

Canine Oil Detection: Field Trials Report

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Executive Summary

- Field Trials were undertaken in June 2015 to evaluate the applicability of canine oil detection teams (referred to as K9-SCAT) to support assessment surveys to locate and delineate the horizontal extent of subsurface oil for shoreline and inland spills response operations. The study is part of the American Petroleum Institute (API) Joint Industry Task Force (JITF) Shoreline Protection & Clean-Up Technical Working Group within the Oil Spill Preparedness and Response program.
- The trials involved:
 - o two detection canines imprinted with a West Texas Intermediate crude oil,
 - o a certified handler who had no knowledge of the target locations,
 - o evaluation of two survey techniques: an off-leash Wide Area Search (WAS) procedure and an on-leash Delineation procedure, and
 - o recording using documentation forms and by videotape.
- Seven (7) WAS tests were conducted on open fields to evaluate the ability to rapidly survey a 0.5 ha (1.2 acre) area to either detect a single shallow target or to “clear” the area if no oiled sediment targets had been deployed.
 - o In terms of accuracy, the teams detected and located each WAS target during four (4) tests and cleared (No Oil Detected) the areas searched during the other three (3) tests with no false alerts, equating to **100% accuracy**.
 - o In terms of performance, the WAS tests were equivalent to a survey rate of **2 km/hour**, or on the order of 15–25 linear km/day, for a High Confidence-Low Risk survey with 100% coverage of a 50-m wide shoreline or pipeline Right of Way.
- Fourteen (14) Delineation search tests involved a gridded layout within a 1,250 m² area using six (6) different target designs to represent continuous, discontinuous and isolated subsurface oil distributions, as well as a linear pipeline scenario. Oiled sediment targets were “buried” at depths between 30 and 90 cm (12 and 36 in.).
 - o Oil was detected at all depths up to 90 cm (36 in.).
 - o In terms of accuracy, two (2) of the 704 oiled sediment and non-oiled targets that were deployed were misidentified for undetermined reasons: twenty (20) targets were misidentified due to survey or experimental issues that were not attributed to the canines, equating to **99.7% accuracy**.
 - o In terms of performance, the average time for the fourteen 1,250 m² Delineation tests was eleven (11) minutes for 100% ground coverage.
- Trained canine detection teams are a non-labor intensive tactic. The study demonstrated the ability to rapidly detect and delineate subsurface oil, and their potential application for subsurface leak detection (including pipelines).
- The survey speed for subsurface oil detection searches or for area clearance is orders of magnitude faster and has greater coverage than can be achieved by pedestrian or vehicle-mobile SCAT teams.

- Canine oil detection teams could be deployed in support of shoreline or inland (lake, river, and terrestrial) assessment (SCAT) programs. Maximum effectiveness can be achieved through coordination with SCAT personnel who are familiar with subsurface oil documentation and canine search procedures and requirements. K9-SCAT is proposed as a designation for the combined canine oil detection/delineation survey capability.

Contents

Executive Summary	v
1 Introduction.....	1
1.1 Study Program	1
1.2 Previous Studies	2
1.3 Acknowledgements	3
2 Objectives.....	3
2.1 Study Objective	3
2.2 Specific Field Trial Objectives	4
3 Field Preparation.....	4
3.1 Schedule	4
3.2 Planning Meetings.....	4
3.3 Field Site Preparation.....	5
3.4 Checklists and Forms.....	8
4 Field Trials.....	13
4.1 Planning and Protocols	13
4.2 Wide Area Search Procedure	15
4.3 Delineation Procedure.....	16
4.4 Test Layout Designs	16
4.5 Procedural Issues	18
4.6 Schedule	19
4.7 Visitor Program.....	19
5 Field Trial Data.....	20
6 Field Trials Results.....	22
6.1 Designs and Field Implementation.....	22
6.2 Test Results	22
6.3 Key Learning Points	23
6.4 Visitor Program.....	23
7 Discussion and Recommendations.....	24
7.1 Experimental Designs	24
7.2 Field Implementation.....	25
7.3 Other Recommendations	26
8 Conclusions.....	26
8.1 Proof of Concept	26
8.2 Designs and Field Implementation.....	26
8.3 Applications	27
9 References	27
Annex A—Test Data	29
Annex B—Examples of Completed Survey Forms.....	31
Annex C—Example GPS Track Maps	36
Annex D—Proposed Canine Oil Detection Team Guidelines.....	40
Annex E—Photography and Videography Log: Example Photographs	43
Annex F—K2 Solutions Report	48

List of Figures

Figure 3.1—Target 9% Oil in Sediment Mix	5
Figure 3.2—K2 Training Facility	5
Figure 3.3—Inner and Outer PVC Pipes for the Wide Area Search Tests	6
Figure 3.4—Target Grid for Delineation Tests—Schematic.....	6
Figure 3.5—Target Grid for Delineation—GPS Waypoints (Map Data: 2015 Google)	6
Figure 3.6—Buried “Outer” Tube	7
Figure 3.7—24 in. Length “Target” Tube.....	8
Figure 3.8—“Target” Tube Loaded in “Outer” Tube	8
Figure 3.9—Canine Oil Detection Field Trial Checklist.....	9
Figure 3.10—Equipment Checklist.....	10
Figure 3.11—Wide Area Search Survey Form.....	11
Figure 3.12—Delineation Survey Form.....	12
Figure 4.1—Layout Designs for Delineation Tests.....	17

List of Tables

Table 3.1—Field Trial Schedule	4
Table 4.1—Field Trial Weather Conditions	14
Table 4.2—Test Layout Design Descriptions.....	17
Table 4.3—Test Schedule	19
Table 5.1—Data Summary.....	20
Table 5.2—Survey Duration Times	21
Table 5.3—Survey Distances, Times, and Speeds.....	22
Table A.1—Field Trial Data Summary	21
Table A.2—Misidentified Targets	30

Canine Oil Detection: Field Trials Report

1 Introduction

1.1 Study Program

The Shoreline Protection & Clean-Up Technical Working Group of the American Petroleum Institute (API) Joint Industry Task Force (JITF) Oil Spill Preparedness and Response program has completed several studies to evaluate the current state-of-the-art in Subsurface Oil Detection and Delineation technologies in support of inland and shoreline oil spill response. The field trials documented in this report are part of Phase 3 of this program.

Phase 1

- Described the current best practices for subsurface oil detection in shoreline sediments and identified promising detection and delineation techniques (API, 2013a).

Phase 2

- Developed *Field Guide to the Detection and Delineation of Subsurface Oil in Shoreline Segments* (API, 2013b).
- Developed recommendations for the development and testing of emerging technologies that have a demonstrated application to shoreline, river and terrestrial oiling issues (API, 2014).

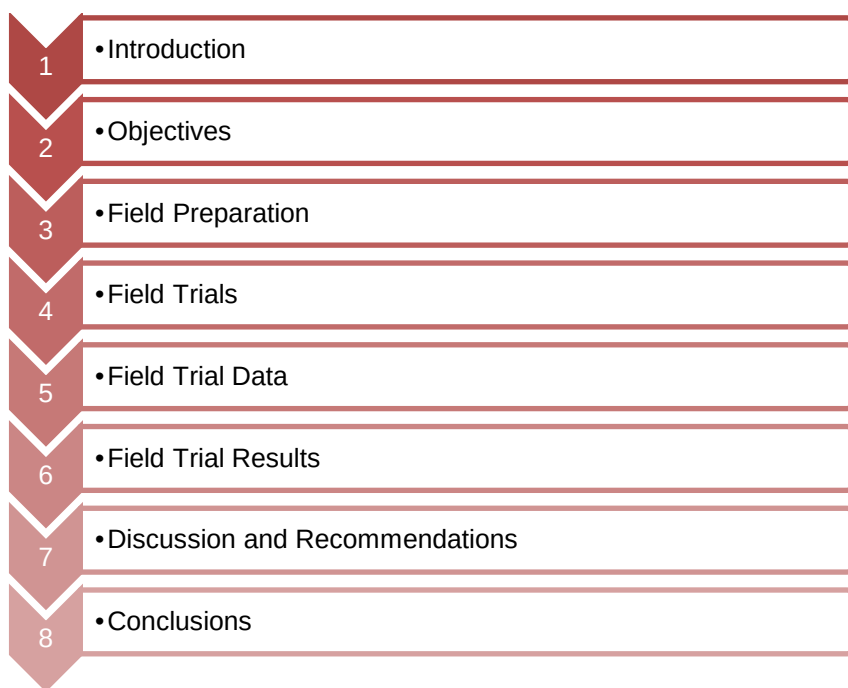
Phase 3

- (*this project*) Conducted field trials to demonstrate and evaluate the applicability of using oil detection canines and to identify further development options.
- (*in preparation*) Develop a Canine Spilled Oil Detection Guidance report for planners and decision makers.

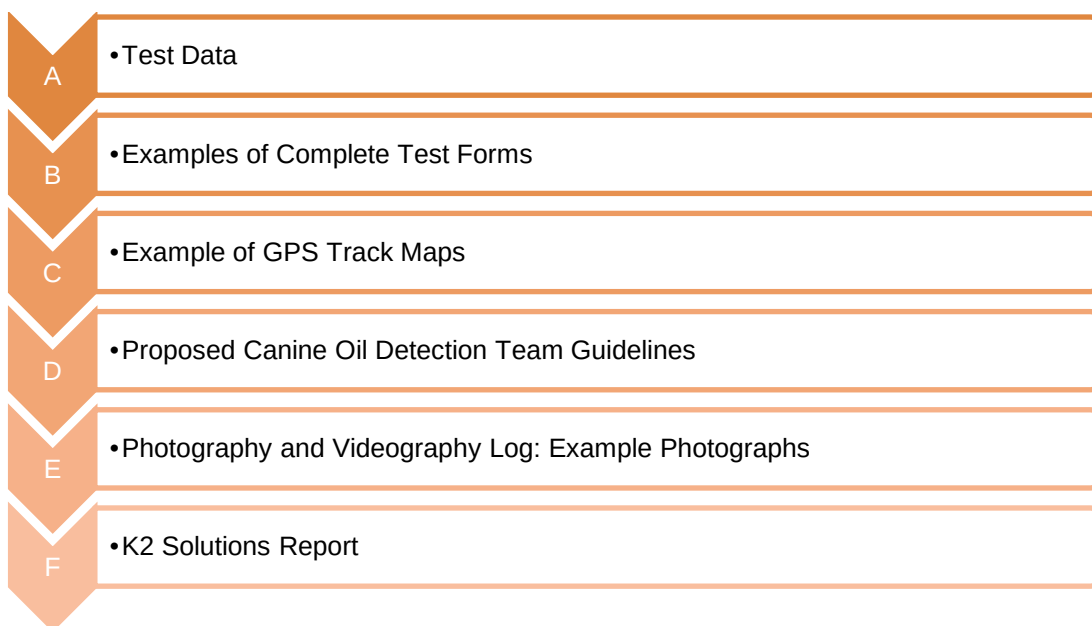
The Phase 2 recommendations identified significant potential for the use of oil detection canines to support Shoreline Cleanup Assessment Technique (SCAT) teams. This recommendation was implemented by way of the field trials that were conducted on 2–4 June 2015. The canine training and field trials were conducted at the K2 Solutions Inc. K9 Training Center in Jackson Springs, NC. A Visitor Program on 4 June enabled interested government and industry representatives to observe the detection teams in action.

The Field Trials were conducted under the direction of OCC with support by RCE Inc. and K2 Solutions.

The content and format of this report are summarized below:



The following Attachments provide additional data and information:



1.2 Previous Studies

Canine detection teams are used to locate a wide range of materials (e.g. drugs, accelerants, cadavers, and foods) (e.g. USDA, 2012; Ensminger, 2013), and the US military has routinely used canine teams for many years to detect mines and buried ordnance (e.g. Paterni, 2014; US Dept. of the Army, 2005; US Dept. of the Navy, 2012). An Internet search yields many references to the use of canines in a wide range of detection and tracking applications and many books have been published on the topic (e.g. Warren, 2015).

Detection canines have successfully located oil buried in sediments, and buried within ice and underwater during a series of field trials. The most rigorous field tests were conducted in Svalbard (Dickins et al., 2010) and were funded in part by MMS-BLM (now BOEMRE).

Since 2006, SINTEF and Trondheim Hundeskole (Trondheim Dog Training Academy) have verified that trained canines can detect oil residues in beach sediments or hidden in snow/ice (Brandvik and Buvik, 2007; Brandvik and Buvik, 2009; Buvik and Brandvik, 2009). The canines have been used in several spill response operational situations in Norway (Brandvik, 2009).

In North America and Europe, detection canines have located subsurface leaks, sometimes with the aid of an odorant injected into the pipeline (Canadian Energy Pipeline Association, 2012; K9 Pipeline Leak Detection, nd; The Sniffer, nd). In the UK, results of field trials on pipeline leaks report that trained canines were 96 per cent reliable in detecting leaks as small as 0.07 ml (Kerrigan, 2012; Penspen Integrity, 2010).

Research comparing detection canines with mechanical detection techniques identifies a number of advantages and limitations of both techniques, but concludes that canines are at least as accurate as mechanical tools and are more efficient and versatile (Furton and Myers, 2001). Quote: *“Overall, detector dogs still represent the fastest, most versatile, reliable real-time explosive detection device available. Instrumental methods, while they continue to improve, generally suffer from a lack of efficient sampling systems, selectivity problems in the presence of interfering odor chemicals and limited mobility/tracking ability.”*

With this information in mind, a recommendation was made to the API Shoreline Protection & Clean-Up Technical Working Group for a Phase 3 study to evaluate the applicability of a canine oil survey team to locate and delineate subsurface oil in support of a SCAT program.

1.3 Acknowledgements

The concept of canines to support shoreline oiling assessment surveys was initiated and pioneered by Per Johan Brandvik with SINTEF and Turid Buvik at the Trondheim Hundeskole (Trondheim Dog Training Academy).

At K2 Solutions, Paul Bunker was the program manager. Lindsey Dixon and Neil Copeland trained the two Labradors, Patton and Sam, who, along with their handler Neil, did all the work.

2 Objectives

2.1 Study Objective

The primary objective of the field trials for Phase 3 of the program was to:

- demonstrate and evaluate the applicability of canine oil detection teams to support assessment surveys to locate and delineate subsurface oil for shoreline and inland spills response operations.

Key elements of the trials were to:

- work and cross-train with the canine detection professionals at K2 Solutions,
- develop lessons learned for inclusion in a parallel API study in the same program to create a Canine Oil Detection Guidelines document for planners and decision makers, and
- based on the results of the trials, propose appropriate situations for which a Canine Oil Detection (K9-SCAT) team could usefully support an assessment (SCAT) survey related to pipeline or other land spills, river spills, marine shoreline spills, lake shoreline spills, or spills under ice or snow.

2.2 Specific Field Trial Objectives

The specific objectives of the canine oil detection team field trials included (not listed in any priority):

1. Demonstrating successful imprinting of a crude oil odor on two search-trained canines.
2. Evaluating trained canine teams to detect subsurface oil and clear non-oiled areas by Wide Area Search (off leash) surveys.
3. Evaluating the accuracy of delineation of various detailed configurations of subsurface oil using on-leash survey procedures for continuous, discontinuous, isolated and linear (pipeline) configurations.
4. Demonstrating the repeatability of the range of tests.
5. Documenting the activities with survey/evaluation forms for each test, GPS tracking, videography, and still photography.
6. Evaluating the coordination and training required between canine detection teams (canine and handler) and SCAT personnel.
7. Enabling government and industry representatives to observe the field demonstration of a Wide Area Search pattern and three Delineation tests, and allowing the team to receive input and answer questions from these stakeholders.

3 Field Preparation

3.1 Schedule

The schedule of the planning and execution of the field trials is provided in Table 3.1.

Table 3.1—Field Trial Schedule

2015	
28 April	Kick-off conference call meeting between OCC and K2 Solutions
Week of 4 May	K2 commenced oil imprinting of ready-trained detection canines
Week of 4 May	K2 mixed oil and sediment to allow weathering
Week of 11 May	K2 buried and set in place outer PVC tubes (Section 3.3.3)
Week of 11 May	K2 filled target (inner) PVC tubes—oiled and blanks (Sections 3.3.2 and 3.3.3)
1 June	Pre-trial team brief at K2 Solutions offices
2–4 June	Field Trials
4 June	Visitor Program (morning)

3.2 Planning Meetings

Two extensive planning meetings were held between OCC and K2:

- A Kick-off meeting (conference call) on 28 April 2015, during which the field trial schedule was confirmed, and the site layout, target set-up, and test documentation were agreed between the teams.
- A pre-trial brief at K2 Solutions facility on 1 June 2015, during which OCC and K2 shared knowledge of SCAT, subsurface oil detection, and the use of canines for detection. Test procedures, documentation and deliverables were confirmed during the meeting.

3.3 Field Site Preparation

3.3.1 Oil Mixing and Weathering

A commercially available Texas Intermediate Crude (www.texasrawcrude.com) was mixed with native (sandy) sediment from the K2 training facility at a ratio of 1:10, producing a 9% oil mix (Figure 3.1). The mix was allowed to weather naturally in the open for 24 hours prior to loading in the target tubes (see Sections 3.3.2 and 3.3.3).



Figure 3.1—Target 9% Oil in Sediment Mix

3.3.2 Wide Area Search

Two open fields within the K2 training facility grounds were chosen by K2 for the Wide Area Search (WAS) tests (WAS-1 and WAS-2 in Figure 3.2).



Figure 3.2—K2 Training Facility

The targets were prepared by placing 5 ml of the 9% oil/sediment mix at the bottom of two closed PVC 6 in. long “target” pipes (1½ in. diameter), which were then filled to the top with clean native sediment. An open “outer” (2 in. diameter) pipe was cut to aid the burial of the oiled target (Figure 3.3).



Figure 3.3—Inner and Outer PVC Pipes for the Wide Area Search Tests

3.3.3 Delineation Tests

Fifty (50) 2 in. internal diameter PVC “outer” tubes were buried in a 10 × 5 diagonal grid, spaced 5 m apart (Figures 3.4, 3.5, and 3.6) in the Delineation Test Area (DTA) field (Figure 3.2). The five end tubes (A1, C1, E1, B10, and D10) were 36 in. deep; the remainder was 24 in. deep. These outer tubes were open ended to allow drainage and prevent accumulation of rainwater.

	1	2	3	4	5	6	7	8	9	10		
A												A
B												B
C												C
D												D
E												E

Figure 3.4—Target Grid for Delineation Tests—Schematic



Figure 3.5—Target Grid for Delineation—GPS Waypoints (Map Data: 2015 Google)

Inner “target” PVC (1½ in. internal diameter) tubes were cut to 24 in. and 36 in. lengths, sealed at the bottom and filled with a range of different oiled sediment depth configurations and blanks (clean sediment) (Figure 3.8):

- Blank targets: 36 in. and 24 in. length tubes filled only with clean native sediment (no oil)
- 36 in. depth targets: 36 in. length tubes with 10 ml of 9% oil-sediment mix at the bottom and covered to the top with clean native sediment
- 24 in. depth targets: 24 in. length tubes with 10 ml of 9% oil-sediment mix at the bottom and covered to the top with clean native sediment
- 18 in. depth targets: 24 in. length tubes with 6 in. of clean native sediment, then 10 ml of 9% oil-sediment mix, and covered to the top with clean native sediment
- 12 in. depth targets: 24 in. length tubes with 12 in. of clean native sediment, then 10 ml of 9% oil-sediment mix, and covered to the top with clean native sediment.

The “target” tubes fit snugly into the buried “outer” tubes so that they could be easily and quickly deployed in different designs (see Section 4.4). Half of the target tubes were capped and half of the tubes were left open for 3 weeks prior to the field trials to allow further weathering. All tubes were stored outside. Loaded “target” tubes were capped during deployment handling to prevent cross contamination and spillage.



Figure 3.6—Buried “Outer” Tube



Figure 3.7—24 in. Length “Target” Tube



Figure 3.8—“Target” Tube Loaded in “Outer” Tube

3.4 Checklists and Forms

A series of checklists and forms were designed for use during the field trials:

- Canine Oil Detection Field Trial Checklist: A checklist of actions needed from planning to completion (Figure 3.9)
- Equipment Checklist: A checklist for equipment required for the canine trials (Figure 3.10)
- Canine Oil Detection Field Trial Survey Form: Wide Area Search (Figure 3.11)
- Canine Oil Detection Field Trial Survey Form: Delineation (Figures 3.12 and 3.13).

These checklists and forms will be revised for the API Canine Oil Detection Guidelines report based on lessons learned during their use on these trials.

Canine Oil Detection Field Trial Checklist	
1. PLANNING	
	Determine search type (Wide Area Search and/or delineation)
	Determine number of test designs
	Determine individual test designs and details (locations, materials, volumes, depths, substrate, etc.)
	Create/revise Survey Forms
2. INITIAL SET-UP	
	Dig and set target pipes in advance (to allow settlement)
	Record GPS waypoints/coordinates of each target pipe recorded (Target Form)
	Allow oils to weather (if desired)
	Load test materials into inner (training pipes) according to test designs, recording and labeling: • Training pipe number • Oil type • Oil volume/amount • Depth of oiling layer (cm–cm) • Cover material (sediment type, water, etc.)
3. DAY OF TRIAL - PREPARATION	
	Assign roles: • Observation and recording using Canine Oil Detection Field Trial Survey Form • Photography • Videography
	Synchronize the times on tracking GPS(s), camera and video-camera
4. INDIVIDUAL TEST PREPARATION	
	Set training pipes according to test design
	Record target locations (3) and descriptions (4) on Survey Form (can be done in advance if the layout design is already known)
	Allow to cook/settle (time?)
	Set up and locate video camera so that the search will be fully captured
5. INDIVIDUAL TEST EXECUTION	
	Attach GPS tracking device to canine, note device number
	Record general, weather (1) and team (2) information on Survey Form prior to test
	START TEST (note time on form)
	Note all alerts (including false alerts)
	Continue search until team indicates completion
	END TEST (note time on form)
	In comments box (5), note success/no success, any false alerts, missed targets, and other observations, photographs/videos taken, and who completed the form
	Repeat 4 through 5 for each test design
POST TEST	
	Download GPS device track lines
	Download photos/videos
	Collect and collate forms/data
FINALLY	
	Dispose of the oil and oiled materials appropriately (safely, legally)
	Produce Trial Report

Figure 3.9—Canine Oil Detection Field Trial Checklist

EQUIPMENT CHECKLIST: Canine Oil Detection Field Trials**INITIAL SET-UP**

- ☐ Target (outer) pipes cut to specified lengths
- ☐ Training (inner) pipes cut to specified lengths
- ☐ End caps for pipes
- ☐ Test material (i.e. oil, sediment for mixing, etc.)
- ☐ Cover materials (soil, sand, water, etc.)
- ☐ Nitrile gloves (for handling oil target tubes)

TRIALS

- ☐ Handheld GPS
- ☐ GPS Tracking device (fitted to canine collar)
- ☐ Camera
- ☐ Video camera
- ☐ Spare batteries for GPS, camera, video camera
- ☐ Tripod for video camera

- ☐ Smart phone with local weather information
- ☐ Canine Oil Detection Field Trial Survey Forms
- ☐ Clipboard
- ☐ Notebook (waterproof)
- ☐ Pens/pencils
- ☐ Survey flags to mark alerts

- ☐ Sturdy footwear (e.g. hiking boots)
- ☐ Sunglasses
- ☐ Hat
- ☐ Foul weather gear
- ☐ First aid kit
- ☐ Water

CANINE REQUIREMENTS

- ☐ Water
- ☐ Food
- ☐ Rewards
- ☐ Shelter
- ☐ Harness/leash

Figure 3.10—Equipment Checklist

CANINE OIL DETECTION FIELD TRIAL SURVEY FORM: WIDE AREA SEARCH

1. GENERAL INFORMATION						
Date: (dd/mm/yyyy)		Weather:	Sun / Clouds / Fog / Rain (circle)	Air Temp:		°F
Time Start: (24hr EST)		Humidity:	____ %	Wind Direction:		
Time End: 24hr (EST)		Pressure:	_____ mb rising / falling (circle)	Wind Speed:		mph
2. DOG TEAM						
Team Number:		Handler Name:				
Canine Name:		Tracking Collar #:				
Start Point:	Waypoint #:	Coordinates:				
3. TARGET LAYOUT						
Layout Design: (A, B, C...)						
Sketch:						
4. TARGET DESCRIPTION						
Target #	GPS Waypoint #	Coordinates	Oil Type/ Material	Oiling Depth (cm-cm)	Oil Volume	Substrate/ water cover
1						
2						
3						
4						
5						
6						
5. COMMENTS						
6. TEST RESULTS						
Target #	Oiled Target? (Y/N)	Result - Select only one				CORRECT (✓/ X)
		BLANK correct ignored	BLANK False alert	OILED correct identified	OILED not identified	
1						
2						
3						
4						
5						
6						
Photographs? Yes / No		Numbers: (-)		Video? Yes/ No		Video Time: (-)
Completed by:						

Figure 3.11—Wide Area Search Survey Form

CANINE OIL DETECTION FIELD TRIAL SURVEY FORM: DELINEATION

1. GENERAL INFORMATION										
Date: (dd/mm/yyyy)		Weather:	Sun / Clouds / Fog / Rain (circle)				Air Temp:	°F		
Time Start: (24hr EST)		Humidity:	_____ %				Wind Direction:			
Time End: (24hr(EST)		Pressure:	_____ mb rising / falling (circle)				Wind Speed:	mph		
2. DOG TEAM										
Team Number:						Handler Name:				
Canine Name:						Tracking Collar #:				
3. TARGET LAYOUT										
Layout Design: (A, B, C...)										
	1	2	3	4	5	6	7	8	9	10
A	○	○	○	○	○	○	○	○	○	○
B	○	○	○	○	○	○	○	○	○	○
C	○	○	○	○	○	○	○	○	○	○
D	○	○	○	○	○	○	○	○	○	○
E	○	○	○	○	○	○	○	○	○	○
4. TARGET DESCRIPTION										
Target #	Oil Type/ Material	Oiling Depth (cm-cm)	Oil Volume	Substrate/ water cover	Target #	Oil Type/ Material	Oiling Depth (cm-cm)	Oil volume	Substrate/ water cover	
A1					C6					
A2					C7					
A3					C8					
A4					C9					
A5					C10					
A6					D1					
A7					D2					
A8					D3					
A9					D4					
A10					D5					
B1					D6					
B2					D7					
B3					D8					
B4					D9					
B5					D10					
B6					E1					
B7					E2					
B8					E3					
B9					E4					
B10					E5					
C1					E6					
C2					E7					
C3					E8					
C4					E9					
C5					E10					
5. COMMENTS										
Photographs?	Yes / No	Numbers: (	-	)	Video?	Yes/ No	Video Time: (	-	)	
Completed by:										

Figure 3.12—Delineation Survey Form

4 Field Trials

4.1 Planning and Protocols

4.1.1 Design and Planning

- **Basic Premises.**
 - o Canines can detect a wide range of materials for which they are imprinted.
 - o The concept of subsurface oil detection by canines is based on the release, or venting, of molecules that move through a medium (sediment or water) to the surface.
 - o There are two types of environmentally affected scent molecules: ground scent and air scent. Dogs will use either/both to detect a target odor. Subsurface odor is detected at the point the molecules reach the surface of the substrate (ground scent). The odor carried on the air (air scent) can easily reach, and be detected, at 15–20 m under favorable conditions.
 - o Molecules contained within the surface soil structure (ground scent) can be detected by a trained canine that has been imprinted for that odor. The surface molecules are attached to grains of soil/sand, etc., and the canine's "sniffing" action either disturbs the molecules for investigation or soil/sand particles containing odor molecules are taken into the nose for investigation.
 - o Once in the air above the ground surface, the resulting oil odor plume can be detected by a trained detection canine that has been imprinted for that odor. The canine can detect the variance in the concentration of odor carried in the air, enabling the canine to follow the increasing odor concentration towards the source.
 - o The distance from the odor plume at which a canine can detect the odor is a function of many parameters and environmental variables. A typical minimum range for subsurface oil would be on the order of 15 to 20 m under ideal conditions, and 10 m or less in more challenging conditions. This range of 15 to 20 m was selected for planning purposes for this set of tests. During the Norwegian trials on ice, the air scent of a large surface snow-covered patch of oil (400 L) was detected 5 km downwind, and 400 mL of oil buried in ice at 30 cm was detected at distances on the order of 50 m (Brandvik and Buvik, 2009).
- **Canine Team (K2)—SCAT Liaison (OCC) Knowledge Exchange.** The assumption was made that spill response personnel and search canine teams would work together during a spill response, and would benefit from an exchange of objectives, data needs, and procedures used by each team. Planning meetings and discussions (by telephone and e-mail) and on-site presentations allowed the sharing of understanding and expectations.
- **Field Trials Canines and Handler.** Two K2 Labrador retrievers were selected for testing. Both canines had successfully completed prior detection training. A single certified canine handler worked with both canines during the familiarization and oil imprinting process (Section 2.1 in Annex F).
- **Oil Imprinting.** Two oils (West Texas Intermediate (WTI) Crude Oil and North Dakota Crude Oil) were obtained from www.onta.com and selected for testing and imprinting for both canines. WTI is a relatively low density and low sulfur (sweet) crude oil with fairly consistent properties and is used as a benchmark in oil pricing. Samples of this oil are also available commercially on-line, making it a suitable selection as a "standard" for Canine Oil Detection Team testing. Both canines were successfully imprinted.