

RESPONSE TO INLAND OIL SPILLS



This article is a compilation of articles first published in the ISCO Newsletter starting with issue 364 and contributed by Mark Francis of Oil Spill Situations. It provides a refreshing insight into a wide variety of inland oil spill situations with many helpful observations and useful information.

Mark Francis, FISCO, has been involved with the oil industry since 1975. He attended his first oil spill in 1976, the Tanker Elaine V incident. He became head of response for inland spills within the UK for British Petroleum E & P in 1980 for 10 years responding to well, storage tank and pipeline spills throughout the UK. Over the next 20 years he continued to build international experience and has also specialised in spill response training, delivering IMO and other courses in more than 20 countries.

Mark's website is at <http://oilspillsolutions.org>

Inland spills can be very much more difficult to clean up than marine spills.

This depends upon various factors e.g. local geology, soil structure, angle of the surface, depth to ground water and access to the impacted areas.

Here are a few causes of inland oil spills



Illegal dumping



Road accidents



Insufficient bunding



Pipeline leaks

As with most emergency situations, the initial hours after the incident are typified by a certain amount of confusion due to the lack of reliable information.

How this situation influences the decisions of the clean up team leader which ultimately reflects on the performance of the team during the event.

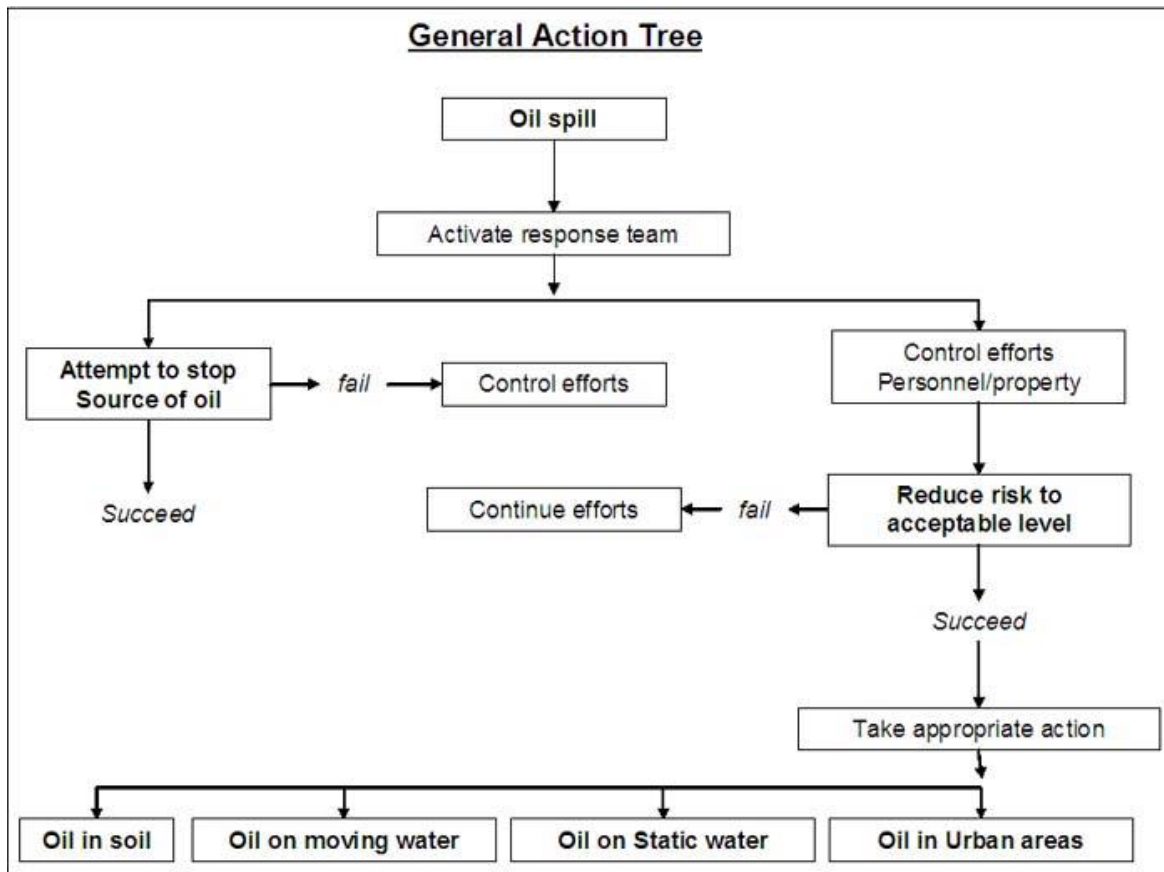
The following items should help ensure those in charge of the operation initiate the most appropriate actions quickly and efficiently at the beginning. Removing any chance of the headless chicken management system, where people run around in circles never achieving anything constructive.

- The team and its leader have a detailed working knowledge of the area for which they are responsible.
- They are fully conversant with the alternative methods of control available to them.
- An adequate communication system is in place.
- The priority of specific emergency measures is established.
- The basis of an integral clean up system has been established.
- Alternative strategies for a number of situations have been prepared.



Action trees like these you will find below from CONCAWE (CONservation of Clean Air and Water in Europe) provide quickly the thought pattern required for different responses.

This speeds up the response process by reducing the thinking process.



Clean up Operations

One area that has a direct bearing on the performance of the team is the planned deployment of personnel and equipment to ensure their most effective use and the continued operation of a clean up team.

In any incident where oil is being recovered there are a number of physical tasks that must be carried out to assure success.

- Booming or oil containment.
- Recovery of oil or oil / debris.
- Temporary storage.
- Transport of recovered material to permanent storage or treatment centre.
- Treatment of oiled material.

Emergency measures

Whilst the whole process of cleaning up an oil spill may take a long time, there are a number of actions that need to be taken immediately which ensure that future actions can be carried out with the minimum risk to both the team and other life in the vicinity.

Isolate source

It is essential that the source of the oil is identified and, where possible, further leakage prevented. In some cases a tank may have lost all its contents, but in many cases the leak is identified before the total loss occurs. Then every attempt should be made to stop the release of oil, either by plugging the hole, closing the valves, or deflecting the oil into an alternative containment area.

Fire and Explosion

In any event where oil is spilled safety must be of prime consideration and all appropriate measures taken.

- Liaison with the authorities at the spill site must be maintained particularly with the fire department and police.
- Where there is any possibility of the presence of a flammable mixture the atmosphere should be checked with an explosimeter.

- Until the area is known to be safe only certified flame proof or intrinsically safe equipment must be used in the danger area (cameras, tape recorders and radios may not be safe).
- Until it is certain that there is no risk of an explosion or fire, sources of ignition should not be allowed in the area and all engines should be turned off.
- Traffic should be stopped or diverted.
- Warning notices and No Smoking signs should be displayed and public access limited.



Ecological considerations

Few reports have been written on the impact of oil on the ecology of rivers or lakes and how to treat successfully such occurrences.

A notable exception to this is the cleaning of birds. Despite this fact, a number of useful points can be made.

- Where wildlife is affected, any action should be in full consultation with the appropriate expert or organisation.
- In general, oil will be collected among the vegetation along the river banks and lakes and on the trunks of trees close to the waters edge.
- Where oil is spilt in or near agricultural land, there may be adverse effects on crops and remediation will be required.
- Where pasture land is adjacent to the contamination, the banks should be fenced off to prevent livestock eating oiled vegetation or drinking contaminated water.

Communications

In the event of a large spill, the team will have to co-ordinate remedial measures and clean up activities. Investigations have to be made into oil movement including how far it has gone and whether it has reached or is likely to reach, one or more water courses.

It is important that the decision makers know all the geographical and physical features of the area and the leader must know at all times what personnel and equipment is available to counter the spill. Because rapid and co-ordinated actions give the best results and lowest costs, effective communications are essential.

The leader of operations should have a communications centre at his base. All reports from the field are received and analysed there, this enables the leader to ensure that up to the minute directives are given to the operators in every location where remedial action is taking place.

Points to remember

- The oil spill leader must have good communications.
- Fire departments, police, pipeline companies, etc. normally operate on different frequencies so it may be necessary to have a number of transmitters available at the control centre.
- When positioning mobile communications take into account the possibility of radio shadows cause by buildings, large trees, valleys etc, the associated aerial must be erected in an unshielded position.
- Spare batteries and chargers should be issued.
- In an emergency all messages should be relayed quickly and briefly so communication lines are not blocked.

Oil on the ground

People that work in refineries or terminals where oil is stored in tanks should make a point of marking the lowest area within the bund so that pumps or skimmers can be positioned in the best place at the beginning of the recovery operation. It is amazing that people walk these areas daily to check valves and verify quantities in tanks.

When the spill occurs nobody knows where the low spot is because now it is level with oil.

Drains are another basic problem if oil enters which way does it go?

With modifications and extensions to these places over the years this sort of important information tends to be forgotten.

Dependent on the area and the oil type it could be many days or weeks before the oil is seen again.

Containment on impermeable surfaces



Surface containment: Purpose: to prevent the spread of oil on the surface and to prepare it for recovery.

Materials and equipment:

- Earth moving machinery
- Damming materials
- Pumps, vacuum trucks and storage systems
- Synthetic or natural absorbents

Method:

- Block drains, sewage systems, pipe and cable ducts to prevent risk of explosion or contamination of sewage plants or water courses.

- Concentrate the oil so that it can be transferred into a storage system
- Use absorbents to limit spreading
- Pay attention to fire hazards

In banded areas:

- Introduce a water bottom to reduce oil penetration.
- Block all inlets except to oily water drains to prevent deep penetration of the oil on oversaturated areas.

Spills on permeable surfaces

- Block all drains
- Try to increase the spread of oil on the surface to prevent deep penetration in oversaturated areas
- Pump out puddles of free oil as quickly as possible
- Increase the sorption capacity of surface layers by spreading sorbents.
- Move any free oil and oil saturated soil to the nearest natural or artificial impermeable area.



Points to remember

- Always pay attention to fire and health hazards
- Start confinement operations immediately to prevent oil from reaching a watercourse or the groundwater
- As far as possible do not allow vehicles to run on oil saturated areas
- Do not flush oil down drains and other inlets
- Do not use excavators on areas with free oil on the surface
- Containment is easier on land than on water

Advantages

Confinement and damming can be achieved using easily available materials and are important if the oil is to be pumped or skimmed

Disadvantage

For permeable soils, if oil is spread over a large area to prevent deep penetration, this will result in more oil contaminated material for disposal; however, it may be preferable to long term operation of subsoil and groundwater clean up.

Containment on permeable surfaces (continued)

If you have no other sorbent products available, dry sand or earth may soak up a spill of oil or chemicals. Sand bags can be used to channel substances to a collection point, to block off drains, contain spills or to dam ditches. Once contaminated, sand and sand bags should be properly disposed of and not washed into drainage systems.



Drain mats or surface drain seals seal a drain by covering the surface of a manhole cover or drainage gully. They stop liquid flowing into the drainage system and help contain it. There are different types, including clay mats and water-filled bags. Clay mats are single use but you may be able to have other types cleaned for re-use.

Keep drain mats close to where they might be used. Identify where liquid that is held back by a drain mat will collect as you may need to keep people away from it until it can be cleaned up.

Photo left shows oil spilled on an impermeable running to a permeable surface where it will penetrate the soil under the influence of gravity and capillarity action.

Photo right shows a mat with a synthetic gel in the under part. The gel is heavy and flexible and seals with the ground as well as closing of the slots in the drain, closing it off to oil flow.

Photo right (below) shows a yellow version of the mat. I have not used this type but am just showing that there are other manufactures making similar products.



Photo left shows the sad fact that some people do not have respect for our environment.

The blue and white sticker says "Don't Dump Save Your Creek".

It is difficult to understand why someone would dump oily waste including a vehicle's oil filter



If the spill has spread so far that it's already entered the drainage system, try to stop it. If you can close the drainage system, you may be able to use its capacity as a temporary containment system to hold the pollutant safely until it can be dealt with properly.

In some cases, it may be possible to hose any remaining spilt material into the sealed drainage system, allowing the incident to be dealt with more quickly and safely.

You must also be aware of what will happen to overflows from gullies and other entry or exit points to the drainage system. This will vary depending on where the drain flows to, slopes and weather conditions. Contaminated liquid may back up and discharge through storm overflows, collect in areas of the site or overflow and bypass the drainage system.

High rainfall will reduce the capacity of your drainage system and create higher volumes of contaminated water. It may cause flooding if the drains back up that could create a hazard itself. If your pollution incident response plan includes the option to contain spills in the drainage system, consider separating your roof and yard drainage from areas where a spill is likely and other site drainage.

Oil separators are designed to contain spills of hydrocarbons and other liquids that are lighter than, and don't mix with, water. They won't contain soluble substances such as soluble oils, biofuels, emission reduction solutions e.g. solvents that mix with water. An oil separator will not work properly if degreasing agents or detergents can drain to, or are put into, it.

Oil separators can be fitted with manual or automatic closing penstock valves at both inlet and outlet to contain larger spills. If you have a spill that has entered the drainage system, it may be possible to close the entrance to the separator to stop it becoming overwhelmed and protect it, or close the exit valve to allow the spill to collect in the separator. If your incident response planning includes using separators to contain large spills of hydrocarbons, you should not use bypass separators.

Check the separator after any spill has entered the drainage system and have it emptied and maintained if needed. Oil spills may have reduced your separator capacity and other spills may affect how well your separator works. Use a specialist contractor to maintain your separator.

If your drainage system does not have shut-off valves that you can close in an emergency, or they are not in suitable places, you may be able to seal your drainage system using pipe blockers. These can be fitted inside a pipe or gully. They're usually purpose-made bags or tubes which are inflated with air, although a drain bung *right* can also be effective.

Old football bladders have been pushed into small culverts and inflated to close them off.



Make sure the pressure head of the contained liquid doesn't cause the pipe blocker to fail.



One of the simplest ways to block a leaking container or pipe is to cover the hole with a temporary sealant. Leak sealing putty is available either ready mixed, or as a powder you mix with water. You should follow the manufacturer's instructions to apply the putty. A more permanent method may be required before you can move the damaged container.

If you can, roll a small container, for example an oil drum, so that the damaged part is to the top and the material is no longer spilling from it. Secure the container so it can't roll or turn back over. This will give you time to take action to stop already spilt material spreading further and to make other plans to secure the damaged container.



If possible, place a leaking primary container into a clean undamaged container to prevent any more leakage *right*. You will need to plan for this option to make sure the second container has no contamination, so any spilt material you put into it doesn't react with its former contents, and is made from a material that won't be damaged by the leaking material and cause a bigger problem.

Salvage/oversize drum. These are large plastic drums designed to safely store leaking or damaged drums, or other containers. They're made from chemically resistant plastic, but you should check with your supplier to make sure they're suitable for the materials you have on site. Liners may be available to make re-use easier.

Oversize drums can also be used for temporary storage for a small quantity of a spilt liquid.






Spills on Permeable Surfaces (continued) - Penetration

The amount of oil retained in the soil at saturation is shown (approx. litres per cubic meter) and is dependent on its structure (see table below right).

Concentrations exceeding 50 l/m³ are rare but can occur in dry soils beneath buildings and covered areas or where porous rocks are involved.

Oil will penetrate quickly at the side of concrete constructions as the soil will have been disturbed when the hole was dug for the concrete to be poured. The back fill of soil is never compacted to the same state as undisturbed soil as can be seen from this photo (below left).



Soil Type	Cap (l/m ³)
Pebbles	 5
Pebbles / rough grain sand	 8
Grit sand / medium grain sand	 15
medium grain sand / fine sand	 25
Fine sand / fine sediments	 40

Pipeline tracks work the same as the pipe is usually placed on a layer of sand and when back-filled the trench becomes the passage of least resistance. Pipelines in hollows will end up with the trench filled whereas pipeline tracks further uphill will allow the oil to flow by gravity to the lowest point. This then leave you with the problem of digging test holes up the hill to find the point of the leak.

In homogenous soil, maximum penetration occurs where pools of oil are formed on the surface. These provide a pressure head and encourage penetration.

Ground water movement is very slow; often between 0.5 m and 1.5 m per day. Thus, if oil reaches the groundwater table, there is usually plenty of time available to study the geology of the underlying strata and decide upon the best location for recovery of the oil.

Groundwater or aquifer

Aquifers are complicated systems, they are filled by rainfall, some rivers add to them, other rivers take from them.

What needs to be uppermost in our minds is not to allow the oil to get into this kind of area as it is a very complicated problem to resolve.

An aquifer is one of man's greatest treasures and a source that may be needed for long into the future. Allowing oil to contaminate an aquifer will render it useless for drinking water for many years or for ever, e.g. in the south of England during the 90's a town's water supply was contaminated by oil. This town had always been an agricultural area, never industrial. When the investigation came to its conclusion the pollution it was found that the oil had come from a stockpile of fuel and oil for the "D Day" invasion of France during World War 2. It had taken 50 years for the oil to penetrate to the depth of the aquifer now lost forever.

One hundred and forty six groundwater sources in the UK have been closed since 1975 because of groundwater quality problems. At least 425,000 m³ per day have been lost in licensed output from the closures, about seven per cent of current abstraction levels.

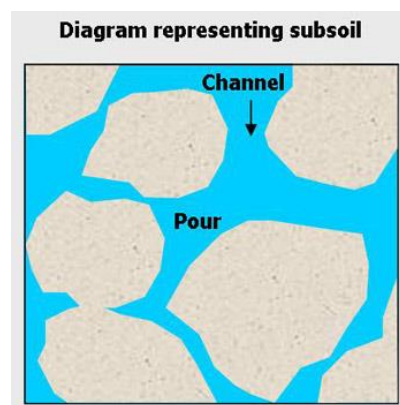
The capital investment required to maintain drinking water quality is expected to be at least £15 to £36 million every year. Problems with groundwater quality cost the UK water industry £754 million between 1975 and 2004. Source: <http://cdn.environment-agency.gov.uk/geho0906bldb-e-e.pdf>

Spills on Permeable Surfaces – Water-bearing Formations

I copied the diagrams below from a CONCAWE publication of the late 70's

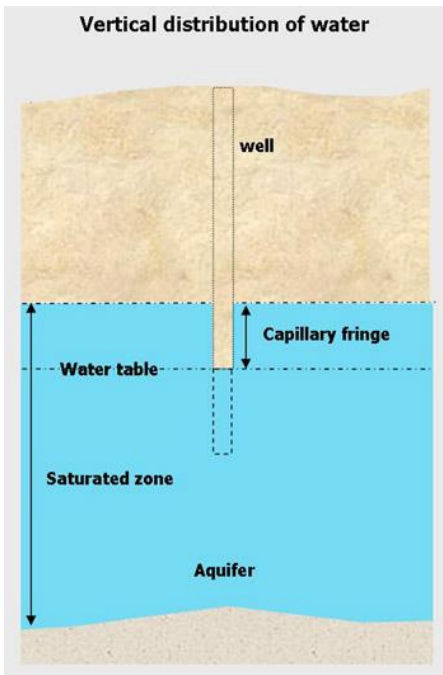
Soil and rock are made up of small fragments or grains separated by empty spaces or pores. More often than not the pores are connected by fine channels where groundwater may circulate.

The water content of the subsoil increases with depth; a distinction can be made between the unsaturated zone where the pores are only partly filled with water and the saturated zone where all pores are completely filled.



In the unsaturated zone, also referred to as the aeration zone or retention zone, the water is retained or suspended there by absorption over the surface of the grains and by capillary forces (meniscus effect) in the channels connecting the pores. The remainder of the porous space is filled with air, which is free to circulate. Within the water phase, the pressure is below atmospheric pressure.

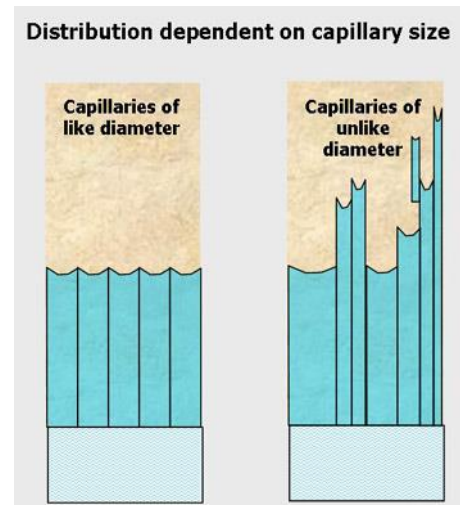
In the saturated zone, the pressure within the water phase increases with depth. The limit where the pressure is equal to the atmosphere is called the free surface and represents the water table or piezometric surface. It corresponds to the level of water in a well, i.e. static water level.



Above the water table and within the saturated zone is the capillary fringe where water is held by capillary suction.

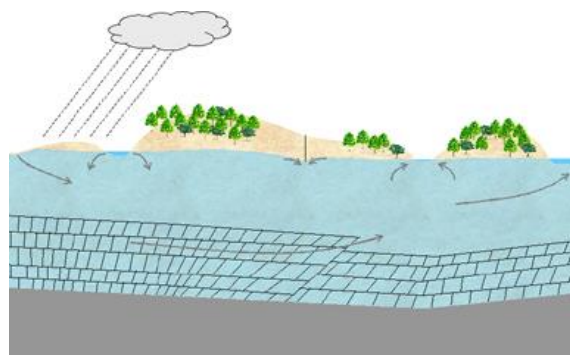
This zone may vary in thickness according to pore size in the sediment.

The capillary rise will be at a maximum in the finest channels.



In real life the thickness of the capillary fringe may be expected to be constant in very homogenous mediums but may exhibit large variations for non-homogenous soils.

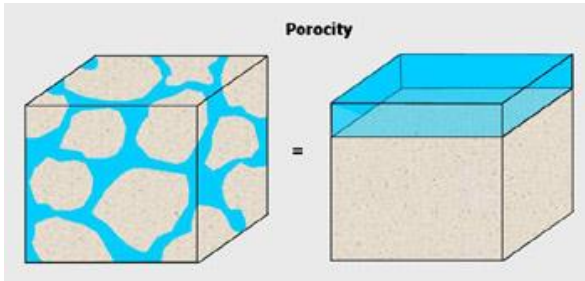
Within the saturated zone groundwater freely circulates and may be tapped by wells. This zone may be seen as a reservoir, the capacity of which is the total volume of the pores filled with water. The associated geology is called an aquifer, water bearing formation or groundwater reservoir.



Types of aquifers:

- Strata made of rock where water circulates through fissures (cracks), e.g. fractured limestone.
- Strata made rock where water circulates through pores, e.g. sandstone.

In rock where water circulates through fissures, the rate of flow is much faster than in rock which has pores; consequently any pollution can spread with greater ease. In addition, the direction of flow is more erratic and more difficult to predict the progress since the characteristics of the terrain are more difficult to determine.



An aquifer acts as a storage reservoir and as a water carrying body. The two main parameters associated with these functions are their porosity and permeability. The porosity of an aquifer refers to the volume of void spaces compared with the total volume. It may range between 5% and 45%.

The permeability is a measure of the ease with which water flows through the formation. It is a function of the average diameter of the pores and the shape and orientation of the grains.

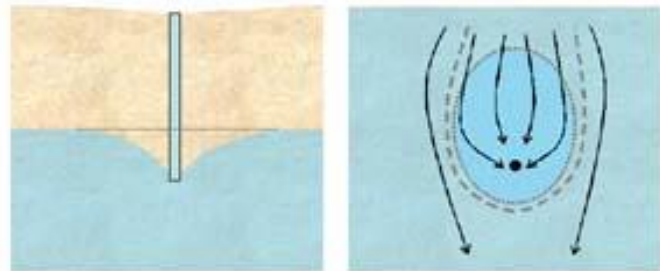
Groundwater flow

Since the recovery of free oil means modifying the normal flow pattern, some understanding of the way groundwater moves is necessary.

In the majority of cases, groundwater moves under the influence of gravity, but the rate at which it moves may vary enormously, e.g. from meters per day to meters per year, dependent on the permeability of the aquifer and any gradient.

Below is a guide in meters per annum (mpa) or meters per day (mpd):

- Dune sand 4-5 mpa
- Fine sand 16 mpa
- Medium sand 65 mpa
- Gravelly sand 250 mpa
- Fine gravel 1650 mpa or 5 mpd
- Alluvia 1-10 mpd



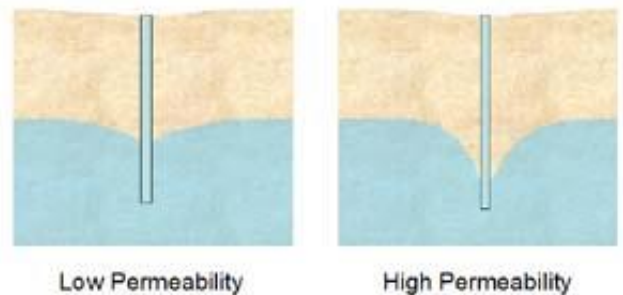
In practice, the direction and shape of the natural flow pattern in an aquifer is modified by the presence of water extraction wells. When pumping from a well, an equilibrium is eventually reached between the outflow of water from the well and the inflow from the aquifer. The water table surface becomes conical in shape, the axis of which is the well.

This is known as the cone of depression, the distance up to the surface of the water table is influenced by the well which is being pumped is known as the radius of influence. All fluid in this zone will tend to migrate to the well.

Natural flow can therefore be considerably disturbed by man. When pumping takes place the water table may be lowered and it is possible to reverse the flow. This is a common phenomenon where water extraction takes place.

The size of the cone of depression will depend on the permeability of the surrounding rock, as shown the lower permeability the wider the cone.

When pollution occurs in such areas careful hydrogeological monitoring is necessary to minimise its effects.



Measuring groundwater velocity

When oil has or is thought to have contaminated the groundwater it is very important to know in which direction and at what velocity the oil is being transported, particularly when drinking water wells are present in the area.

A reliable picture of the flow patterns can be obtained from a series of measurements:

1. Observing the level of water a number of observation wells and the production of producing wells. Usually observation wells are not present and have to be drilled for this purpose. From the levels contour lines for the depth of the water table may be mapped. Making use of the measured well capacities, local flow velocities can be derived.

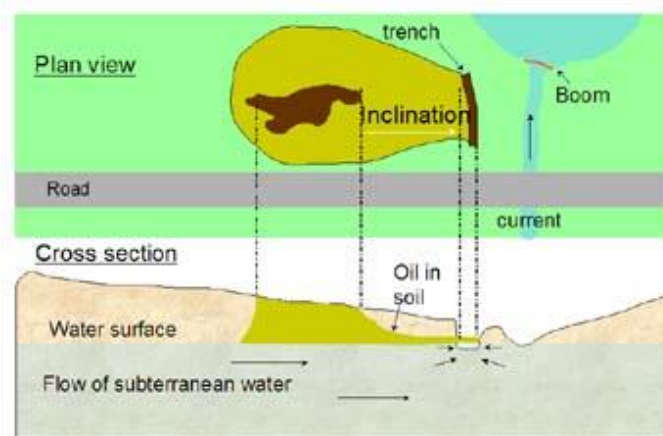
2. Observing tracer breakthrough times to a number of wells. Various materials such as dyes, salts, etc. may be used as tracers.
3. Observing the rate of dilution of a tracer in a well as a result of the underground flow. This relatively simple and quick experiment provides the velocity and direction of the flow.

This data may be used to add to mathematical models to predict the behaviour of the aquifer. *Remember the better the data the better the result.*

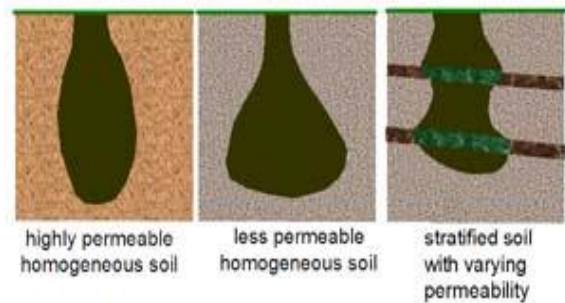
Looking at the surface relief gives us some idea of how the rocks are formed below the surface e.g. A hill will have its roots below the surface and so the water will flow around the hill. How far out from the bottom of the hill can only be found out by drilling a series of boreholes. Having found the water we also have to know in what direction it is flowing.

Migration through the retention zone

The degree of penetration is a function of ground structure as well as the type of product involved. A product with low viscosity will penetrate more rapidly than one with a high viscosity. In homogeneous ground, without stratification or marked variations in pore size, the front of the penetrating product tends to be pear shaped, with the bulbous part at the bottom.



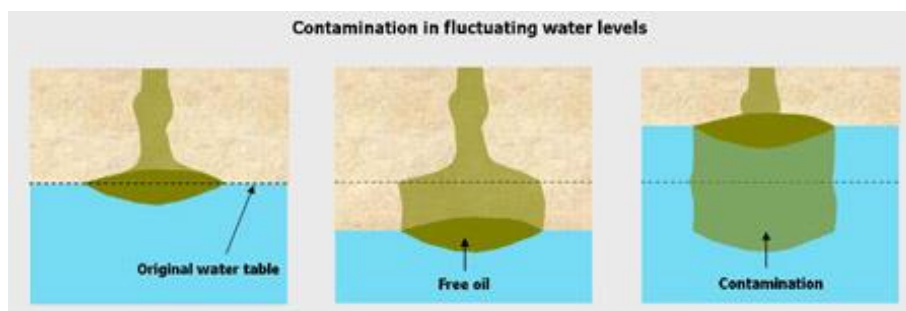
The vertical penetration is due to gravity while the horizontal is due to capillary action. In permeable stratum the penetration is mainly vertical whereas in less permeable stratum it is more horizontal. The heterogeneity of the subsoil has a considerable influence on the shape of the penetrating body.



In some places the water table is very close to the surface. In this case trenches can be excavated in front and downhill of the incident when water enters the trench the oil will arrive on its surface allowing skimmers or absorbents to be used for its recovery. All of these incidents take a long time to complete, and can be very costly. The speed of the operation depends on the porosity of the substrate and the speed of the water flow.

Migration on the water table

When free oil reaches the capillary fringe and if the volume is large enough, it first forms a layer of increasing thickness under the influence of the further descending oil. This exerts pressure depressing the water surface. Gravity acts to restore the initial level and causes a pancake which moves laterally in the direction of the flow.



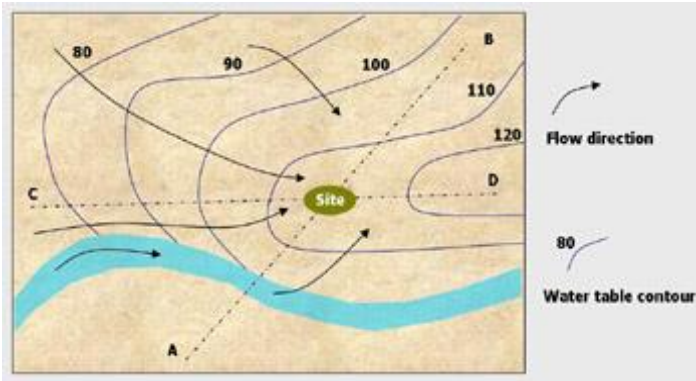
During the migration some oil clings to the grains of rock due to capillary action.

Two important considerations may lead to inaccurate estimations of oil present on the water table

1. Repeated water table fluctuations expose the oil to soil which had not previously been contaminated. Each contact retains part of the volume of free oil and the effect is a reduction of the volume of free oil.
2. Fluctuations in fractured rock may increase the apparent volume by a washing out process of pockets of trapped oil.
3. The thickness of oil spread out over the water table is not as thick as that measured in the wells.

Spills on Permeable Surfaces (continued)

Piezometric (water table) monitoring

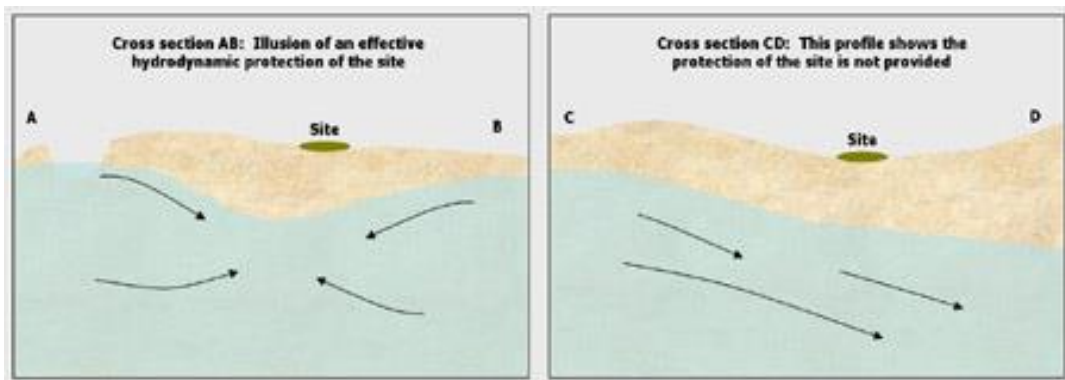


This involves a network of observation wells which allow the sector to be adequately monitored by observing fluctuations in the groundwater levels:

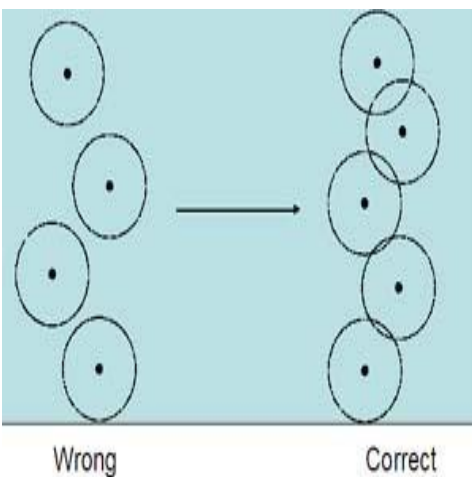
1. In the case of hydrodynamic protection, it is absolutely necessary to have available a piezometric map updated 2 to 4 times per year, or after exceptional weather conditions.

2. Fluctuation may be due to natural phenomena such as variations in rainfall, or to artificial phenomena such as intensive pumping in the proximity of the site.

3. The use of one single profile such as A to B may be misleading as shown *left* so various cross sections have to be made to give a true picture of what is really happening.



Recovery of oil from wells



The principal factor to be considered when recovering free oil is to use an existing gradient or induce one. The required total pumping rate to create the cone or cones of depression will depend on the characteristics of the aquifer. These characteristics are found from separate pumping tests. If the pumping rate is too high for one well the required rate can be obtained by installing more wells.

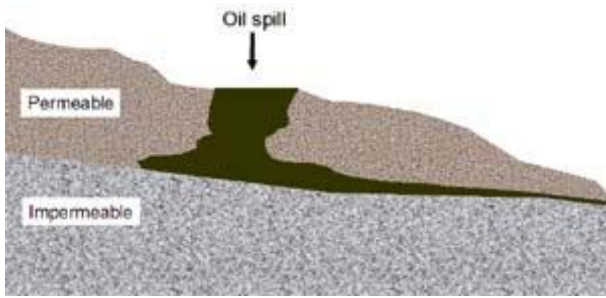
More rapid removal of oil is obtained in the early stages of recovery when several wells are used and additional soil contamination is kept to a minimum as the water table is lowered.

The correct spacing between the wells to ensure adequate overlapping between the cones of depression needs to be determined by to avoid oil bypassing the cones.

This is why this type of response is very much a long term project and also very costly.

In some cases the clean-up can be completed only to find oil in a stream weeks later.

In some cases oil may travel great distances underground without affecting ground water before resurfacing this maybe because of impermeable layers or in agricultural land drainage systems.



In the case of land drains the system will need to be removed cleaned or replaced and so the cost rises again.

It cannot be stressed enough that when an incident happens, a response needs to be mounted immediately and major efforts are made to stop the penetration. If oil does penetrate into the soil there is a need to remove it as soon as possible to save time and money as well as the complicated work that will have to be undertaken.

Groundwater Treatment

[The following remediation techniques section was taken from http://en.wikipedia.org/wiki/Groundwater_remediation]

Ground water remediation techniques span biological, chemical, and physical treatment technologies. Most ground water treatment techniques utilize a combination of technologies. Some of the biological treatment techniques include bio-augmentation, bioventing, bio-sparging, bio-slurping, and phytoremediation.

Some chemical treatment techniques include ozone and oxygen gas injection, chemical precipitation, membrane separation, ion exchange, carbon absorption, aqueous chemical oxidation, and surfactant enhanced recovery. Physical treatment techniques include, but not limited to, pump and treat, air sparging, and dual phase extraction.

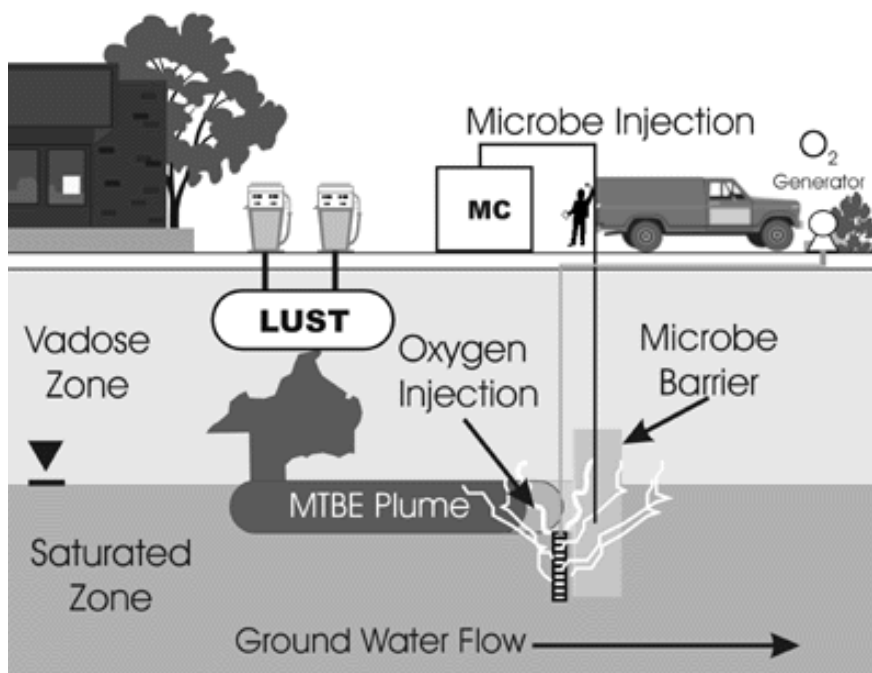
Biological treatment technologies

Bio-augmentation and Bio-stimulation

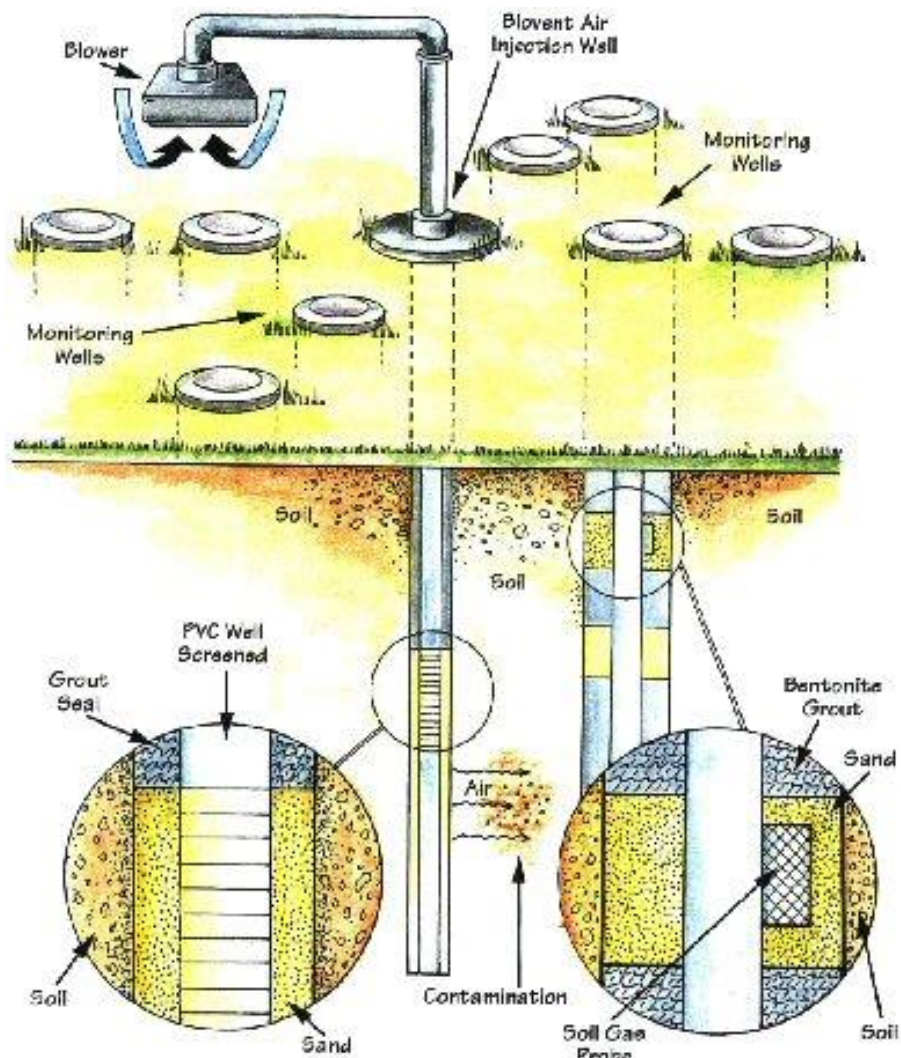
If a treatability study shows no degradation (or an extended lab period before significant degradation is achieved) in contamination contained in the groundwater, then inoculation with strains known to be capable of degrading the contaminants may be helpful.

This process increases the reactive enzyme concentration within the bioremediation system and subsequently may increase contaminant degradation rates over the non-augmented rates, at least initially after inoculation.

Stimulating existing indigenous microbes with nutrients to increase the population can assist with the decomposition of contaminates.



[Diagram <http://www.clu-in.org>]



Bio-ventilation

Bioventing is an in situ remediation technology that uses microorganisms to biodegrade organic constituents adsorbed in the groundwater.

Bioventing enhances the activity of indigenous bacteria and simulates the natural in situ biodegradation of hydrocarbons by inducing air or oxygen flow into the unsaturated zone and, if necessary, by adding nutrients.

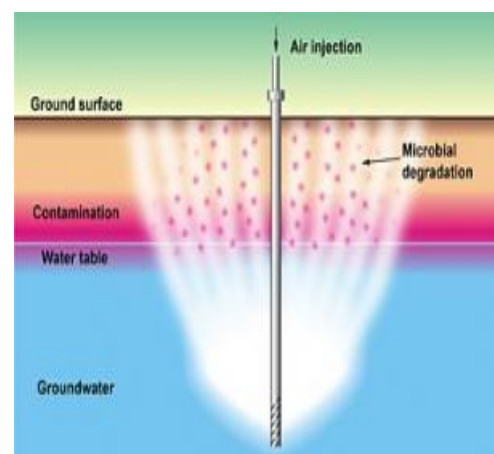
During bioventing, oxygen may be supplied through direct air injection into residual contamination in soil.

Bioventing primarily assists in the degradation of adsorbed fuel residuals, but also assists in the degradation of volatile organic compounds (VOCs) as vapours move slowly through biologically active soil. [Diagram <http://www.afcee.af.mil>]

Bio-sparging (scattering)

Bio-sparging is an in situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents in the saturated zone.

In bio-sparging, air (or oxygen) and nutrients (if needed) are injected into the saturated zone to increase the biological activity of the indigenous microorganisms.

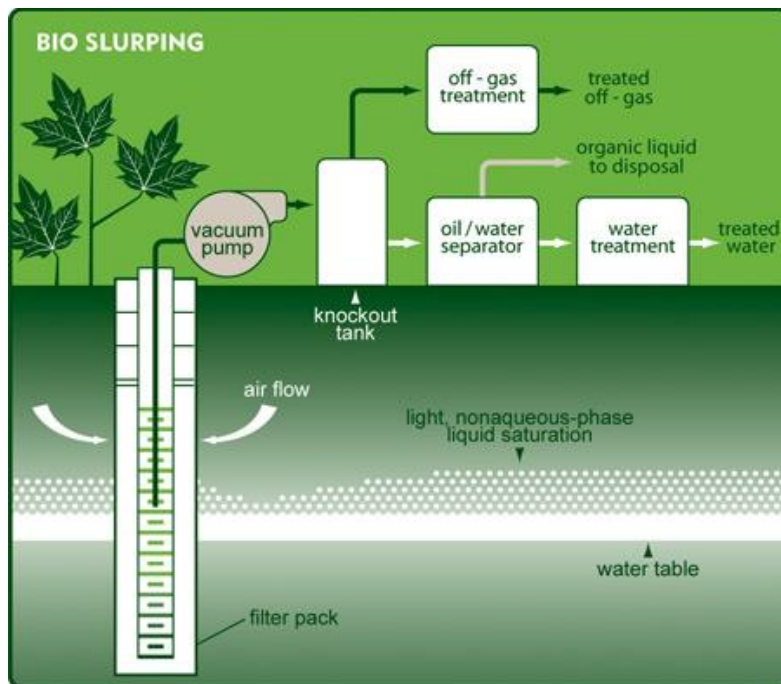


Bio-sparging can be used to reduce concentrations of petroleum constituents that are dissolved in groundwater, adsorbed to soil below the water table, and within the capillary fringe. [Diagram <http://www.sciencedaily.com>]

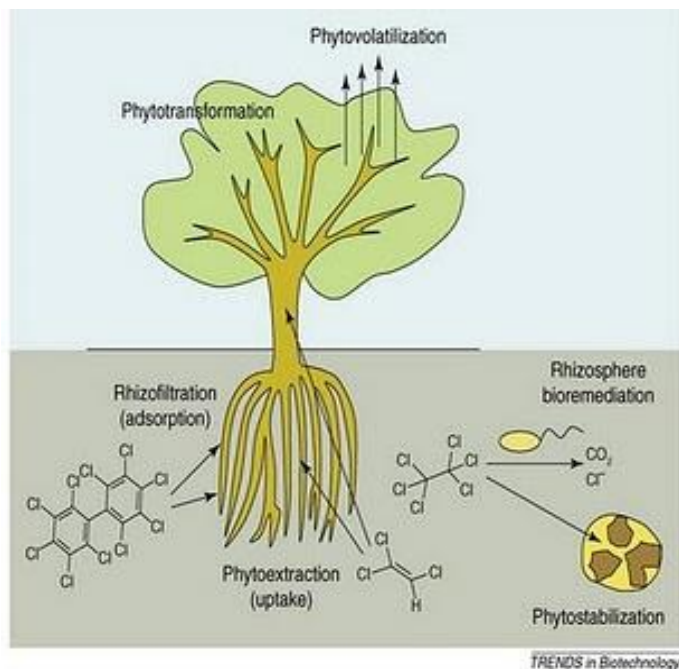
Groundwater Treatment (continued)

Bio-slurping (sucking)

Bioslurping combines elements of bioventing and vacuum-enhanced pumping of free-product that is lighter than water (light non-aqueous phase liquid or LNAPL) to recover free-product from the groundwater and soil, and to bioremediate soils. The bioslurper system uses a "slurp" tube that extends into the free-product layer. Much like a straw in a glass draws liquid, the pump draws liquid (including free-product) and soil gas up the tube in the same process stream. Pumping lifts LNAPLs, such as oil, off the top of the water table and from the capillary fringe (i.e., an area just above the saturated zone, where water is held in place by capillary forces). The LNAPL is brought to the surface, where it is separated from water and air. The biological processes in the term "bioslurping" refer to aerobic biological degradation of the hydrocarbons when air is introduced into the unsaturated zone. (Diagram <http://www.threer.co.uk>)



Phytoremediation



In the phytoremediation process certain plants and trees are planted, whose roots absorb contaminants from ground water over time, and are harvested and destroyed. This process can be carried out in areas where the roots can tap the ground water. An example of plants that are used in this process is the Chinese Ladder fern *Pteris vittata*, also known as the brake fern, which is a highly efficient accumulator of arsenic. Genetically altered cottonwood trees are good absorbers of mercury and transgenic Indian mustard plants soak up selenium well.

(Diagram <http://ebt-gmo.blogspot.com>)

Permeable Reactive Barriers

Certain types of permeable reactive barriers utilize biological organisms in order to remediate groundwater.

Chemical treatment technologies

Chemical precipitation

Chemical precipitation is commonly used in wastewater treatment to remove hardness and heavy metals. In general, the process involves addition of agent to an aqueous waste stream in a stirred reaction vessel, either in batches or with steady flow. Most metals can be converted to insoluble compounds by chemical reactions between the agent and the dissolved metal ions. The insoluble compounds (precipitates) are removed by settling and/or filtering.

Ion exchange

Ion exchange for ground water remediation is virtually always carried out by passing the water downward under pressure through a fixed bed of granular medium (either cation exchange media and anion exchange media) or spherical beads. Cations are displaced by certain cations from the solutions and ions are displaced by certain anions from the solution. Ion exchange media most often used for remediation are zeolites (both natural and synthetic) and synthetic resins.

Carbon absorption

The most common activated carbon used for remediation is derived from bituminous coal. Activated carbon absorbs volatile organic compounds from ground water by chemically binding them to the carbon atoms.

Chemical oxidation

In this process, called In-Situ Chemical Oxidation or ISCO, chemical oxidants are delivered in the subsurface to destroy (converting to water and carbon dioxide or to nontoxic substances) the organic molecules. The oxidants are introduced as either liquids or gasses. Oxidants include air or oxygen, ozone, and certain liquid chemicals such as hydrogen peroxide, permanganate and persulfate. Ozone and oxygen gas can be generated on site from air and electricity and directly injected into soil and groundwater contamination. The process has the potential to oxidize and/or enhance naturally occurring aerobic degradation. Chemical oxidation has not been proven to be an effective technique for dense non-aqueous phase liquid or DNAPL when it is present.

Surfactant enhanced recovery

Surfactant enhanced recovery increases the mobility and solubility of the contaminants absorbed to the saturated soil matrix or present as dense non-aqueous phase liquid. Surfactant-enhanced recovery injects surfactants (surface-active agents that are primary ingredient in soap and detergent) into contaminated groundwater. A typical system uses an extraction pump to remove groundwater downstream from the injection point. The extracted groundwater is treated aboveground to separate the injected surfactants from the contaminants and groundwater. Once the surfactants have separated from the groundwater they are re-used. The surfactants used are non-toxic, food-grade, and biodegradable. Surfactant enhanced recovery is used most often when the groundwater is contaminated by dense non-aqueous phase liquids (DNAPLs). These dense compounds, such as trichloroethylene (TCE), sink in groundwater because they have a higher density than water. They then act as a continuous source for contaminant plumes that can stretch for miles within an aquifer. These compounds may biodegrade very slowly. They are commonly found in the vicinity of the original spill or leak where capillary forces have trapped them.

Permeable reactive barriers

Some permeable reactive barriers utilize chemical processes to achieve groundwater remediation. One particular type of permeable reactive barrier utilizes a swellable, organically-modified silica embedded in iron, which is injected in situ in order to create a permanent soft barrier in the ground. Water filters through the barrier, and the silica material absorbs toxins, such as TCE. The iron dechlorinates the solvents in the groundwater, often reducing toxicity levels below detectable limits with no toxic daughter products, no solid waste removal, and no air pollution. This type of permeable reactive barrier is also more dispersed than others.

Physical treatment technologies

Pump and treat

Pump and treat is one of the most widely used ground water remediation technologies. In this process ground water is pumped to the surface and is treated with either biological or chemical agents to remove the impurities.

Air sparging

Air sparging is the process of blowing air directly into the ground water. As the bubbles rise, the contaminants are removed from the groundwater by physical contact with the air (i.e., stripping) and are carried up into the unsaturated zone (i.e., soil).

As the contaminants move into the soil, a soil vapour extraction system is usually used to remove vapours.

Dual phase vacuum extraction

Dual-phase vacuum extraction (DPVE), also known as multi-phase extraction, is a technology that uses a high-vacuum system to remove both contaminated groundwater and soil vapour.

In DPVE systems a high-vacuum extraction well is installed with its screened section in the zone of contaminated soils and groundwater. Fluid/vapour extraction systems depress the water table and water flows faster to the extraction well. DPVE removes contaminants from above and below the water table.

As the water table around the well is lowered from pumping, unsaturated soil is exposed. This area, called the capillary fringe, is often highly contaminated, as it holds undissolved chemicals, chemicals that are lighter than water, and vapours that have escaped from the dissolved groundwater below. Contaminants in the newly exposed zone can be removed by vapour extraction.

Once above ground, the extracted vapours and liquid-phase organics and groundwater are separated and treated. Use of dual-phase vacuum extraction with these technologies can shorten the clean-up time at a site, because the capillary fringe is often the most contaminated area.

Monitoring-Well oil skimming

Monitoring-wells are often drilled for the purpose of collecting ground water samples for analysis. These wells, which are usually six inches or less in diameter, can also be used to remove hydrocarbons from the contaminant plume within a groundwater aquifer by using a belt style oil skimmer.

Belt oil skimmers, which are simple in design, are commonly used to remove oil and other floating hydrocarbon contaminants from industrial water systems.

A monitoring-well oil skimmer recovers various oils, ranging from light fuel oils such as petrol, light diesel or kerosene to heavy products such as No. 6 oil, creosote and coal tar.

It consists of a continuously moving belt that runs on a pulley system driven by an electric motor. The belt material has a strong affinity for hydrocarbon liquids and for shedding water. The belt, which can have a vertical drop of 100+ feet, is lowered into the monitoring well past the LNAPL/water interface. As the belt moves through this interface it picks up liquid hydrocarbon contaminant, which is removed and collected at ground level as the belt passes through a wiper mechanism.

To the extent that DNAPL hydrocarbons settle at the bottom of a monitoring well, and the lower pulley of the belt skimmer reaches them, these contaminants can also be removed by a monitoring-well oil skimmer.

Water supplies



A ship's captain's knows it only takes a teaspoon of oil to contaminate a ships drinking water supply.

So let's take that theory to a road accident. 5ml of diesel can contaminate 75,000 lts of drinking water.

Here we have a road tanker on its side with a capability of losing 30,000 lts of diesel which translates to a possible contamination of 450,000,000 lts of drinking water.

Not letting this product get into a water course is of course extremely important.

The blocking of drains is one of the first priorities. This used to be made more difficult, as when the fire brigade arrived they often spread foam over the product, thus obscuring any drains in the area.

This has now changed with legislation.

Oil in Urban Areas

If oil is spilled on soft surfaces, or even into soil from buried tanks or pipelines, reference should be made to appropriate clean up methods.

Containment

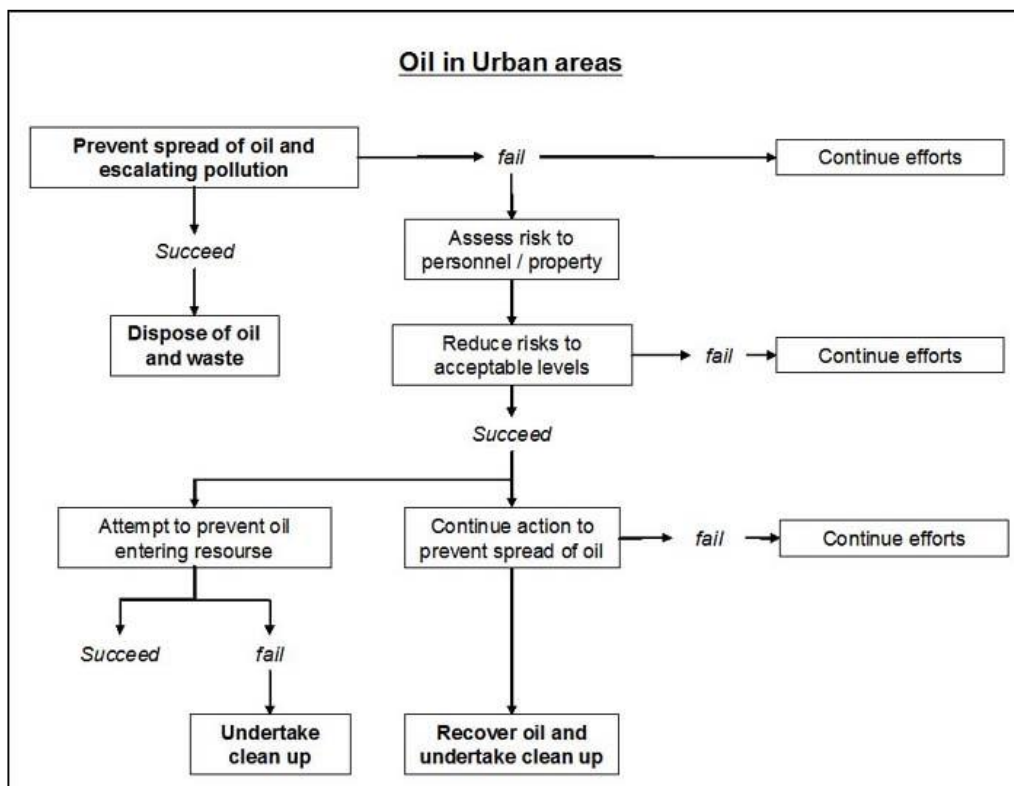
Surface containment:- purpose: to prevent the spread of the oil on the surface and to collect it for recovery.

Materials and equipment

- Damming materials.
- Pumps, vacuum and storage systems.
- Synthetic or natural absorbents.

Method

- Prevent oil from entering drains, sewage systems, pipe and cable ducts, ventilation ducts of rail tunnels etc. to prevent the risk of explosion and contamination of sewage treatment plants and water courses.
- Use dams made from soil, sand bags or absorbents to protect inlets.
- Seal drain gratings with plastic bags filled with water and sand.
- Plug drain pipes up to 30 cm with football bladders.
- If oil has entered and underground pipeline systems contact the operators immediately to get an overview of the contaminated system.
- In some cases it may be advantageous to wash the oil down the line to less sensitive places; employ sewage cleaning contractors.



Points to remember

- Pay particular attention to matters of safety
- Stop traffic and any ignition source
- Inform the police and fire service
- Inform affected system operators (utilities, railways, telephone etc)
- Initiate evacuation of endangered people

Advantages

- Confinement and damming can be achieved using readily available materials and ease the task of subsequent oil recovery.

Disadvantage

- Oil vapours are heavier than air and will gather in underground pipes and ducts where they will not be able to evaporate therefore there will be a high risk of fire and explosion.



Rubble in center of street destroyed by sewer explosions in Guadalajara, 1992. Photo credit, with permission (Jon Seals); Disaster Recovery Journal at: http://www.drj.com/drworld/content/w2_028.htm; accessed May 5, 2006.

An example: The result of petrol getting into a sewer system was seen in Guadalajara, Mexico on April 22, 1992 when 5 explosions between 10:06 and 14:20 blew open the streets and carved an enormous 9 mile ditch down the middle of Avenida Gante 80 feet wide and 25 feet deep.

The blast threw a bus onto the second floor of a house.

Approximately 1,000 buildings collapsed or were heavily damaged.

Initial reports by the Mexican Government and confirmed by team member Al Nixon of the Atlanta Red Cross said at least 2,000 people were injured, 200 people were killed and over 20,000 were left homeless.

Damage to building was estimated at \$300million.

An investigation into the disaster found that there were two precipitating causes:

- New water pipes, made of zinc-coated iron, were built too close to an existing steel gasoline pipeline. The underground humidity caused these materials to create an electrolytic reaction, akin to that which occurs inside a zinc-carbon battery. As the reaction proceeded it eventually caused the steel gasoline pipe to corrode, creating a hole in the pipeline that permitted gasoline to leak into the ground and into the main sewer pipe.
- The sewer pipe had been recently rebuilt into a U-shape so that the city could expand its underground metro railway system. Usually sewers are built in a slope so that gravity helps move waste along. In order to get the U-shape to work, an inverted siphon was placed so that fluids could be pushed against gravity. The design was flawed, however. While liquids were successfully pumped through, gases were not, and gasoline fumes built up.



Corrosion and hole in larger gas pipe caused by smaller water pipe on top. Photo courtesy of Jose M. Malo, Electrical Research Institute, Mexico. Source: <http://www.corrosion-doctors.org/Localized/sewer.htm>; accessed May 5, 2006.

In the aftermath, city officials and corporations pointed fingers at each other. Some people initially thought a cooking oil manufacturing company was leaking hexane, a flammable liquid similar to gasoline, into the sewers, but this was later found to be erroneous. Numerous arrests were made in an attempt to indict those responsible for the blasts. Mayor Enrique Dau Flores was indicted for ignoring the warnings; he subsequently resigned from office. Eight others in the government and PEMEX, the national oil company, were also charged in the case. Ultimately, however, these people were cleared of all charges.

Oil in Urban Areas (continued)

Recovery

Materials and equipment

- Pumps and vacuum systems (intrinsically safe)
- Storage systems and transportation
- Synthetic or natural absorbents

Method

- The oil is removed from the surfaces using vacuum systems. Sometimes recovery is assisted by flushing the oil with water to points where oil can be better recovered than at the spill site. Final removal of trace oil may be achieved with absorbent material.

Points to remember

- Recovery should be done as early as possible to remove pressure on containment and damming material
- Special heads for suction hoses will increase the recovery efficiency.
- Special care should be taken if there is any risk of damaging underground services e.g. telephone, electricity etc.

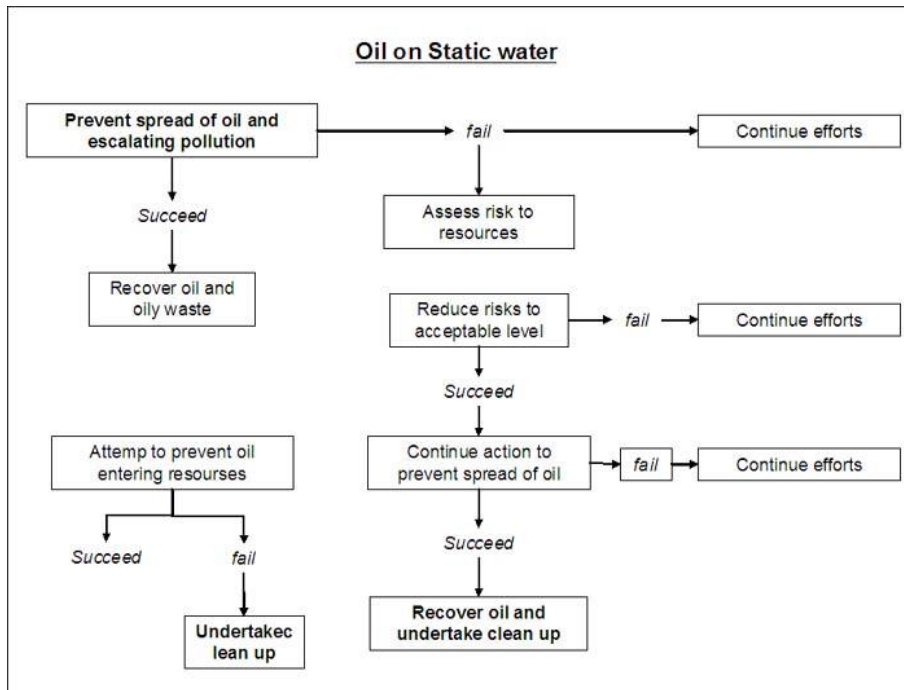
Advantages

- Most of the equipment required is the same as that which is usually available for sewage system cleaning.

Disadvantages

- Oil in complicated underground pipeline and cable systems may be difficult to recover
- Trenches associated the services often act as ducts underground and carry the oil to unpredictable points.

Oil on Static Water



Response in Lakes

The direction and strength of the wind dominates oil movement. The geometry of the lake and direction of the wind can result in columns of complex currents. Currents are usually stronger in the shallow parts than in deep areas. This is a main simplification of the movement of the wind in the flow of the lakes.



The effect of wind and waves during oil spills in rivers and lakes are important to know. In rivers wind is of secondary importance to the current dependent on the width and amount of trees on the banks. In lakes, these effects normally determine the distribution of the oil.



The waves alter the movement and expansion of the oil. The slick absorbs the energy of the waves so that the amount of movement is decreased.

Collection points are usually visible in the areas where debris builds up. The removal of any debris should be done before the oil arrives as the oiled debris will cause another waste disposal problem.

This has various effects:

- Small waves tend to push the slick in the same direction.
- The oil is moved slightly faster than the water where it is floating. Depending on the waves the speed is between 0.7% and 1.4% of the wind speed. This is only true when the oil surface is smooth.
- With large waves the oil may form small droplets in the water column and be dispersed permanently. Large quantities may re-float. In fresh water the oil will stay submerged for more time than it would in salt water. In turbulent conditions over washing may happen, where oil drops can be submerged to greater depths.
- Large amounts of oil may be below the surface making it difficult to observe from the air.
- It is not uncommon for observation flights to inform that the spill has vanished, only to return when the weather improves.

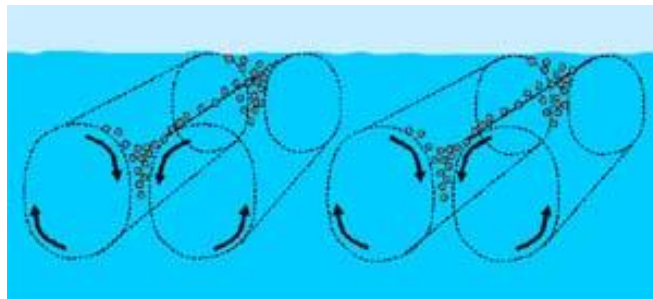
The current dynamic process as the wind it moves the water is complex.

The oil trajectory is the usually 3% of the velocity of the wind and in the same direction as the wind.

Current flow is unstable and it tends to break into patterns called Langmuir cells called after the Nobel prize winning chemist Irving Langmuir.

These appear when the wind is stronger than 3-4 knots. They are formed from vortices in line with the wind.

The distance between these cells can be from centimeters to meters. They are seen as strips, smooth water where debris collects .It is thought that these cells in theory cause the oil windrows.



Pneumatic Barriers

These can only be used in very calm conditions with very weak currents. They create a current on the water surface which prevents floating liquids or debris from passing and therefore spreading. The current is generated by compressed air flowing through a thick walled pipe placed on the bed of the water body. The air rises through special nozzles incorporated in the pipe to the surface, forming a vertical bubble curtain in the water column. When it reaches the surface the vertical current is transformed into a horizontal current which acts as barrier.



Basic components of a bubble barrier

1. Compressed air from a compressor.
2. Pipes with incorporated special nozzles and anchor blocks
3. Surface current generated by bubble curtain
4. Drain valves at the end of the nozzle pipes

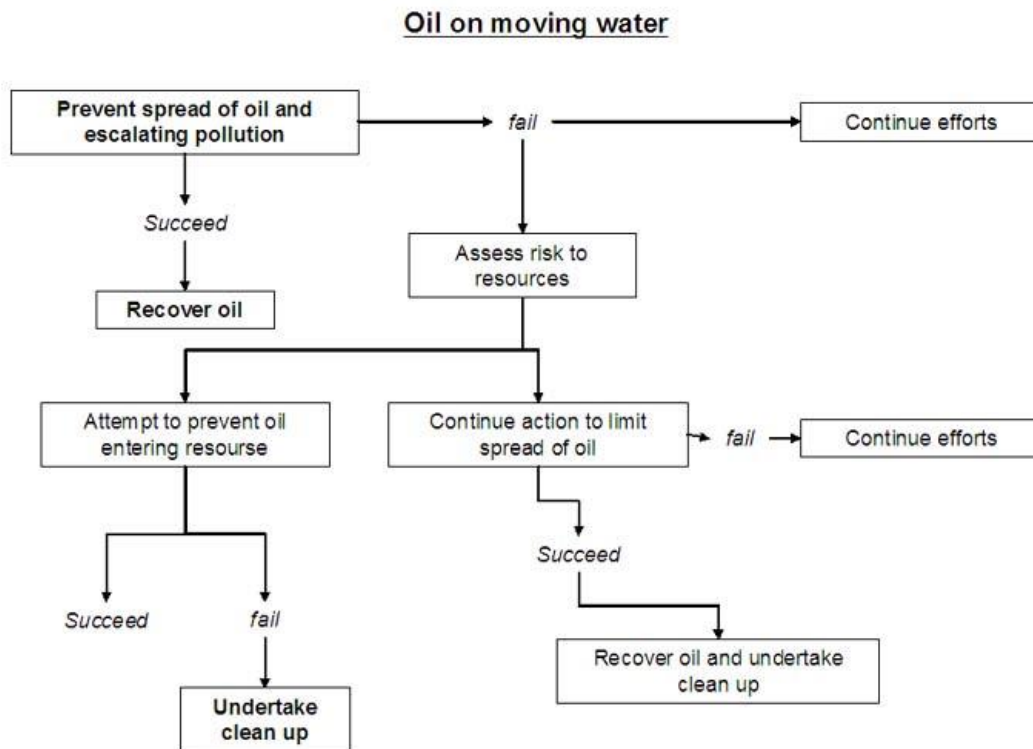
Main advantages of Pneumatic oil barriers

1. Very fast deployment with little manpower requirement.
2. 200 m can be blocked in 60 seconds by just starting the compressor.
3. The barrier is no hindrance to vessel movements.
4. Minimal maintenance costs with a long operational life.
5. Maintenance is necessary for the compressor only.
6. Air exiting the nozzles in the distribution pipe stops mud or silt from entering the pipe.

Points to be considered

1. This technique requires continuous bubble production.
2. Water jets can also inhibit oil spreading.
3. Turbulence can favour the emulsifying process.
4. Limitations are found in large areas or if the wind increases.
5. Water depth can influence formation of marine growth and how regularly growth removal cleaning has to be done.

Oil on moving water



Dams

If the spilt material mixes with water you can't boom the watercourse as the pollution will just flow under the boom. If it's a small watercourse and has a low flow rate, you may be able to dam it and stop the water flow which will prevent the pollution spreading.

You will see below that different materials can be used to build a dam, e.g. sand bags, wooden planks, hay bales and soil. Keep these near any planned damming point and train people how to dam the watercourse.

You'll need an alternative response plan in case high flow or rainfall makes damming impractical.

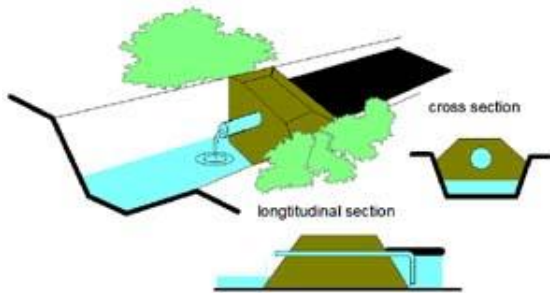
There are two types of basic dams – first, those ones that allow the water to flow normally and, second, those that form a large dam obstructing water flowing. The latter is easier to build because a barrier will increase the water level, and have outlets made in the barrier to allow the control of the water level in the barrier.

Hand-made dams, by excavators only, with sacks of sand, soil or with pre-fabricated materials, such as wooden boards, aluminium or steel plates, can be made with or without discharging the water.

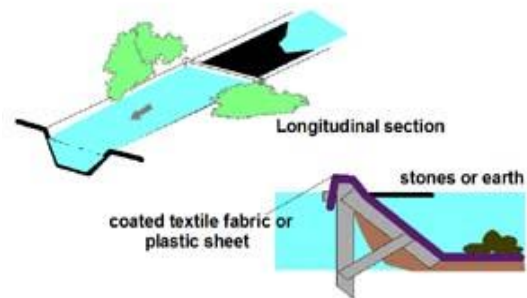
If the water course is shallow and the width is small then in many cases dams can be built quickly and cheaply to reduce the spread of the oil. There is always a need to allow water to flow through the dam and in many cases this flow is regulated. If this is not done there is a danger that the weight of water will push the dam over. Care also has to be taken with flooding. As the water level rises at the dam it also starts to back up in the stream.

Here is a collection of different types of dams which appeared in a CONCAWE report no 10/83 "A field guide to inland oil spill clean-up techniques".

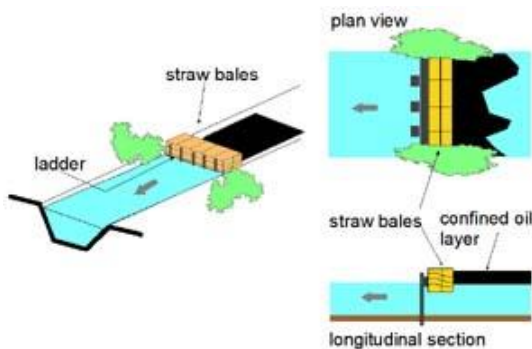
They can quickly be put into place before the manufactured equipment arrives e.g. boom and skimmers.



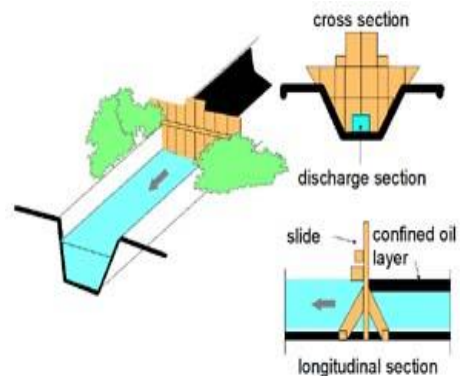
Earth dam



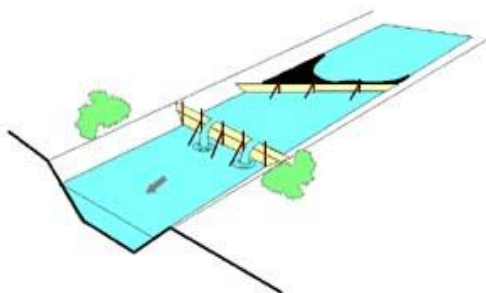
Plastic sheet dam



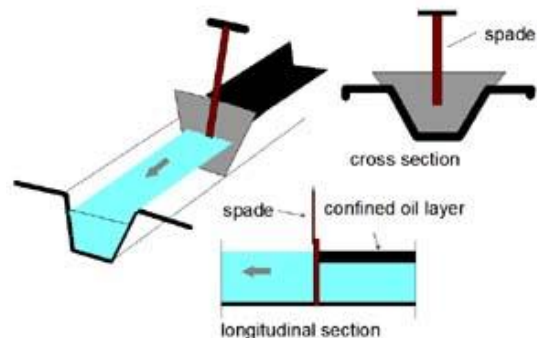
Straw bale dam



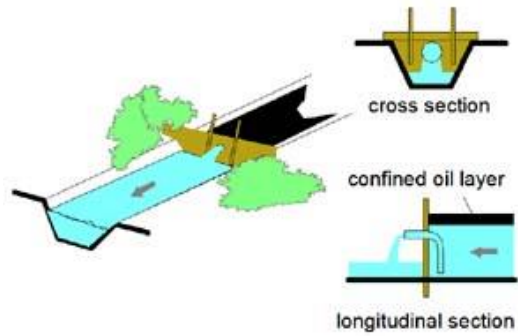
Wooden plank dam



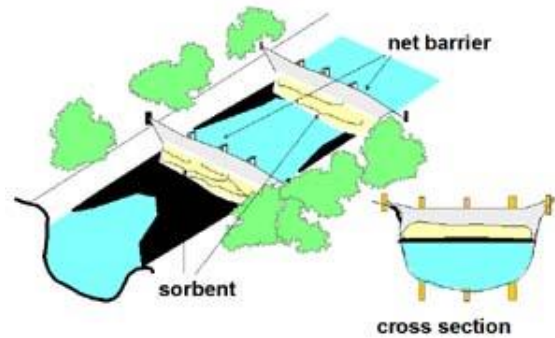
Wooden weir and barrier



Prefabricated spade dam



Improved prefabricated spade dam



Net barrier with sorbent



It needs to be said that the straw bale dam is very temporary as the straw absorbs large quantities of water and the bales left are tied with two thin polypropylene strings and are designed to be handled dry.

When wet they weigh considerably more than the string was made to withstand and they fall apart when removing them from the water thus causing even more contamination and work.

Picture on right shows someone who has not learned the lesson yet. Here the bale when dry weigh approx.1 ton. Imagine when they get wet.

Just to cause another problem these bales are made like a swiss roll with the straw being held together with a plastic mesh. So we have plastic as one type of waste, the natural fibres as another, and the oil as yet another all needing different destinations.

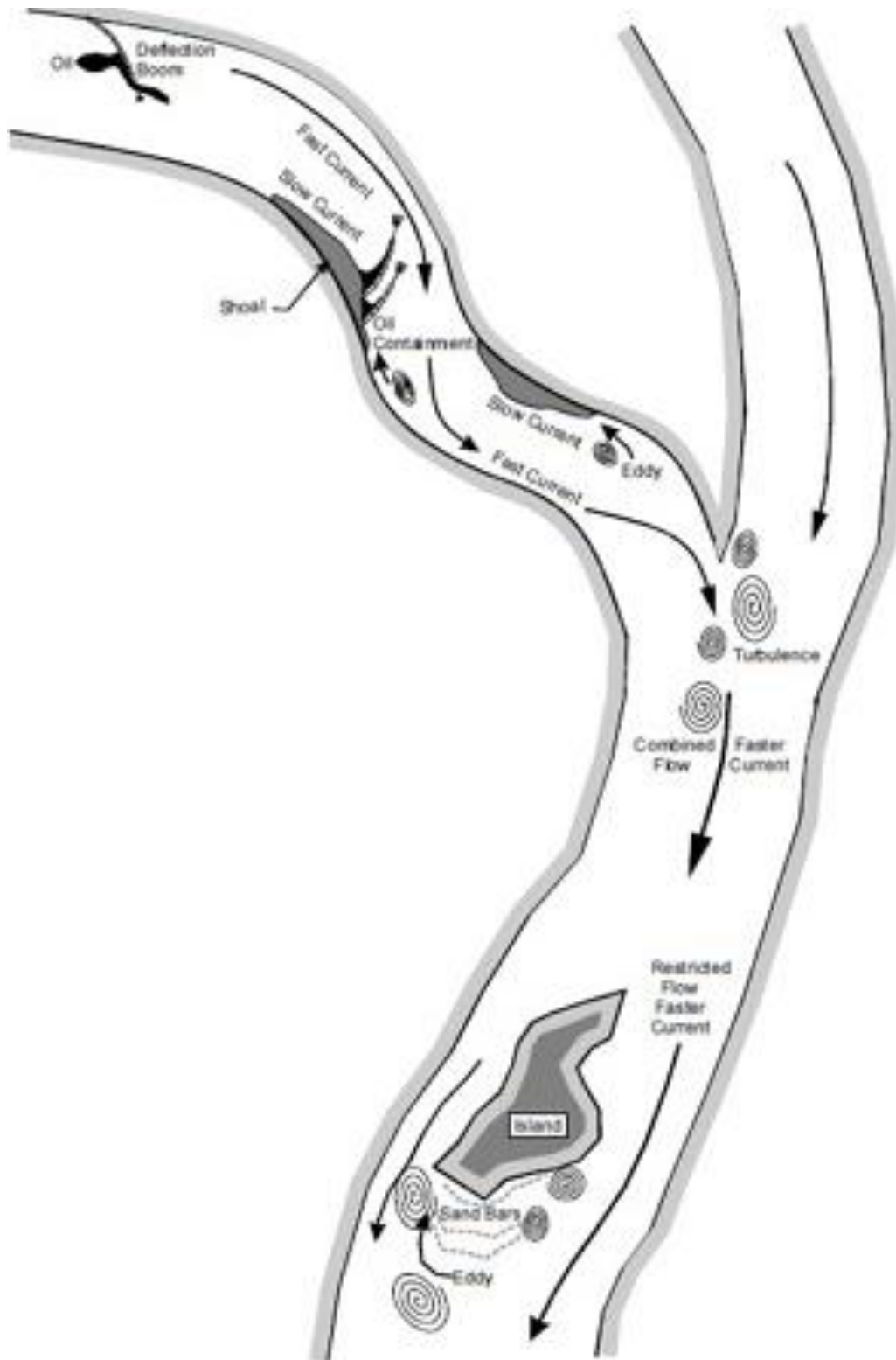
Rivers

Big wide rivers, in many cases sometimes form borders between states or countries, the effect of the wind may determine which bank the oil will impact.



Wider rivers with higher current speeds need to be studied to see where access and the best opportunity exist to recover oil.

Below is a diagram showing many of the natural problems we find in rivers.



Rivers normally flow in one direction but in some places rivers can flow in opposite direction. This can be caused by the laying down of eroded material as shown in the diagram (Bottom left, page 23) These areas give options that can be useful for recover operations.

Rivers are never satisfied with what they have and where they are. They are always trying to change their route by eroding the banks away as can be seen in this photograph (bottom right, page 23). Over millennia this river has moved through the valley leaving Oxbow lakes behind throughout the area.



The two images above show different places where access is only by river or parachute

The photo on the left is in the Arctic region of FSU. The *photo on the right* is in Amazonia, Brazil. In both cases there are thousands of square kilometers of rivers with access only from the river. During the rainy season in tropical regions, you are just seeing the canopy of the trees under that is also water, up to 10 meters deep.

Meandering rivers always have faster currents on the outside of a bend, this is where the erosion is being done.

So when looking for boom collection points we need to be on the inside of the bend.

As in the diagram *right* deflection booms are positioned to deflect the oil to the inside where it will be recovered.

It is always advisable to position at least two collection booms as oil usually finds its way past the first one. Make sure the distance between the booms allow for the oil resurfacing.

I have been doing it this way since I got involved in this business and have taught people all over the world to do it this way.

So why do we find the diagram (*right*) in a guide showing how to do it wrong.

Maybe it was done this way because that was where the trees were growing.

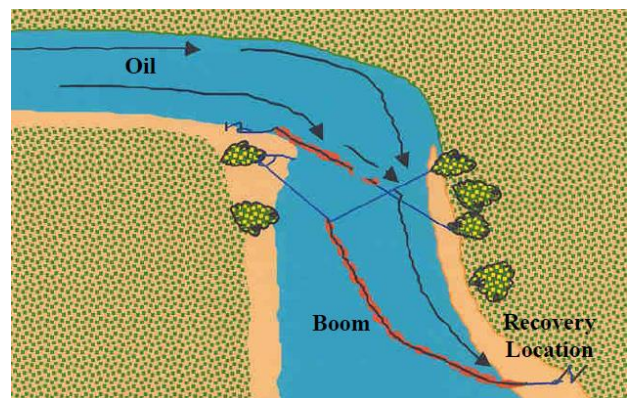
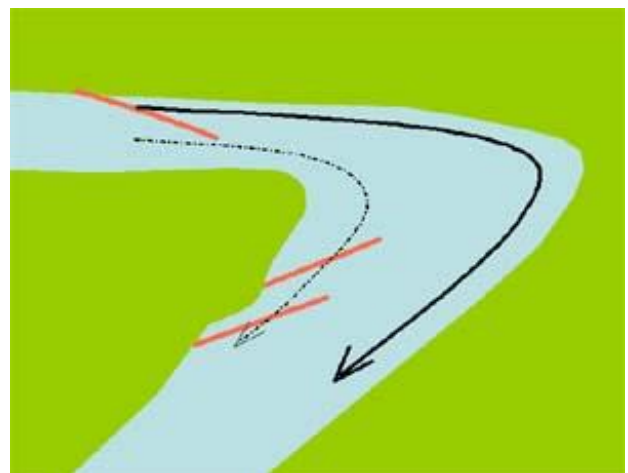
Note in some countries it is illegal to tie booms or any other equipment off to trees.

There are different schools of thought. Train both ways and decide which is right.

The photo on right shows how to do it wrong as well.

- 1. Access from the road is where the smallest amount of oil is along with the fastest current.
- 2. Vessels on the side of the boom with the oil (more fumes and unnecessary contamination).
- 3. Very little tank space on vessels and none on the river bank.

Access is always the main problem, having enough time to position the booms before the oil arrives is obviously the aim.



The next access point downstream may be only 1 kilometer by river, but we cannot always use the river e.g. too much equipment for the boat, no boat, too shallow etc.

By land it may be many kilometers of cart tracks and therefore too much time is spent to get there and position the equipment before the oil arrives.

When you find a good access point do the maximum possible to make sure the oil does not pass by.



Reconnoitre the next access point and even position equipment there if you have the manpower and extra equipment.

If there is a large quantity of spilt oil, the installation of many containment barriers will be needed. One single barrier will not block or deflect all the oil in moving water.

Water courses with currents of more than 1 meters per second bring more difficulties.

The distance between booms should be wide enough to let oil particles cross the first barrier and have enough time to float to the surface before reaching the next and so on.

The type of barriers to be used will be decided by local conditions and material availability.

Some operations start in quiet rivers only to be interrupted later by flood waters.



There is always a need to know what the weather is doing as well as the topography of the region. It may be sunny where you are, but miles away in the hills where your river comes from, it may be raining.

Sometimes it may take hours or days for the flood water to reach your site and you need to be prepared.

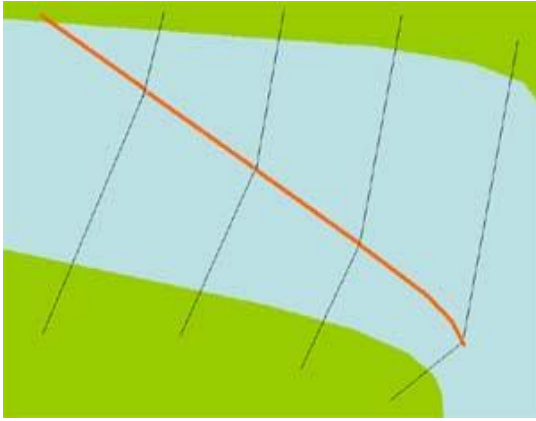
This is a real problem in tropical regions where hours of rain produces many tons of water and the level may rise a couple of meters in a short time.

Booms should always be secured with ropes with less breaking strain than the boom. As in the case *above*, the rope breaks but the boom remains with you. In this case when the river calmed down the oil was over 30 km from this point.

Booms should be anchored either in the river or on the banks to maintain the angle as good as possible. In currents of more than 1mps, shorter lengths of boom should be used to provide more anchor points at the connections.

The fewer anchor point the greater the likelihood of sections of the boom bellying and oil getting away.

Stakes of either wood or steel are usually used in these cases and many long lengths of rope. Make sure you have enough of both.



The *photo (above right)* was taken at a spill in the Rio Guarapiche, Venezuela. The mind boggles as to why you have boom but have to use half naked men instead of anchors.



In order to reduce the stress and strain on boom anchor points a series of booms are positioned one behind the other to work like a cascade allowing the oil to be directed into calm water recovery points *photo left*.

This reduces the strain dramatically as the booms are separate and not on continuous length.

Each boom is angled across the river to allow the oil to flow off the end onto the next and so on until it arrives in the collection boom at the bank.



There needs to be a good seal against the bank to allow the oil to become thick enough for recovery to take place. This can be difficult in many places as environmental agencies may not allow the bank to be dug away to allow a smooth seal with the boom.

If the boom is not sealing properly there will be a vortex form on the point of the boom which will entrain the oil under the boom. This problem is lessened when heavy fuel oil or cold conditions increase the viscosity of the oil.

The photo (*left*) shows how with no seal any oil that is directed to the shore will just escape through the gap.

Rivers (continued)

I have argued that a little damage to a river bank, which can be repaired after the operation, is better than many kilometers of oiled river banks.



The photo *left* shows the use of a trench to contain oil and be recovered by vacuum trucks.

The boom could do with being at a better angle but with the volume of oil it would be difficult to achieve.

Note: oil escaping under the apex of the boom is caught by the back up.

As over 60% of inland oil spills occur in rivers with currents in excess of 0.5 metres/sec. various techniques and equipment have been developed over the years.

Some are common and others are very rare to find. Here is a small selection of some of these innovations.

Here is a type of boom *right* that seems to be difficult to find these days. It was designed to work in fast currents.

Skirts were made shorter and holes were made to allow the water to flow through the skirt reducing the water pressure and therefore reducing the likelihood of the boom being submerged.

The *photo right* is a pallet of this type of boom in a base in Baku, Azerbaijan.

If you don't have this boom available, the boom skirt can be rolled up and tied around the floatation to reduce drag and facilitate deployment. Deploy the boom so that the current faces the smooth backside of the rolled up skirt.

After deployment, cut enough of the ties loose starting at the apex to permit the boom to bow out due to increased drag on the skirt. Leave the remainder of the skirt tied. The floatation and compressed skirt are enough to deflect oil at shallow angles.



The Flow-Diverter system was tested in the 1970s and was found to be effective at diverting and converging oil at speeds up to 5mps.

In more moderate currents it can be used in place of an anchor, towboat or outrigger arm to deploy and position the outboard end of a deflection boom.



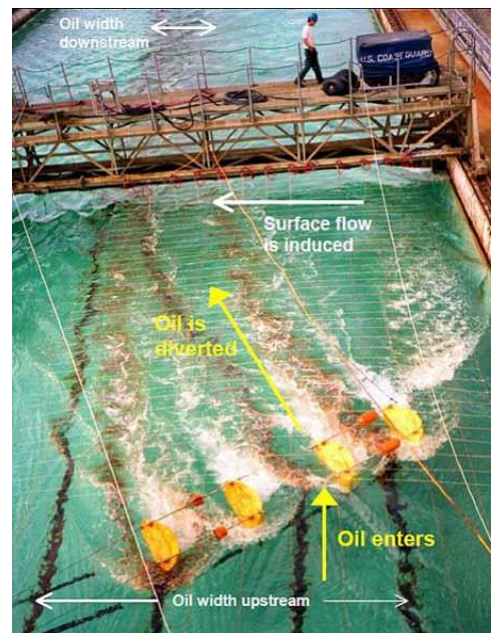
Photograph *left* is of the prototype. The diverter is a unique stable catamaran design that consists of two hulls. Each hull comprises of symmetrical foils with integral buoyancy.

The foils are pinned to a rigid connecting structure so that they can pivot but remain parallel to each other. Two or more catamarans can be connected together with cables to increase the total sweep width. Two control lines are anchored to the shore or to a boat and are used to deploy the system by adjusting the foil angle to the oncoming water. With the control lines secured, the system is launched into the current and drives out into the a stable position balanced by the hydrodynamic lift force of the passing water and the tension in the lines.



The foils create a strong transverse surface current downstream to achieve the desired diversion and consolidation effect on the floating oil.

Unlike most skimmers and deflection booms, the diverters are not adversely affected as current increases. The oil is diverted by the same amount irrespective of current speed.



The photograph *left* is current at 1.5 mps and the right is at 2mps.

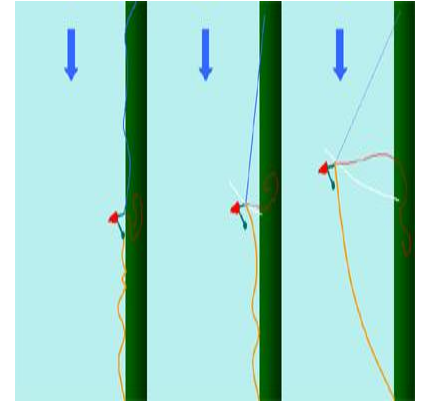
The USCG Research and Development Center initiated a request for the development of innovative fast-water spill response equipment. CSC Advanced Marine Center won a contract to develop and demonstrate the Oil Spill Flow Diverter™ concept.

Rivers (continued)

The Boom Vane® is simply a series of vertical vanes which drive into the current. The boom is attached to a towing bridle which is towed behind. The main tethering rope is anchored on the river bank upstream of the recovery point, when the Boom Vane is launched it drives into the current on an arch as in the diagram. The faster the current the tighter the angle of the boom.



There is a serious safety issue with this equipment, dependent on whether it is fitted with a spring on the rudder or not. If the spring is fitted then a sharp tug on the thin red line will stop it in mid-stream and start to return to the original bank. It can be stopped and started again which is useful if boat need to pass during operations. If the spring is not fitted it cannot be stopped until it reaches its stopping point. If someone gets the rope around his foot he is going with it until it stops and there will be no slack in the rope to escape until that point.



The system can be operated in rivers with heavy traffic as the Boom Vane control rudder allows for speedy and effortless retrieval from midstream.



Standard version:

The BoomVane is 1.1m high and was constructed as a cascade of vertical wings mounted in a rectangular frame. Powered by the current flow, the BoomVane, held by a single mooring line only, swings out towards the opposite shore with the oil boom in tow.

Shallow version:

This version is .55m high and was designed for operations in shallow waters (less than 1 m / 3'). It may also be deployed off a towing vessel to reach near the shoreline with booms and absorbents, where it is too shallow for the vessel to go.



To make things difficult for people using this equipment for the first time, the colour code is wrong, this has been reported to the manufacturer but nothing has changed. It can be put together to work from both banks of a river or from both sides of a vessel.

The colours are red and green which are maritime colours for port and starboard unfortunately they are the wrong way around. It would be easy to deploy it from the port side using the red indicators but for it to work they need to be green. It's not difficult to get the paint out and change it, but some people do and others don't which just leads to even more confusion.

Having said this it is a very good piece of equipment, they come in various sizes 0.5m and 1m for rivers. The bigger the size the faster the current needs to be for it to work correctly. There is also an open sea version where the vessel provides the current speed. This should dramatically reduce the damage to offshore booms as only one vessel is needed.

I have used the boom vane in sheltered bays and close to the shore with good results. [.Video of boom vane click here.](#)

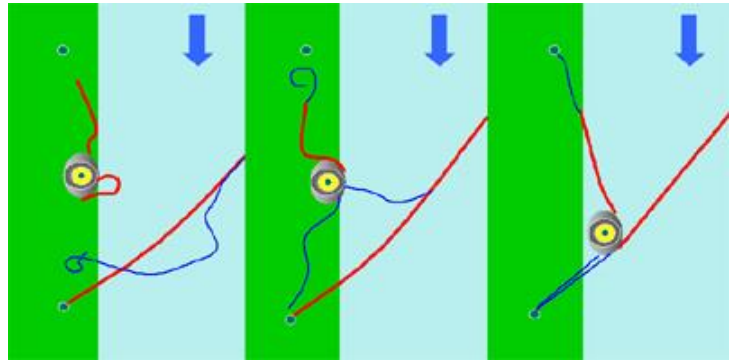


These boom deflectors act like the boom vane but are smaller and fit in between the boom sections, each one drives into the current removing the need for anchors. This is particularly useful in shallow rivers.

These types of inventions reduce the manpower requirements and response times but mainly the need for anchor points and the amount of rope required for the deployment. *Photos courtesy of Seacor*



Rivers (continued) Recovery of oil in faster currents



This device, known as Capt Blombergs Hydro dynamic Circus[®] is now a River Circus[®].

It uses a small opening which then opens into a wide collection area with a skimmer is fitted in the middle. The oil flows through the gap at speed but when it gets into the wide area it slows down giving the skimmer time to work.



A simple system to deploy but requires a depth of approx. 0.5m next to the bank.

Above right is the Mini Fastflo[®] which works on the same principle as the Circus oil enters through a restriction which then widens allowing the flow to reduce in speed and enter the skimmer section at the back. As can be seen it will work in very shallow rivers or streams and is simple to deploy.

The Boom Vane is a device for boom deployment in rivers and other waterways. This powerful yet light response tool allows for rapid deployment of small boom in fast waters, without the use of boats, anchors or fixed installations.

In-situ burning



Burning is being considered with growing interest as a response tool for wetlands as a viable strategy in various countries.

Photo left is the result of a burst pipeline in a peat bog in Minnesota, USA.

Burning of wetland grasses has been conducting prescribed burns of wetlands to rejuvenate wetlands that have accumulated high litter loads, to generate green vegetation or open spaces to attract wildlife for many years, to restore habitats in areas that are historically dependent on frequent wildfires to sustain these ecosystems.

Burning of oiled wetlands is relatively new and will not be allowed in many countries.

The presence of oil in a wetland may have two important effects: the high BTU of the oil may increase the temperature and heat penetration of the burn, and oil residue may remain after the burn.

Deciding how to respond to an oiled wetland is a complex issue for which there can be no single answer.

It must be determined if any clean-up is necessary or desirable a consultation with a biologist, botanist, or ecologist would be extremely helpful in accessing options.

Clean-up in a wetland appears to be justified when oil can be removed with minimum impact, when other natural resources (such as migrating birds) are at high risk of being oiled, or when unassisted recovery is likely to be very slow.



Photo right was taken during the Komi, FSU spill in 1996. This was done to minimise spreading of the oil into the Kolda River which flows into the Arctic Ocean. There were also no waste disposal routes in this remote location.

Natural recovery may be the best option to follow when:

- Oiling is light and natural recovery is likely to occur in an acceptably short time frame
- Clean-up activities would be detrimental to the wetland
- Wildlife is at low risk of being oiled.

In-situ burning as a spill response method may provide a means to remove the oil from the impacted area without resorting to mechanical clean-up methods, which may be destructive or impossible to carry out.

Advantages

- Minimises physical damage: Where access is limited or mechanical/manual removal has the potential to cause unacceptable levels of impact by equipment mobilisation and trampling, burning can rapidly remove oil from sensitive areas.
- Provides an option when other options fail or where oil residues will be unacceptably high with other options, including natural recovery.
- Removes oil quickly from the habitat when there is a time-critical element, such as a short-term change in the physical conditions which will likely cause loss of containment and further spreading (e.g., rain or flooding), or a seasonal increase in wildlife use, such as arrival of large numbers of migratory waterfowl.

Disadvantages

- Burning can cause substantial initial plant damage because the above ground/water vegetation is removed.
- Burning can cause long-term impacts to vegetation, when the fire is so hot or the water is too low, that the below-ground plant parts are killed.
- There is a potential for burning to increase oil penetration into the substrate when there is no standing water.
- Any animals present and unable to escape will be killed.
- Heavy fuel oils, when burned, may produce residues that are difficult to remove.

[Text taken from [RRT6 ISB Guidelines 1996](#)]