

US EPA ARCHIVE DOCUMENT

Shoreline Cleanup of Oil Spills

4

INTRODUCTION

FRESHWATER and marine shoreline areas are important public and ecological resources. However, their cleanliness and beauty, and the survival of the species that inhabit them, can be threatened by accidents that occur when oil is produced, stored, and transported. Oil is sometimes spilled from vessels directly into waterways; spills from land-based facilities can flow into waters and foul shorelines. These accidents affect both oceans and freshwater environments. Despite the best efforts of response teams to contain spilled oil, some of it may contaminate shorelines of oceans and lakes, banks of rivers and streams, and other ecologically sensitive habitats along the water's edge. To help protect these resources from damage and to preserve them for public enjoyment and for the survival of numerous species, cleaning up shorelines following oil spills has become an important part of oil spill response.

SHORELINES: PUBLIC AND ENVIRONMENTAL RESOURCES

FRESHWATER and *marine* shoreline areas serve as homes to a variety of wildlife during all or part of the year. Many bird species build their nests on sand or among pebbles, while others regularly wander the shoreline searching for food. Marine mammals, such as elephant seals and sea lions, come ashore to breed and bear their pups. Fish, such as salmon, swim near shorelines on their upriver migrations during spawning season, and their offspring swim through these same areas on their trips to the sea in the following year. In addition, freshwater environments are important to human health as they are often used for drinking water and are home to many different mammals, aquatic birds, fish, insects, *microorganisms*, and vegetation.

Freshwater and marine shorelines also provide public recreation throughout the world. Rivers, streams, and

other freshwater bodies are known for their fishing activities, while many beaches are famous for their wide expanses of beautiful sand and rugged rocky cliffs, providing opportunities for sports such as swimming, boating, and windsurfing. When response teams develop strategies for cleaning up a shoreline after an oil spill, they must consider the characteristics of the shoreline and the natural and recreational resources it provides.

FACTORS AFFECTING CLEANUP DECISIONS

FREQUENTLY, oil spills will start on land and reach shore areas. Whenever possible, control and cleanup of an oil spill begins immediately. If the oil spill can be controlled, it is less likely that it will reach sensitive freshwater or marine habitats. If the oil does reach the shore, however, decisions about how best to remove it must be made. These decisions will be based on factors such as the following:

- Type of oil spilled
- Geology of the shoreline and rate of water flow
- Type and sensitivity of biological communities likely to be affected

Each of these factors is described below.

Type of Oil Spilled

Lighter oils tend to evaporate and degrade (break down) very quickly; therefore, they do not tend to be deposited in large quantities on banks and shorelines. Heavier oils, however, tend to form a thick oil-and-water mixture called *mousse*, which clings to rocks and sand. Heavier oils exposed to sunlight and wave action also tend to form dense, sticky substances known as *tar balls* and *asphalt* that are very difficult to remove from rocks and sediments. Therefore, deposits from heavy oils generally require more

aggressive cleanup than those from lighter ones. Shoreline clean-up of inland spills usually involves lighter oils. Inland oil spills often involve refined petroleum products, although spills of other types of oil are not uncommon. Spills in marine ecosystems often involve crude oils and heavy fuel oils originating from accidents during tanker operations.

Geology of the Shoreline and Rate of Water Flow

Shorelines can vary dramatically in their forms and compositions. Some marine shorelines are narrow, with beaches formed from rounded or flattened cobbles and pebbles; some are wide and covered in a layer of sand or broken shell fragments; and still others are steep cliffs with no beach at all. Generally, freshwater shorelines are composed of sediments and may be lined with trees or heavy vegetation. The composition and structure of the bank will determine the potential effects of oil on the shoreline.

Oil tends to stick to sediments and to the surfaces of cobbles and pebbles. It also flows downward in the spaces between cobbles, pebbles, and sand grains, and accumulates in lower layers of sediments. Oil that sticks to sediment particles suspended in the water column, or to cobbles and pebbles along the bank, is exposed to sunlight and waves, which help it to degrade and make it less hazardous to organisms that come into contact with it. Oil that sticks to rocks and pebbles can be wiped or washed off. Oil that flows onto sandy banks, however, can “escape” downward into sand, making it difficult to clean up and reducing its ability to degrade.

The effects of an oil spill on marine and freshwater habitats varies according to the rate of water flow and the habitat’s specific characteristics. Standing or slow-moving water, such as marshes or lakes, are likely to incur more severe impacts than flowing water, such as rivers and streams, because spilled oil tends to “pool” in the water and can remain there for long periods of time. In calm water

The type of environment needs to be considered when devising a cleanup plan.



conditions, affected habitats may take years to recover. When oil spills into a flowing river, the impact may be less severe than in standing water because the river current acts as a natural cleaning mechanism. Currents tend to be the strongest along the outside edge of a bend in a river where the current tends to flow straight into the outside bank before being deflected downstream. Oil contamination is usually heavy in this area because currents drive the oil onto the bank.

In marine environments and on large lakes and rivers, waves affect the movement and spreading of oil spills in several different ways. Initially, the oil spreads to form a thin film, called an oil *slick*. The slick appears smooth compared to the water around it. Momentum is then transferred from the waves to the oil slick. Small waves tend to push oil slicks in the direction of wave propagation. This makes oil slicks move slightly faster than the surface of the water that they are floating on. Short, relatively steep waves can result in a surface current that will move the oil in a downwind direction. As waves break, the resulting plunging water creates a turbulent wake, carrying particles of oil down into the water column.

Type and Sensitivity of Biological Communities

Biological communities differ in their sensitivity to oil spills and the physical intrusion that may be associated with various cleanup methods. Some ecosystems seem to recover quickly from spills, with little or no noticeable harm, while others experience long-term harmful effects.

Animals and plants may be affected by the physical properties of spilled oil, which prevent respiration, photosynthesis, or feeding. Animals, such as elephant seals, which depend on the marine environment for breeding and pupping, can lose their ability to stay warm in cold water when their skin comes into contact with oil. Birds lose their ability to fly and to stay warm when their feathers are coated with oil, and fish can suffocate when their gills are covered with oil. An oil spill can disrupt an ecosystem’s food chain because it is toxic to some plants which other organisms may depend on for food. In addition, oil in sediments like those that are common in freshwater shorelines may be very harmful because sediment traps the oil and affects the organisms that live in, or feed off, the sediments.

CLEANUP PROCESSES AND METHODS

BOTH NATURAL processes and physical methods aid in the removal and containment of oil from shorelines. Sometimes physical methods are used to enhance naturally occurring processes. Examples of a technology that uses both natural processes and physical methods to clean up an oil spill are *biodegradation* and *bioremediation*, which are described later.

Natural Processes

Natural processes that result in the removal of oil from the natural environment include *evaporation*, *oxidation*, and *biodegradation*.

Evaporation occurs when liquid components in oil are converted to vapor and released into the atmosphere. It results in the removal of lighter-weight substances in oil. In the first 12 hours following a spill, up to 50 percent of the light-weight components may evaporate. Since the most toxic substances in oil tend to be those of lightest weight, this evaporation decreases the toxicity of a spill over time.

Oxidation occurs when oxygen reacts with the chemical compounds in oil. Oxidation causes the complex chemical compounds in oil to break down into simpler compounds that tend to be lighter in weight and more able to dissolve in water, allowing them to degrade further.

Biodegradation occurs when naturally occurring bacteria living in the water or on land consume oil, which they can use to provide energy for their various biological needs. When oil is first spilled, it may be toxic to some bacteria, which makes the initial rate of biodegradation quite slow. As the oil evaporates and the more toxic substances are removed, the population of bacteria grows and biodegradation activity accelerates.

In nature, biodegradation is a relatively slow process. It can take years for a population of microorganisms to degrade most of the oil spilled onto a shoreline. However, the rate at which biodegradation occurs can be accelerated by the addition of nutrients, such as phosphorus and nitrogen, that encourage growth of oil-degrading bacteria. This process is called *biostimulation*. Biodegradation rates can also be increased by adding more microorganisms to the environment, especially species that are already used to consuming the type of oil spilled. Adding microorganisms is referred to as *bioaugmentation*. The use of nutrients or the addition of microorganisms to encourage biodegradation is called *bioremediation*.

When oil spill response personnel develop bioremediation strategies, they have to consider the effects of waves, tides, and currents on the nutrients and microorganisms they are applying to oil-contaminated areas. Contamination of coastal areas by oil from offshore spills usually occurs in the intertidal zone where waves and tides can quickly carry away dissolved nutrients. Adding nutrients may not be effective on beaches with a great deal of wave action and tidal flows because most of the nutrients will be lost to dilution. On calmer shorelines, adding nutrients may be an effective bioremediation strategy.

With respect to freshwater shorelines, an oil spill is most likely to have the greatest impact on wetlands or marshes rather than on a wide shoreline zone like a marine intertidal zone. Less research has been conducted in these types of environments, so it is not yet known how well bioremediation enhances oil removal. The same principals apply to this environment as a marine environment,

namely, that nutrients should be applied in ways that will keep them from washing away from the affected areas long enough to affect the enhanced treatment. In wetlands, bioremediation may not work as well because there is less oxygen in the sediments than there is on a sandy beach; even with added nutrients, microorganisms may not have enough oxygen to effectively combat the spill.

EPA is currently studying the biodegradability of *non-petroleum oils* (vegetable oils and animal fats) and their impacts on freshwater and marine environments during biodegradation.

Chapter three discusses bioremediation and other alternative cleanup approaches.

Physical Methods

Physical removal of oil from shorelines, and especially beaches, is time-consuming and requires much equipment and many personnel. Methods used to physically clean oil from shorelines include the following:

- Wiping with absorbent materials
- Pressure washing
- Raking or bulldozing

Before physical cleaning methods are used, booms made of absorbent material are often set up in the water along the edge of the bank. Booms prevent oil released during bank cleanup activities from returning to the water and contain the oil so that it can be skimmed from the water for proper disposal.

Wiping with Absorbent Materials

Materials that are capable of absorbing many times their weight in oil can be used to wipe up oil from contaminated shorelines. These materials are often designed as large squares, much like paper towels, or shaped into “mops.” The squares or mops are used to wipe the shoreline or oily rocks during which time the absorbents are filled with as much oil as they can hold.

There are advantages to the use of absorbents. They can be used to clean up any kind of oil on any shoreline that can be reached by response personnel. The use of absorbents is generally not harmful to the shoreline itself or to the organisms that live on it, and no material is left behind following the cleanup effort. Some sorbents are reusable, reducing the need for disposal after a spill.

Wiping with absorbent materials requires the use of a large quantity of material and several personnel. Personnel must wear proper protective clothing to minimize direct contact with the oil as they are removing it. Oil-filled absorbents and protective clothing that are used by response personnel must be properly disposed of following cleanup, which can be costly. In addition, the intrusion of many people onto an isolated shoreline may disrupt animal behaviors such as breeding or nesting.

Pressure Washing

Pressure washing involves rinsing oiled shorelines and rocks using hoses that supply low- or high-pressure water streams. Hot or cold water can be used to create these streams. The oil is flushed from the shoreline into plastic-lined trenches, then collected with sorbent materials and disposed of properly. Since many river banks, and some lakes, have vegetation extending down into or growing in the water, plants may have to be cleaned or removed. Depending on the type of oil, low-pressure washing will usually remove most of the oil from the vegetation. In a marine ecosystem, high-pressure washing usually does more harm than good by driving the oil deeper into the beach and by killing many of the organisms on the beach. Additionally, high-pressure water streams can accelerate bank erosion and dislodge organisms, such as algae and mussels, from the rocks and sediments on which they live, or can force oil deeper into sediments, making cleanup more difficult.

Pressure washing has the advantage of being relatively inexpensive and simple to apply; however, it requires many people.

Raking or Bulldozing

When oil moves downward into the sands or between pebbles and cobbles on a shoreline, it becomes more difficult to remove. If the oil has moved downward only a short distance, tilling or raking the sand can increase evaporation of the oil by increasing its exposure to air and sunlight. If the oil has penetrated several inches into the sand, bulldozers may be brought in to remove the upper layers of sand and pebbles. This allows the oil to be exposed so it can be collected and removed from the site, washed with pressure hoses, or left to degrade naturally.

Raking and bulldozing are simple methods for helping to remove oil that might otherwise escape into sediments. However, these methods can disturb both the natural shape of the shoreline and the plant and animal species that live on and in the sediments. In addition, the use of

Response crews using high pressure hose to wash an oil covered beach.



bulldozers requires specially trained operators who can maneuver them without damaging the shoreline unnecessarily; raking and tilling are time-consuming and require many people.

DISPOSAL OF OIL AND DEBRIS

CLEANUP FROM an oil spill is not considered complete until all waste materials are disposed of properly. The cleanup of an oiled shoreline can create different types of waste materials, including liquid oil, oil mixed with sand, and tar balls. Oil can sometimes be recovered and reused, disposed of by *incineration*, or placed in a landfill. States and the federal government strictly regulate the disposal of oil.

Reuse or recovery of oil requires that the oil be processed and separated from the other materials, such as water, that are mixed in with it. The recovered oil can then be blended with other fuels for use in power plants or boilers.

Incineration uses extremely high temperatures to convert compounds, such as oil, into carbon dioxide and water. When a mobile incinerator is used at a remote spill site, the need for transporting large volumes of oiled wastes to distant disposal sites is eliminated. This can be a practical and efficient method to manage large volumes of waste generated during a cleanup. Because incineration can potentially produce air pollution, it is important that it be used in strict compliance with air pollution laws.

Landfilling is another method of disposing of oiled debris. The oil is mixed with chemicals, such as calcium oxide ("quicklime"), that stabilize the oil and make it less able to leak into groundwater or soils. Mixtures of quicklime and oil must sometimes be taken to specially designed landfills for disposal.

SUMMARY

CLEANING shorelines after an oil spill is a challenging task. Factors that affect the type of cleanup method used include the type of oil spilled, the geology of the shoreline and rate of water flow, and the type and sensitivity of biological communities in the area. Natural processes, such as evaporation, oxidation, and biodegradation, help to clean the shoreline. Physical methods, such as wiping with sorbent materials, pressure washing, and raking and bulldozing, can be used to assist these natural processes. Oil collected during cleanup activities must be reused or disposed of properly, using such methods as incineration or landfilling. Choosing the most effective yet potentially least damaging cleaning methods helps to ensure that the natural systems of shorelines and the recreational benefits they offer will be preserved and protected for future generations.