Alabama, Mississippi, and Northwest Florida Area Contingency Plan (AL, MS, and NWFL ACP)

Risk Analysis: Shoreline Cleanup Methods

Annex 1

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Table of Contents

1000 Introduction 1

2000 Major Shoreline Types 1

2100 Shoreline Type Definitions 1
2101 Coastal Structures 1
2102 Bluffs 2
2103 Fine Sand Beaches 2
2104 Coarse Sand Beaches 3
2105 Shell Beaches 3
2106 Perched Sand Beaches 3
2107 Perched Shell Beaches 4
2108 Sandy Tidal Flats 4
2109 Muddy Tidal Flats 4
2110 Swamps 5
2111 Fresh Marshes 5
2112 Salt Marshes 5

2200 Shoreline Types in Northern Gulf of Mexico 6

2300 Shoreline Sensitivities and Cleanup Concerns 7

3000 Cleanup Method Decision-Making Guidance 8

3100 Cleanup Factors 8
3101 Type of substrate 8
3102 Amount of oil contamination 9
3103 Type of oil 9
3104 Depth of oil contamination in the sediments 9
3105 Type of oil contamination 9
3106 Shoreline exposure 9
3107 Trafficability of equipment on shoreline 9
3108 Environmental sensitivity of contaminated shoreline 9

3200 Cleanup Methods 10

3300 Physical Properties of Different Types of Spilled Oil 13

3400 Shoreline Cleanup Matrices for Various Oils/Shorelines 14
3401 Shoreline Cleanup – Very Light Oil 14
3402 Shoreline Cleanup – Light Oil 15
3403 Shoreline Cleanup – Medium Oil 16
3404 Shoreline Cleanup – Heavy Oil 17

List of Tables

Table 1: Shoreline Types in Northern Gulf of Mexico 6 6
Table 2: Shoreline Sensitivities, Oil Behavior and Cleanup Concerns 7
Table 3: Shoreline Cleanup Descriptions 10
Table 4: Physical Properties of Various Oil Types 13
Table 5: Shoreline Cleanup Matrix – Very Light Oil 14
Table 6: Shoreline Cleanup Matrix – Light Oil 15
Table 7: Shoreline Cleanup Matrix – Medium Oil 16
Table 8: Shoreline Cleanup Matrix – Heavy Oil 17

1000 Introduction

The best cleanup method for a particular shoreline segment will be determined during the shoreline assessment process. Teams will usually visit each contaminated shoreline segment and inventory the geological and ecological resources in order to select the most appropriate cleanup method(s). This annex provides shoreline cleanup matrices for use in the selection process of a particular cleanup method(s).

2000 Major Shoreline Types

A total of 12 types of shorelines were identified for the purposes of oil spill cleanup recommendations in the northern Gulf of Mexico. Table 1 lists the 12 types of shoreline and their physical and biological characteristics. Each shoreline type describes the nature of the land/water interface and intertidal zone. Each shoreline type is not intended to represent a coastal landform, although in some cases a shoreline type may be a landform. From the perspective of developing a relevant oil spill shoreline classification, all coastal landforms have shorelines. A knowledge of the coastal landform shoreline is important for trafficability, access, habitat sensitivity, oil behavior, and cleanup method selection. In all cases, spilled oil that reaches the shoreline impacts the intertidal zone, in some cases storms can disperse the oil onto subaerial surfaces. This is the reasoning used in developing the shoreline classification specifically for oil spill cleanup assessment and operations focused on the intertidal zone. The following sections describe each of the 12 shoreline types, providing information on physical characteristics, distribution, sediment texture, and landform associations within coastal Alabama, Mississippi, and Northwest Florida. There may be some cases where different shoreline types overlap. This overlapping structure occurs when a coastal landform has multiple shoreline types. An example of this is a prograding river delta where freshwater marsh and forested swamps are fronted by muddy tidal flats. Overlap may also be a function of seasonal variability, a summer fine sand beach versus a winter fine sand perched beach. Similar shoreline types are faced with similar response strategies and cleanup methods. On a shoreline cleanup operation, the knowledge of the types and amounts of shoreline oiled will allow you to accurately forecast manpower and logistical needs rapidly and accurately. Table 2 lists the sensitivity, oil behavior, and cleanup concerns for the 12 shoreline types found in Alabama, Mississippi, and Northwest Florida.

2100 Shoreline Type Definitions

2101 Coastal Structures

The coastal structure classification describes the variety of man-made hard structures that can be found on the shoreline. This classification includes seawalls, jetties, breakwaters, groins, piers, port facilities, pipelines, and oil and gas facilities. The typical construction material and texture include rock, steel, wood, and concrete.

- Seawalls are coastal protection structures built parallel to shore and constructed of rock or concrete rip rap, concrete textiles, wood or concrete wall, or just debris and junk such as old cars.
- Jetties are shore-normal navigation structures typically built of rock rip rap.
- Breakwaters are shore-parallel, segmented seawalls that are placed in the surf to retard coastal erosion. Breakwaters are built of rock rip rap and wood.

- Groins are short, shore-normal coastal structures that extend from the shoreline into the surf zone in order to trap sediment and slow coastal erosion. The typical construction material is wood.
- Piers describe shore-normal and shore-parallel structures that provide a working platform extending from the shore. The typical construction technique is wood or concrete pilings supporting a deck.
- Port facility is used to describe major developed waterfronts built of seawalls, piers, and other coastal structure types. The primary construction materials include steel, rock, wood, and concrete.
- Numerous pipelines make landfall and associated with them are typically a small timber or rock seawall protecting the dredging access area.
- Oil and gas facilities occur throughout the area and consist of platforms, tank farms, production plants and more. Primary construction materials are steel, concrete wood, and rock.

The environmental sensitivity of coastal structures is low because of the limited habitat these features create and the amount of animal and plant colonization they attract. Oil typically coats these structures and the sparse plant and animal life associated with them. Oil penetration is limited to surface roughness features and cracks. Some of the major cleanup concerns are logistics and the recovery of treated oil. This environment typically can handle the use of intrusive cleanup techniques such as low and high pressure wash.

2102 Bluffs

The bluff classification is used to describe a shoreline backed by an eroding bluff and fronted by a narrow sand beach. The bluff erodes by slope failure and wave undercutting. Narrow beaches are a mixture of fine and coarse sand as well as organic debris. In many cases, the slope failure process deposits trees, shrubs, scrubs, and man-made features such as roads and homes onto the shoreline. The fringing beaches tend to be moderately sloping with a distinct storm berm and multiple nearshore bars on a shallow platform. One major bluff shoreline can be found in coastal Alabama on the eastern shore of Mobile Bay.

The environmental sensitivity of this shoreline type is low due to limited plant and animal colonization. Oil typically stains the sediments and the nearshore debris. The sediment penetration potential is low due to a high water table. Some of the cleanup concerns center on poor access and trafficability.

2103 Fine Sand Beaches

The find sand beach classification describes beaches with low slopes and a grain size of 0.0625 to 0.200 mm. These beaches can be natural or man-made. Generally, there is always a low percentage of shells and shell hash. Typical beach widths are 20 – 100 m.

Fine sand beaches have a low sensitivity to oil spill impacts and cleanup methods. Oil typically stains and cover the beach sands. The penetration is low to moderate depending on the water table and the position of the oiling on the shoreline. A major environmental concern during beach cleanup is the protection of the dune habitat from the cleanup operations. Fine sand beaches typically have poor access, but good trafficability. Fine sand beaches are relatively easier to clean

in contrast to marshes. Large volumes of stained sand and debris can be generated by beach cleanup.

2104 Coarse Sand Beaches

The coarse sand beach classification describes beaches with moderate slopes and grain of 0.2 – 0.4 mm. These beaches can be natural or man-made. Generally, there is always a low percentage of shells and shell hash. Typical beach widths are 10 – 50 m. There are no true coarse sand beaches in northern Gulf of Mexico due to the character of the sediment load in the Mississippi River. The coarse sand shoreline type is included here, for completeness because the 12 shoreline types apply to the northern Gulf of Mexico.

The environmental sensitivity of coarse sand beaches is low due to the limited animal and vegetation population. Spilled oil typically stains and coats coarse grain beach sands. Sediment penetration on coarse grain beaches is moderate/high depending on the water table and the location of oil deposition. A major environmental concern is the protection of the dune habitat from cleanup operations. The trafficability of this shoreline type is less than fine sand beaches because the bearing strength is lower and this type of sand builds steep beach faces. Access is typically poor.

2105 Shell Beaches

The shell beach classification is used to describe shoreline types comprised almost entirely of shell. The shell material may be in the form of shell hash or whole shells. The sources for the shells include the nearshore zone or back barrier areas. The major shell shorelines are found on the Mississippi River chenier and delta plains. Typically, in northern Gulf of Mexico, shell beaches form where coastal erosion is reworking former back barrier environments containing rangia and oyster reefs. Shell beaches form extremely steep beach faces because of the coarse shell fragments and whole shells making up the shoreline.

The environmental sensitivity of shell beaches is moderate due to the use of this shoreline by estuarine organisms and extensive wash over terrace development. Oil typically stains and coats the shell hash and whole shells comprising the beach. The oil penetration is high due to the porous beach character created by the shell material. This beach type quickly turns into an asphalt payment under heavy oiling conditions. Shell beaches have poor trafficability due to the low bearing strength and steep beach face. Shell beaches usually have poor access in northern Gulf of Mexico.

2106 Perched Sand Beaches

The perched sand beach classification is used to describe a shoreline type where a thin sand beach (fine or coarse) overlies a fresh marsh or salt marsh with an eroded marsh platform outcropping in the surf zone. This shoreline type is common in the Mississippi River chenier and delta plains. Perched sand beaches can occur as a continuous straight shoreline or as a series of contiguous pocket beaches. Organic and shell debris is common to this shoreline type. Where the marsh platform outcrops on the shoreline, it can become revegetated by marsh grass. Perched sand beaches are erosional. It is the erosion of a marsh shoreline that produces a thin low prism of sand that overlies the eroded marsh outcrop.

The environmental sensitivity of perched sand beaches is moderate due to the presence of wetland habitat. Oil typically coats and covers sediment and vegetation. The sediment penetration potential

is low/moderate depending on the water table level and sediment thickness. A major environmental concern in the cleanup of wetland habitat associated with perched sand beaches. This shoreline type is characterized by poor trafficability and access.

2107 Perched Shell Beaches

The perched shell beach classification is used to describe a shoreline type where a thin shell beach overlies a fresh or salt marsh with an eroded marsh platform outcropping in the surf zone. This shoreline type is common in the Mississippi River chenier and delta plains. Perched shell beaches can occur as a continuous straight shoreline or as a series of contiguous pocket beaches. Organic debris is common to this shoreline type. Where the marsh platform outcrops on the shoreline, it can become revegetated by marsh grass. Shell beaches are erosional. It is the erosion of a marsh shoreline that produces a thin prism of shell material that overlies the eroded marsh outcrop.

The environmental sensitivity of perched shell beaches is moderate due to the presence of wetland habitat. Oil typically coats and covers sediment and vegetation. The sediment penetration potential is moderate/high depending on the water table level and sediment thickness. A major environmental concern is the cleanup of wetland habitat associated with perched shell beaches. This shoreline type is characterized by poor trafficability and access.

2108 Sandy Tidal Flats

The sandy tidal flat classification is used to describe shoreline types comprised of broad intertidal areas consisting of fine and coarse grain sand and minor amounts of shell hash. The mean grain-size ranges between 0.0625 mm and 0.4 mm. Sandy tidal flats are typically found in association with barrier island and tidal inlet systems. Sandy tidal flats are submerged during each tidal cycle. At low-tide, a typical sandy tidal flat may be 100 – 200 m wide. The most common sandy tidal flat occurrences are associated with flood-tidal deltas, recurved spits, and backbarrier areas. Salt marsh vegetation often develops along the upper intertidal areas of sand flats. Due to the low tidal flat gradient, slight changes in water levels can produce significant shoreline changes. Low water levels can expose extensive tidal flat areas to oiling.

The environmental sensitivity of sandy tidal flats is moderate due to the presence of wetland habitat. Oil typically stains and covers sediment and vegetation. The oil penetration potential is low/moderate depending on the water level and the location of oil deposition. The trafficability of sandy tidal flats is moderate/good depending on substrate character. Major environmental concerns related to cleanup include the protection and cleanup of wetland habitat and further subsurface contamination due to trampling and equipment movement. Tidal flat access in the northern Gulf of Mexico is typically poor.

2109 Muddy Tidal Flats

The muddy tidal flat classification is used to describe shoreline types comprised of broad intertidal areas consisting of mud and minor amounts of shell hash. The grain size is finer than 0.0625 mm. Muddy tidal flats are typically found in association with prograding river mouths. Muddy tidal flats are soft, dynamic shorelines rich in newly developing habitat. Mudflats located at prograding river mouths are vegetated by willow tree and sugar cane swamps. Prograding mudflats on the coast are vegetated by lush growths of salt marsh.

The environmental sensitivity of muddy tidal flats is high due to presence of developing wetland habitat. Oil usually coats and covers sediment and vegetation. The sediment penetration potential is low due to the high water table and water content in the sediment. The major environmental concern associated with muddy tidal flats is the damage done by the cleanup of wetland habitats as well as their protection from cleanup operations. Both access and trafficability of muddy tidal flats is poor. The potential exists for further contamination of subsurface sediments due to trampling and equipment movement.

2110 Swamps

The swamp classification describes shoreline types that are comprised of scrubs, shrubs, evergreen trees, and hardwood forested wetlands. This shoreline type is essentially a flooded forest. This shoreline type is common in the river valleys of the chenier plain, and the interior areas of the delta plain. The sediments within the interior swamps tend to be silty clay and contain a large amount of organic debris.

The environmental sensitivity is high for swamps because of the presence of wetland habitat. Oil usually coats and covers the sediment and vegetation. The sediment penetration potential is low due to the high water table and the water content of the sediments. A major environmental concern is that the cleanup may be more damaging than the oil itself. The access and trafficability of swamps are poor due to the soft sediment and the presence of dense tree growth.

2111 Fresh Marshes

The fresh marsh classification is used to describe shoreline types found in the coastal interior. Freshwater marshes include floating aquatic mats, vascular submerged vegetation, needle and broad leaved deciduous scrubs and shrubs, and broad leaved evergreen scrubs and shrubs. The sediments are highly organic and muddy. Fresh marshes are characterized by high biodiversity and rich wetland habitat. This shoreline type is found within the river valleys that dissect the chenier plain as well as between the individual ridges. On the delta plain, freshwater marshes occur in the upper reaches of individual delta complexes as well as along distributary courses.

The environmental sensitivity of fresh marshes is high because of the presence of wetland habitat. Oil usually coats and covers the sediment and vegetation. The sediment penetration potential is low due to the high water table and water content of the sediments. A major environmental concern about fresh marsh is that the cleanup can be more damaging than the oil itself, left alone. Access to fresh marshes is typically poor due to the soft sediment. Trafficability of fresh marsh is poor due to the soft sediment. Access is typically poor in northern Gulf of Mexico.

2112 Salt Marshes

The saltwater marsh classification describes shoreline types that are wet grasslands vegetated by salt-tolerant species. This shoreline type includes saline, brackish, and intermediate marsh types. Saltwater marshes are extensive throughout the outer fringe of the chenier and delta.

The environmental sensitivity is high for salt marsh because of the presence of wetland habitat. Oil usually coats and covers the sediment and vegetation. The sediment penetration potential is low/moderate due to the high water table and water content of the sediment. A major

environmental concern is that the cleanup may be more damaging than the oil itself. The trafficability of salt marsh is poor. Access is typically poor in northern Gulf of Mexico.

2200 Shoreline Types in Northern Gulf of Mexico

Table 1: Shoreline Types in Northern Gulf of Mexico

Shoreline Types in Coastal Northern Gulf of Mexico`				
	Type	**Description**	**Texture**	**Vegetation**
1	Coastal Structures	Man-made structures for coastal transportation and protection; includes sea walls, jetties, groins, bulkheads, pipelines, breakwaters	Concrete, Rock, Wood, Steel	None
2	Bluffs	Unconsolidation bluffs experiencing erosion by slope failure and wave undercutting; relief ranges 2m – 50m; narrow fringe beach	Fine sand, Coarse sand	None
3	Fine Sand Beach	Fine sand beach with low sloping beach face	Fine sand, Shell hash	None
4	Coarse Sand Beach	Coarse sand beach with moderate sloping beach face	Coarse sand, Shell hash	None
5	Shell Beach	Shell beach with steeply sloping beach face	Broken shells, Shell hash, Fine sand, Coarse sand	None
6	Perched Sand Beach	Narrow and thin beach resting on outcropping marsh deposits; moderately sloping beach face with an erosional scarp	Broken shells, Shell hash, Fine sand, Coarse sand	Salt marsh, Fresh marsh
7	Perched Shell Beach	Narrow and thin beach resting on outcropping marsh deposits; moderately sloping beach face with an erosional scarp	Broken shells, Shell hash, Fine sand, Coarse sand	Salt marsh, Fresh marsh
8	Sandy Tidal Flat	Sandy tidal flats associated with tidal inlet systems; low gradient surface	Shell hash, Fine sand, Coarse sand	Salt marsh, Fresh marsh
9	Muddy Tidal Flat	Muddy tidal flats associated with tidal inlet systems; low gradient surface	Clay, Silt, Shell hash	Salt marsh, Fresh marsh, Forested swamp
10	Swamp	Forested freshwater wetland of evergreen and hardwood trees	Wood, Clay, Silt	Tree, Shrub, Scrub
11	Fresh Marsh	Grass wetlands associated with river deltas and interior coastal areas	Clay, Silt, Organic	Floating aquatic mats; Submerged vegetation; Deciduous scrubs and shrubs; Evergreen scrubs and shrubs
12	Salt Marsh	Grass wetlands vegetated by salt-tolerant species; includes saline, brackish, and intermediate marsh	Clay, Silt, Fine sand, Organic	Deciduous grasses, Scrubs, and Shrubs; Submerged vegetation

2300 Shoreline Sensitivities and Cleanup Concerns

Table 2: Shoreline Sensitivities, Oil Behavior and Cleanup Concerns

Sensitivity, Oil Behavior, and Cleanup Concerns				
	Type	**Sensitivity**	**Oil Behavior**	**Cleanup Concerns**
1	Coastal Structures	Low	Coats structure Little penetration	Low biodiversity and biomass Logistically difficult Recovery of treated oil
2	Bluffs	Low	Coats sediment Low permeability	Low biodiversity and biomass Poor trafficability Poor access
3	Fine Sand Beach	Low	Coats sediment Low permeability	Low biodiversity and biomass Stained sediment Good trafficability Poor access Existing dune habitat
4	Coarse Sand Beach	Low	Coats sediment Moderate/high sediment permeability	Low biodiversity and biomass Stained sediment Moderate trafficability Poor access Existing dune habitat
5	Shell Beach	Medium	Coats sediment High sediment penetration	Moderate biodiversity and biomass Stained sediments Poor trafficability Poor access
6	Perched Sand Beach	Moderate	Coats sediment Coats marsh outcrop Low/moderate sediment penetration	Moderate biodiversity and biomass Stained sediments Poor trafficability Poor access Existing wetland habitat
7	Perched Shell Beach	Moderate	Coats sediment Coats marsh outcrop High sediment penetration	Moderate biodiversity and biomass Stained sediments Poor trafficability Poor access Existing wetland habitat
8	Sandy Tidal Flat	Moderate	Coats sediment Coats vegetation Low/moderate sediment penetration	High biodiversity and biomass Stained sediment Stained vegetation Moderate/good traffic ability Poor access Existing wetland habitat
9	Muddy Tidal Flat	High	Coats sediment Coats vegetation Low sediment penetration	High biodiversity and biomass Stained sediment Stained vegetation Poor trafficability Poor access Existing wetland habitat

Sensitivity, Oil Behavior, and Cleanup Concerns				
	Type	**Sensitivity**	**Oil Behavior**	**Cleanup Concerns**
10	Swamp	High	Coats sediment Coats vegetation Low sediment penetration	High biodiversity and biomass Stained sediment Stained vegetation Poor trafficability Poor access Existing wetland habitat
11	Fresh Marsh	High	Coats sediment Coats vegetation Low sediment penetration	High biodiversity and biomass Stained sediment Stained vegetation Poor trafficability Poor access
12	Salt Marsh	High	Coats sediment Coats vegetation Low/moderate sediment penetration	High biodiversity and biomass Stained sediment Stained vegetation Poor trafficability Poor access

3000 Cleanup Method Decision-Making Guidance

The matrices contained in this section show which shoreline cleanup methods have been considered for the 12 shoreline types described in Section 2100 of this annex. Four matrices have been constructed for the major categories of oil (very light, light, medium, and heavy) and are shown in Tables 5-8 in Section 3400 of this annex. The shoreline cleanup methods are described in Section 3200 of this annex. Each matrix in Section 3400 can be used as a cleanup advisory tool.

The matrices are only a general guide for cleanup method selection and should be used in conjunction with field observation and scientific advice, and practical experience. The countermeasures listed are not necessarily the best under all circumstances, and any listed technique may need to be used in conjunction with other techniques. The FOSC has the responsibility and authority to determine which cleanup methods are appropriate for the various situations encountered.

Selection of a specific cleanup method to be used is based upon the degree of oil contamination, shoreline types, and the presence of sensitive resources. Extremely sensitive areas are limited to manual cleanup methods. It is important to note that the primary goal of the implementation of the cleanup method is the removal of oil from the shoreline with no further injury or destruction to the environment.

3100 Cleanup Factors

Selection of the proper cleanup method for a particular shoreline type is controlled by the major variables listed below.

3101 Type of substrate

The type of substrate making up the oiled shoreline controls penetration and persistence. Oil cannot penetrate rock surfaces except where cracks and crevices exist. Typically, fine-grained, poorly

sorted sediments resist oil penetration and coarse-grained, well-sorted sediments experience deeper oil penetration.

3102 Amount of oil contamination

The amount of oil contamination affects the level of manpower needed for cleanup and the selection of the cleanup methods. Small spills tend to rely on manual methods and large spills tend to rely on mechanical methods or, occasionally, chemical agents.

3103 Type of oil

The type of oil controls persistence, penetration and cleanup difficulty. Table 4 lists the physical, chemical and toxicological properties of different types of oil. Table 5 lists the pertinent cleanup attributes of the four major oil types.

3104 Depth of oil contamination in the sediments

The depth of oil contamination controls the selection of cleanup methods. Surface contamination is easier to remove and will typically require only manual or washing methods. Deeper substrate penetration usually requires mechanical or biochemical methods.

3105 Type of oil contamination

The type of oil contamination affects the level of effort and method. The range of primary oil morphology or contamination includes film, coating, tar balls, mousse and asphalt.

3106 Shoreline exposure

The degree of exposure of the contaminated shoreline to waves and currents controls the oil persistence and the decision to cleanup. High energy shorelines tend to clean naturally and low energy shorelines tend to require cleanup activities.

3107 Trafficability of equipment on shoreline

Shoreline trafficability controls the selection between manual, mechanical, and biochemical methods. Areas of low-bearing capacity and poor access typically rely on manual and biochemical methods. Areas of high-bearing capacity and good access also allow for mechanical methods. However, areas with good-bearing and poor access can also be candidates for mechanical cleanup.

3108 Environmental sensitivity of contaminated shoreline

The sensitivity of the contaminated shoreline is the most important factor in the development of cleanup recommendations. Shorelines of low productivity and biomass can withstand the more intrusive cleanup methods such as pressure washing. Shorelines of high productivity and biomass are very sensitive to intrusive cleanup methods; in many cases the cleanup is more damaging than the natural recovery.

3200 Cleanup Methods

Table 3 below provides cleanup recommendations within the framework of the distribution of habitat types found in the northern Gulf of Mexico. For each cleanup method, the technique is described, shoreline applications are discussed, and the environmental concerns identified.

Table 3: Shoreline Cleanup Descriptions

Shoreline Cleanup Descriptions			
Technique	**Technique Description**	**Primary Use**	**Potential Environmental Effects**
I. Natural Recovery			
No Action	Allow natural processes to degrade and disperse stranded oil.	Used on heavily exposed and/or light to moderately oiled beaches to avoid additional impacts created by cleanup.	Potential toxic and physical effects of remaining oil. Persistent oil can inhibit recolonization.
II. Manual Recovery			
Removal	Oil and oiled sediments or debris are removed by hand using shovels, rakes, trowels, sorbents, putty knives, etc.	Used on shorelines with light or sporadic oil conditions or where access is limited.	Foot traffic may crush organisms and some organisms may be removed from the substrate/sediments.
Passive Collection	Lengths of snare or sorbent boom are anchored along the shoreline just downslope of the oiled area to collect the oil as it is flushed by tidal wave action.	Used to remove a small amount of mobile oil that are continually released from oiled shorelines.	No significant effects.
Vegetation Cutting	Oiled vegetation is cut by hand, collected, and placed into plastic bags or containers for disposal	Used on heavily vegetated shorelines or marsh/estuarine environments to remove heavily oiled vegetation.	Heavy foot traffic can crush organisms and cause root damage in marshes.
III. Mechanical Recovery			
Heavy Equipment	Heavy equipment (backhoe, loader, motor grader, elevating scraper, dump truck, etc.) is used for excavating and offsite transfer of oiled sediments.	Used on finer sediment beaches to remove heavily oiled surface and near-surface sediments.	Removes shallow burrowing organisms and reduces beach stability, creating erosion potential.
IV. Washing			
Flooding	A perforated header pipe or hose is placed at the top of the beach through which large quantities of sea water are pumped, flushing the oil	Used on medium to coarse sediment beaches to remove oil from the interstices and pore spaces.	Potential for impacting previously clean lower intertidal or adjacent areas. Unrecovered oil can remain toxic to organisms.

Shoreline Cleanup Descriptions			
Technique	**Technique Description**	**Primary Use**	**Potential Environmental Effects**
	out into the water for containment and recovery.		
Lower Pressure	Ambient or heated seawater is pumped through hoses at low to medium pressure to agitate sediments and flush oil back into water for containment and recovery. Typically used in conjunction with Flooding.	Used on medium to coarse sediment beaches to remove oil from the interstices and pore spaces.	Can remove some organisms from the substrate or cause adverse thermal effects.
High Pressure	High pressure ambient or heated water streams remove oil from substrate or hard surfaces where it is channeled to recovery areas.	Used to remove oil coatings from boulders, rock, man-made structures, and other solid surfaces.	Removes most organisms from the substrate. Potential for impacting previously clean lower intertidal or adjacent areas.
Steam	Steam is applied to oiled surfaces to loosen and remove oil where it is channeled to a recovery area.	Used to remove sticky, viscous, and weathered oil coatings from solid surfaces (boulders, rock, man-made structures).	Removes some organisms and thermal effects can cause substantial mortality.
Sand Blasting	Sand in a high-velocity air stream is applied to oiled surfaces to remove the oil. The oiled sand is typically recovered manually.	Used to remove thin residues of weathered oil from man-made structures, rocks, or other soiled surfaces.	Removes all organisms from surface. Unrecovered oil can be toxic to downslope organisms.
V. Vacuum			
Suction	Vacuum truck or suction pump is positioned near pooled oil and oil is recovered via suction hose. Portable skimmers are positioned within containment booms or in areas of oil concentrations to recover the oil	Used to pick up oil on shorelines where pools have formed in natural or manmade depressions, or from water surfaces in backwater or contained areas	Vacuuming can remove some organisms. No significant effects from skimmer use
VI. Sediment Reworking			
Washing	Oiled sediments are evacuated and put through a bath or continuous feed washing unit with the	Used on moderate to heavily oiled, medium sediment, sheltered beaches to remove oil	Loss of organisms in removed sediments, some loss of finer- grained

Shoreline Cleanup Descriptions			
Technique	**Technique Description**	**Primary Use**	**Potential Environmental Effects**
	cleaned sediments returned to the beach.	without a net sediment loss.	materials and temporary destabilization of beach.
Relocation	Heavy equipment is used to transfer oiled sediments from the supra-tidal and top of the upper-intertidal zones to the middle of the upper-tidal zone.	Used on exposed, light to moderately oiled cobble/pebble beaches to enhance natural cleaning processes and prevent potential erosion problems associated with sediment removal.	Potential for remobilizing oil and impacting adjacent areas. Adversely affects organisms inhabiting the relocated sediments and in the relocation area.
Tilling	Tractor fitted with tines or ripper blades is used to till the near surface sediments in the oiled area.	Used on low amenity, medium to fine sediment beaches with light to moderate oil conditions to break up surface and/or expose subsurface oil to natural degradation processes.	Disturbs shallow burrowing organisms. Can mix oil deeper into sediments.
VII. Combustion			
In-Situ Burn	Oiled debris is collected and piled in a central location and burned. Ignition device or fluids and portable fans can be used to facilitate burning.	Used on beaches with significant quantities of heavily oiled logs, driftwood, and debris.	Temporary degradation in local air quality. Organisms in the vicinity of burn pile may suffer adverse thermal effects.
VIII. Biochemical Recovery			
Chemical Treatment	Chemical "beach cleaning" agents are applied to the oiled sediments, a "pre-soak" followed by water flushing. Agents may also be mixed in with the flush water.	Used on viscous, sticky, and weathered oils to reduce adhesion to coarse sediments and aid in removal by flushing.	Some agents may be mildly toxic to biota. Potential for impacting previously clean lower-intertidal and adjacent areas.
In-Situ Bioremediation	Liquid or granular fertilizer is applied to oiled area to stimulate growth of naturally occurring oil-metabolizing microbes.	Used on light to moderately oiled, medium to coarse sediment shorelines to enhance microbial degradation of the oil.	Some fertilizers can be toxic to organisms when first applied. Algal blooms are possible in protected areas.

3300 Physical Properties of Different Types of Spilled Oil

Table 4 below describes the physical and toxicological characteristics of different types of spilled oil.

Table 4: Physical Properties of Various Oil Types

Oil Type	Physical/Chemical Properties	Toxicological Properties
Light Oils - Jet fuels - Gasoline - Diesel - No. 2 fuel oils - Light crudes	- Spread rapidly - High evaporation and solubility rates - Tend to form unstable emulsions - Very toxic to biota when fresh - May penetrate substrate - Can be removed by low pressure flushing	- Acute toxicity is related to the content and concentration of the aromatic fractions. - Aromatic fractions are very toxic due to the pressure primarily of naphthalene compounds and, to a lesser extent, benzene compounds. - Heavy molecular weight compounds are immediately less toxic, but may be chronically toxic since many are either known or potential carcinogens. - Acute toxicity of individual aromatic fractions will vary among species due to differences in the rate of uptake and rate of release of these compounds. - Mangroves and marsh plants may be chronically affected due to penetration and persistence of aromatic compounds in sediments.
Medium Oils - Most crudes	- Moderate to high viscosity - Toxicity variable depending on light fraction - In tropical climates, rapid evaporation and solution form less toxic weathered residue with toxicity due to more smothering - Tend to form stable emulsions under high physical energy conditions - Variable penetration, a function of substrate grain size - High potential for sinking after weathering and uptake of sediment - Generally removable from water surface when fresh - Weather to tar balls and tarry residue	- Acute and chronic toxicity in marine organisms is likely to result from: 1. Mechanical or physical coverage – oil completely smothering organism causing death. 2. Chemical toxicity – results from the exposure of very toxic aromatic fractions of the oil to marine organisms. 3. A combination of mechanical or physical coverage and chemical toxicity. - Mechanical or physical smothering causing acute toxicity in many marine organisms and chronic toxicity in many marine plants (especially mangroves).
Heavy Oils - Heavy crude oil - No. 6 fuel - Bunker crude - Asphalt - Waste fuel	- Form tarry lumps at ambient temperatures - Non-spreading - Relatively non-toxic due to substrate - May soften and flow when exposed to the sun - Cannot be recovered from water surface with most cleanup equipment - Easily removed manually from beaches	- Acute and chronic toxicity occurs more from smothering effects than from chemical toxicity, due to the small proportion of toxic aromatic reactions found in heavy, residual oils - Toxicity is more common in marine plants (especially mangroves) and sedentary organisms than in mobile organisms - Acute and chronic toxicity also results from the thermal stress, due to the elevation of temperature in oiled habitats.

3400 Shoreline Cleanup Matrices for Various Oils/Shorelines

3401 Shoreline Cleanup – Very Light Oil

Table 5: Shoreline Cleanup Matrix – Very Light Oil

SHORELINE CLEANUP MATRIX Very Light Oil	SHORELINE TYPES											
	Coastal Structures	Bluffs	Fine Sand Beach	Coarse Sand Beach	Shell Beach	Perched Sand Beach	Perched Shell Beach	Sandy Tidal Flat	Muddy Tidal Flat	Forested Swamp	Fresh Marsh	Salt Marsh
CLEANUP METHOD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
No Action	A	A	A	A	A	A	A	A	A	A	A	A
Manual Debris Removal	A	A	A	A	P	P	P	P	P	P	P	P
Manual Sediment Removal	X	P	P	P	P	P	P	P	X	X	X	X
Manual Sorbent Application	A	P	P	P	P	X	X	X	X	X	X	X
Manual Scraping	X	P	P	P	X	P	X	P	X	X	X	X
Manual Vegetation Cutting	X	X	X	X	X	X	X	X	X	X	X	X
Motor Grader/Elevating Scraper	X	P	P	P	P	X	X	X	X	X	X	X
Elevating Scraper	X	P	P	P	P	X	X	X	X	X	X	X
Motor Grader/Front-End Loader	X	P	P	P	P	X	X	X	X	X	X	X
Front-End Loader: Rubber Tired or Tracked	X	P	P	P	P	X	X	X	X	X	X	X
Bulldozer: Rubber-Tired Front End Loader	X	P	P	P	P	X	X	X	X	X	X	X
Backhoe	X	P	P	P	P	X	X	X	X	X	X	X
Beach Cleaner	X	P	P	P	P	X	X	X	X	X	X	X
Dragline/Clamshell	X	P	P	P	P	X	X	X	X	X	X	X
Cold Water Deluge Flooding	A	P	P	P	P	P	P	P	P	A	A	A
Low Pressure Cold Water Washing	A	X	P	P	P	X	X	X	X	A	A	A
High Pressure Cold Water Washing	A	X	X	X	X	X	X	X	X	X	X	X
Low Pressure Hot Water Washing	A	X	P	P	P	X	X	X	X	X	X	X
High Pressure Hot Water Washing	A	X	X	X	X	X	X	X	X	X	X	X
Steam Cleaning	A	X	X	X	X	X	X	X	X	X	X	X
Sand Blasting	A	X	X	X	X	X	X	X	X	X	X	X
Vacuum	A	P	P	P	P	P	P	P	P	P	P	P
Trenching/Vacuum	X	P	P	P	P	X	X	P	X	X	X	X
Sediment Removal, Cleaning, and Replacement	X	X	X	X	X	X	X	X	X	X	X	X
Push Contaminated Substrate into Surf	X	X	X	X	X	X	X	X	X	X	X	X
Pavement Breakup	X	X	X	X	X	X	X	X	X	X	X	X
Disc into Substrates	X	X	X	X	X	X	X	X	X	X	X	X
Burning †	X	X	X	X	X	X	X	X	X	X	X	X
Chemical Oil Stabilization †	X	X	X	X	X	X	X	X	X	X	X	X
Chemical Protection of Beaches †	X	X	X	X	X	X	X	X	X	X	X	X
Chemical Cleaning of Beaches †	X	X	X	X	X	X	X	X	X	X	X	X
Nutrient Enrichment †	P	P	P	P	P	P	P	P	P	P	P	P
Bacterial Enrichment †	P	P	P	P	P	P	P	P	P	P	P	P

A	Advised - Method which best achieves the goal of minimizing destruction or injury to the environment.
P	Possible - Viable and possibly useful but may result in limited adverse effects to the environment.
X	Do Not Use
†	Requires RRT approval

3402 Shoreline Cleanup – Light Oil

Table 6: Shoreline Cleanup Matrix – Light Oil

SHORELINE CLEANUP MATRIX Light Oil	SHORELINE TYPES											
	Coastal Structures	Bluffs	Fine Sand Beach	Coarse Sand Beach	Shell Beach	Perched Sand Beach	Perched Shell Beach	Sandy Tidal Flat	Muddy Tidal Flat	Forested Swamp	Fresh Marsh	Salt Marsh
CLEANUP METHOD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
No Action	P	P	P	P	P	P	P	P	P	P	P	P
Manual Debris Removal	A	A	A	A	P	P	P	P	P	P	P	P
Manual Sediment Removal	X	P	P	P	P	P	P	P	X	X	X	X
Manual Sorbent Application	A	P	A	A	P	P	P	P	P	P	A	A
Manual Scraping	A	P	A	A	P	P	P	P	P	X	X	X
Manual Vegetation Cutting	X	X	X	X	X	X	X	X	X	X	P	P
Motor Grader/Elevating Scraper	X	P	A	A	P	P	P	P	X	X	X	X
Elevating Scraper	X	P	A	A	P	P	P	P	X	X	X	X
Motor Grader/Front-End Loader	X	P	A	A	P	P	P	P	X	X	X	X
Front-End Loader: Rubber Tired or Tracked	X	P	A	A	P	P	P	P	X	X	X	X
Bulldozer: Rubber-Tired Front End Loader	X	P	A	A	P	P	P	P	X	X	X	X
Backhoe	X	P	A	A	P	P	P	P	X	X	X	X
Beach Cleaner	X	P	A	A	P	P	P	P	X	X	X	X
Dragline/Clamshell	X	P	A	A	P	P	P	P	X	X	X	X
Cold Water Deluge Flooding	A	P	A	A	P	P	P	P	X	A	A	A
Low Pressure Cold Water Washing	A	A	A	A	P	P	P	P	X	P	P	P
High Pressure Cold Water Washing	A	X	X	P	X	X	X	P	X	P	P	P
Low Pressure Hot Water Washing	A	P	P	P	P	P	P	P	X	X	X	X
High Pressure Hot Water Washing	A	X	X	P	X	X	X	P	X	X	X	X
Steam Cleaning	A	X	X	X	X	X	X	X	X	X	X	X
Sand Blasting	A	X	X	X	X	X	X	X	X	X	X	X
Vacuum	A	P	P	P	P	P	P	P	P	P	P	P
Trenching/Vacuum	X	P	P	P	P	X	X	P	X	X	X	X
Sediment Removal, Cleaning, and Replacement	X	X	P	P	X	X	X	X	X	X	X	X
Push Contaminated Substrate into Surf	X	X	P	P	P	X	X	X	X	X	X	X
Pavement Breakup	X	X	P	P	P	X	X	X	X	X	X	X
Disc into Substrates	X	X	P	P	X	X	X	X	X	X	X	X
Burning †	X	X	X	X	X	X	X	X	X	X	X	X
Chemical Oil Stabilization †	X	X	X	X	X	X	X	X	X	X	X	X
Chemical Protection of Beaches †	X	X	X	X	X	X	X	X	X	X	X	X
Chemical Cleaning of Beaches †	X	X	X	X	X	X	X	X	X	X	X	X
Nutrient Enrichment †	P	P	P	P	P	P	P	P	P	P	P	P
Bacterial Enrichment †	P	P	P	P	P	P	P	P	P	P	P	P

A	Advised - Method which best achieves the goal of minimizing destruction or injury to the environment.
P	Possible - Viable and possibly useful but may result in limited adverse effects to the environment.
X	Do Not Use
†	Requires RRT approval

3403 Shoreline Cleanup – Medium Oil

Table 7: Shoreline Cleanup Matrix – Medium Oil

SHORELINE CLEANUP MATRIX Medium Oil	SHORELINE TYPES											
	Coastal Structures	Bluffs	Fine Sand Beach	Coarse Sand Beach	Shell Beach	Perched Sand Beach	Perched Shell Beach	Sandy Tidal Flat	Muddy Tidal Flat	Forested Swamp	Fresh Marsh	Salt Marsh
CLEANUP METHOD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
No Action	P	P	P	P	P	P	P	P	P	P	P	P
Manual Debris Removal	A	A	A	A	P	P	P	P	P	P	P	P
Manual Sediment Removal	X	P	P	P	P	P	P	P	X	X	X	X
Manual Sorbent Application	A	P	A	A	P	P	P	P	P	A	A	A
Manual Scraping	A	P	A	A	P	P	P	P	P	X	X	X
Manual Vegetation Cutting	X	X	X	X	X	X	X	X	X	P	P	P
Motor Grader/Elevating Scraper	X	P	A	A	P	P	P	P	X	X	X	X
Elevating Scraper	X	P	A	A	P	P	P	P	X	X	X	X
Motor Grader/Front-End Loader	X	P	A	A	P	P	P	P	X	X	X	X
Front-End Loader: Rubber Tired or Tracked	X	P	A	A	P	P	P	P	X	X	X	X
Bulldozer: Rubber-Tired Front End Loader	X	P	A	A	P	P	P	P	X	X	X	X
Backhoe	X	P	A	A	P	P	P	P	X	X	X	X
Beach Cleaner	X	P	A	A	P	P	P	P	X	X	X	X
Dragline/Clamshell	X	P	A	A	P	P	P	P	X	X	X	X
Cold Water Deluge Flooding	A	A	A	A	P	P	P	P	P	A	A	A
Low Pressure Cold Water Washing	A	P	P	P	P	P	P	P	X	P	P	P
High Pressure Cold Water Washing	A	X	X	P	X	X	X	P	X	X	X	X
Low Pressure Hot Water Washing	A	P	P	P	P	P	P	P	X	X	X	X
High Pressure Hot Water Washing	A	X	X	P	X	X	X	P	X	X	X	X
Steam Cleaning	A	X	X	X	X	X	X	X	X	X	X	X
Sand Blasting	A	X	X	X	X	X	X	X	X	X	X	X
Vacuum	A	P	A	A	P	P	P	P	P	P	P	P
Trenching/Vacuum	X	P	P	A	P	X	X	P	X	X	X	X
Sediment Removal, Cleaning, and Replacement	X	X	P	P	X	X	X	X	X	X	X	X
Push Contaminated Substrate into Surf	X	X	P	P	P	X	X	X	X	X	X	X
Pavement Breakup	X	X	P	P	P	X	X	X	X	X	X	X
Disc into Substrates	X	X	P	P	X	X	X	X	X	X	X	X
Burning †	P	P	P	P	P	X	X	X	X	X	P	P
Chemical Oil Stabilization †	P	P	P	P	P	P	P	P	X	X	X	X
Chemical Protection of Beaches †	A	P	P	P	P	P	P	X	X	P	P	P
Chemical Cleaning of Beaches †	A	P	P	P	P	P	P	X	X	P	P	P
Nutrient Enrichment †	P	P	P	P	P	P	P	P	P	P	P	P
Bacterial Enrichment †	P	P	P	P	P	P	P	P	P	P	P	P

A	Advised - Method which best achieves the goal of minimizing destruction or injury to the environment.
P	Possible - Viable and possibly useful but may result in limited adverse effects to the environment.
X	Do Not Use
†	Requires RRT approval

3404 Shoreline Cleanup – Heavy Oil

Table 8: Shoreline Cleanup Matrix – Heavy Oil

SHORELINE CLEANUP MATRIX Heavy Oil	SHORELINE TYPES											
	Coastal Structures	Bluffs	Fine Sand Beach	Coarse Sand Beach	Shell Beach	Perched Sand Beach	Perched Shell Beach	Sandy Tidal Flat	Muddy Tidal Flat	Forested Swamp	Fresh Marsh	Salt Marsh
CLEANUP METHOD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
No Action	P	P	P	P	P	P	P	P	P	P	P	P
Manual Debris Removal	A	A	A	A	P	P	P	P	P	P	P	P
Manual Sediment Removal	X	P	P	P	P	P	P	P	X	X	X	X
Manual Sorbent Application	A	P	A	A	P	P	P	P	P	A	A	A
Manual Scraping	A	P	A	A	P	P	P	P	P	X	X	X
Manual Vegetation Cutting	X	X	X	X	X	X	X	X	X	P	P	P
Motor Grader/Elevating Scraper	X	P	A	A	P	P	P	P	X	X	X	X
Elevating Scraper	X	P	A	A	P	P	P	P	X	X	X	X
Motor Grader/Front-End Loader	X	P	A	A	P	P	P	P	X	X	X	X
Front-End Loader: Rubber Tired or Tracked	X	P	A	A	P	P	P	P	X	X	X	X
Bulldozer: Rubber-Tired Front End Loader	X	P	A	A	P	P	P	P	X	X	X	X
Backhoe	X	P	A	A	P	P	P	P	X	X	X	X
Beach Cleaner	X	P	A	A	P	P	P	P	X	X	X	X
Dragline/Clamshell	X	P	A	A	P	P	P	P	X	X	X	X
Cold Water Deluge Flooding	A	A	A	A	P	P	P	P	P	A	A	A
Low Pressure Cold Water Washing	A	P	P	P	P	P	P	P	X	P	P	P
High Pressure Cold Water Washing	A	X	X	P	X	X	X	P	X	X	X	X
Low Pressure Hot Water Washing	A	P	P	P	P	P	P	P	X	X	X	X
High Pressure Hot Water Washing	A	X	X	P	X	X	X	P	X	X	X	X
Steam Cleaning	A	X	X	X	X	X	X	X	X	X	X	X
Sand Blasting	A	X	X	X	X	X	X	X	X	X	X	X
Vacuum	A	P	A	A	P	P	P	P	P	P	P	P
Trenching/Vacuum	X	P	P	A	P	X	X	P	X	X	X	X
Sediment Removal, Cleaning, and Replacement	X	X	P	P	X	X	X	X	X	X	X	X
Push Contaminated Substrate into Surf	X	X	P	P	P	X	X	X	X	X	X	X
Pavement Breakup	X	X	P	P	P	X	X	X	X	X	X	X
Disc into Substrates	X	X	P	P	X	X	X	X	X	X	X	X
Burning †	P	P	P	P	P	X	X	X	X	X	P	P
Chemical Oil Stabilization †	P	P	P	P	P	P	P	P	X	X	X	X
Chemical Protection of Beaches †	A	P	P	P	P	P	P	X	X	P	P	P
Chemical Cleaning of Beaches †	A	P	P	P	P	P	P	X	X	P	P	P
Nutrient Enrichment †	P	P	P	P	P	P	P	P	P	P	P	P
Bacterial Enrichment †	P	P	P	P	P	P	P	P	P	P	P	P

A	Advised - Method which best achieves the goal of minimizing destruction or injury to the environment.
P	Possible - Viable and possibly useful but may result in limited adverse effects to the environment.
X	Do Not Use
†	Requires RRT approval