Incident-specific Feasibility Issues

After assessing the situation, defining goals, priorities, objectives, and identifying the possible response strategies, the next step is to consider the feasibility of field operations. Tables 1 and 2 summarize the issues (discussed in detail in the following section) to be considered in developing incident-specific, on-water and shoreline operations.

Incident start (window of opportunity) →	...hours... (very early) →	...hours/days/weeks... (early) →	...months... (later)
PHASE / STRATEGY	STABILIZE/SECURE SOURCE	ON-WATER CONTAIN/ RECOVER/PROTECT	SHORELINE TREATMENT/CLEANUP
MECHANICAL	Close valves Patch Pump/offload	Manual oil removal Boom, skimmers Sorbents Mechanical oil removal Vacuum Barriers	Sorbents Manual oil removal Mechanical oil removal
CHEMICAL		Shoreline cleaning agents Dispersants Emulsion treating agents Solidifiers Herding agents Elasticity aodifiers	Shoreline cleaning agents Solidifiers
OTHER COUNTERMEASURES		In-situ Burning	Bioremediation
WASTE MANAGEMENT		On-siteStorage Recycle Incineration	Stabilization Recycle Landfill Incineration Bioremediation

Figure 1. Types of response options during a major oil spill (modified from Walker et al., 1993).

Table 1. Incident-specific on-water strategy issues.

Category	Issues
Nature and Amount of Oil	• Oil type spilled • Oil volume and area and shape of slick(s) and stranded oil • Average oil thickness and distribution • Emulsification
Proximity	• Source considerations • Water depths • Shoreline and resources at risk • Air and vessel traffic • Equipment staging and support locations • Exclusion zones
Timing	• Personnel and equipment availability • Logistics support for sustained operations • Time until impact • Weathering

Table 1. (cont.)

Category	Issues
Environment	• Water depth • Wind and waves • Tides and currents • Visibility • Temperature • Ice and floating debris • Vulnerable species and habitats • Human use
Authorization	• Approval to burn and/or apply CCPs* • Approval to access restricted areass • Transport and disposal of recovered oil or wast • Permits

* Agents requiring approval can include dispersants, surface washing agents, surface collecting agents, bioremediation agents, and miscellaneous oil spill control agents.

Table 2. Incident-specific shoreline strategy issues.

Category	Issues
Safety	• Slip and fall hazards • Worker oil exposure hazards
Nature and Amount of Oil	• Oil type spilled • Stranded oil amount • Stranded oil distribution
Proximity	• Access from on water and/or roads • Worker support services • Staging/deployment sites
Timing	• Timely strategy development • Rapid cleanup to prevent oil remobilization
Environment	• Waves and breakers • Tides • Currents • Weather • Shoreline type • Water depth and sea bottom character

Table 2. (cont.)

Category	Issues
Environment	• Vulnerable species and habitats • Human use constraints • Cultural constraints
Authorization	• Approval to burn and/or apply CCPs* • Approval to access restricted areass • Transport and disposal of recovered oil or waste • Permits

* Agents requiring approval can include dispersants, surface washing agents, surface collecting agents, bioremediation agents, and miscellaneous oil spill control agents.

On-Water Feasibility Issues

On-water response strategies and procedures must address a broad range of site-, spill-, and environment-specific issues, including:

- Safety risks;
- Environmental effects; and
- Timing, spatial, and environmental limits.

These must be carefully considered in establishing response option performance levels. Safety is always paramount, but other priorities can be different for each spill.

Nature and Amount of Oil

Oil Type

Identifying the type of oil spilled and being able to anticipate its changing physical and chemical character as it spreads and degrades will help responders:

- Conduct personnel safety assessments;
- Determine fire or explosion risks;
- Identify response option feasibility; and
- Determine windows of opportunity.

Oil Volume, Area, and Shape

Because on-water response equipment has predictable, limited areal coverage rates, a slick's volume, changing area, and shape as it is transported and spread by wind and currents will determine response option feasibility, effectiveness, and efficiency. Since mechanical recovery will remove only a fraction of the oil spilled:

- Spills on water must be attacked early (a sudden release, even in a light surface current, can spread and be transported rapidly beyond any at-source containment; moderate- to large-volume spills on the order of 1,000 barrels or more can easily spread over 1 to 10 square miles [3 to 26 square kilometers] in a day or two); and
- Response methods should be combined wherever possible (large spills can quickly exceed the holding capacity of most containment barriers).

Average Oil Thickness and Distribution

Though oil slick thickness can vary by orders of magnitude within different parts of a slick, average slick thickness and actual oil distribution are crucial for determining response method feasibility. Figure 2 illustrates the general relationships between on-water response techniques and average slick thickness. Windrows, heavy oil patches, tarballs, etc., must also be considered, as they influence oil encounter rates, chemical dosages, and ignition potential.

Emulsification

Weathering often involves water-in-oil emulsification, which can impair response operations by:

- Increasing overall oil volume and recovered fluid storage requirements;
- Decreasing oil's buoyancy (increasing its tendency to submerge);
- Increasing the oil's viscosity (or pumpability) and stickiness (complicating recovery operations);
- Decreasing the oil's affinity for surface tension modifiers (reducing its dispersibility);
- Decreasing the oils' ignitability (burning is difficult or impossible); and
- Decreasing available surface area for biodegradation (less biodegradable).

All of the above are important for understanding and estimating on-water response effectiveness, since some options may only be appropriate for a few hours under adverse conditions, or for several days during ideal conditions.

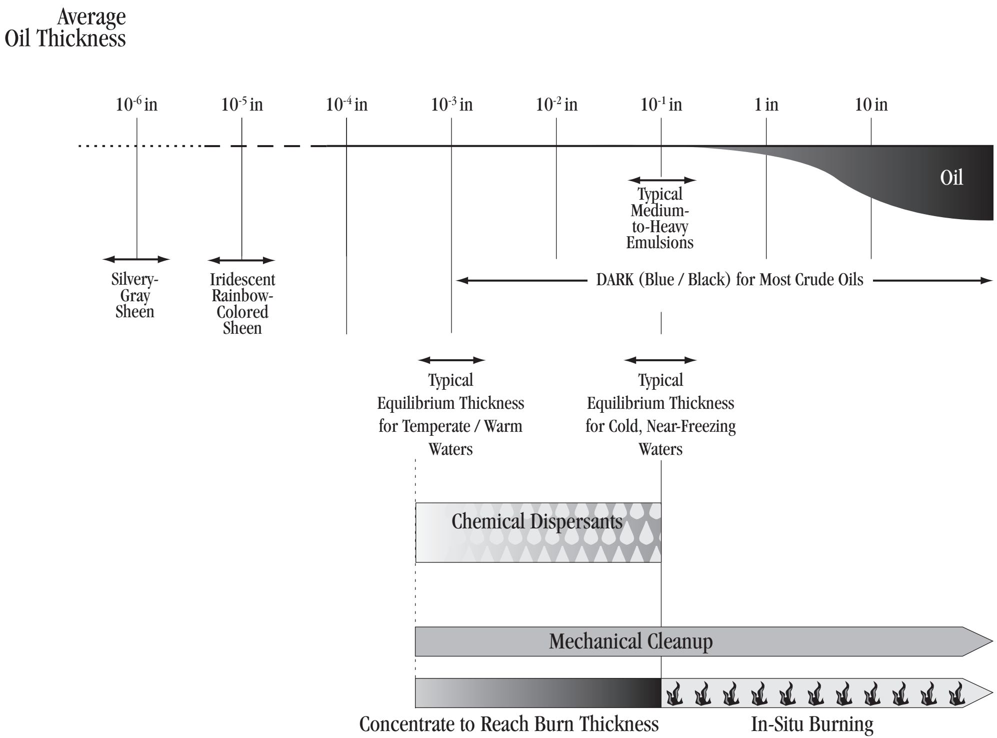

Figure 2. Average oil thickness versus potential response options (modified from Allen and Dale, 1996).

Proximity

Source Considerations

Response operations must be conducted at safe distances from existing or potential spill sources, to reduce the risks of accidental ignition, exposure to harmful vapors, or changes in source characteristics that could endanger personnel or equipment.

Shoreline and Resources at Risk

Recovering or treating oil at sea can reduce the consequences to open-water and shoreline resources. Distance to shore is important because it will influence the type of vessels and equipment employed (size, draft, maneuverability, anchoring limitations) and the response countermeasures used. It is often more efficient and effective to recover or treat oil before it comes ashore.

Air and Vessel Traffic

On-water response and monitoring normally involve boats and/or aircraft, and activities of these vehicles must be carefully planned and controlled to prevent interference with other, ongoing (or planned) operations.

Equipment Staging and Support Locations

Response success will depend, in part, on the proximity of equipment and personnel staging locations to actual operations. Because response activities may interfere with each other (e.g., vessels transiting to and from staging areas) or with private or commercial activities, support operations will require careful planning.

Designated Response Exclusion Zones

Designating certain areas as public, private, or government exclusion zones may be necessary for conducting effective on-water operations. These zones may include national marine sanctuaries, archaeological sites, military operations areas, or may be pre-designated chemical dispersant operations or in-situ burning areas. Some exclusion zones may have special activity or time requirements.

Timing

Personnel and Equipment Availability

The time required to bring resources to the scene will be a significant factor in establishing an effective response. Because response operations are critically influenced by oil spreading, transport, and weathering, realistic estimates of time to arrive on scene must be established in response plans and re-evaluated as daily Incident Action Plans are developed.

Logistics Support for Sustained Operations

Effective, sustained response operations must be supported with:

- Trained, well-rested personnel for crew rotations (food, shelter);
- Spare parts and supplies (fuel, dispersants, personal protection equipment, boom, ignition systems, etc.) to keep equipment and personnel functioning;
- Secondary storage containers for recovered oil/water; and
- Sufficient, certified final disposal sites.

Time Until Impact

Responders must determine realistic oil encounter and recovery rates, to make maximum use of the time available before oil impacts sensitive resources. If estimates show that on-water, mechanical response systems cannot handle a sufficient portion of a spill, the environmental impact tradeoffs among containment and mechanical recovery, dispersant use, or in-situ burning must be carefully weighed against the impacts of that same oil reaching the shoreline. In some instances, it may be necessary to forego some on-water response in order to use those resources for shoreline protection and cleanup.

Oil Weathering

During the first 24 to 48 hours of open water exposure, most oil spills become difficult to recover, burn, or chemically disperse, because:

- Evaporation accelerates as oil spreads and thins, increasing its density, viscosity, and tendency to emulsify;
- Emulsification can produce oily fluids of greater volume and viscosity than the original spill; and
- Decreasing slick thickness makes removing oil increasingly difficult.

Environment

Water Depth

Shallow-water response requires careful use of response equipment, since:

- Vessel size and/or draft will limit speed, maneuverability, and operating areas;
- Vessel or boom anchors can disturb benthic communities;
- Shallow-water locations with strong currents create unique problems:
  - Booms with a draft greater than 1/4 the water depth will lose significant amounts of oil from entrainment.

– Vessel squat (settling of the stern as speed increases) may limit operating areas or parameters.

Chemical dispersant use must not unnecessarily expose local biota to harmful concentrations of dispersed oil.

Water depth may be a consideration during in-situ burning deliberations because residues may sink, but heat transferred from a burning slick to the water is negligible and will not be a factor.

Wind and Waves

All weather will affect spill response activities, and rising wind and waves will:

- Increase oil spreading, transport, evaporation, and emulsification;
- Increase responder fatigue due to vessel and equipment handling difficulties; and
- Reduce containment boom effectiveness.

While there are exceptions for certain types and conditions of oil, and specific types of equipment or dispersant, Figure 3 illustrates wind and wave influences on response operations feasibility over a broad range of average oil film thicknesses:

- **Mechanical Cleanup:** Effectiveness drops significantly because of entrainment and/or splash-over as short-period waves develop beyond 2 to 3 feet (0.6 to 0.9 meters) in height. Containment and recovery decrease rapidly as slick thicknesses drop below a thousandth of an inch (i.e., very low oil encounter rates).
- **Dispersants:** Effective dispersion requires a threshold amount of surface mixing energy (typically a few knots of wind and a light chop) to be effective. At higher wind and sea conditions, dispersant evaporation and wind-drift will limit chemical dispersion application effectiveness; and, there is a point (~25-kt winds, 10 -foot [3 meter] waves) where natural dispersion forces becomes greater, particularly for light oils. Because of droplet size versus slick thickness constraints and application dose-rate limitations, dispersants work best on slick thicknesses of a few thousandths to hundredths of an inch. Improved dispersants, higher dose rates, and multiple-pass techniques may extend the thickness limitation to 0.1 inch (0.25 centimeters) or more.

- **Burning:** Fire boom is affected by the same entrainment and splash-over problems as most conventional booms in 2 to 3 feet (0.6 to 0.9 meters), short-period waves. During calm conditions, sustained burning is easier and normally requires a minimum oil thickness of about 0.1 inch (0.25 centimeters) of oil; for heavier and emulsified oils, this thickness will be greater. When oil has spread and thinned, it may sometimes be possible to collect and concentrate it to minimum combustion thickness.

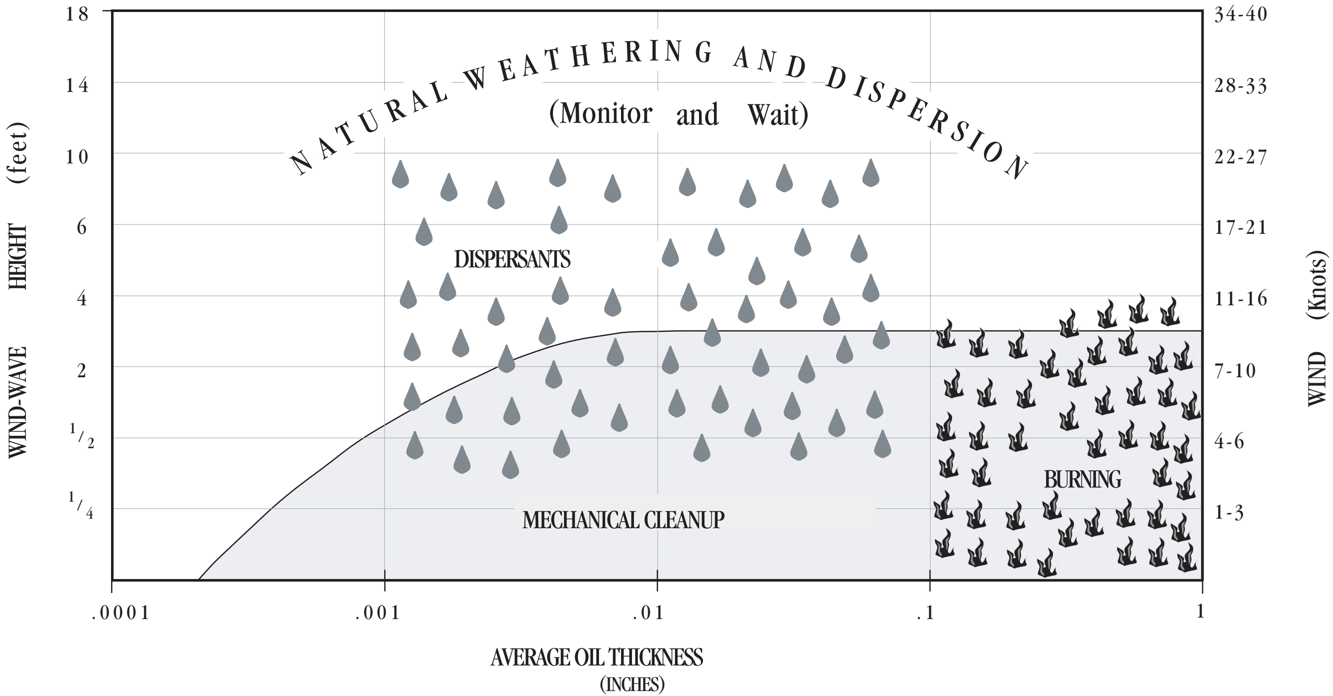

Figure 3. Primary spill response options under various wind/sea conditions and oil film thicknesses (modified from Allen, 1988).

Fresh, volatile oil slicks cannot be ignited in winds greater than 20 knots.

- Surveillance: Remote sensing technologies may be helpful for locating floating oil depending on environmental conditions.

Tides and Currents

Tides can:

- Change or reverse the direction and speed of water flow; and
- Change water depth.

Tides and currents can:

- Operate with wind to transport surface and subsurface oil over great distances.

Thus, tide and currents will dictate vessel size and power requirements; anchor size, type, and placement; towed boom drift distances; the time and location of possible sensitive resource impacts; and the amount of oil loss from entrainment (particularly with high-viscosity oils and oils of density near 1.0). Booming and skimming while drifting with the current will help minimize such losses.

Visibility

If response activities are conducted in low visibility, artificial light, or bright moonlight it will be difficult to find the heaviest oil concentrations or to monitor oil losses from booms and skimmers. Depending upon incident specifics, it may be feasible to conduct on-water operations in static or on-station modes during low visibility, allowing oil to come to recovery sites.

Temperature

Low temperatures will generally increase oil viscosity (requiring viscous-oil recovery system use), inhibit spreading, evaporation, and emulsification, and may extend response windows of opportunity (but some oils may form stable emulsions in low temperatures).

During extreme cold weather, ice may limit the spread of oil and improve the chances of recovery or burning. Extreme cold will also:

- Increase hypothermia potential, requiring responders to use special, cold-weather personnel protection equipment, machinery, and procedures.

In high temperature and humidity situations, the above constraints will usually be reversed: oil will spread and evaporate faster, increasing fire and explosion potential, accelerating weathering processes, reducing response windows, and impacting equipment deployment times (equipment that works better on thicker oils that have retained their lighter ends must be deployed quickly). Extreme heat and humidity will also:

- Increase hyperthermia potential, requiring use of warm-weather personnel protection procedures, equipment, and machinery.

Ice and Floating Debris

In some situations, ice or other floating debris may actually help contain oil and enhance in-situ burning, but heavy concentrations, particularly in strong currents, will clog, overload, or destroy most interception barriers. Debris will also tend to keep oil thick, dampen waves, and reduce dispersant effectiveness.

Frequent surveillance, and assigning resources to keep debris clear of recovery operations, will be necessary. If the debris is not too large, responders may be able to use interception barriers or screens with relatively narrow oil interception swaths.

Authorization

Approval to Burn and/or Apply Dispersants

In-situ burning or dispersant use requires government authorization, (generally requested by the party responsible for the spill). Because safety, environmental impact, wildlife, and public concern issues are involved, a number of formal, pre-spill agreements allow an On-Scene Coordinator (OSC) to authorize dispersant use or in-situ burning. Specific constraints are usually applied regarding:

- Zone and boundary designations;
- Distances from shore;
- Water depths;
- Weather; and
- Time (daylight, season).

Some states and regions may consider these requests only on a case-by-case basis, which delays response activity and may force responders to miss particular windows of opportunity. Such delay must be factored into the response planning process.

Approval to Access Restricted Areas

As noted earlier, vessels and/or aircraft response operations may require special clearances or approvals, particularly near shore, where residential, commercial, industrial, recreational, or environmentally sensitive areas may be directly or indirectly impacted. Permission from government or owners/operators may be necessary before responders can enter or use these areas.

Transport and Disposal of Recovered Oil or Waste

Response planners must assess the time, cost, and effectiveness of storing, transporting, and disposing of recovered oil/oily wastes, including the effects that such operations will have on available resources (e.g., the length of time that response systems may be suspended due to lack of storage space). Disposal of recovered oil and oily wastes must comply with government regulations. Planners must also address:

- Temporary storage (onshore, offshore) of oil and oily debris, or sorbent materials;
- Decanting and discharging free water from recovered fluids;
- Transfer of waste from vessels/barges to onshore facilities;
- Handling waste from offshore equipment/vessel cleaning operations;
- Disposing of waste, burn residue, and debris at approved sites; and
- Product sampling and analyzing.

Shoreline Feasibility Issues

Shoreline response strategies may be constrained by safety, physical, or environmental considerations.

Safety

The dangers or risks inherent in land-based operations involving mechanized equipment are similar to those of on-water activities. Weather-related hazards from high winds, waves, currents, and tides, though less critical on land, still exist near the shoreline.

Stranded oil, or nearshore oil, has usually weathered, and the threat of harmful exposures or accidental ignition is lower than at, or near, its source; however, some oils may still contain enough light ends to make exposure, inhalation, or ingestion risky (except for asphalt-type oils).

Nature and Amount of Oil

Understanding how a particular spill has weathered will help responders select appropriate treatment or cleanup options. Such information can be gathered by shoreline assessment surveys; these involve systematically collecting data to describe (using standard terms and definitions) the location, amount, distribution, and character of stranded or nearshore oil.

Proximity

Responders must consider shoreline proximity issues so that inshore on-water operations can be safely conducted. Considerations may include distance(s) to:

- Safe or sheltered anchorage;
- Support services (e.g., medical, food, lodging, maintenance and repair, and communications);
- Suitable staging or deployment sites; and
- Shoal waters; uncharted, underwater obstacles, etc.

Timing

Shoreline assessments must be conducted as soon as practicable so that planners can incorporate the information into response strategies and provide sufficient resources to remove the oil and prevent it from refloating and impacting other areas.

Environment

The operating environment for shoreline protection and cleanup involves a number of issues, including: waves and breakers, tides, currents, water depths, weather, shoreline features, ecological constraints, human use or cultural resource constraints, and public or government requirements or perceptions.

Waves and Breakers

Small boats operating near shore, or responders working near the water's edge, are directly exposed to hazards from nearshore waves and breakers. Although these can usually be easily seen and activities adjusted to account for them, unexpected or unpredictable conditions can occur, since:

- Vessel wakes can travel several miles, and produce unexpected, steep, breaking waves 3 or 4 feet (0.9 or 1.2 meters) high;
- Wave and breaker heights can vary unexpectedly (and rare, but dangerous, "sneaker" waves can occur on open ocean coasts); and
- Dangerous wave backwash and rip currents are common along open ocean coasts.

Most shallow- or calm-water booms are ineffective in waves over two feet, because they cannot follow short, choppy waves. Although specifically designed for use at the water's edge, shoreline or intertidal booms can be easily rolled or twisted by wave action.

Tides

Though tides and currents are predictable, rapid changes in water levels can isolate and strand unwary personnel, particularly in areas with high tidal ranges, or on wide, flat intertidal areas. Tidal changes from storm surges or wind setups are not as readily predictable, but must also be considered.

Currents

Nearshore currents may be strong (particularly tidal inlet currents, longshore currents, or rip currents), and booms must be regularly redeployed or reconfigured to account for changing water flow.

Weather

Coastal weather can change rapidly and responders must consider the risks from:

- High wind – violent winds (wind shear/microbursts) in electrical storms;
- Remote access – isolation of responders;
- Low visibility – fog, rain, snow, smoke, darkness, or extreme light intensity;
- Ice formation – rafting, damming, or breakup – vessel or equipment icing; sea/river ice floes;
- Intense precipitation – flooding, ground destabilization (mudslides/sinkholes); and
- Extreme temperature/humidity – hypothermia/hyperthermia.

Shoreline Condition

Not all response methods are appropriate for every shoreline type; some may be impractical, unfeasible, environmentally intrusive, or damaging. Shoreline conditions to be evaluated, so responders can select proper response methods, will include:

- Rock falls or slides from backshore cliffs;
- Slippery rock surfaces;
- Presence of ice;
- Limited bearing capacity on mud flats, sand flats, beaches, backshore areas;
- Beach or backshore width and accessibility; and
- Surface mat stability in floating marshes (bogs).

Water Depths and Sea Bottom Character

Nearshore operational safety depends, in part, on responders' knowledge of bottom configuration and navigation conditions (e.g., bottom conditions will dictate which anchors or mooring systems will work; generally, rock bottoms provide poor anchorage). Keys to success include local knowledge, and the scale, accuracy, and availability of:

- Nautical charts; and
- Sailing directions and Notices to Mariners.

Environmental (Ecological) Constraints

Response strategies must allow responders to meet defined response objectives without causing more damage than the oil itself. If, after initially removing gross oil amounts, the level of intrusion necessary to remove any residual oil may cause unacceptable changes, damage, or become inefficient, response activities should be modified. This concept is discussed in Section 2.3.

Certain animals, plants, or insects may be hazardous to shore-zone responders, and response managers must make full use of local knowledge to help reduce such risks (during the Exxon Valdez response, armed guards were used to protect responders from Kodiak brown bears).

Human Use Constraints

Day-to-day human activities can affect responder safety afloat or ashore:

- Small boats, commercial traffic, ocean-going vessels, or ferries may transit areas where response activities are planned or underway;
- Vehicle traffic on piers, wharves, docks, or backshore roads may be dangerous; and
- Backshore residential, commercial, industrial, or recreational activities may conflict with response operations.

Cultural Constraints

Historically, archaeologically or culturally-significant sites or resources are found on all coasts, but are more likely in areas remote from, or undisturbed by, recent human activity (e.g., much of the Pacific Northwest coast). Even if these sites are not directly affected by oil, shoreline activities may result in contact with these resources.

If such sites are present within response areas, special permission will normally be required from cognizant tribal, government, cultural, historic, or archaeological organizations prior to commencing cleanup activities.

Authorization

In addition to shoreline access, which may require permission from outside the response organization, government organizations:

- May restrict use of non-mechanical countermeasures listed on the National Contingency Plan Product Schedule (e.g., dispersants, surface washing agents, bioremediation agents, or burning); and
- Will require specific authorization and permits to transport and dispose (including temporary storage of recovered oily materials) of recovered oily wastes.