SUBSURFACE OIL DETECTION AND DELINEATION IN SHORELINE SEDIMENTS

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Abstract

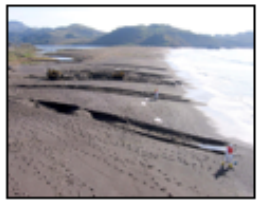
Oil deposited on shorelines during oil spill events can penetrate into sediments, be mixed with underlying sediments, and/or be buried by natural shoreline processes. The resulting subsurface accumulations can consist of a continuous layer or layers of solid or emulsified oil, oil-saturated sediments, or scattered discontinuous deposits. Field surveys to detect, delineate and understand the characteristics of subsurface oiling are essential in the development of shoreline treatment end points and cleanup plans. A key factor when choosing survey techniques is to compare detection efficiencies. Although there exist a variety of survey techniques for vertical delineation of subsurface oiling, there are currently no proven efficient methods for horizontal delineation. Current accepted tactics, such as pitting, trenching and augering, are time consuming and labor intensive and provide a relatively small sample of the horizontal distribution and character of subsurface deposits. This study describes an ongoing API project to investigate potential innovative methods for subsurface oil detection.

Project Phases

Phase 1: Published the 2013 API Report (1149-1) that describes current best practice and identifies promising detection techniques;

Phase 2: Published the 2013 API "*Field Guide to the Detection and Delineation of Subsurface Oil in Shoreline Segments*" (Report 1149-2), based on current technology and practices, and a report (in press) that assesses prospective new technologies and includes recommendations for R&D studies appropriate to advance the application of these options; and

Phase 3: Develop of a guidance report on Detection Dogs and planning for the implementation of laboratory and field tests/trials to develop and verify the applicability of high potential subsurface oil detection techniques (planned/ongoing).



Attributes Considered

Scope: Individual tactics may not collect all of the required data. Combinations of existing and developing tactics are acceptable as long as they contribute to improve of the speed, quality and economics of data collection.

Availability: Any necessary equipment, trained operators and/or other support services should be readily available.

Calibration: Calibration requirements should be minimal and, preferably, field rather than laboratory protocols.

Data Turn-around Time: Observations are extremely time sensitive and should be available to the Spill Management Team on a near real-time basis (i.e. a time scale of days). Immediate data processing and presentation of summary information is crucial to the decision process.

Delineation of Extent: Sufficient detail should be provided to delineate the extent and the distribution of subsurface oil deposits both horizontally and vertically. This information may include: depth and thickness of oil or oiled sediment layer(s), characteristics and distribution of oil within those layer(s), and properties of shoreline sediments (grain size, mineralogy, water content/depth to beach groundwater, presence of burrows, sediment bearing capacity, etc.).

Detection Levels: Detection levels must be consistent with the requirements of each situation. At a minimum, observations should be consistent with SCAT definitions (typically visual). Some promising technologies can offer much higher detection levels. In these cases, speed, reliability and cost factors should be considered.

Location Control (vertical and horizontal): Precise positioning is essential in all surveys. Current practice increasingly relies upon GPS positioning/tracking equipment and GIS data management. High precision GPS and real-time data reduction are desirable

Cost: The relative cost of the methods (including equipment, personnel and logistics) aids decision-making and planning

User's Guide Matrix – Current Practices:

	Pits / Trenches			Cores			Water Jets	UV Handheld
	Manual	Mechanical	Snorkel	Manual	Auger / Probe	Vibrate		
Depth (m)								
< 0.5	√	√	?	√	–	–	√	√
< 1.0	√	√	–	√	√	√	√	√
< 2.0	–	?	–	?	√	√	√	√
> 2.0	–	–	–	?	√	√	√	√
Oil Character								
Fresh	√	√	√	√	√	√	√	√
Emulsion	√	√	√	√	√	√	√	√
Weathered	√	√	√	√	√	√	√	?
Tar balls	√	√	√	√	√	√	√	?
Pavement	√	√	?	√	√	√	√	?
Subsurface Distribution								
Vertical	√	√	?	√	√	√	√	√
Horizontal	–	–	–	–	–	–	–	?
Moisture								
Dry	?	?	–	√	√	√	√	√
Damp	√	√	–	√	√	√	√	√
Saline	√	√	–	√	√	√	√	√
Saturated (wet)	–	–	√	–	√	√	√	√
Grain size								
Clay/Silt	√	√	?	?	√	?	?	√
Sand/granules	√	√	√	√	√	√	√	√
>Granules	?	√	?	–	?	?	?	√
Sensitivity								
Presence (ON/T)	√	√	√	√	√	√	√	√
Depth Discrimination	√	√	?	√	√	√	?	√
Layer Discrimination	√	√	?	√	√	√	?	√
Tar / SPBs	√	√	?	√	√	√	?	√
Sub - Water table	√	√	–	√	√	√	?	?
Trace Level - Subsurface	–	–	–	–	–	–	–	–

√ = tactic operational under most conditions
? = tactic operational in most cases, subject to incident conditions,
– = tactic of limited applicability or not generally applicable

Screening Tool: Physical Conditions:

Comparison of Attributes of Existing and Developing Technologies:

- **Green** indicates a favorable application
- **Yellow** indicates that the strategy may be effective, depending on circumstances,
- **Red** indicates important limitations or 'not applicable'

User's Guide Matrix – Potential Practices:

	Service Dogs	In situ Sensor Probes	Geophysics GPR	Geophysics ESI / ER	Gas Detectors
Depth (m)					
< 0.5	√	?	?	?	√
< 1.0	√	?	?	√	√
< 2.0	√	√	√	√	√
> 2.0	?	?	√	√	√
Oil Character					
Fresh	√	√	√	√	√
Emulsion	√	√	√	√	?
Weathered	√	√	√	√	?
Tar balls	√	√	?	√	?
Pavement	√	√	√	√	?
Subsurface Distribution					
Vertical	–	√	?	?	–
Horizontal	–	–	√	√	√
Moisture					
Dry	√	√	√	?	√
Damp	√	√	?	√	√
Saline	√	√	–	√	√
Saturated (wet)	–	?	–	–	?
Grain size					
Clay/Silt	?	√	√	√	?
Sand/granules	√	√	√	√	√
>Granules	√	√	√	√	√
Sensitivity					
Presence (ON/T)	√	√	–	?	√
Depth Discrimination	–	√	√	?	–
Layer Discrimination	–	√	√	?	–
Tar / SPBs	√	?	?	?	?
Sub - Water table	–	√	–	–	–
Trace Level - Subsurface	?	?	–	–	?

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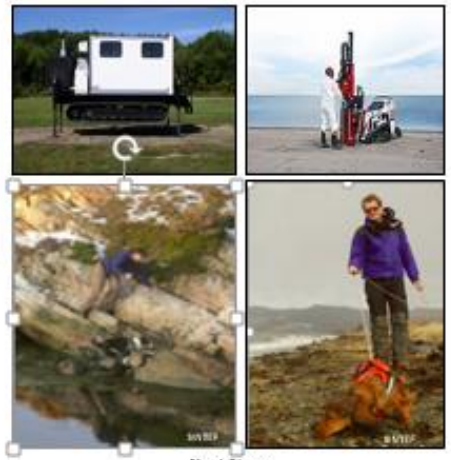
– = tactic of limited applicability or not generally applicable



Next Steps

Phase 1 has identified a number of procedures and technologies that promise to significantly improve emergency response capabilities in the detection and delineation of oil buried on sediment shorelines. Many of these procedures are ready for field trials, but some would benefit from additional development efforts.

Push Probe Technology
- Wide variety of useful high quality data
- May be more appropriate for NRDA and calibration of other field detection and delineation procedures and equipment
- Ready for field trials on actual spills

Detection Dogs
- Proven technology for subsurface oil detection, for example, in Norwegian field projects (see photos courtesy SINTEF)
- Can utilize existing trained commercial teams based on "match the sample"
- Recommended studies: Evaluation of subsurface gradients and boundary identification; conduct field exercises and tests to gain acceptability and credibility: take advantage of "spills of opportunity"

Geophysical Techniques
- Mixed results for delineation of buried oil on shorelines
- Very rapid, minimal resources required, real-time data possible
- Recommended study: Comparative testing

Gas Measurements
- Promising technology with new systems that can detect and measure total hydrocarbons rather than just methane and ethane
- Recommended study: Sensitivity evaluation

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