THE SHORELINE RESPONSE DECISION-MAKING PROCESS

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ABSTRACT

The decision process that generates oil spill response objectives, strategies and tactics at regional and site-specific scales is a form of risk management. Typically this decision process involves an analysis of the probabilities and consequences of events and the selection of actions to achieve the defined objective(s). Coastal marine, lake and river oil spills frequently are the more difficult ones to manage due to the dynamics and complexity of the environment in terms of physical processes, ecosystem variability and sensitivity, and human use activities. The development of a systematic approach to decision-making is intended to address and reduce the complexity of these issues. This can be achieved by the identification of the elemental components of a response operation in terms of four phases: preplanning; reactive response; planned response; and the completion and monitoring response phase. The framework of the decision process within each of the three response phases is a logical and systematic sequence of nine integrated steps. This discussion explains the purpose and actions that are involved in each step and the manner in which the different components relate to each other.

INTRODUCTION

Oil spill response management has evolved significantly over the past two decades to the point where the basics concepts of a unified command and some form of a standard command structure are internationally accepted (Waller 1997). The size and character of a spill management team varies depending on the size of a spill, the agencies involved, the presence or absence of a responsible party, and the geographic location. A key function of the spill management team is to define response objectives, strategies and tactics. The decision process that generates the response objectives, strategies and tactics at regional and site-specific scales is a form of risk management. Typically this decision process involves an analysis of the probabilities and consequences of events and the selection of actions to achieve the defined objective(s).

This discussion focuses on the decision process as it applies to the shoreline component of a coastal marine or lake oil spill. Activities and response to oil at the shoreline usually present the greatest challenge in management due to the dynamics and complexity of the environment in terms of physical processes, ecosystem variability and sensitivity, and human use activities. In addition, there are typically more stakeholders involved when dealing with oiled shorelines, particularly in populated areas. Although a spill response involves a wide range of decisions and actions, the components can be broadly organized and addressed in a logical and sequential process. The development of a systematic approach to decision-making is intended to address and reduce the complexity of issues and to assist those involved in the process. This can be achieved by the identification of the steps involved and by providing an explanation of the purpose and actions that are involved in each step.

The primary objective of an oil spill response operation is to minimize further impacts to the environment and public health. In the event of a marine or freshwater oil spill there are a number of options that should be considered to minimize the effects. The most immediate actions focus, when possible, on source control (Figure 1). At the same time, on-water containment and recovery (control on water) strategies focus on minimizing the spread of the oil. This discussion deals with the third line of response strategies, the protection and treatment or cleanup of shorelines, that is the fall back position after source control and/or control on water.

The process as presented is an integrated generic approach, the framework and principles of which can be applied to any country and to to any range of spill scales at different level of rigor. The focus of the methodology is on a systematic step-wise approach and the paper identifies and describes the various elements of the shoreline response decision process and illustrates how the different components relate to each other.

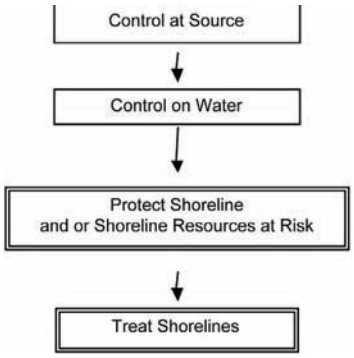


FIGURE 1 SPILL CONTROL OPTIONS

SHORELINE RESPONSE PHASES

The framework for shoreline response actions and decisions is shown in Figure 2. The components in this step-wise process fall within four phases that can form a cycle which continually improves knowledge and the effectivess of the response.

In the majority of situations, both government and potential responsible parties contribute to a pre-spill **Preparation Phase** by the development of resources (knowledge, tools and expertise) that can be called up when a spill occurs.

The **Reactive Phase** or **Emergency Phase** that immediately follows a spill incident typically focuses on source control and/or control on water. During this phase, shorelines are addressed in the context of sensitive area protection priorities, strategies, and tactics. The initial response actions often take place before a spill management team is organized and often may follow strategies prescribed in oil spill response or oil spill contingency plans.

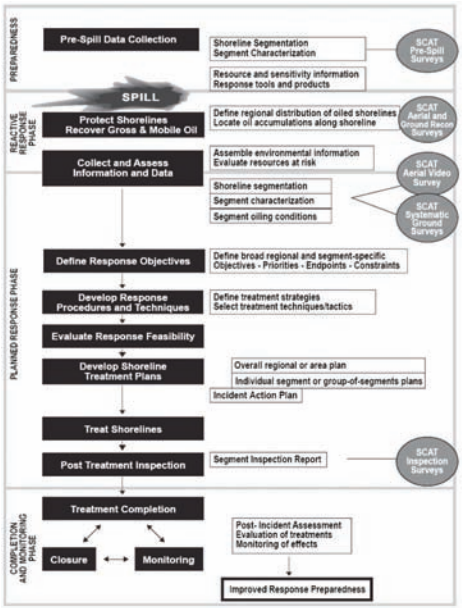


FIGURE 2 A SHORELINE OIL SPILL DECISION PROCESS (SERGY AND OWENS 2007)

The response operation transitions from the reactive phase to a **Planned Response Phase** under the direction of a spill management team. Management by objectives for shoreline treatment involves a series of planned activities that are based on an assessment of the situation, the development of regional and site-specific objectives, and decisions regarding response priorities. The implementation of planned shoreline protection and treatment activities includes determination of the process by which treatment completion can be achieved. It is critical that operational end points be established quickly as these targets determine the level of operational effort in the response.

Once the shoreline treatment has been completed according to the plans, the response shifts to a **Completion and Monitoring Phase**, which eventually leads to closure. Ideally there is also a post incident assessment during which lessons learned can be fed back into an improved prevention and preparedness plan.

PREPARATION PHASE

Pre-spill preparation activities can greatly improve oil spill response effectiveness. From the perspective of shoreline response, there are three important planning or preparedness elements:

- **Pre-spill SCAT surveys:** Mapping projects can be linked to the SCAT (Shoreline Cleanup Assessment Technique) process to create shoreline segments and acquire basic physical shoreline data for each segment in the same manner that data would be generated during the response (e.g. shoreline type, substrate type, coastal character, access, data, etc.). These key elements of the SCAT database are then in place prior to a potential incident and are particularly appropriate for high-risk locations.
- **Environmental Data Collection**: Information on ecological, economic and cultural resources and other baseline data are commonly collected for resource management. The nature and location of this information should be identified to facilitate rapid access during the spill response to evaluate the resources at risk, set priorities and endpoints.
- **Preparedness Planning and Products**: There are a wide array of applications, tools and products that can be produced to improve response readiness. Examples include contingency plans, response manuals, training exercises, sensitivity maps, recommendations for shoreline protection and treatment strategies, tactics and priorities (e.g. API 2001; IMO/IPIECA 1996; IPIECA 2000; NOAA 1992, 2000, 2001, 2002).

REACTIVE RESPONSE PHASE

The shoreline response strategy during the reactive phase is relatively straightforward. The primary objectives are to

- scope the magnitude of shoreline oiling, (actual and predicted),
- protect the shorelines, and
- recover or contain mobile shoreline oil that can be remobilized to affected non-oiled or cleaned shorelines.

The three primary components of this phase are:

- Reconnaissance SCAT surveys to scale the problem and locate stranded oil.
- Evaluation of environmental data and information.
- Establishment of shoreline protection objectives, strategies and priorities.

A key element of the reaction phase is the rapid assessment of the character of the spill and the scale of the affected or potentially affected shoreline area. This assessment is supported by (a) predictions of potential coastal land falls (trajectory analysis) and (b) by aerial and ground reconnaissance SCAT surveys. This information is then used to define shoreline protection and initial shoreline treatment objectives and strategies.

Reconnaissance-SCAT: The objective of a reconnaissance (SCAT) survey is to define the overall scale of the problem in a relatively

short time period in order to develop regional objectives and facilitate more detailed planning for the next stage of the response (Owens and Sergy 2004). Detailed mapping or documentation is not required from reconnaissance surveys, except to provide information on the general geographic distribution and amounts of oil on the shoreline. When the affected shoreline area is small and can be surveyed in one or two days, a ground or boat survey likely would be sufficient. For longer sections of coast an aerial reconnaissance would be necessary.

A second objective of a reconnaissance survey is to evaluate the remobilization potential of that stranded oil. Once oil reaches a section of coast it may be possible to remove the mobile oil or to contain that oil against the shore so that is not re-floated and transported elsewhere. This type of reactive phase strategy can minimize spreading and the extent of the affected area. Stranded oil may pose an immediate threat, for example to wildlife that use that site or to public health or commercial interests (water intakes, recreational beaches). The immediate removal and/or containment of mobile or pooled oil can reduce the on-water effort should that oil be refloated. In addition, this mobile oil may pose a threat to adjacent or nearby resources, unoiled segments, or already cleaned segments. The information obtained by the reconnaissance SCAT survey would be applied to identify those locations for priority treatment or cleanup.

Environmental Data Collection: The acquisition and evaluation of existing ecological, economic and cultural baseline data and sensitivity mapping should commence as soon as possible. This information is used in setting protection priorities and more so in establishing treatment objectives in the subsequent planned response phase. If there are no pre-spill SCAT surveys data, then a SCAT aerial video survey may be desirable in the reactive response phase to create shoreline segments.

Protection Priorities: Information from a variety of sources, including overflights, ground- or boat-based observations, and a reconnaissance SCAT survey, is used in the initial decision process to identify the likely oil transport direction or to locate stranded oil. Initial protection priorities are selected based on the transport pathway and combined existing environmental information on resources at risk in the spill path. A distinction exists between "sensitivity", which is the response or reaction of a resource to the presence of oil, and "vulnerability" which is the probability that a resource would be affected by the oil spill. For example, some bird species, such as surface seabirds and waterfowl, are very vulnerable whereas others, such aerial sea birds (gulls, gannets, etc.) are less vulnerable as they spend comparatively little time on the water surface (French McCay and Rowe, 2004).

PLANNED RESPONSE PHASE

As the response operation transitions from the reactive phase to a managed and planned series of activities, decisions regarding an appropriate shoreline treatment strategy and operational end points require site specific information. The management of this planned phase involves a decision process that allows for operational activities to be developed within a set of specified goals. Management by objectives for shoreline treatment is achieved by a decision process that follows a logical sequence of steps:

1. collect and organize detail information on the shoreline character, oiling conditions and local environment using systematic SCAT surveys and existing resource information,
2. define broad regional and site-specific (segment) response objectives (treatment endpoints, priorities, constraints),
3. develop strategies to meet the objectives,
4. select appropriate tactics or methods to implement the strategies,
5. evaluate the feasibility of the strategies and tactics in light of the environmental conditions, the character of the spill and operational factors (available resources; accessibility; sea state, currents and wind; safety),
6. prepare an overall Shoreline Treatment Plan and individual segment treatment plans,
7. obtain appropriate approvals, permission, or permits,
8. implement the field response operations plan (treat the shorelines), and
9. inspect segment(s) that have been treated and approve completion when treatment has achieved the planned objectives or end point(s).

Shoreline Character and Oiling Conditions

SCAT Surveys: SCAT teams systematically survey the affected area to provide accurate geo-referenced documentation on the physical character of the shoreline and on surface and subsurface oiling conditions using standardized methods and terminology (MCA 2007; Michel *et al.* 2001; Owens and Sergy 2000, 2004). These data are critical as they provide the basis for the entire sequence of shoreline treatment or cleanup planning and field operations through to completion.

In addition, the SCAT field teams document operational features, backshore staging conditions, access, and operational or safety constraints. The teams can identify or verify environmental, cultural, recreational, economic features and constraints consideration. Frequently, SCAT teams are asked to provide recommendations regarding appropriate treatment methods and to define constraints or limitations on the application of cleanup techniques, so that the treatment operations do not result in additional damage to the shore zone.

A SCAT systematic ground survey is the basis for detailed data collection. For larger spills and/or where pre-spill SCAT data is not available, a SCAT aerial video survey may be appropriate in advance of ground surveys to rapidly generate information for segment generation and to map locations and lengths of oiled shorelines at a level of detail required to initiate planning.

SCAT teams focus on the tasks described above. Attempts to assign sampling or other environmental assessment work to a SCAT team invariably slow the rate of progress and often complicate data management.

Treatment Objectives:

An important element of the planned response phase involves decisions to agree upon treatment objectives, priorities, cleanup endpoints and constraints. These decisions lay the groundwork for, and shape the nature of, subsequent planning and treatment. Typically this is the first opportunity for organized cooperation and input from various stakeholders and for planned management of expectations. Although general and specific treatment objectives, priorities and endpoints can be established at a broad regional level, each segment must have its own set of criteria to implement a treatment operation. The criterion may be segment unique, or common to segment groups or regionally universal.

Oiling Conditions and Response Strategies: The presence of oil does not necessarily result in shoreline cleanup or treatment. Non-persistent oils, such as gasoline or diesel, can pose safety issues for responders and if stranded on open coasts typically weather rapidly, over a time frame of hours to days, so that natural recovery may be the most appropriate course of action. The shoreline treatment decision process involves an evaluation of:

- the type and amount of oil on a segment of coast,

- whether the oil is on the surface or has penetrated sediments,
- the likely residence time (persistence) of the oil,
- the resources that would be at risk during that residence time period,
- the sensitivity and vulnerability of those resources,
- access and logistics to the affected area or sites,
- the likely effectiveness of cleanup or treatment to reduce environmental impacts or risks, and
- feasibility, practicality, and safety.

Treatment Priorities: One of the objectives of a SCAT survey is to identify the character and amount of oil that has stranded so that the planners can assess the risk(s) associated with the presence of that oil. The timing and sequence of shoreline treatment activities is based on this risk assessment and, typically, priority is give to segments where the potential exists for the remobilization of mobile or pooled oil or where the presence of the oil poses an immediate and real threat to ecological resources or public health. In addition, SCAT data and information on ecological and cultural or human use resources are evaluated in the decision process to identify priority segments and the sequence of treatment as a whole. In most cases, from a logistics standpoint, it is easier and more efficient to move progressively along the coast rather than require an operations team(s) to jump from one segment to another.

Treatment Endpoints: Shoreline treatment or shoreline cleanup endpoints are specific criteria assigned to a segment that define when sufficient treatment effort has been completed for that segment. In effect, the endpoints are the practical definition of 'clean" for that particular segment of shoreline in that particular spill. The endpoints are a standard against which the treatment activities can be evaluated. When the pre-defined endpoints have been achieved then the specified treatment of that segment of oiled shoreline has reached the agreed objective or goal and the operations team has completed the assignment in that segment. There is no consensus in defining the term 'clean' or the concept of 'how clean is clean' (Baker 1997). In effect, 'clean' is defined by the treatment endpoints which in turn are set by the treatment objectives (Sergy and Owens, 2007; 2008).

Treatment endpoints are an important and integral part of the decision-making and planning process, the operational response, and the completion phase. Clearly defined endpoints:

- Assist the spill management team in the selection of treatment objectives and tactics for a specified area or segment before the treatment begins;
- Provide shoreline operations supervisors with a clear goal so that they can tailor their activities towards a known point of completion; and
- Provide an inspection team with criteria and standards with which to evaluate the condition of the shoreline, the results of the treatment activities and to determine the completion of treatment.

Other important reasons or benefits of clearly defined endpoints are to:

- Facilitate recognition and assessment of all the various environmental, social and economic factors that are should be considered in the shoreline treatment decision-making process and
- Facilitate recognition and resolution of concerns between the responsible party and stakeholders.

Typically, the establishment of the treatment endpoints is a joint decision of the spill management team and the responsible government agencies, with input from the responsible party when the spill is from a known source. A successful and effective response is far more likely to be achieved when all parties have a common expectation of what has to be accomplished.

It is important that all parties have the same understanding of endpoints, an appreciation of the anticipated appearance of the final treated shoreline and that those who would be measuring endpoints have the experience and ability to make that determination.

Treatment Strategies and Tactics

Regional and segment-specific treatment strategies are developed in the context of the treatment objectives, priorities, endpoints and constraints and with the knowledge on oiling conditions, shoreline character and environmental resources at risk. Specific procedures, techniques and tactics and defined to meet the treatment objectives and strategies.

Shoreline treatment or cleanup techniques should be selected to be compatible with the character of the shore zone and with the oiling conditions (type and volume of oil) as documented by the SCAT process. All options except for natural recovery involve some form of intrusion on the ecological character of the shoreline type that is treated or cleaned so that the decision process involves assessment of the appropriateness and the anticipated effects of the selected tactic(s).

Feasibility and Safety

Two important considerations in the decision process for shoreline treatment are the ability of the response team(s) to achieve the desired cleanup goal (i.e. end points) and the safety aspects of the field operations.

After the planners have established the end point(s) for a segment or section of coast, the operations team prepares a plan designed to achieve that goal. If operations questions the feasibility or practicality of achieving the end point(s) it may be necessary for planners to reconsider and, working with operations, identify target end points that are practical, effective, and achievable. There is little value in attempting to clean or treat shoreline in the expectation that the end point(s) cannot be met.

Safety, for responders and the public, is the primary objective of all spill response operations. Among the primary safety issues are:

- the character of the spilled oil (in particular the volatility of light oils or products)
- the operating environment (temperature, winds, waves, currents, tides)
- site conditions (boulders, bedrock cliffs)
- wildlife or plants (alligators, bears, hippo, poison oak, snakes).

Situations may occur where cleanup or treatment is not carried out due to one or more safety concerns.

Shoreline Treatment Plans: The end product of the planning activity is a Shoreline Treatment Plan. The development of the Plan involves participation of the spill management team and representatives of appropriate federal, provincial and other government or non-government agencies or stakeholders. For all but small spills, treatment plans would range in application and scale. A broad regional plan is used to address common issues, conditions and criteria that apply to the entire affected spill area, i.e. to all segments. Specific segment plans are used to identify modifications to the above, explicit conditions for that segment and detailed supplemental information.

Regional Treatment Plans: Spill management typically involves the development of an overall plan to serve as a framework for the various activities that constitute a response operation. Some activi-

ties, such as waste management, safety, or logistics, are an integral part of shoreline treatment whereas others, such as documentation and finance, deal with non-operational components of spill management. A number of separate plans focus on individual aspects, such as Wildlife, Waste Management, and Safety Plans.

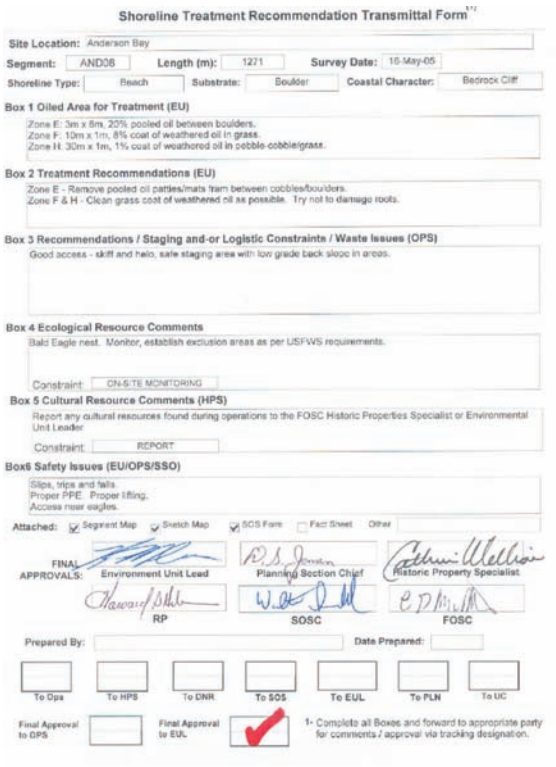
The Regional Shoreline Treatment Plan typically includes topics on:

- the SCAT program (teams, schedule, priorities, forms, data management)
- shoreline segments (geographic area of the SCAT survey; segment maps)
- shoreline treatment endpoints and inspection procedures
- shoreline operations (management , schedule, priorities)
- shoreline treatment tactics (approved methods)
- cultural resource and ecological constraints
- safety issues

Segment Treatment Plans: The site-specific segment treatment plans are the culmination of the sequence of planning activities that provide a 'what-where-when-how' methodology for operations to treat the shorelines. The plans reflect the deliberate assessment and decisions of stakeholders; in essence an agreement on the best course of action. Ideally, each segment would have an individual treatment plan which includes the universal conditions of the regional shoreline treatment plan, plus any modifications or supplementary conditions specific to that segment. In some cases there may be none. In some cases they can be significant and unique to the segment, for example, where there is a feature of ecological or cultural significance. Whether or not there is a segment specific plan, the management team still needs to communicate their decisions and to provide the operations team(s) with approved segment-specific information and instructions.

Transmittal of Plans to Operations: The segment treatment plan is typically combined with a cover document containing signature blocks for approval by responsible agencies as necessary or appropriate. One approach adopted recently in Alaska involves completion of a "Shoreline Treatment Recommendation Transmittal" (STRT) form (Figure 3)(Owens *et al.* 2005). This form briefly describes the oiling character of the location to be treated, contains recommendations for treatment tactics, comments on ecological and cultural resource constraints and identifies any special safety issues in that segment .

In essence, the plan constitutes a work order for that segment of shoreline that ensures that the expectations and instructions of the planners, decision makers and safety officers are clearly and succinctly communicated to the field response team supervisors. Later in the operation this plan would provide the basis for post treatment inspection and assessment.


Shoreline Treatment Recommendation Transmittal Form

Site Location: Anderson Bay

Segment: AND08 Length (m): 1271 Survey Date: 16-May-05

Shoreline Type: Beach Substrate: Boulder Coastal Character: Bedrock Cliff

Box 1 Oiled Area for Treatment (EU)

Zone E: 3m x 8m, 20% pooled oil between boulders.
Zone F: 10m x 1m, 8% coat of weathered oil in grass.
Zone H: 30m x 1m, 1% coat of weathered oil in pebble-cobble/grass.

Box 2 Treatment Recommendations (EU)

Zone E - Remove pooled oil patties/mats from between cobbles/boulders.
Zone F & H - Clean grass coat of weathered oil as possible. Try not to damage roots.

Box 3 Recommendations / Staging and-or Logistic Constraints / Waste Issues (OPS)

Good access - skiff and helo, safe staging area with low grade back slope in areas.

Box 4 Ecological Resource Comments

Bald Eagle nest. Monitor, establish exclusion areas as per USFWS requirements.

Constraint: ON-SITE MONITORING

Box 5 Cultural Resource Comments (HPS)

Report any cultural resources found during operations to the FOSC Historic Properties Specialist or Environmental Unit Leader

Constraint: REPORT

Box6 Safety Issues (EU/OPS/SSO)

Slips, trips and falls.
Proper PPE. Proper lifting.
Access near eagles.

Attached: Segment Map Switch Map SCS Form Fact Sheet Other

FINAL APPROVALS: Environment Unit Lead | Planning Section Chief | Historic Property Specialist

RP | SOSC | FOSC

Prepared By: Date Prepared:

To Ops | To HPS | To DNR | To SOS | To EUL | To PLN | To UC

Final Approval to OPS | Final Approval to EUL

1- Complete all Boxes and forward to appropriate party for comments / approval via tracking designation.

FIGURE 3 SHORELINE TREATMENT RECOMMENDATION TRANSMITTAL (STRT) FORM

COMPLETION AND MONITORING PHASE

Inspection and Completion of Treatment: As a result of treatment activities or natural removal processes, the conditions within each shoreline segment at some point would approach or achieve the specific endpoints pre-established for that segment of shoreline. A process is therefore required to assess and verify that the endpoint condition(s) are achieved and to permit treatment operations either to demobilize for that location, move elsewhere, or proceed to the next stage of treatment.

The primary elements of this component can include

- a treatment inspection by the SCAT team and/or an inspection team that represents the interests of both the responsible parties and stakeholders,
- a decision on the treatment completion, and
- a decision on closure and/or the need for subsequent monitoring

The inspection process and the criteria used to determine if treatment objectives have been met are established as part of the planning process, before treatment commences.

The first step is the process is taken when the shoreline operations supervisor or an environmental monitor (if one is part of the operations team), is of the opinion that the pre-established endpoint has been achieved. Then, typically, an inspection survey is conducted by the SCAT team and/or a team that represents the interests of both the responsible party and stakeholders. This survey team evaluates that:

(1) the end-point criteria/treatment objectives have been met (on some spill responses this has been referred to as the point when No Further Treatment (NFT) is required), or

(2) the end-point criteria have not been achieved and recommend where work is required and what should be done to complete the planned end point, or
(3) one treatment stage has been completed so that the next stage can be initiated.

Observations and recommendations of the survey team are recorded on a Segment Inspection Report (SIR) or equivalent (Owens *et al.* 2005). This form documents that an inspection has been completed and that either NFT is required or specifies the location and extent of further treatment that would be necessary to reach the endpoint(s). In some cases, the inspection team may have the authority to make the NFT decision in the field whereas in other cases they may provide a recommendation to the spill management team who would then approve the recommendation or conduct the final inspection. Once the decision is made and confirmed the operations can be demobilized from the segment or can move on to the next stage of treatment in that segment.

The path from No Further Treatment to final closure may be direct or staged. The latter case usually involves a monitoring function to detect and alert the spill management team if there is a change of conditions that would trigger re-assessment of treatment

Monitoring: As part of the SCAT and/or spill response program, repetitive shoreline monitoring surveys can provide a temporal picture of changes in oiling conditions. In some instances, repetitive shoreline monitoring surveys may be conducted to:

- Ensure that shoreline conditions in the segment remain acceptable and/or that the endpoints continue to be maintained e.g. external locations may cause re-oiling; e.g. exposed shorelines are dramatically affected by seasonal processes, especially during the storm season, which may expose subsurface oil that had previously not been observed, or
- Assess changes in oiling conditions over time (days to months) that result from treatment and cleanup activities (by man) and/or natural self-cleaning processes e.g. is self cleaning meeting our expectations on a particular segment, or
- Evaluate the effectiveness (performance and effects) of treatment decisions and tactics that were applied.

CONCLUSIONS

A logical and systematic step-wise approach can be applied to actions and decisions that are an integral part of a response to oil spills on shorelines. In the initial *Reactive Response Phase* following an incident, the focus is to first provide a rapid assessment of the nature of the spill (oil volume and type) and scale of the affected or potentially affected shoreline area. This assessment can be achieved by reconnaissance SCAT surveys. In parallel, existing environmental information is assembled to evaluate resources at risk. The information is then used to define shoreline protection and initial shoreline cleanup or treatment priorities. In some circumstances, proactive preparedness activities may have already documented shoreline segmentation and character by SCAT pre-spill surveys.

As soon as is practical, the response operation transitions from the reactive phase to a *Planned Response Phase*. Management by objectives for shoreline treatment is achieved by a systematic decision process that follows a logical sequence of steps: (1) gather detail information on segment character, oiling conditions, constraints using systematic SCAT surveys and existing resource information, (2) define regional and site-specific (segment) response objectives, priorities, endpoints and the environmental, social, cultural treatment constraints, (3) develop treatment strategies, (4) select appropriate treatment tactics or methods to implement the strategy, (5) evaluate the response feasibility of the strategies and tactics in view of the environmental conditions and the nature of the spill, (6) prepare an overall Shoreline Treatment Plan and individual segment plans, (7) obtain appropriate approvals, permission, or permits, (8) implement the field response operations plan, and (9) inspect the segment(s) that have been treated to approve completion (i.e. attainment of the treatment end point(s).

Nearing the completion of the treatment plan for each segment, the response shifts to a *Completion and Monitoring Phase*. At this stage, inspections and assessments of each segment are made in order to ascertain if (a) the end-point criteria /treatment objectives have been met (and therefore no further treatment is required) or (b) if not, then to identify what further work is needed. Post-treatment monitoring surveys may be conducted over the longer term as part of a staged progress towards closure.

BIOGRAPHY

Dr. Ed Owens has been involved with oil spill response and research since 1970 and has participated in spill response operations in North and South America, the Middle East, Australia, and Europe, including the 1991 Kuwait "DESERT STORM" spills, and the 1994 Komi pipeline spills in Russia. He was the Technical Advisor to Exxon's SCAT team on the "T/V EXXON VALDEZ" spill in Alaska. Recently he participated in response operations following the T/V ESTRELLA PAMPEANA spill in the River Plate (Argentina), the Bolivian Altiplano Río Desaguadero pipeline spill, and the M/V SELENDANG AYU oil spill (Unalaska Island, Alaska).

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