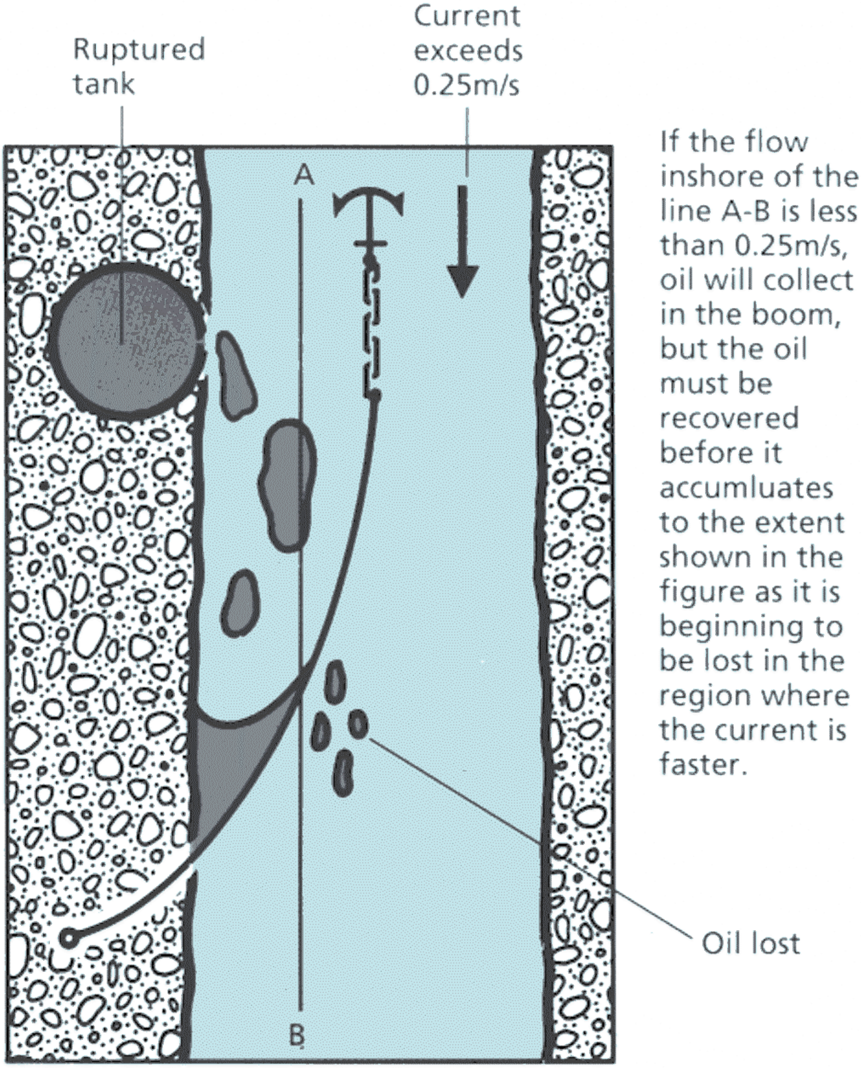


Figure 15 Use of a spur boom

In some cases, there may be no requirement to contain floating oil, only to divert it from a fresh or cooling water intake. The arrangement shown in Figure 16 is one way of siting a boom for use in tidal flow.

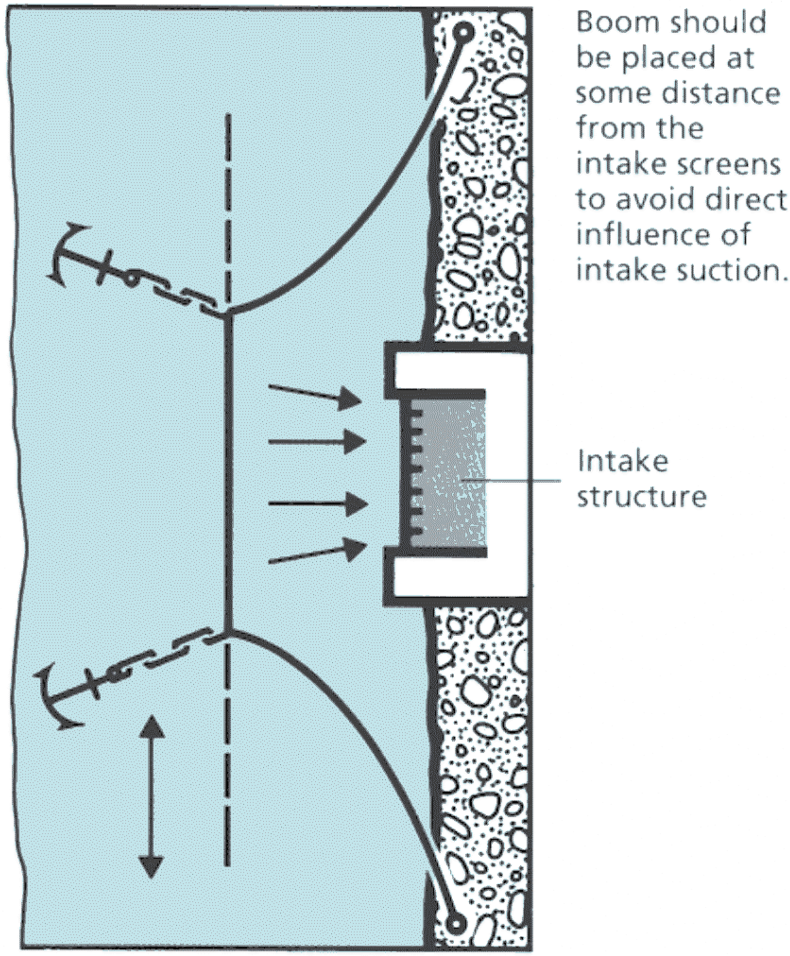


Figure 16 Diversionary booms at intake structures

In operation, boom layouts should be inspected regularly and freed of any floating debris such as logs etc. which inhibit satisfactory performance. Moorings in some areas may need frequent attention and should he marked by buoys if used in a busy waterway.

<u>Collection of oil</u>

The previous section showed various boom arrangements for collecting oil. Oil has to be removed at the rate at which it accumulates; otherwise it will build up and eventually be lost beneath the boom.

5.2 Shore-sealing booms

Shoreline barriers have two main uses in dealing with oil spills. Firstly, for coastal protection by preventing oil from being stranded on shore. Secondly, in the collection of oil being washed down or along a beach; either as part of an oil recovery operation or simply to prevent stranded oil from being allowed to spread over a wider area.

Most booms can be used to protect a particular stretch of coastline. Shore-sealing booms (Figure 17) are designed specifically for this task.

Figure 17 Shore-sealing boom

They have a clover-leaf shaped cross-section, with air or foam as buoyancy in the upper chamber, and water as ballast in the lower section (Figure 18).

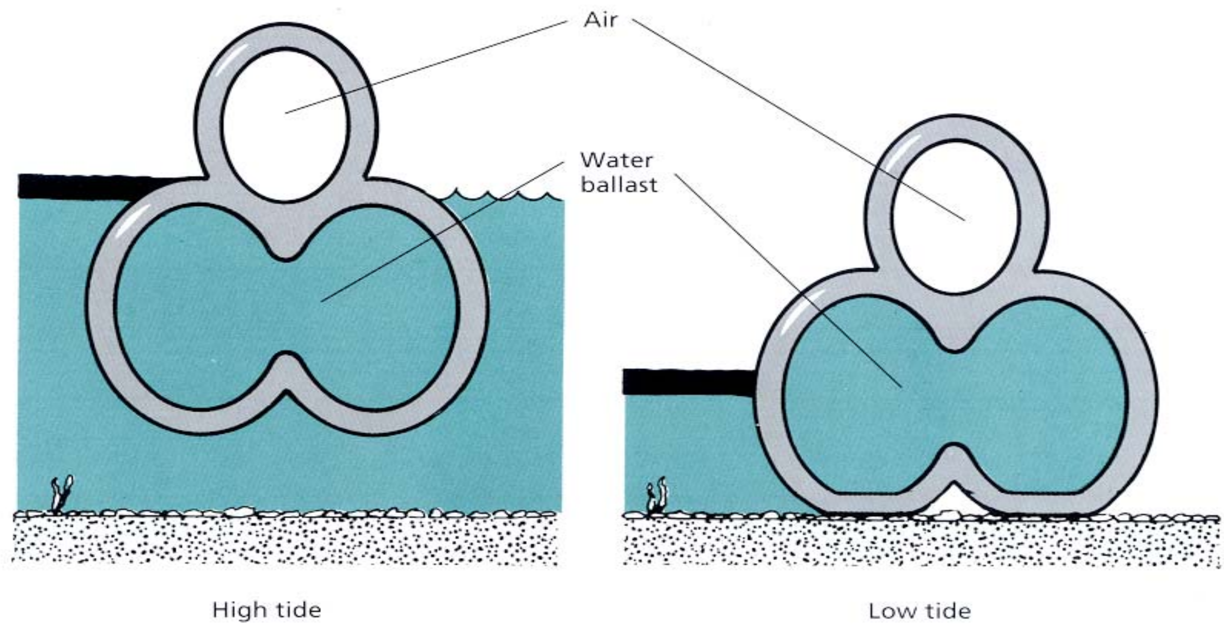


Figure 18 Structure and function of a shore-sealing boom

This arrangement allows it to float in deeper water, but settle and make a seal with the bottom in shallow water or on the beach itself. It is thus particularly useful for inter-tidal areas on a beach, perhaps as an end-piece connected to a conventional boom further out to sea.

Although shoreline barriers may only be in the water part of the time, they still need to be held in place by adequately strong moorings as described for conventional floating booms. As with conventional floating booms, oil must be recovered at the same rate as it accumulates, otherwise it will build up and be swept under or flow over the barrier.

5.3 Other Types of barrier

5.3.1 Bubble barriers

The main disadvantage of any solid boom is that it may block the path of boats and ships as well as oil. One solution to this problem is a bubble barrier. This uses a length of perforated tubing laid underwater at depths of up to 12 m, supplied with compressed air. The escaping stream of air bubbles generates an upward current in the surrounding water and sets up a barrier to the passage of oil and debris but one through which vessels can pass unhindered (Figure 19).

This type of barrier is most likely to be useful in areas where there is high traffic flow, e.g. at the entrance to a harbour. Like floating booms, it may be used as a permanent fixture or deployed in the event of a spill. Clearly, the effectiveness of a bubble barrier will be reduced by wave chop and strong currents, with a limiting value of one knot (about 0.5 m/s). In addition the air holes can become blocked by silt and marine growth. An efficient bubble barrier system also requires a powerful compressor that can maintain an adequate pressure along the total length of perforated tube. Running costs for such compressors can be high.

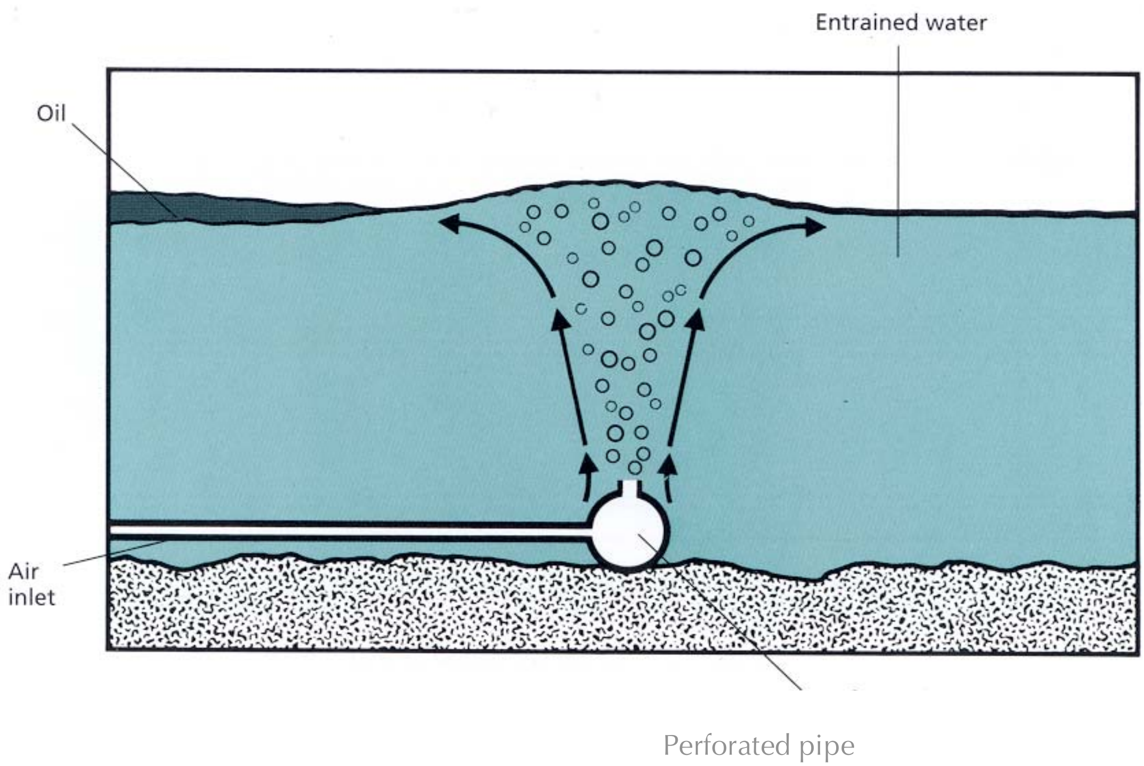


Figure 19 Bubble barrier

5.3.2 Net booms

Netting can be used as a boom to collect viscous oils at sea. Vessels deploy the netting, manoeuvring it to surround and concentrate the oil for recovery. In inshore waters, it may be possible to use nets as a moored boom. Net booming is based on the principle that air and water will pass through the net but not viscous oil. Therefore, there is little or no downward current to carry oil underneath the net and the net is less prone to being blown flat. Because of the lower resistance of nets to water movement, it should also be possible in theory to deploy net booms in faster currents than is possible with conventional booms. Net booms have not yet been fully tested in an actual oil spill but results from field trials have been encouraging.

A net boom consists of a long strip of netting, supported at frequent and regular intervals by poles with floats and weights attached to keep the netting upright (Figure 20).

Figure 20 Net boom

The netting is around one metre high and typically 200-300 metres long. The poles are attached vertically to the net at 1 m intervals, with a float half way up and a weight at the base so that about half of the net remains above water. The mesh of the net has apertures of about 1 to 2 mm, depending on the tension.

Deployment of the net can be achieved by hand from small fishing vessels. Strengths of moorings must be taken into account as for conventional booms.

Recovery of the net boom is a messy and time-consuming operation. Considerable amounts of oil tend to adhere to the netting. Lightly soiled netting can be washed by spraying with dispersant concentrate (e.g. in a ship's hold) and rinsed out by redeploying and towing in the sea. However, it is likely that much of the net will be heavily soiled and not worth the cost of cleaning, although the poles, weights and floats can be reused after washing in solvent.