Environment Canada   Environnement Canada

Guidelines for Selecting Shoreline Treatment Endpoints for Oil Spill Response

Canada

Guidelines for Selecting Shoreline Treatment Endpoints for Oil Spill Response

by

G.A. Sergy
Environment Canada

and

E.H. Owens
Polaris Applied Sciences, Inc.

October 2007

Environment Canada Environnement Canada

Canada

PREFACE

This guide is one of a series of initiatives taken by Environment Canada to provide the best available knowledge, guidance, and standards for responders and decision-makers faced with issues of protection and cleanup of oil spills in coastal marine and freshwater environments. The science and technology knowledge base is combined with experience from recent responses, experts, and practitioners to craft manuals, job aids, and other tools to educate spill responders and enhance the spill response process.

For further information, contact the authors or the Emergencies Science and Technology Division of Environment Canada at the following addresses.

Emergencies Science and Technology Division
Environmental Science and Technology Centre
Science and Technology Branch
Environment Canada

335 River Road
Ottawa, Ontario, K1A 0H3 Canada

Phone: (613) 998-9622
Fax: (613) 991-9485

Citation: Sergy, G.A. and E.H. Owens, "Guidelines for Selecting Shoreline Treatment Endpoints for Oil Spill Response", Emergencies Science and Technology Division, Environment Canada, Ottawa, ON, 30 p., 2007.

Also available in French under the title: "*Directives pour définir les critères de fin de nettoyage des rives mazoutées suite à des déversements d'hydrocarbures*"

October 2007

Paper: En4-84/2008E
978-0-662-47696-2

PDF: En4-84/2008E-PDF
978-0-662-47697-9

Graphic Design: Amanda O'Connell

TABLE OF CONTENTS

TABLES

FIGURES

1 INTRODUCTION

This document provides direction and guidance for selecting and measuring treatment endpoints for oiled shorelines. Although a number of discussion papers, philosophical frameworks, and simple endpoint summaries have been prepared, there are no existing national or international treatment criteria and standards or any agency-specific procedures that provide sufficient detail to have broad application. Owens and Sergy (2003) concluded that it is not feasible to have a single, detailed decision-making methodology for endpoints that is relatively simple and practical, yet comprehensive and universally applicable. As the circumstances of each spill are different, the endpoints must meet the specific conditions of the event. There are, however, basic generic concepts and principles that can be applied, as well as explanations and examples that can be used as a framework for this vital decision-making process. These concepts and principles are presented in this guideline for use in Canada. They may also have a wider application for the international community.

2 DEFINITION OF ENDPOINTS

Shoreline treatment or shoreline cleanup[1] endpoints are specific criteria assigned to a segment[2] or unit of oiled shoreline that stipulate when sufficient treatment effort has been completed for that segment or unit. In effect, the endpoints are the practical definition of 'clean'[3] for that particular segment of shoreline in that particular spill. The endpoints are a standard against which treatment activities can be evaluated. 'Clean' has been achieved when the pre-defined endpoints have been attained and the specified treatment of that segment of oiled shoreline has reached the agreed objective or goal.

---

[1] The terms 'treatment' and 'cleanup' refer to the method or technique by which the objective will be met. Although the two terms are often used interchangeably, treatment is commonly interpreted as the broader range of response options, most notably natural recovery without human intervention. On the other hand, if response crews physically remove oil from the site, this is clearly a cleanup method. In this guideline, 'treatment' is the preferred term as 'cleanup' can give the impression that the site will be totally oil-free.

[2] 'Segments' are distinct alongshore sections of shoreline that can be used as operational units, and within which the shoreline character is relatively homogeneous in physical features and types of sediment. Segments are bounded by prominent geological or operational features, or by changes in shoreline type, substrate, or oiling conditions. See "The SCAT Manual" (Owens and Sergy, 2000) for further discussion on this topic.

[3] There is no consensus in defining the term 'clean' or the concept of 'how clean is clean' (Baker, 1997). As a working definition, 'clean' is defined by the treatment endpoints, which are in turn set by the treatment objectives.

3 PURPOSE OF ENDPOINTS

Establishing treatment endpoints for an oil spill response is an important and integral part of the management decision-making process, operational response, and determination of treatment completion. Spill managers must be aware of the value of proactively developing endpoints.

The practical reasons for assigning shoreline treatment endpoints are to:

- assist the spill management team in selecting treatment objectives and techniques for a specified area or segment of shoreline before the response operation begins;
- provide Operations supervisors with a clear objective or target so 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 and the results of the treatment activities with respect to the response objectives.

Other important benefits of developing endpoints are to:

- facilitate recognition and assessment of the various environmental, social, and economic factors that should be considered in the shoreline treatment decision-making process and assist in selecting appropriate and practical response options; and
- facilitate recognition of the concerns of the various responsible parties and stakeholders and attempt to create a consensus between them. An effective and successful response is far more likely when all parties share the same expectation of what must be accomplished.

4 BASIC TECHNIQUES FOR MEASURING ENDPOINTS

Treatment endpoints from past spills and different agencies are grouped into the following four categories based on the approach or methodology used (Owens and Sergy, 2003).

Qualitative Field Observations are used to describe the presence or absence of stranded oil and/or the character of such oil, e.g., no observed oil (NOO), no mobile oil, no oiled debris, or no rainbow sheens. The determination of this type of endpoint is relatively easy and rapid with a simple descriptive output. Direct observations can be supplemented with still or videotape camera images taken from the air or on the ground. Qualitative field observations have been used at many spills and are common components of the chosen set of endpoints. The steps involved in this method are outlined in Section 10.

Quantitative Field Measurement Methods are based on visual measurements and observations of the quantity of oil. These methods have been used during many response operations. Measurements taken include one or more numerical standards, such as the extent of the oiled area, the percentage of surface oil distribution, oil coverage, oil thickness, and oil volume. Sometimes the standards are also keyed to the type of oil or a specific location.

This visual measurement approach is a rapid and straightforward procedure with simple descriptive and numerical outputs that provide clear guidelines and targets for Operations supervisors. The measurement standards and terminology are often the same as those typically used in the Shoreline Cleanup Assessment Technique (SCAT) process (Owens and Sergy, 2000; 2004). The steps involved in this method are outlined in Section 11.

Analytical Measurement Methods typically require the collection of representative field samples of various media and subsequent analysis using instruments in a laboratory. Three types of analytical measurement methods are:

- **chemical analyses** for measuring the concentration of oil or specific chemicals;
- **toxicological analyses** for measuring the response of test organisms to toxic effects; and
- **organoleptic analyses** to determine human detection of offensive odours.

In addition to laboratory analysis, a limited selection of field analytical tools can be used to measure endpoints. Although not common, analytical measurement methods can play a role in specific or unusual circumstances. Most analytical criteria, however, have been developed as health standards related to chronic issues rather than to acute ones. The analytical approach is often impractical in terms of collecting representative samples and generating results in a timely manner in order to evaluate whether the endpoints are met. Further information on this method is provided in Section 12.

Interpretive Impact Assessment Methods develop treatment endpoints based on an evaluation of system impacts. These methods can include environmental, social, economic, and/or cultural factors (Dicks *et al.* 2002). The approach can vary greatly in complexity. At one level it can involve a detailed, multi-factor synthesis using a combination of qualitative, quantitative, and/or descriptive indicators and can use techniques similar to those applied for environmental impact assessment studies. On the other hand, it can be a subjective judgement call against a simple criterion based on the evaluator's own experience. The method is basically one of interpretative assessment rather than quantitative measurement and it therefore has the greatest degree of personal subjectivity. Further information on this method is provided in Section 13.

Endpoints based on qualitative and/or quantitative field measurements are recommended as a first option. These methods are suitable for almost all spills.

As endpoints based on qualitative and/or quantitative field measurements are suitable for almost all spills, these guidelines are written from the perspective of the qualitative and/or quantitative field measurement approach to endpoints. Nevertheless, most of the material in Sections 5 to 9 also pertains to other approaches for establishing and measuring endpoints.

5 ISSUES AFFECTING THE SELECTION OF TREATMENT ENDPOINTS

Establishing treatment endpoints is usually a joint decision made by the spill management team and the responsible government agencies, with input from the responsible party when the spill is from a known source. The mechanics of the process depend on the organization of the spill management team. Often the initial draft of treatment endpoints is prepared by experienced technical and scientific advisors with the government and/or Environmental Unit (EU), at which point the broader group of stakeholders are brought into the decision-making process.

The process of determining an appropriate endpoint ranges from a relatively simple one to one that is difficult and complex and involves several rounds of negotiation. It often requires a compromise due to the wide range of factors that come into play and the varied interests of the national, regional, and local government agencies, political groups, the media, and the local population that live in or use the affected area. Despite this, endpoints must be established for every spill, either generically or for individual segments.

The selection of endpoints is influenced by the following issues and criteria:

- the type of shoreline, i.e., bedrock, sea walls, sand beaches, wetlands, or marshes;
- the value of the habitat or use of the segment and the timing of that use, i.e., wildlife refuge, residential area, industrial area, seal haul-out, park, or remote area;
- operational feasibility, i.e., access, staging, resources and effectiveness of techniques;
- the degree and type of oiling;
- the Net Environmental Benefit of treatment;
- the anticipated rate of natural cleaning; and
- environmental influences such as weather and sea states.

6 GUIDING PRINCIPLES IN SETTING ENDPOINTS

1. Shoreline treatment endpoints can be applied at different scales of coverage. Endpoints are most often set at three levels:
   (i) a universal scale, whereby certain endpoints apply to the entire affected spill area and all segments in the region must meet these minimum criteria;
   (ii) a cluster scale that applies endpoints to groupings of different types of habitats, shorelines, or land use;
   (iii) a detailed scale that describes specific endpoints for each individual shoreline segment or shoreline unit.
2. Different criteria and standards apply to different segments of shoreline.
3. Individual endpoints, even the same ones, can be applied to different environmental components, for example, to water, vegetation, surface and subsurface sediments, and intertidal zones, depending on variations in land use or the distribution of species. The endpoints for each segment can thus be further focused or compartmentalized within that segment.
4. Each shoreline segment or unit must ultimately have its own 'set' of endpoints, whether they are generic or unique. These endpoints can be a combination of different types of standards and they can apply to specific environmental components of that segment.
5. It is possible to have more than one 'set' of treatment endpoints within one shoreline segment when the treatment plan is based on the use of a number of sequential treatment actions or methods.
6. The practical requirements for completing the endpoint measurement must be taken into consideration, e.g., level of precision, level of effort, turnaround time, and safety issues.
7. There is no uniform or standard approach that can be applied universally. Treatment criteria and endpoints vary from one spill to another, depending on the unique features of the incident. Treatment criteria and endpoints also vary within a single response operation as impacts and risks are often not uniform within the affected area.
8. The endpoint definition must be concise, clear, and understandable as ambiguities could lead to misinterpretations in the field by Operations and/or the inspection team.
9. Even with a clearly defined standard, the spill management team may still need to make a judgement call or reach a compromise.

Endpoint Modifiers

While caveats and operational constraints are often attached to treatment plans, they can also be attached to specific endpoints. Operational constraints typically involve factors related to treatment feasibility and safety. Caveats are typically related to environmental issues, e.g., “No visible (submerged) oil in reeds, unless further oil recovery dislodges new-growth reed shoots”. Exclusion clauses can also be used, e.g., “No surface oil except ....”.

Feedback between Decision-Makers and Operations

Those who develop and set treatment endpoints should work in cooperation with the shoreline treatment operations team, to validate both the value and the feasibility of the initial endpoint selection and to be responsive to adjustments if required. Despite having clear endpoints, sometimes the ‘Lowest Practicable Level of Contamination’ (see Section 13) must be considered during treatment of shoreline types, e.g., when a divergence develops between the endpoint and the original objective of treatment due to logistics or when feasibility or safety factors prevent operations personnel from achieving the desired objective. This scenario would require a reassessment of the response objectives and endpoints as well as the response techniques.

7 MEASURING AND VISUALIZING ENDPOINTS

It is critical that ALL parties have the same understanding of endpoints and an appreciation of the anticipated appearance of the final treated shoreline. Those who will be measuring endpoints must have the ability and experience to make that determination. This includes those who conduct the post-treatment inspection survey, the Planning Section, the Operations Section, the On-scene Coordinator (OSC), the Responsible Party (RP), and the landowners or managers.

Orientation, calibration, and/or training sessions should be planned and integrated into the response program particularly to:

- show stakeholders how the different shoreline endpoints appear visually;
- provide consistency between members of the post-treatment inspection survey and between those representing the interests of stakeholders and the RP; and
- provide Operations, from the crew chief level upwards, with some appreciation of the issues, clear instructions on the endpoint(s) for each segment, and a reasonable level of skill to judge when the endpoint has been attained. The field crew chief must be skilled enough to guide and train the team to meet and not exceed the appropriate endpoints.

Examples of calibration and training tools include:

- textual descriptions of endpoints;
- visual job aids;
- actual/real samples of ‘cleaned’ beaches to match the various endpoints and serve as benchmarks for calibration and training; and
- trial-run inspection surveys (these may be “calibration exercises”).

Exercising Judgement

The visual determination of an endpoint is not always straightforward despite the use of clear and simple definitions. In this regard, photographs or other graphic examples may be valuable. It may not be practical or feasible to strictly adhere to the absolute “letter of the law”. A judgement call may be required for unforeseen circumstances, minor divergences of the endpoint definition or/and the amount of deviation that will be allowed or accepted. The inspection teams should be aware of the need to consider these discretionary actions during calibration runs.

8 THE ROAD TO COMPLETION

As a result of treatment activities or natural removal processes, at some point the conditions within each shoreline segment will approach or achieve the specific endpoints pre-established for that segment of shoreline. A process must be established to assess and verify whether this endpoint condition has been attained and to permit treatment operations either to demobilize for that location, to move elsewhere, or to proceed to the next stage of treatment. This process becomes a formal agreement or documented decision when a stage or phase in treatment is completed and the next stage can begin and eventually the process is completed. If endpoints have not been clearly defined before the treatment program, this process could become a contentious stage in the response.

A typical process would begin with a pre-assessment by monitors from Operations and/or the Environmental Unit to determine if the standard measure of ‘clean’, i.e., the endpoint, has been or is being attained. When Operations provide notice that the endpoint(s) have been achieved, a post-treatment inspection survey is typically conducted by the SCAT team and/or an inspection team. This inspection survey should represent the interests of both the responsible parties and stakeholders.

This post-treatment inspection survey team evaluates either that:

(i) the endpoint criteria/treatment objectives have been met [this is sometimes referred to as the point when No Further Treatment (NFT) is required (Owens *et al.* 2005)]; or

(ii) the endpoint criteria have not been met and recommendations are made as to where work is required and what needs to be done to pass inspection.

The survey team's observations and recommendations can be documented with a Segment Inspection Report, an example of which is shown in Figure 1. The team must be empowered to agree or disagree in the field that the endpoint has been reached using the pre-defined criteria. There must be a definition as to what constitutes team agreement and which members are involved in the decision, i.e., some may be observers only. If there is a minority position within the team or from outside stakeholders, then that position or viewpoint should be noted and steps taken to address legitimate concerns.

The process for formally terminating treatment for each segment varies with the organizational and command structure in place for the particular spill. In some cases, for example, the post-treatment inspection team may have the authority to make this decision in the field whereas in other cases they may provide a recommendation to the On-scene Commander who would then approve the recommendation or conduct the final inspection.

Note that treatment plans based on sequential treatment methods may require a phased inspection process to assess whether each stage of treatment, i.e., each set of endpoints, is complete.

Note also that endpoints based on interpretive impact assessment methods - minimum regret strategies - vary from the procedure outlined above. In these cases, the cessation of treatment is a judgement call made by the treatment specialist or environmental monitor based on pre-defined indicators. Such a decision would typically be based on the premise that further treatment could cause unacceptable environmental damage.

The *Generic* Spill
SEGMENT INSPECTION REPORT (SIR)

Operations Division:
Segment ID:
Segment Length:

Inspection Date:
Tide Stage:
Weather: Sun/Cloud/Rain/Snow

Inspection Team		
Name	Agency	Signature

Pre-Treatment Oiling Conditions: (also can be provided as an attachment e.g. SOS form, sketch, STRT) ❏ attached
Treatment Method or Plan: (also can be provided as an attachment) ❏ attached
Treatment Endpoint Criteria: ❏ attached

Observations and Recommendations: Inspected Entire Segment: Y / N

❏ Segment meets endpoint criteria and conditions. The following specific treatment actions are required.
❏ Segment DOES NOT MEET endpoint criteria and conditions. The following specific treatment actions are required. ❏ attached

Approved by:

FOSC ____________ **POSC** ____________ **RP** ____________

❏ First Nation, Landowner or Other Stakeholder comments attached.

Figure 1 Segment Inspection Report

Events after 'No Further Treatment' Status is Reached

The inspection and spill management teams interpret the NFT concept to mean that endpoint criteria/treatment objectives have been met and that treatment operations on that segment can be demobilized. Practically speaking, demobilized operations eventually lead to a completion of the active response and treatment phase. If there is a lack of agreement or consensus, it is important to qualify and clarify unresolved issues at this step. These unresolved issues can be documented in the shoreline treatment plan, on the Segment Inspection Report, or during the closure process.

The path from NFT to final closure may be direct or staged. The latter case usually involves a monitoring function to detect whether there is a change of conditions that would trigger re-assessment of treatment and alert the spill management team accordingly. This is discussed in Section 8.2.

Typically, segments are inspected and assigned an NFT status as they become eligible. During a large spill when significant time has passed between completion of operations and inspection, regulators should consider whether a follow-up inspection would be appropriate to ensure that shoreline conditions have not changed.

Post-treatment Monitoring Stage

As part of the SCAT and/or spill response program, repetitive shoreline monitoring surveys can provide a temporal picture of changes in oiling conditions. This monitoring may be part of the staged progress towards closure. Monitoring can be used to:

- document conditions where oil continues to wash ashore over an extended time period, e.g., chronic re-oiling such as from submerged oil;
- ensure that shoreline conditions in the segment remain acceptable and/or that the endpoints continue to be maintained, 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;
- assess changes in oiling conditions over time (days to months) that result from treatment and cleanup activities (by people) and/or natural self-cleaning processes, e.g., that self-cleaning meets the expectations on a particular segment;
- evaluate the effectiveness (performance and effects) of treatment decisions and options that were applied; and
- investigate environmental processes that affect the fate, behaviour, and effects of oil or of treatment methods.

The Re-oiling Predicament

The process of final inspection and approval is generally not implemented while mobile or potentially remobilized oil remains a threat. Understandably, it is difficult to conclude completion of treatment when further oiling is still possible. Re-oiling is likely to occur if not all surface slicks are contained yet. Some shoreline treatment operations or natural removal processes have the potential to remobilize stranded oil. In addition, the presence of submerged or sunken oil can present chronic and/or unexpected re-oiling scenarios.

Recurring oiling or re-oiling of a treated shoreline has occurred in several spills. In such cases, the process must be adjusted. A common compromise is an interim inspection or assessment that indicates to Operations that the segment attained endpoint status at that time. This decision allows resources to be deployed to other sites and leaves a process in place for monitoring and recovering new oil on that segment. Final inspection and approval is not scheduled until it is demonstrated that there is no possibility of re-oiling or some agreement is reached to address the re-oiling scenario. As mentioned earlier, post-treatment monitoring of completed shorelines on a longer term may also be appropriate to check for unacceptable re-oiling.

9 SUMMARY OF STEPS IN THE PROCESS

The activities directly related to endpoint development are outlined in Table 1. A generic shoreline treatment decision process is shown in Figure 2. Note that endpoints are set in the planning stage, well before treatment plans are finalized or operations commence.

The following are the basic steps in selecting shoreline treatment endpoints.

1. Define the regional distribution of oiled shorelines.
2. Divide the shoreline into segments or work units.
3. Determine and engage the members or representatives of the spill management team who will set the endpoints.
4. Define the issues and criteria that drive the selection of treatment endpoints.
5. Define the treatment or cleanup endpoints and how they are measured.

6. Define the post-treatment inspection and treatment completion processes.

7. Transmit the standards to the appropriate parties for review, comment, and where appropriate, approval.

8. Ensure that Operations understands the issues and the endpoint standards for each segment and that they agree that they are achievable in terms of feasibility and safety.

Note: This is not necessarily a static, once-through process. New segment-specific information may become available from SCAT surveys or resource surveys that impacts the issues and thus the endpoints agreed upon for a particular segment.

Table 1 Role of Endpoints in the Shoreline Treatment Decision Process

Steps in the Decision Process	Relevance to Endpoints
Collect and evaluate information	Information, issues, and criteria influence endpoint selection
Define the response objectives Develop treatment strategies	Includes the selection/setting of specific endpoints
Select response procedures and tactics	Endpoints influence the selection of tactics
Evaluate response feasibility	Response is evaluated to achieve desired endpoints
Prepare treatment plans	Endpoints become fixed and formalized
Treat shorelines	Endpoint definitions provide a target for Operations treatment crews
Post-treatment survey or inspection	Endpoints determine whether or not further treatment is required
Treatment completion	Endpoints are a standard to determine completion of treatment
Monitoring	Endpoints are a guide to trigger evaluation of further treatment

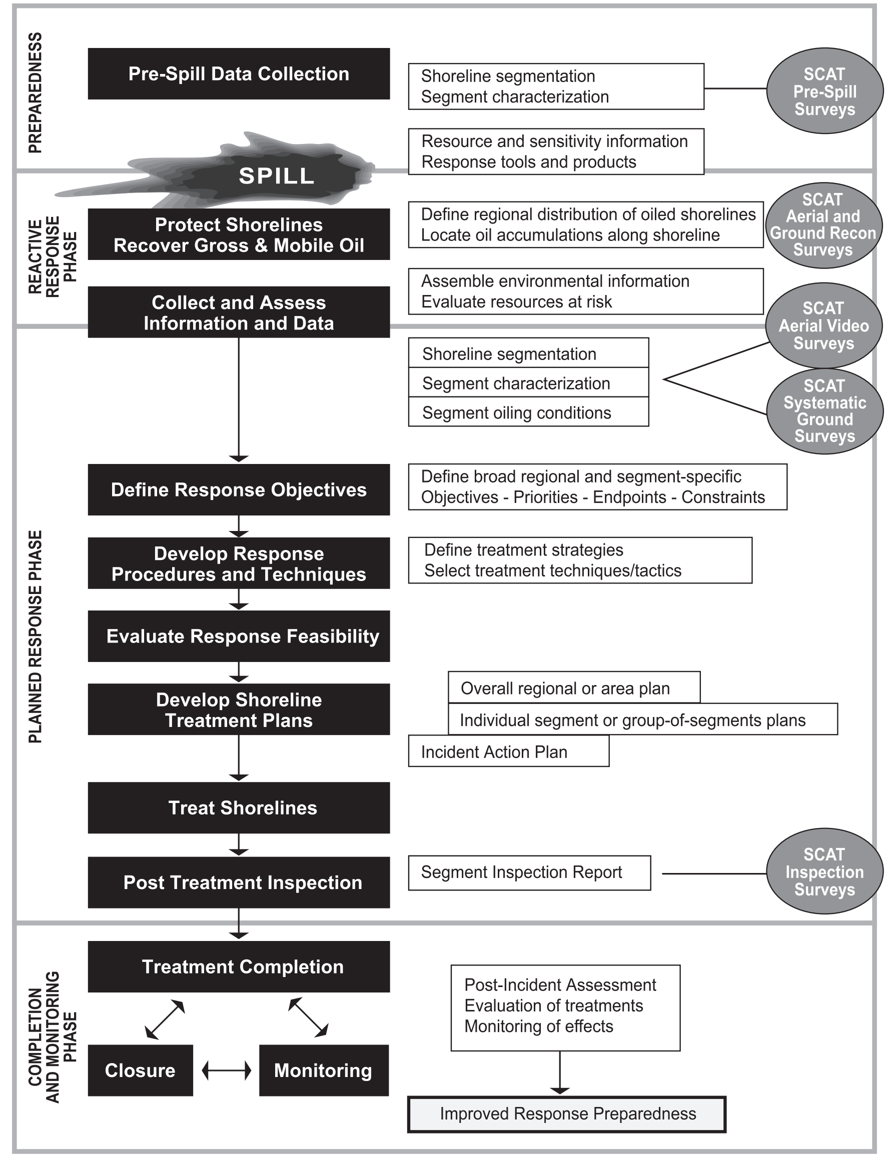

Figure 2 Oiled Shoreline Treatment Decision Process

10 STEP-BY-STEP GUIDE TO DEFINING TREATMENT ENDPOINTS BY QUALITATIVE FIELD OBSERVATIONS[4]

Basis - These are straightforward, non-numerical standards based on the presence or absence of oil with optional descriptors on character and/or behaviour and/or location of oil.

Measurement Techniques - A "yes/no" judgement on attainment of the endpoint is made by direct visual observations at ground level and/or aerial observations and/or photography.

Instructions - Complete and repeat the process as many times as necessary to establish a set of endpoints.

The endpoint definition would take a form similar to the following.

No Observed	(**Oil Character**)	at/on	(**Location**)
	Step 1		Step 2

Step 1 Describe the character of the oil as one of the following.

→

- Oil
- Sticky oil
- Mobile oil
- Oil residue
- Tar balls
- Floating oil
- Oil sheen
- Oiled debris
- Other (define)

[4] For presentation purposes, qualitative and quantitative field measurements have been separated. In practice, the first two steps are identical in each method and both types of endpoints could be found in most spills.

Step 2 Select a location if necessary to further define oil presence.

- All locations, i.e., applies everywhere in that segment
- Surface or subsurface sediments
- Shore zone →
  - Lower intertidal zone
  - Mid-intertidal zone
  - Upper intertidal zone
  - Supratidal zone
  - Backshore
- Type of habitat/use
  For example, mouth of a stream used by anadromous fish
- Type of substrate →
  - Bedrock
  - Unconsolidated
  - Boulder
  - Cobble
  - Pebble
  - Granule
  - Sand
  - Mud/silt/clay
  - Organic/Peat/Soil
  - Live Vegetation
  - Man-made solid
  - Man-made permeable
- Type of shoreline →

Marine	Freshwater
Bedrock – Cliff/vertical	Bedrock – Cliff/Ramp
Bedrock – Sloping/ramp	Bedrock – Platform/Shelf
Bedrock – Platform	Man-made Solid
Man-made Solid	Glacier/Ice shelf
Glacier/Ice shelf	Man-made permeable
Man-made permeable	Sediment cliff
Sand beach	Mud/Clay bank
Mixed sediment beach	Sand beach/bank
Pebble/cobble beach	Mixed sediment beach/bank
Boulder beach	Pebble/cobble beach/bank
Mud flat	Boulder beach/bank
Sand flat	Peat/Organic beach/bank
Mixed sediment flat	Mud flat
Pebble/cobble/boulder flat	Sand flat
Wetland	Mixed sediment flat
Peat shoreline	Vegetated bank
Tundra cliff – ice rich	Marsh
Tundra cliff – ice poor	Swamp
Inundated low-lying tundra	Bog/Fen
	Wooded upland

- Other (define)
  For example, stems of vegetation

Examples of Endpoints Measured by Qualitative Field Observations

- NO visible surface oil
- NO mobile oil
- NO sticky oil
- NO oil/oiled debris that could contact/effect wildlife
- NO oil on beaches in front of resorts
- NO oil sheening from shoreline substrates
- NO mobile oil that could be released by wave and tidal action
- NO oil in the mid- or upper intertidal zone
- NO recoverable floating oil
- NO subsurface or buried oil

11 STEP-BY-STEP GUIDE TO DEFINING TREATMENT ENDPOINTS BY QUANTITATIVE FIELD MEASUREMENTS AND OBSERVATIONS

Basis - These endpoints are based on the presence of oil that exceeds specified conditions with regard to location, surface distribution, size/area, thickness, and character of the oil. One or more of the conditions are numerical. The conditions are identical to the standard terminology for describing oiling conditions in the Shoreline Treatment Assessment Team (SCAT) approach (Owens and Sergy, 2000; 2004).

Note: As discussed in "The SCAT Manual" (Owens and Sergy, 2000), the parameters 'distribution', 'width', and 'size' can be combined into categories to rate the degree of oiling, e.g., "heavy, moderate, light". This practice is NOT recommended for the purpose of setting endpoints.

Measurement Technique - Endpoints are determined by visual observation and visual measurement of the quantity and character of oil using the SCAT methodology and terminology or similar techniques. SCAT terminologies are listed in the boxed text.

Instructions - Complete and repeat the process as many times as necessary to establish a set of endpoints for surface oil and subsurface oil.

For Surface Oil

Complete Step 1 + Step 2 + [Step 3 and/or Step 4 and/or Step 5]

Note that Steps 1 and 2 are identical to those for selecting qualitative endpoints. Steps 3, 4, and 5 add the numerical criteria.

The endpoint definition would take a form similar to the following.

No Observed	(Oil character)	at/on	(Location)	with >	(Thickness)	and/or	(Distribution)	and/or	(Size)
	Step 1		Step 2		Step 3		Step 4		Step 5

Step 1 Describe oil character as one of the following.

- Oil
- Fresh oil
- Sticky oil
- Mobile oil
- Oil residue
- Tar balls
- Oiled debris
- Other (define)

Step 2 Select a location, or combination of locations, to which this condition applies.

- All locations, i.e., applies everywhere in that segment
- Shore Zone →
  - Lower intertidal zone
  - Mid-intertidal zone
  - Upper intertidal zone
  - Supratidal zone
  - Backshore
- Type of Habitat/Use
  For example, mouth of stream used by anadromous fish
- Type of Substrate →
  - Bedrock
  - Unconsolidated
  - Boulder
  - Cobble
  - Pebble
  - Granule
  - Sand
  - Mud/silt/clay
  - Organic/Peat/Soil
  - Live Vegetation
  - Man-made solid
  - Man-made permeable

- Type of Shoreline →

Marine	Freshwater
Bedrock – Cliff/vertical	Bedrock – Cliff/Ramp
Bedrock – Sloping/ramp	Bedrock – Platform/Shelf
Bedrock – Platform	Man-made Solid
Man-made solid	Glacier/Ice shelf
Glacier/Ice shelf	Man-made permeable
Man-made permeable	Sediment cliff
Sand beach	Mud/Clay bank
Mixed sediment beach	Sand beach/bank
Pebble/cobble beach	Mixed sediment beach/bank
Boulder beach	Pebble/cobble beach/bank
Mud flat	Boulder beach/bank
Sand flat	Peat/Organic beach/bank
Mixed sediment flats	Mud flat
Pebble/cobble/boulder flat	Sand flat
Salt marsh	Mixed sediment flat
Tundra cliff – Ice-Rich	Vegetated bank
Tundra cliff – Ice-Poor	Marsh
Peat shoreline	Swamp
Inundated low-lying tundra	Bog/Fen
	Wooded upland

- Other (define)
  For example, stems or reeds

Step 3 If applicable, select the maximum thickness of surface oil.

Thick:	Accumulation >1 cm
Cover:	>0.1 cm and <1 cm
Coat:	>0.01 cm and <0.1 cm. Can be scratched off with fingernail on coarse sediments or bedrock.
Stain:	<0.01 cm thick. Cannot be scratched off easily on coarse sediments or bedrock.
Film:	Transparent/translucent film or sheen.

Step 4 If applicable, select maximum surface oil distribution (% of surface covered by oil).

By a specific unit percentile, e.g., 25%

By distribution category →

Trace (TR)	<1%
Sporadic (SP)	1–10%
Patchy (PT	11–50%
Broken (BR)	51–90%
Continuous (CN)	91–100%

Step 5 If applicable, specify the size of the area to which this condition applies in terms of:

Along-shore **length*** and/or
Across-shore **width**** and/or
Diameter

* **Length** refers to the along-shore distance (parallel to the shoreline) of the oiled area within a segment, sub-segment, or zone.
** **Width** refers to the average across-shore distance (perpendicular to shore) of the intertidal oil band within a segment, sub-segment, or zone.

For Subsurface Oil

Complete Step 1 + [Step 2 and/or Step 3 and/or Step 4]

The endpoint definition would take a form similar to the following.

No Observed	(Oil character)	at/on	(Location)	with >	(Depth/Thickness)	and/or	(Size)
	Step 1		Step 2		Step 3		Step 4

Step 1 Describe oil character/concentration as one of the following.

Oil: All and any oil

Oil-filled pores: Pore spaces in the sediment matrix are completely filled with oil. This is often characterized by oil flowing out of the sediments when disturbed.

Partially filled pores: Pore spaces are filled with oil, but oil generally does not flow out when exposed or disturbed.

Oil Residue as a Cover (> 0.1 to 1 cm) or Coat (0.01 to 0.1 cm) of oil on sediments and/or some pore spaces partially filled with oil. Oil can easily be scratched off with fingernail on coarse sediments or bedrock.

Film or Stain (< 0.01 cm) of oil residue on the sediment surfaces. Non-cohesive. Oil cannot easily be scratched off on coarse sediments or bedrock.

Trace: Discontinuous film or spots of oil on sediments or an odour or tackiness with no visible evidence of oil.

No Oil: No visible or apparent evidence of oil.

Other (define)

Step 2 If applicable, select location or combination of locations to which this condition applies. Follow the instructions for Step 2 of surface oil.

Step 3 If applicable, describe allowable conditions in terms of vertical distribution:

- maximum depth of penetration or burial; and
- maximum thickness of oiled lens.

Step 4 If applicable, specify the maximum area to which this condition applies in terms of:

Along-shore **length*** and/or
Across-shore **width**** and/or
Diameter

*Length refers to the along-shore distance (parallel to the shoreline) of the oiled area within a segment, sub-segment, or zone.
**Width refers to the average across-shore distance (perpendicular to shore) of the intertidal oil band within a segment, sub-segment, or zone.

Examples of Endpoints Measured by Quantitative Field Observations

- NO surface oil patches of 100% coverage >3 mm thick and 50 x 50 cm in area
- NO oil >20% surface oil coverage >10 m long
- NO surface oil patches >1 m wide and >3 mm thick
- NO liquid oil patches >1 m in diameter that could be remobilized
- NO tar balls over 1 cm in diameter and >5% surface distribution
- NO oil over 0.01 cm thick and 30% coverage on bedrock
- NO oil stains on sand >5% coverage
- NO oil patches >3 cm across that could contaminate wildlife
- NO oil on >30% of vegetation stems
- NO fresh or sticky oil on >10% of vegetation stems
- NO oil with >20% distribution as 'coat' on cobble fronting First Nation land
- NO subsurface oil >10 cm deep
- NO subsurface tar patties and tar balls more than 2 cm in diameter
- NO "available" subsurface pooled oil

12 TREATMENT ENDPOINTS BY ANALYTICAL MEASUREMENTS

This category of endpoints is determined by analytical as opposed to visual measurements. As such, they have a significantly longer response time and higher cost. The analytical approach typically requires the collection of representative field samples of various media and subsequent instrumented analysis in a laboratory. Chemical analyses may be used to measure the concentration of oil or specific chemicals. Toxicological analyses may be used to measure the response of test organisms to toxic effects. Organoleptic analysis may be used to determine human detection to offensive odours. In addition to laboratory analysis, there is a limited selection of field analytical tools that can be used to measure endpoints.

Chemical Analyses

- Based on the analytical measurement of the concentration of oil or of a specific chemical in a sample.
- Requires a definition of the:
  - prescribed substance: oil, individual constituent, or compounds;
  - nature of the sample media;
  - acceptable concentration or concentration per unit area;
  - sample collection methodology; and
  - laboratory analytical methodology and data analysis procedures.
- Examples of Endpoints
  - total petroleum hydrocarbons (TPHs) in oiled intertidal sediments not to exceed an average concentration of 10 ppm (with reference on how to measure TPH), sample size, depth and placement, and number of samples per unit area of beach;
  - < 0.002 mg/L of benzene in sediment pore water (with methods reference);
  - <100 ppm TPH at a 500-foot interval on a sand beach (with methods reference); and
  - not to exceed U.S Environmental Protection Agency (U.S. EPA) and state primary maximum contaminant levels for BTEX (benzene, toluene, ethylbenzene, and xylenes).

Toxicological Analyses

- Based on the measured response of test organisms to the toxic effects of a sample.
- Requires specifications on:
  - the type of bioassay, test organism, test duration, and the endpoint. Includes acute and chronic and lethal and sub-lethal testing. (Note: Environment Canada has a broad series of standardized biological test methods). Example assays include: 96-hour rainbow trout acute lethality test; amphipod, 28-day survival, growth, reproduction assay; sea urchin fertilization; sediment pore water test.
  - the sample and how to collect it;
  - the bioassay pass/fail criteria; and
  - data analysis and application.

- Examples of Endpoints
  - 96-hour LC50 value (lethal concentration to 50% of the test organisms) for local fish species;
  - chronic EC20 value (lethal concentration to 20% of the test organisms) for BTEX, naphthalene, and gasoline range hydrocarbons;
  - acute to chronic toxicity ratios for spawning habitats of local fish species;
  - acute to chronic toxicity ratios for non-critical habitats; and
  - U.S. EPA limits for toxicity characteristic leaching procedure for benzene and metals.

Organoleptic Analyses

- Based on human detection of offensive odours.
- Requires specifications on:
  - the sample type and collection procedures; and
  - the assay methodology and pass/fail criteria.
- Examples of Endpoints
  - "Is there an unacceptable odour remaining in beach sediment?" (with reference to the detection methodology)
  - "Is there an unacceptable odour in the flesh of cooked lobster?" (with reference to detection methodology).

13 TREATMENT ENDPOINTS BY INTERPRETIVE IMPACT ASSESSMENT

Interpretive Impact Assessment Methods develop treatment endpoints based on an evaluation of impacts or risk of impacts on the system. They can include environmental, social, economic, and/or cultural factors. Typically, this approach could address the following types of questions.

- Is the remaining oil likely to have an unacceptable ecological, aesthetic, recreational, or economic impact?
- Will further oil removal cause environmental damage?
- Are the costs of further cleanup or treatment excessive in relation to the threat or benefit?

The concept of using risk assessment to make go and stop decisions on oil spill treatment has been in place for decades. Different methods have been developed and applied, but all have a similar theme or intent.

Common terms that embody the concept include:

- As Low As Reasonably Practical (ALARP);
- Minimum regret strategy;
- Lowest Practicable Level of Contamination (LPLC);
- Net Environmental Benefit Analysis (NEBA).

The ALARP principle is that the residual risk shall be "as low as reasonably practicable". In the UK the equivalent phrase is "so far as reasonably practical" (SFARP). Both are regarded as best common practice of judgement in the evaluation of the balance of risk and benefit. LPLC is a legal term defined in Alaskan state law which requires that spillers clean up a discharge until the lowest practicable level of contamination is achieved. The State of Alaska determines the lowest practicable level of contamination based on several items including protection of human health, safety, and welfare, and of the environment; the nature and toxicity of the hazardous substance; the extent to which the substance has migrated or is likely to migrate; and the natural dispersion, attenuation, or degradation of contamination. NEBA is one of the better known impact assessment methods and has been well described by Baker (1995) and IPIECA (2000). The NEBA approach typically considers different levels of treatment or cleanup, i.e., concentrations of remaining oil, levels of cleanup effort, and environmental intrusion, and relates these to oiling conditions in the context of (a) potential risks to human health, (b) potential risks to activities related to human use, (c) environmental recovery rates, and (d) potential collateral or ancillary effects (see Figure 3).

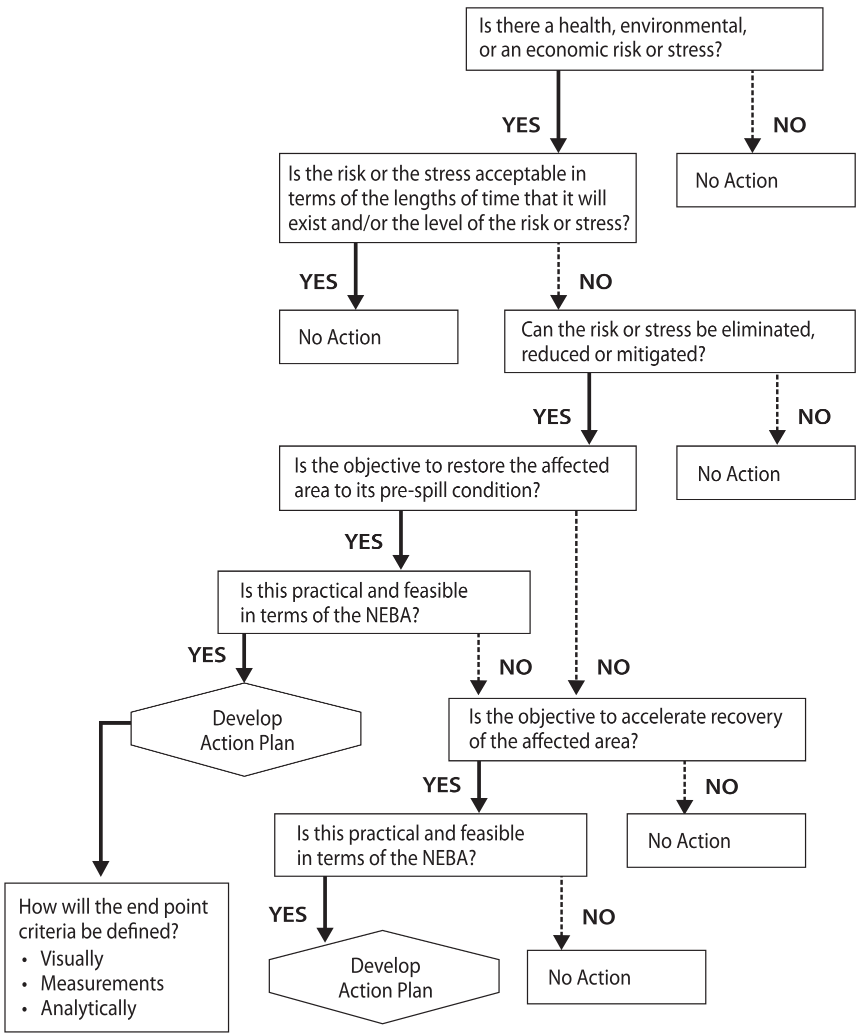

Figure 3 A Decision Tree for Treatment using NEBA Principles

Whatever the name or method, an important and common constant is that interpretive impact assessment methods all are subject to personal judgement. The actual technique can vary greatly in detail and complexity. It can involve a detailed, multi-factor synthesis using a combination of qualitative, quantitative, and/or descriptive indicators and may use techniques similar to those in environmental impact risk assessment studies. On the other hand, it can be a subjective judgement call based on a simple criterion and the evaluator's own experience.

Using a Simplified Impact Assessment Endpoint

Although endpoints based on qualitative and/or quantitative field measurements are generally recommended as the first option, there are circumstances when some type of impact assessment method is required or preferred. It is recommended, whenever feasible, to keep the process relatively simple with clear principles. A simplified impact assessment endpoint determination could be used when:

- there is a concern that further treatment will cause unacceptable impact or damage over and above that of the oil;
- it is difficult to define those boundaries based on oil concentration/distribution measurements and/or precise textual or visual depictions;
- it is possible to isolate the indicator or simplify the decision, for example, "no visible submerged oil in reeds, unless further oil recovery dislodges unacceptable number of new-growth shoots".

It is usually environmental impact that is the issue of concern, with wetlands/marshes being the classic example. However, there can also be critical social, economic, or cultural concerns that trigger a situation-specific assessment.

Whatever the situation, the impact assessment endpoint is usually characterized as requiring:

- a judgement call (a stop-cleanup decision) be made by an experienced assessor/technical specialist; and/or
- relatively close monitoring during the treatment phase.

14 REFERENCES

Baker, J.M., "Net Environmental Benefit Analysis for Oil Spill Response", *Proceedings International Oil Spill Conference*, American Petroleum Institute, Pub. No. 4620, Washington, DC, pp. 611–614, 1995.

Baker, J.M., "Differences in Risk Perception: How Clean is Clean?", issue paper prepared for the 1997 International Oil Spill Conference, American Petroleum Institute, Technical Report IOSC-006, Washington, DC, 52 p., 1997.

Dicks, B., H. Parker, K. Purnell, and R. Santner, "Termination of Shoreline Cleanup - A Technical Perspective", *Proceedings of the Technical Lessons Learnt from the Erika Incident and Other Oil Spills*, CEDRE, Brest, 12 p., 2002.

IPIECA, "Choosing Spill Response Options to Minimize Damage (NEBA)", IPIECA Report Series, Volume 10, International Petroleum Industry Environmental Conservation Association, London, UK, 20 p., 2000.

Owens, E.H. and G.A. Sergy, "The SCAT Manual - A Field Guide to the Documentation and Description of Oiled Shorelines", Second Edition, Environment Canada, Edmonton, AB, 108 p., 2000.

Owens, E.H. and G.A. Sergy, "Treatment Criteria and Endpoint Standards for Oiled Shorelines and Riverbanks", Manuscript Report EE-171, Environmental Protection Service, Environment Canada, Ottawa, ON, 2003.

Owens, E.H. and G.A. Sergy, "The Arctic SCAT Manual: A Field Guide to the Documentation of Oiled Shorelines in Arctic Environments", Environment Canada, Edmonton, AB, 172 p., 2004.

Owens, E.H., H.A. Parker-Hall, G.S. Mauseth, A. Graham, T. Allard, P.D. Reimer, J.W. Engles, S. Lehmann, J. Whitney, S. Penland, C. Williams, and C. Wooley, "Shoreline and Surveillance Surveys on the *M/V Selendang Ayu* Spill Response, Unalaska Island, Alaska", *Proceedings of Twenty-eighth Arctic Marine Oilspill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, pp. 509-525, 2005.