# Canine Oil Detection (K9-SCAT) Guidelines

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## Executive Summary

1. Canine detection searches involve a rapid, straightforward, proven concept that is based on sound scientific principles. Research has demonstrated that the canine sense of smell is at least as sensitive as commercial gas analytical instruments.

2. A trained K9-SCAT detection team that includes a canine, handler, and K9-SCAT Team Lead can provide an efficient, versatile, rapid, reliable, cost-effective, and real-time support tool for a SCAT program to locate surface and subsurface oil in a wide range of environmental settings.

3. Imprinting of a trained detection canine with the target oil is quick (hours) so that an experienced and prepared team can be deployed rapidly during a spill response with minimal additional training.

4. <u>Surface oil</u> searches can survey large areas rapidly or can search in wetlands, dense undergrowth, and rough terrain where pedestrian movement is difficult or undesirable, or the oil is hidden in boulders, riprap, or vegetation. A detection canine senses for an airborne odor cloud working toward the potential or suspected oil source. The canine may use a combination of air and ground scenting as s/he approaches the source of hidden oil, or in low wind conditions.

5. In a search for potential or suspected <u>subsurface oil</u>, a detection canine senses for an airborne odor cloud that has migrated to the surface from the source through sediment, snow, and/or water to create an odor "footprint." The canine typically uses a combination of air and ground scenting as s/he approaches the odor footprint, or in low wind conditions.

6. Locating a subsurface or hidden oil deposit is not a challenge for a canine in many scenarios. Successful delineation of the surface footprint of a continuous or discontinuous (including lens-type) subsurface oil deposit requires training, experience, coordination, and good communication between the K9-SCAT Team Lead and the handler, and between the handler and the canine.

7. The objective of delineating a subsurface oil deposit is to identify areas for excavation and investigation by a SCAT team who then determine the character of the oil and the exact vertical and horizontal dimensions.

8. The combination of the fast survey speed with real-time GPS tracking is a valuable strategy to search large areas rapidly and to quickly re-survey areas in dynamic situations where oil may be remobilized and redistributed.

9. A K9-SCAT Team can rapidly clear large shoreline/inland areas or pipeline corridors with a high-confidence, low-risk survey to ensure that oil is not present in those areas. This type of survey would be time consuming for a traditional ground observation and excavation team.

10. A skilled and attentive handler is essential to ensure that the safety, health, and welfare of the animal are the first priority at all times.

Shoreline assessment (SCAT) surveys provide information to document the location, characteristics, and environmental conditions present on shorelines or other terrains where spilled oil is present. These assessments typically are time consuming and labor intensive and may need to be repeated periodically as the oil is redistributed (and often buried) by natural processes. In cases where oil penetrates into, or is buried in the, subsurface sediments, accurate location and delineation of the horizontal distribution is based on spot samples and has a limited accuracy. Frequently, the distribution of the oil changes by the time an assessment survey program is completed.

A canine detection team can support a traditional SCAT program in a number of field roles to significantly increase the efficiency of surveys and the level of confidence in oil detection and delineation, and to enable a more timely provision of information for planning and direction of response operations.

The ability of canines to detect and accurately locate a wide variety of odors at extremely low levels is well known and currently in use for the detection of a wide range of materials including drugs, contraband materials, explosives, and a wide variety of other substances. The current state-of-knowledge for oil detection using canines is based on limited testing and a relatively small data set. However, field and laboratory research and the real-world experience with detection canines from many other applications have generated an extensive body of data and knowledge that is applicable to oil detection. These Guidelines present the current known capabilities, potential applications, advantages, and the limitations of using canines in support of SCAT assessments (K9-SCAT). As the application of canines to oil spills is relatively new, it should be considered a developing technology.

Canine oil detection is a relatively straightforward and sound scientific concept that requires the canine to identify and communicate the presence of odor from an oil deposit. This is achieved with:

- a trained detection canine that has been imprinted with the target odor,
- a trained and experienced handler to control the search pattern and reward the canine,
- an experienced SCAT Team Lead to manage and direct the K9-SCAT survey,
- GPS tracking equipment to facilitate tracking the search patterns and observations of the K9-SCAT team,
- an animal health and welfare protocol implemented by the handler and supported by a canine veterinarian(s).

Animal health and welfare protocols are the responsibility of, and implemented by, a trained handler and supported by a canine veterinarian. These protocols are essential to ensure that the canine remains healthy and well conditioned during initial training, maintenance, calibration, transportation, deployment, and post deployment. Animal health and wellbeing is an ethical responsibility and ensures a high-quality and well-maintained “tool” for oil detection.

An important element of planning and deployment of K9-SCAT recognizes that the implementation of a detection team is fundamentally different from a human observation SCAT team survey or gas detection using analytical instruments. In all cases, a field test before a full deployment is important to validate that the detection team can achieve the survey mission application and expectations.

In particular, a K9-SCAT program has the potential to:

- rapidly clear large shoreline/inland areas or pipeline corridors with a high-confidence, low-risk survey to ensure that oil is not present in those areas; a process that otherwise would be time consuming for a traditional ground observation team;
- be effective in areas that would be difficult or hazardous for a ground team, such as large sediment (boulder and riprap), bedrock, or dense undergrowth terrain and deep snow;
- survey in areas where pedestrian movement is undesirable, such as wetlands;
- repeat surveys with a rapid (real-time) data turnaround when oil stranded on shorelines or river banks has been remobilized and redistributed by wave and/or current action;
- detect subsurface oil to depths of at least a meter (several feet) with 100% coverage, versus spot sampling by manual or mechanical excavation.

There are three primary survey missions for which a K9-SCAT program can provide a rapid, reliable, and low risk, high confidence support role:

**Table E.1—K9-SCAT Missions**

| MISSION OBJECTIVE | APPLICATION |
|---|---|
| **CLEARANCE – NO DETECTED OIL (NDO)** | During an initial SCAT phase where surface, hidden or subsurface oil is not anticipated, but confirmation is required. For example:<br>• a survey in an area not believed to have been oiled<br>• a routine pipeline inspection. |
| **OIL DETECTION (WITH DELINEATION)** | During an initial SCAT phase where hidden or subsurface oil possibly exists, and where confirmation, location (detection) and delineation are required, or where the area is cleared as No Detected Oil (NDO). For example:<br>• a survey where oil is suspected to have penetrated into, or been buried by, sediment or snow<br>• a survey where oil is suspected to be present in a wetland or scrub area and cannot be directly observed from the air or ground, or where human traffic in a wetland can be avoided, or in difficult terrain<br>• rapid localized surveys to precisely locate buried oil on a shoreline in support of active cleanup<br>• a resurvey following high water levels or following a significant event, such as a storm or a river flood period, which probably would remobilize and redistribute, or bury, stranded oil<br>• a routine pipeline survey following a leak warning and/or third-party report.<br>The objective of delineating a continuous or discontinuous subsurface oil deposit is to provide location information so that a SCAT team can excavate the site and the immediately adjacent area to determine the character of the oil and the exact vertical and horizontal dimensions. |
| **CONFIRMATION OF ENDPOINT ACHIEVEMENT** | As part of a post-treatment survey where the location of oiling is known, and either:<br>• recommended treatment has been completed, or<br>• a suitable period of natural recovery has transpired. |

K9-SCAT requires close interaction and communication between the K9-SCAT Team Lead and the canine handler, and requires a high level of understanding of each other's roles, expectations, protocols, and skills in order to communicate effectively and develop a good working relationship. An effective and successful K9-SCAT Team must fully integrate the two very different disciplines of SCAT and canine detection, with inter-disciplinary training, cooperation, and calibration.

In an ideal situation, a SCAT program may use a combination of techniques for different phases of a survey:

- reconnaissance aerial visual observations or remote sensing using aircraft or drones to locate Heavy or Medium category surface oil deposits;
- ground visual surveys of those locations to document the oiling conditions;
- detection canines to clear areas for NDO, or to locate and delineate:
    - Light or Very Light category surface oils,
    - oil "hidden" in salt marshes, reed beds, peat, river bank shrubs, undergrowth, between boulders or riprap, or covered by snow or blown sand,
    - subsurface oil;
- manual or mechanical excavation to provide vertical delineation and oil characterization where subsurface oil has been located.

Detection canines can be imprinted with multiple targets (oil odors) and trained to discriminate and ignore other, background, oils that may be present, such as tar balls, spilled machine or vehicle oils, etc. They can analyze the variance in the concentration of an odor carried in the air and follow the increasing odor concentration to the surface expression (footprint) of the target; that is, they can detect spilled oil down wind and follow an odor cloud up wind to the source.

Field and laboratory research, and real-world experience over several decades with detection canines from many other applications has generated an extensive body of data and knowledge that is applicable to oil detection, in particular:

- odor detection and discrimination,
- calibration and reward,
- handler/canine communications,
- distraction avoidance,
- search pattern techniques,
- animal welfare,
- many other aspects of a detection team training program and deployment techniques.

Bearing in mind the existing knowledge base and experience for other applications, it is reasonable to expect that trained and calibrated teams can detect oil in a range of situations and conditions well beyond the current tested scenarios, including underwater targets and targets in deep snow.

These Guidelines are provided to aid decision making and planning for, and deployment of, K9-SCAT during an oil spill response, monitoring program, or oil spill exercise or drill.

A summary of the specific key points on the full range of topics covered in these Guidelines is provided as a K9-SCAT Fact Sheet in Annex E.

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# Canine Oil Detection (K9-SCAT) Guidelines

## 1 Introduction

The purpose of these Guidelines is to provide information on the potential for detection canines to support a shoreline or inland oiled area assessment (SCAT) program. This information includes:

- how oil detection dogs use their sense of smell and what they can do to locate and delineate surface and subsurface oil,
- the current state of knowledge regarding situations and types of support surveys that a K9-SCAT team can undertake as part of a SCAT program,
- how to plan and design a K9-SCAT survey and collect the appropriate data to document that mission.

### 1.1 Objectives

The purpose of these Guidelines is to provide information on the realistic potential for detection canines to support a shoreline or inland oiled area assessment (Shoreline Cleanup Assessment Team: SCAT) program. Although detection canines have been used extensively for many years for a wide range of purposes, there have been only a few occasions when oil detection canines have been studied in research programs or have been used in response operations (Section 2.3).

A K9-SCAT team consists of a trained animal, a professional handler, and a SCAT field assessment expert. This specialist team is a tool in the same way that an experienced, trained human oil observer or a gas detection instrument is a professional tool. These Guidelines present the current known capabilities, the potential applications, and the limitations of a K9-SCAT team.

### 1.2 Content, Format, and User Guide

**What is in this guide:**

- How to integrate SCAT and canine oil detection

**What is not in this guide:**

- How to train and imprint canines
- How to train canine handlers
- How to conduct a traditional (non K9-SCAT) program

The following table provides a quick reference to locate the key topics presented in these Guidelines.

| TOPIC | SECTION |
|---|---|
| How detection canines use their sense of smell | 2.2 |
| What detection canines can do | 2.3, 2.4, 2.5 |
| Appropriate situations for a K9-SCAT Survey Program | 3, 7.1.1 |
| Setting up and planning a K9-SCAT Survey Program | 4, 5, 6, 7 |
| Conducting a K9-SCAT Survey Program | 7.4, 7.5, 7.7 |
| What data to collect | 8.2, 8.3, 8.4 |

A summary of the section headings is provided on the following page.

A summary of the specific key points on the full range of topics covered in these Guidelines is provided as a K9-SCAT Fact Sheet in Annex E.

**2. Background: Canine Oil Detection**

- Current Accepted SCAT Survey Detection Practices
- Canine Air Detection Theory and Techniques
- Canine Oil Detection Field Experience
- Applications, Constraints, Limitations: Current State-of-Knowledge
- People, Canines, and Machines: A Comparison

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- Confirmation Testing and Vertical Delineation

**8. Data Collection and K9-SCAT Data Management**

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- ANNEX B: Creating and Using a Calibration and Reward Target
- ANNEX C: K9-SCAT Survey Forms
- ANNEX D: GPS Guidelines
- ANNEX E: K9-SCAT Fact Sheet

# 2 Background: Canine Oil Detection

- Current oil detection practices are based on physical observations and can be slow and, for subsurface oil, may provide only a partial (<0.01%) coverage.

- Canine surveys for surface oil detection can support ground SCAT teams in difficult or heavily vegetated terrain, or to “clear” large areas with no surface or subsurface oil within the affected area, or where pedestrian movement is undesirable.

- The positive attributes of canine subsurface oil surveys (speed, versatility, reliability, and accuracy for low-risk, high-confidence, real-time horizontal detection) and of excavation tactics (for documentation, vertical delineation, and oil characterization) do not directly overlap, but rather are complementary.

## 2.1 Current Accepted SCAT Survey Detection Practices

- The current SCAT practice is for experienced observers to locate surface oil and to excavate to detect and delineate subsurface oil.

- Typically, this is a slow and time-consuming process.

- Aerial observations can detect only relatively large surface oil deposits so that ground surveys are required to locate and characterize smaller concentrations; even detecting large surface deposits on the ground may be difficult in heavily vegetated areas.

- The primary detection method for subsurface oil is spot sampling by manual or mechanical excavation.

- Spot sampling for subsurface oil has a limited potential for success, with a high probability of non-detection, particularly for horizontally discontinuous or lens-type oiling.

A primary role of a SCAT program is to describe the oiling conditions following a spill, and this can be achieved by a variety of methods and tools that range from simple, real-time observations and remote sensing to off-site laboratory sample analyses. For the most part, SCAT information is generated by direct, systematic aerial or ground observations to locate and then delineate and characterize the oil (IPIECA, 2014). A typical SCAT program may use a combination of techniques for different components of a survey:

- reconnaissance aerial visual observations (Figure 2.1a) or remote sensing using aircraft or drones to locate Heavy or Medium category surface oil;

- ground visual surveys of those locations to document the oiling conditions (Figure 2.1b);

- manual or mechanical excavation to locate subsurface oil and vertically delineate, observe, and characterize that oil (Figure 2.3).

This section identifies the basic survey techniques in common use and highlights some of the limitations of these current practices that are relevant for evaluating the applicability and value of a K9-SCAT Team to support a survey program.

**a)** **b)**

**Figure 2.1—a) Aerial Reconnaissance; b) Ground SCAT Survey**

### 2.1.1 Surface Oil

**Surface oil surveys:**

- The current SCAT practice is for experienced observers to locate surface oil.
- Visual aerial surveys usually can detect and define Heavy and Moderate Surface Oiling Categories but may not be able to detect low oil concentrations (Light, Very Light, or Trace Oiling Categories).
- Visual ground surveys may not be able to locate surface oil hidden by vegetation in wetlands or river banks, or between boulders or riprap.
- Ground-based survey teams may be very slow in rough and difficult terrain, such as irregular bedrock and coarse sediment (cobble-boulder or riprap) environments, dense vegetation, or snow conditions.
- Typically, a considerable portion of the SCAT program survey effort involves a ground-based determination that no oil is present (No Observed Oil – NOO).

Systematic ground-based surveys may be very slow and tiring in areas of difficult terrain, such as exposed bedrock, cobble, boulder, or riprap substrates, heavily vegetated areas, and in snow conditions. Pedestrian surveys may not be desirable to avoid disturbance in habitats such as wetlands.

A large portion of the reconnaissance-level survey effort typically is undertaken to ensure that oil is not present in the affected area (Table 2.1).

- This type of “clearance” survey is a time-consuming effort for ground-based teams.
- Clearance surveys may tie up resources that may be better deployed elsewhere, particularly during the early phase of a response.

**Table 2.1—Surface Oil Survey Data**

| RESPONSE | TOTAL SHORELINE LENGTH SURVEYED (km) | LENGTH WITH NO OBSERVED OIL (NOO) (km – %) | SOURCE |
|---|---|---|---|
| **Deepwater Horizon** | 7,058 | 5,285 – 75% | Michel et al., 2013 |
| **T/V Exxon Valdez, AK** | 5,459 | 3,359 – 61% | Owens, 1991 |
| **M/V Selendang Ayu, AK** | 763 | 345 – 45% | Owens et al., 2008 |
| **M/V Cosco Busan, CA** | 379 | 232 – 61% | Unpub. SCAT database |

### 2.1.2 Subsurface Oil

**Subsurface oil surveys:**

- The current SCAT practice for subsurface oil detection involves manual or mechanical excavation tactics to survey for and locate subsurface oil.
- This is a very labor-intensive and time-consuming tactic.
- This is a spot sampling technique that typically covers only a fraction of the area being surveyed (potentially <0.01%), and has a high probability of non-detection for horizontally discontinuous lenses of subsurface oil.

Current practice for the detection and delineation of subsurface oil in sediment shorelines, river banks and on land (e.g. Figure 2.2) relies primarily on manually (Figure 2.3a) or mechanically (Figures 2.3b and 2.3c) excavated pits and trenches or auguring to allow visual examination and documentation of subsurface conditions and/or sampling for off-site analysis. These procedures are typically labor intensive and very time consuming. Other currently acceptable techniques include coring and water jetting. A range of other potential techniques has been reviewed (API, 2013a), but these are either not proven or have a limited applicability.



a) b)

**Figure 2.2—a) Continuous Layer of Oil Buried by Sediment Deposition; b) Discontinuous Subsurface Oil Deposit**

a) b) c)

**Figure 2.3—Pit and Trench Excavation: a) Manual Excavation of a Pit, b) Mechanical Excavation of a Pit, c) Mechanically Excavated Trenches**

The general advantages and limitations of current subsurface oil survey practices are summarized in Figure 2.4. In this presentation:

- Green indicates a favorable attribute,
- Yellow that the strategy may be effective, depending on circumstances, and
- Red that a procedure has important limitations or is "not applicable."

One clear message from Figure 2.4 is that the positive attributes of Excavation and Canine Detection do not overlap, but rather are complementary. If an alternative detection technique is used, such as jetting or canine detection, then excavation in some form would most likely be required for verification and vertical characterization.

| ATTRIBUTES | CURRENT PRACTICES | | | CANINE DETECTION |
|---|---|---|---|---|
| | EXCAVATION | CORES | JETTING | |
| HORIZONTAL DETECTION AND DELINEATION | | | | |
| VERTICAL DELINEATION | | | | |
| SURVEY SPEED | | | | |
| OIL CHARACTER | | | | |

**Figure 2.4—Attributes of Current Accepted Subsurface Oil Detection Practices and Canine Detection (after API, 2013b)**

Excavation with pits, auguring and trenches is a spot-sampling technique so there are limitations in the ability of the survey to accurately and efficiently delineate the three-dimensional extent of subsurface oiling, particularly in the horizontal dimension. In situations of discontinuous or lens-type oiling, there is a high potential for non-detection where individual deposits or layers have small horizontal dimensions.

The location of an excavation is based on either professional judgment, random selection, or on a fixed sampling grid.

- Even with an intensive excavation survey, pitting, trenching or auguring may only cover a small percentage (potentially <0.01%) of the total subsurface area.

- To a large degree, on shorelines or river banks, the selection of sample locations is based on an interpretation by an experienced coastal geomorphologist or sedimentologist of beach/river morphology and the recent history (typically days to weeks) of the processes that cause erosion and deposition.

- Professional judgment in itself does not guarantee that the actual location(s) of subsurface oil would be detected.

- Intensive sampling is atypical due to the very high level of effort involved.

- Many locations excavated in a subsurface oil survey typically have No Observed Oil (NOO) (Table 2.2).

**Table 2.2—Examples of Intensive Excavation Projects to Locate and Delineate Subsurface Oil on Beaches**

| RESPONSE /PROJECT | PERIOD | NUMBER OF PITS/TRENCHES | COMMENT | SOURCE |
|---|---|---|---|---|
| **Deepwater Horizon: SCAT** | May 2010–December 2012 | >180,000 | NOO in 67% | Michel et al., 2013 |
| **Deepwater Horizon: LAASR** | January–June 2013 | >32,000 | NOO in 5 of the 15 selected target areas | OSAT-3, 2014 |
| **Deepwater Horizon: BOP** | June–August 2013 | >8,000 | NOO in 86% of the locations | OSAT-3, 2014 |
| **Bouchard B-155, Tampa Bay FL** | 18–19 August 1993 | 964 | 1 team, 2 days: pits at a 1-m interval on 119 transects spaced at 160 m | Owens et al., 1995 |
| **Refugio, CA** | 15 June 2015 | 360 | 4 teams: 1500 ft × 30 ft area (4,000 $m^2$) with a 10 ft × 10 ft (3 m × 3 m) grid in 6 hours | J. Michel, pers. comm., 10 July 2015 |

## 2.2 Canine Air Detection Theory and Techniques

- Canines can be trained to investigate, analyze, discriminate, and signal the presence of a substance that the animal has been trained to recognize.

- The presence of subsurface oil can be detected as molecules are released and move upwards through sediment, water, or snow. The canine uses either ground or air scent to detect the target odor.

- The canine can be trained to signal the presence of an odor plume or follow that plume to the source (the odor ground "footprint").

- Wide Area Search off-leash patterns are used to cover large areas rapidly whereas on-leash techniques are used to delineate an odor footprint.

### 2.2.1 Detection Dogs

- Canines have on the order of 200–300 million highly sensitive olfactory cells, depending on the breed. Goldblatt et al. (2011) provide a detailed discussion of the olfactory system of canines.

- Canines can detect certain odorants to tens of parts per billion (ppb), and even 500 parts per trillion (ppt) (Johnston, 1999).

- Canines use this highly evolved sense of smell to search for odors of interest, such as food, other canines, etc.

- Canines are naturally driven to elicit reward and avoid pain or conflict. This repeatable behavior enables trainers to use positive reinforcement to develop a canine's skills. Detection canines are trained to focus on specific odors, and to follow the handler's communications and "signal" when those odors are detected.

- Certain breeds of canine can be trained to follow a survey pattern to investigate, analyze, discriminate, and signal odors that the animal has been trained to recognize ("imprinted").

- A well-trained canine is skilled, intelligent, efficient, and versatile and, when combined with a proficient handler, forms an effective and rapid survey and real-time detection tool.

### 2.2.2 Subsurface Odor Detection Theory

- Scent molecules may be present in the environment as ground scent (molecules contained within the surface soil structure) and air scent (molecules carried in the air). Canines use either or both to detect a target odor.

- 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.

- An oil odor plume (air scent) that is in the air just above the ground surface can be detected by a trained detection canine that has been imprinted for that odor.

- The air scent of large surface oil deposits can be detected at ranges of hundreds or more meters (Brandvik and Buvik, 2009).

- The concept of subsurface oil detection by canines is based on the release, or venting, of molecules that move through a medium (sediment, snow, or water) to the surface.

- Subsurface odor is detectable at the point the molecules reach the surface of the substrate (ground scent). The odor is also carried on the air (air scent) and can easily reach, and be detected, at 15 m to 20 m under favorable conditions (P. Bunker, pers. comm., June 2015).

- The canine can be trained to either:

    - communicate to the handler once the presence of an odor plume associated with the target odor has been detected, or

    - analyze the directional variance in the concentration of odor carried in the air and follow the increasing odor concentration to the surface expression (footprint) of the target substance.

### 2.2.3 Search Strategies: Detection vs. Tracking

Canines are trained to search in different ways using scents or odors.

**Detection canines** use air or ground scent to locate a target.

- The strategy is used to locate missing persons, specific materials (accelerants, explosives, drugs, food, etc.).
- The canine identifies the odor from the material that it has been trained to recognize (“imprinted”).
- The strategy does not require a Last Known Place (LKP) as a starting point for a search.

**Tracking or trailing canines**, by contrast, search by scent discrimination.

- Requires beginning the search from LKP and may (“trailing”), or may not (“tracking”), use a scent article.
- The strategy is one that follows an animal or human trail using the scent on the ground and in the air and may involve visual clues, such as disturbed vegetation or soil.
- Typically would not be applicable for a SCAT survey.

### 2.2.4 Air Scent Odor Subsurface Detection Sequence

The sequence involved in the detection process is described in Figure 2.5:

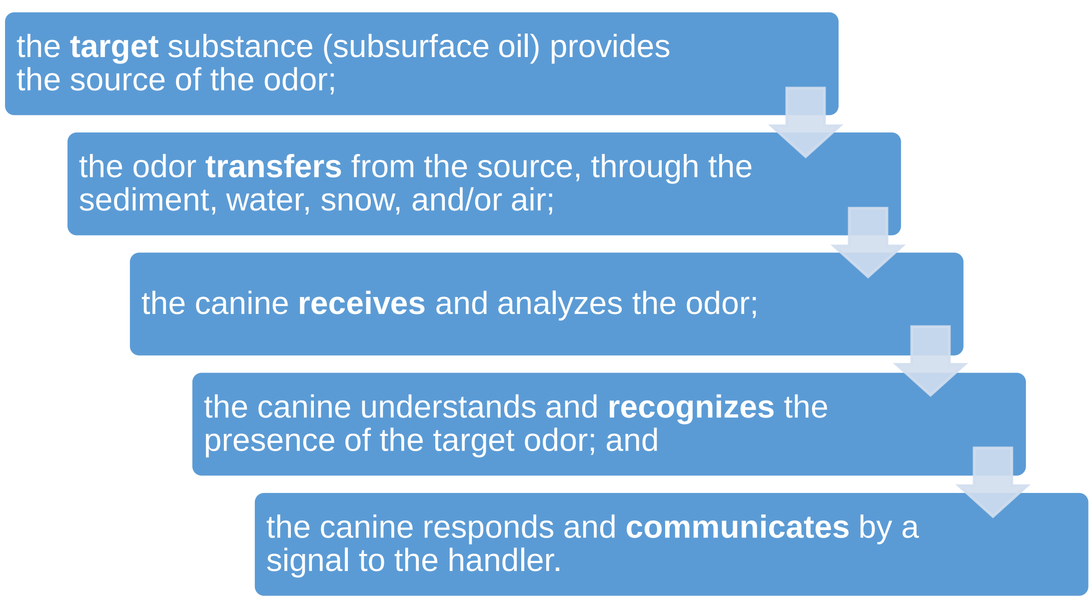


**Figure 2.5—Air Scent Odor Subsurface Detection Sequence**

### 2.2.5 Air Scent Detection and Delineation Survey Techniques

- Canines can be used to detect surface oil, and to detect and delineate subsurface oil.

- The distance at which a canine can detect the odor plume from a surface oil deposit, for example, in a wetland or dense vegetated scrub/woodland, or during low visibility or at night, is a function of many parameters and environmental variables, such as oil concentration, degree of weathering, wind speed/direction, air turbulence, humidity, barometric pressure, etc.

- During the Norwegian trials on ice (Section 2.3.1), the odor plume from a large surface snow-covered patch of oil (400 L: 100 gallons) was detected 5 km (3 miles) downwind (Brandvik and Buvik, 2009).

- During the same set of trials, the odor plume from 400 mL (0.1 gallons) of oil buried by snow in ice at 30 cm (12 in.) depth was detected at distances on the order of 400 m (440 yards) from the target.

- There are two basic detection search strategies (see also Section 7.5):

    - Off-leash **Wide Area Search (WAS)** to locate surface or subsurface oil within an area (Figures 2.6, 7.1, 7.2, and 7.3), and

    - On-leash **Delineation Survey** to inspect smaller areas (Figures 2.7 and 7.4); for subsurface oil this typically is used after a site has been located by a WAS.

**WIDE AREA SEARCH**

**(WAS)**

Wide Area Search (WAS) patterns are used for rapid evaluation of large areas for surface or subsurface target materials. A WAS is a high-confidence, low-risk survey in which the canine:

- searches independently (off leash) by air scenting or by ground scenting if air scent is not readily available, or a combination of both;
- has sufficient appropriate direction from the handler to ensure adequate coverage of the search area through use of visual (hand signals) and/or auditory direction (voice, canine collar sounds, or other audible signals);
- is trained typically to follow a sweeping pattern known as quartering or orbiting;
- typically works at a scales of multiple acres (or hectares) with 100% coverage; and
- can work at a ground survey speed on the order of 5 km/hour (3 miles/hour) or more in favorable conditions.

A WAS team is trained to thoroughly and rapidly cover extensive areas to locate odor plumes or targets that subsequently can be defined in greater detail using delineation search procedures. A WAS pattern also can rapidly clear areas that have no detected odors or targets (No Detected Oil – NDO).

**Figure 2.6—Wide Area Search**

**DELINEATION SURVEY**

Delineation Surveys for subsurface oil are used to inspect smaller areas in detail, where the canine focuses on the ground odor in the footprint of the subsurface oil.

- A Delineation Survey may be the next phase after a WAS has detected the presence of a target odor.
- In a Delineation Survey the canine:
  - works on leash as directed by the handler;
  - may involve "bouncing" around the odor footprint (Figure 7.4) if the survey is inspecting a subsurface pipeline or an alongshore beach feature; and
  - can cover an area on the order of 100 m by 10 m (1,000 $m^2$) in approximately 10 minutes (~0.5 hectare/hour or 1.2 acres/hour).

**Figure 2.7—Delineation Survey**

## 2.3 Canine Oil Detection Field Experience

- Field research studies conducted with oil detection dogs in Norway and the USA provide proof of concept for a range of situations.
- Large surface oil deposits have been detected at distances over 1,000 m (0.6 mile).
- Subsurface oil has been detected at depths of 90 cm (36 in.) in sediments and 30 cm (12 in.) in packed snow.
- Apart from the Norwegian research, field experience on actual spills is limited to anecdotal information.

The odor detecting skills of dogs have been used extensively for many applications including search and rescue, locating surface, buried or underwater cadavers, wildlife detection, narcotics and food interdiction, explosive and accelerant detection, cancer detection, etc. There is a large body of research literature associated with these applications (e.g. USDA, 2012; Ensminger, 2013), and the 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). There exist a large number of manuals and standards that deal with the selection, training, health and wellbeing of detection canines as well as operating procedures (e.g. IMAS, 2013a,b).

Many studies have reported on various canine issues, such as detection performance and capabilities (Johnston, 1999; Furton and Myers, 2001; Williams and Johnston, 2002; Johnen et al., 2013), duty cycles (Garner et al., 2001), the effects of extraneous odors (Waggoner et al., 1989), validation testing (Rooney et al., 2007), handler influences (Lit et al., 2011), odor discrimination tests (Porritt et al., 2015), etc., but little research has been conducted on the use of canines for subsurface oil or gas detection, and only two well documented efforts have focused on the subsurface detection of oil in sediments, within ice, and underwater (Sections 2.3.1 and 2.3.2).

### 2.3.1 SINTEF

SINTEF and the Trondheim Hundeskole (Trondheim Dog Training Academy) have verified, through a series of field tests and informal exercises, that trained canines can detect oil residues in a range of situations:

- Field trials in Svalbard in April 2008 as part of the Arctic JIP program (Dickins et al., 2010) were designed to evaluate the ability of canines to detect oil hidden in snow and ice (Brandvik and Buvik, 2009). The results showed that the canines were able to:
    - detect a small amount of weathered oil (400 mL: 0.1 gallons) that had been buried 30 cm (12 in.) into ice and covered with snow and left for a week;
    - determine the dimensions of large oil deposits by indicating the borders of clusters of smaller amounts of oil at a 10-m (11-yard) spacing;
    - find the location of a larger oil deposit (400 L: 100 gallons) that had been laid down on top of ice and covered by snow, based on the triangulation of detected plume dimensions; with oil detected up to 5 km (3 miles) downwind of the spill location.
- Further field trials funded by Statoil were conducted in Svalbard in September 2008 and in western Norway (Fedje/Austreheim) in November 2008 (Buvik and Brandvik, 2009) to evaluate the ability of canines to detect oil hidden in beach sediments.
    - In the Svalbard survey (Figure 2.8b), an IFO-30 that had been laid down in 1997 as part of a shoreline experiment (Sergy et al., 1998) was detected in upper intertidal zone mixed sand-pebble beach sediments at a depth of 0.8 m (30 in.).
    - At Fedje (Figure 2.8a), on challenging terrain with bedrock and coarse sediment (cobble-boulder) shorelines and with snow and winds gusting to 20 m/s (45 mph), oil from the 2007 M/V *Server* spill was detected in mixed sand-pebble sediments, and in bedrock crevices and cracks. Under these weather conditions the teams worked in two 4–5 hour periods each day. A search speed of 1–5 km/hour (0.6–3.1 mph) was recorded on the challenging terrain with 3–5 km/hour (1.8–3.1 mph) on more favorable terrain.

a) b)

**Figure 2.8—a) Surveying on Rugged Terrain; b) 2008 Svalbard Survey (Buvik and Brandvik, 2009)**

- As one of several informal exercises, oil was buried in an intertidal zone at low tide and later detected at high tide from the adjacent beach in a water depth of approximately 40 cm (15 in.) (P.J. Brandvik, pers. comm., March 2011).

### 2.3.2 API 2015

Field trials to demonstrate and evaluate the applicability of using oil detection canines were conducted in June 2015 as part of an American Petroleum Institute (API) Joint Industry Task Force (JITF) Oil Spill Preparedness and Response program study on Subsurface Oil Detection and Delineation technologies in support of inland and shoreline oil spill response (Figure 2.9).

**Figure 2.9—2015 API Field Trials (API, 2016)**

The trials were conducted at the K2 Solutions K9 Training Center, Jackson Springs, NC, and involved two detection canines imprinted with a West Texas Intermediate crude oil and a certified handler who had no knowledge of the target locations (API, 2016).

- Seven (7) off-leash **Wide Area Search (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.
    - In terms of accuracy, the teams (a) detected and located each WAS target during four (4) tests and (b) cleared (with No Detected Oil) the areas searched during the other three (3) tests with no false alerts, equating to **100% accuracy**.
    - In terms of performance, the WAS tests were equivalent to a survey rate of **5 to 10 km/hour**, (~3 to 6 mph), or on the order of 15 to 20 linear km/day (~9 to 12 linear miles/day), for a high-confidence, low-risk survey with 100% coverage of a 50-m-wide (55-yard-wide) shoreline or pipeline Right of Way (ROW).
- Fourteen (14) on-leash **Delineation Survey** tests involved a gridded layout within a 1,250 m$^2$ (0.3 acre) area using six (6) different target designs to represent continuous, discontinuous and isolated lenses of subsurface oil distributions, as well as a linear pipeline scenario. Oiled sediment targets were "buried" at various depths between 30 cm and 90 cm (12 in. and 36 in.).
    - Oil was detected at all depths up to 90 cm (36 in.).
    - In terms of accuracy, two (2) of the 700 oiled sediment and non-oiled targets that were deployed in the delineation tests 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% canine accuracy**.

- In terms of performance, the average time for the fourteen 1,250 $m^2$ Delineation tests was eleven (11) minutes for 100% ground coverage.

### 2.3.3 Other Field Experience

Very few other studies or case histories for oil detection canines have been documented. In North America and Europe, a few reported field studies or experiences on actual spills have used canines to locate subsurface pipeline leaks, sometimes with the aid of an odorant injected into the pipeline (Canadian Energy Pipeline Association, 2012; K9 Pipeline Leak Detection, nd; The Sniffers, nd.). In the UK, results of field trials on pipeline leaks report that trained canines were 96% reliable in detecting leaks as small as 0.07 mL (0.004 $in.^3$) (Kerrigan, 2012; Penspen Integrity, 2010).

## 2.4 Applications, Constraints, Limitations: Current State-of-Knowledge

- Detection dogs are versatile and can locate small surface oil deposits during Wide Area Searches and at depths up to 90 cm (36 in) in sediments, based on research and experience to date.
- Detection dogs have a wider application, as yet untested, to detect oil at greater depths in sediments and snow as well as sunken oil in shallow water, based on research results and experience with detection dogs in other applications.
- Pre-deployment field trials are important to validate that a detection team can meet survey application and expectations.
- Implementation of a detection team survey is less straightforward than with human observers or analytical instruments as animal/human behavioral factors must be considered and successful deployment requires an experienced SCAT Team Lead and an interactive Team Lead, handler, and canine partnership.

The current state-of-knowledge for oil detection is based on a small data set (Section 2.3). However, field and laboratory research and real-world experience with detection dogs from many other applications have generated an extensive body of data and knowledge that is applicable to oil detection (Sections 2.2 and 2.5). In particular:

- odor detection and discrimination, calibration, handler/canine communications, distraction avoidance, search pattern techniques, animal welfare, and many other aspects of a detection team training and deployments are well understood after decades of research and implementation, and
- canine teams are used routinely and effectively:
  - to detect underwater targets, such as cadavers and marine mammals,
  - for human search and rescue operations following landslides and avalanches,
  - in challenging environments in terms of terrain and climate conditions.

Training and imprinting techniques for land mine detection are designed to, and have achieved, a 100% detection rate in independent scientific trials (P. Bunker, pers. comm., December 2015).

Bearing in mind the existing knowledge base and experience for other applications, it is reasonable to expect that trained and calibrated teams can detect oil in a range of situations and conditions well beyond the current tested scenarios.

### 2.4.1 Applications

Table 2.3 presents a list of those applications for which a K9-SCAT team could, in most situations, be expected to meet survey goals. In all cases, a field test should be conducted before a full deployment to validate that the detection team can achieve the survey application and meet expectations.

**Table 2.3—Current Oil Spill Applications Based on Tested Scenarios**

| | |
|---|---|
| For **SHORELINES, LAKE SHORES, RIVER BANKS AND TERRESTRIAL ENVIRONMENTS,** K9-SCAT teams can: | |
| → | Conduct an off-leash Wide Area Search (WAS) to "clear" areas for surface or subsurface No Detected Oil (NDO) as part of an initial ground survey or as part of a post-cleanup inspection ("completion" or "sign off") process within a SCAT survey program |
| → | Locate hidden or subsurface oil with a WAS mission |
| → | Delineate subsurface oil with on-leash search patterns if oil is located by a WAS mission |
| → | Operate in wetlands and scrub land, where aerial or ground observers may not be able to detect surface or subsurface oil, or on difficult terrain such as vegetated bedrock, boulders, or riprap. |
| For **ONSHORE AND SHALLOW UNDERWATER PIPELINES**, oil detection canines have the potential to support pipeline integrity management, particularly in the following areas: | |
| → | Routine inspection, as part of an integrity management plan |
| → | Situations where corrosion has been identified by In Line Inspection (ILI), and a verification of "no leak" is required |
| → | Situations where coating problems have been identified by above-ground surveys |
| → | Pipelines that cannot be "pigged" |
| → | Delineation of the area ("footprint") of a subsurface leak |
| → | Locations with poor cathodic protection coverage |
| → | Cases where there are suspected "illegal taps" and theft |
| → | Following a hydrotest (where water has been scented and the canine can locate any leak) |

Canine detection is not identified as a "leak detection" tool in the United States (see PHMSA, 2007; Shaw et al., 2012) and relatively little research has been conducted on the use of canines for subsurface oil or gas detection. By comparison, a large body of research literature deals with the other tools that can be used for subsurface oil or gas detection, particularly to support pipeline operations and leak detection. For example:

- Wang et al. (2001) describe a number of surveillance (visual, dogs, thermal sensors), acoustic, and hydraulic methods, and state that "*dogs can be used to locate the minute odours from leaked fluids and gases. There are some successful cases reported, for example three tracking dogs successfully located 150 leaks in a 150km (93 miles) long gas pipeline in 9 days*";
- Hirst et al. (2004) report on a real-time optical ethane detection system for oil and gas prospecting that has a range of several kilometers from the source;
- PHMSA (2007) describes current accepted pipeline leak detection technologies and states the agency position that has a high priority on the advancement of leak detection technology;

- Shaw et al. (2012), review the state-of-the-art and accepted best practices for pipeline leak detection, as well as major current technology gaps: they note the difficulties of identifying small leaks (<1% of flow) with flow meters and pressure sensors;
- Liu et al. (2012) review and classify gas detection techniques for a wide range of applications;
- Mandal (2014) reviews and discusses the advantages and disadvantages of the current range of detection methods for gas leaks, including canines.

### 2.4.2 Constraints and Limitations

An important element of planning and deployment of a K9-SCAT mission is to recognize that the deployment of a detection team is less straightforward than with human observers or analytical instruments (Furton and Myers, 2001).

Canines and their human support partners have limitations. To be successful, a K9-SCAT survey:

- requires a detection-trained animal and an experienced handler,
- requires an experienced SCAT Team Lead partner,
- must be safe for the canine(s), the K9-SCAT team, and responders and the public,
- must take into account animal/human behavioral factors,
- requires defined expectations and a carefully strategized survey design,
- requires samples of the target oil(s) for imprinting.

Some specific constraints or operational limitations on the performance of a canine include:

- a canine that has not been suitably trained and imprinted for air scenting, detection searches or delineation,
- an inexperienced handler and/or SCAT Team Lead support that can influence the animal's performance in terms of survey area locations and survey coverage,
- environmental conditions, such as strong and/or swirling winds patterns, heavy rain, very high temperatures, etc.,
- highly volatile odors, e.g. from gasoline, that can saturate the nasal passages so that the canine's sense of smell is blocked for several minutes,
- high concentrations of hydrogen sulphide ($H_2S$), which can incapacitate olfactory sensory reception, and more importantly, prevent personnel including K9-SCAT teams from entering areas with dangerous levels of $H_2S$,
- large volumes of deep subsurface oil that can saturate the sediments beyond the source area, making it difficult to pinpoint, and therefore accurately delineate, the deposit,
- different oil sources that may confuse the canine, requiring discrimination between target and background oils during imprinting,
- canine performance may be reduced in extreme weather conditions,
- canine performance is reduced if the canine becomes fatigued or bored: factors that are the responsibility of, and can be mitigated by, the handler.

In snow scenarios:

- Snow can absorb vapor. Loose, dry snow is porous and allows vapors to rise to the surface, whereas tightly packed snow is less porous. Wet snow could cause vapor components to go into solution and be aborted by the snow through capillary action, thus changing the overall scent.

- Potentially, one could expect a detection depth of about 2 m to 4 m (6.6 ft to 13 ft) with fresh snow (based on human detection experience; Gilmore, nd), although with heavy wet snow, which is dense and has a high water content, detection limits may be only to 0.8 m (2.5 ft) depths. On one reported occasion, a canine in Austria found a subject buried under 12 m (40 ft) of snow following an avalanche (Gilmore, nd).

## 2.5 People, Canines, and Machines: A Comparison

- Humans observe and document; canines and gas instruments detect, analyze, and communicate.

- Visual surface oil detection and documentation surveys can be conducted from the air for Heavy and Moderate oil concentrations, but have the risk of not detecting small amounts of oil, or oil hidden in vegetation or between boulders/riprap.

- Ground canine searches can cover large areas quickly and detect small amounts of surface and/or subsurface oil.

- The combination of human observational skills and canine detection/delineation skills are highly complementary.

- Aerial observations provide rapid coverage for locations with high surface oil concentrations, whereas canines provide rapid ground coverage in areas with low oil concentrations or with thick vegetation that are hard to observe and detect by humans.

- Canines reliably and rapidly generate real-time data and provide a low risk, high confidence strategy to detect and delineate hidden or subsurface oil deposits or to clear areas with No Detected Oil (NDO).

The selection of the appropriate techniques and tool(s) to conduct a SCAT survey evaluates the advantages and disadvantages of each tactic. The proven ability of canines to detect oil targets, even in very small (Trace) amounts, and to provide complete, rapid survey coverage is a significant advantage over systematic ground-, or vessel-based, surveys. Canines are, however, primarily a support tactic and do not replace the traditional SCAT Team surveys, although they may obviate the need for a ground survey in some areas when used in a “clearance” capacity (Section 2.1.1), or for local Operations support during cleanup.

The development of a SCAT program involves evaluating the different human, canine, or instrumental survey tools based on the current knowledge base.

- Human skills are the primary field survey tool and, although these vary from person to person, there are standard procedures and recommended protocols that are intended to ensure a degree of uniformity in the type and quality of observational data that is collected.

- Commercial portable instruments, as well as others under development, could be used in a SCAT program to detect oil in sediments or water (Goldthorp et al., 2014).

- The ability of canines to detect subsurface oil is well documented (in Section 2.3).

Designing a SCAT survey involves evaluating and selecting the most appropriate human, canine, or instrumental tool for suitability for the mission at hand. In this process, and in particular for subsurface oil surveys, it is important to understand the advantages and disadvantages of each of the current SCAT field techniques.

### 2.5.1 Surface Oil

For visible surface oil, a human aerial observation team can provide rapid and complete coverage for detecting Heavy and Moderate oiling conditions, but is less reliable for small oil concentrations or on beaches with coarse sediments (pebbles and cobbles) on wet, rainy days. By comparison, a canine team can be more reliable than an aerial survey if the oil is hidden in vegetation or between large sediments (cobbles, boulders, or riprap), has a thin sand or snow veneer, or on rainy days. K9-SCAT can provide (a) a high-confidence, low-risk option due to the full areal coverage, and (b) a significantly more rapid survey rate than traditional ground surveys. Table 2.4 compares the traditional human observation and detection techniques with detection dogs for surface oil deposits.

**Table 2.4—Advantages and Limitations of Surface Oil Detection Techniques**

| TECHNIQUE | ADVANTAGES | LIMITATIONS |
|---|---|---|
| **Aerial Observations** | • Rapid.<br>• Can locate Heavy and Moderate surface oil categories. | • Low-confidence, high-risk of not locating small amounts of oil (Light, Very Light, and Trace categories) even when flying low (<50 m) and slow (<50 knots).<br>• Oil in vegetation, between boulders or riprap, or with a thin sediment or snow veneer, may not be visible.<br>• Oil may be difficult to detect on coarse sediments on rainy days. |
| **Aerial Remote Sensing/Drones** | • Rapid.<br>• Can locate Heavy and Moderate surface oil categories. | • Sensor data or image interpretation rather than direct observational data.<br>• May be unable to distinguish false positives from oil on the image.<br>• Low-confidence, high-risk of not locating small amounts of oil (Light, Very Light, and Trace categories) even when flying low (<50 m) and slow (<50 knots).<br>• Oil in vegetation, between boulders or riprap, or with a thin sand or snow veneer, may not be visible.<br>• Oil may be difficult to detect on coarse sediments on rainy days. |
| **Ground Observations** | • High-confidence, low-risk. | • Slow.<br>• Inefficient for “clearing” large areas where little or no oil is present.<br>• Limited mobility in difficult terrain and may not provide 100% coverage.<br>• Human traffic can disturb vegetated areas or mix oil with vegetation/ sediments. |
| **Detection Canines** | • Very rapid, mobile.<br>• 100% coverage: high-confidence, low-risk of missing even small amounts of oil.<br>• Versatile: can work where human access may be difficult.<br>• Minimizes human penetration and disturbance in wetlands.<br>• Has a scent-to-source capability. | • Few limitations as surface oil is readily detectible. |

### 2.5.2 Subsurface Oil

For subsurface oil detection and delineation, compared to a human team, a canine team can provide (a) a high-confidence, low-risk option due to the complete areal coverage, and (b) a significantly more rapid survey rate (Table 2.5). Mechanical excavation offers some labor-saving advantages but is not faster nor provides greater sampling coverage than manual excavation.

**Table 2.5—Advantages and Disadvantages of Subsurface Oil Detection Techniques**

| TECHNIQUE | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| **Manual Excavation** | • Allows vertical delineation.<br>• Allows characterization of oil. | • Very slow.<br>• Labor intensive.<br>• Poor areal coverage (spot sampling): low-confidence, high-risk of missing subsurface oil over a wide area survey. |
| **Mechanical Excavation** | • Allows vertical delineation.<br>• Allows characterization of oil. | • Slow.<br>• Poor areal coverage (spot sampling): low-confidence, high-risk of missing subsurface oil over a wide area survey.<br>• Requires stable and relatively flat surface (trafficability) and good access for equipment. |
| **Detection Canines** | • Very rapid, mobile.<br>• 100% coverage: high-confidence, low-risk of missing detectable subsurface oil.<br>• Versatile: can work where human access may be difficult.<br>• Has a scent-to-source capability. | • Requires the absence of surface oil.<br>• Requires SCAT excavation for verification, vertical delineation, and oil characterization.<br>• Many potential applications have not been evaluated to date: for example, sediment/snow depth limitations, underwater detection, oil under ice, etc. |
| **Gas Detection Machines/FTIR** | • Science based.<br>• No animal/human behavioral considerations (other than spot sample collect locations). | • Limited mobility; slow.<br>• May involve sample collection and off-site analyses.<br>• Requires SCAT excavation for verification, vertical delineation, and oil characterization.<br>• Not well known/proven in the field.<br>• No scent-to-source capability. |

A study by Furton and Myers (2001) on the use of canines to detect explosive materials is a valuable reference and relevant for oil detection as they:

- discuss the theory of detection canines,
- present a detailed comparison between instrumental detection devices and detector canines.

They conclude that both detection technologies are based on well-established principles and that "*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*."

They also note that detector canines are highly cost effective and that the cost of a trained canine versus a calibrated instrument is significantly less in terms of initial acquisition purchase as well as annual maintenance costs. The cost of a detector canine involves a training period with a certified handler(s) and kennel overheads, which may be on the order of one month or more, as well as continued calibration after the initial training is complete.

Furton and Myers state in their summary that "*the available data demonstrates that detector dogs still represent the fastest, most versatile, reliable and cost effective real-time explosive detection devices available. However, the unique operational complexities of the dog handler team and the limited amount of reliable scientific information in many cases makes the implementation of highly reliable and efficient detection teams less straightforward than with analytical instruments*."

The last point is significant as a successful canine survey involves:

- certified handlers and trained detector canines,
- an understanding by the K9-SCAT support person (SCAT Team Lead) on how the handler and canine work together,
- clear management expectations.

# 3 The Decision Process to Deploy K9-SCAT

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A SCAT program design typically includes several survey techniques as part of a multi-phased operation. A K9-SCAT component may be appropriate:

- during the initial phase in areas where the expectation of surface oiling is low,
- after surface oil removal or in the absence of surface oil if subsurface oil is suspected or expected,
- during inspection surveys to confirm that treatment targets have been achieved,
- in dynamic environments when oil may have been remobilized and redistributed after a reconnaissance or ground SCAT survey,
- during routine pipeline inspections.

An element of the evaluation process would be a field trial or assessment test prior to full deployment to ensure that the survey expectations can be achieved.

---

The creation and design of a SCAT survey program considers the range of oiling and environmental conditions within the affected area and a SCAT Plan presents the recommended actions and schedule for a field program (Section 6 and Annex A). In many cases, the standard and accepted aerial and ground survey strategies provide the appropriate data and information for input to the shoreline, river, or inland response program decision process.

A range of potential situations exists where a K9-SCAT team(s) may be more effective and/or efficient than traditional survey techniques. These situations include the following.

- Long sections of shoreline (tens of kilometers/miles or more) or land areas (several hectares/acres or more) where surface, hidden, or subsurface oil is not expected or suspected but where a survey is required to ensure that oil has not been missed. This type of survey can require considerable effort (Tables 2.1 and 2.2) and a K9-SCAT No Detected Oil (NDO) clearance survey can release other SCAT teams who can focus their efforts in areas where oil already has been observed or reported.

- Routine pipeline inspections where oil is not expected but confirmation of NDO is required.

- Any environment where surface oil may be difficult to spot during aerial or ground reconnaissance (e.g. in heavily vegetated areas, or between boulders/riprap).

- Any area (shoreline, river, or inland) where there is no surface oil but where subsurface oil may be expected or suspected due to penetration or burial. A canine detection search would confirm the absence of subsurface oil with a high-confidence, low-risk survey or would locate oil for further delineation by the K9-SCAT team or investigation by a traditional SCAT team.

- Resurveys of dynamic areas where an event, such as a storm or river runoff/flood event, could remobilize, redistribute oil, and potentially bury oil.

- Resurveys immediately prior to subsurface oil cleanup to reconfirm the location and presence of the oil.

- Post-treatment or monitoring surveys to confirm that the recommended treatment has been completed. The K9-SCAT survey would report NDO or locate oil for investigation by a traditional SCAT team to ensure that the remaining oil meets endpoint criteria.

Typically a K9-SCAT team(s) would be activated and deployed after the initial scaling of the affected area has been completed and the survey priorities and levels of required effort have been assessed.

Table 3.1 outlines key considerations for the decision to deploy K9-SCAT.

The evaluation and selection of the most appropriate techniques would consider the advantages and limitations as described in Section 2.4. If a canine team is considered appropriate for one or more types of survey mission, a pre-deployment assessment test or field trial would be required to provide confidence that:

a) the canine(s) can detect the type of target oil,

b) the technique is a viable survey tool for the ambient environmental conditions,

c) the integration with more traditional surveys techniques offers greater resource efficiency and more rapid areal coverage.

**Table 3.1—K9-SCAT Deployment Decision Considerations**

| **The decision to deploy a K9-SCAT team(s) evaluates:** |
|---|
| The ability for canines to achieve the survey or mission objective(s), considering:<br>• anticipated maximum depth of subsurface oil,<br>• potential odor interference, e.g. background (non-target) oiling, or the presence of surface oil during a subsurface survey, and<br>• environmental constraints on field performance (e.g. strong winds, heavy rain). |
| The benefits (time and cost) of traditional versus K9-SCAT survey techniques. |
| The acceptance of the technique by the Unified Command, in terms of data credibility. |
| The availability of oil-trained canines and handlers. |
| The availability of a SCAT support person with K9-SCAT experience to work with the handler. |
| The required coverage rate to determine whether one or more canines would be required. |
| The availability of a traditional SCAT team to accompany the survey to verify and document any subsurface oil that is detected (this could be either an integrated or a separate mission). |
| The potential exposure of the handler and canine to oil and oil vapors. |
| **Although cost is typically not a consideration during a spill response, the deployment and operational costs of a K9-SCAT team(s) can be compared to:** |
| The daily operational costs of a SCAT survey team, including excavation equipment and operators, where required. |
| The effectiveness, efficiency, time saved, area covered, and real-time data generated from a continuous coverage clearance or subsurface oil canine survey versus the data acquired from a spot sampling excavation survey. |
| The ability for canines to operate and cover areas quickly in conditions that would be challenging and slow for a typical multi-agency SCAT survey team (boulder or riprap shoreline, thick vegetation or undergrowth, and wetlands). |
| **During an oil spill response, typically, a SCAT program uses a combination of techniques for different components of a survey:** |
| Reconnaissance aerial visual observations or remote sensing using aircraft or drones to locate Medium or Heavy category surface oil. |
| Ground surveys of those locations to document the oiling conditions. |
| Detection canines to locate and delineate:<br>• Light or Very Light category surface oils,<br>• oil “hidden” by vegetation, boulder, or riprap, or<br>• subsurface oil. |
| Manual or mechanical excavation to provide vertical delineation and oil characterization where subsurface oil has been located. |

# 4 Canine Providers

SCAT program managers typically have little or no experience with canine providers or detection canines. This section summarizes some of the parameters that should be considered in the evaluation and selection of service providers.

The service provider should, at a minimum:

- be a professional organization that trains detection canines,
- have a staff of certified and experienced handlers,
- be able to conduct imprinting after mobilization in the field prior to deployment,
- understand the importance and purpose of SCAT missions,
- have an animal health and welfare protocol that is implemented by the handler, and
- be supported by a canine veterinarian(s).

Each canine provider has their own methods and criteria for canine and handler selection, training, and odor imprinting, some of which may be privileged for commercial reasons. However, when evaluating canine providers, there are several guidelines that may be used to establish selection criteria.

## 4.1 Detection Canine Provider Guidelines

### 4.1.1 Canine Selection and Evaluation

Although canine selection is outside the scope of this manual, canine providers would be expected to follow relevant guidelines, such as those of the US Scientific Working Group on Dog and Orthogonal Detector Guidelines (SWGDOG, 2006a). SWGDOG describes recommendations for canine selection, and considers the following canine evaluation criteria:

- health,
- temperament,
- environmental soundness,
- independence,
- continuity of focus,
- search and retrieve/food drive,
- sociability with people, domestic dogs, other animals.

### 4.1.2 Handler Selection

Although handler selection is outside the scope of this manual, canine providers would be expected to follow relevant guidelines, such as those of the US Scientific Working Group on Dog and Orthogonal detector

Guidelines (SWGDOG, 2006b). SWGDOG describes recommendations for handler selection, including necessary personality traits, training, and experience.

### 4.1.3 Canine Care

As with all survey personnel and equipment, a canine must be well maintained and cared for. The canine handler has the responsibility for the overall health and welfare of the canine (Figure 4.1). The provider should have their own protocols for canine care. An example of guidance on canine care is IMAS's Guide to Occupational Health and General Dog Care (IMAS, 2013d).

**Figure 4.1—Canine with Handler**

## 4.2 Canine Provider Selection Criteria

Different canine providers have different abilities, protocols, and experience; therefore, the careful evaluation of the provider is essential to ensure a good fit within K9-SCAT. Table 4.1 provides a checklist of criteria to consider when evaluating and selecting a canine provider.

## 4.3 Information Required by the Detection Canine Provider

In order to fully understand the nature of the work, the canine provider would need to know certain information about the incident, the oil involved, and the environment and character of the survey area(s). Table 4.2 lists essential information to allow better preparation and planning by the provider.

## 4.4 Detection Team Preparation, Assessment, Deployment, and On-site Imprinting

Canine Teams maintain their proficiency level at all times and are deemed certified by independent review through a defined series of tests (IMAS, 2013b,c). An Odor Detection Test (ODT) is a standard requirement for detection dogs that are trained for narcotics, accelerants, munitions, etc. A canine must pass the ODT before being certified for a particular target material. The certified team must maintain standards by a process of recognized training protocols recorded in the canine's training log. There is a minimum training timeline allowed to maintain efficiency with detection capabilities achieved in each training scenario.

A study of the durability of canine odor discriminations found that canines showed no systematic deterioration in detection performance for up to four months (Johnston, 1999). However, once trained, a canine requires regular maintenance of skills necessary for oil detection, including odor recognition, search patterns, obedience, and agility. Typically, a minimum of four hours of maintenance training per week is recommended.

**Table 4.1—Canine Provider Selection Criteria Checklist**

| | |
|---|---|
| **CANINE AND HANDLER TRAINING** | |
| | Scenting and alerting |
| | Oil imprinting |
| | Non-aggression |
| | Working around public/response personnel |
| | Distraction (such as humans, wildlife, and especially birds) |
| | Conditioning/fitness (for long days, working outdoors, extreme temperature/humidity) |
| | Relevant terrains/environment (such as beach/bedrock shoreline, dense vegetation/forest) |
| | Ability to distinguish between oil odors (e.g. if there is oil present from a previous event) |
| **MOBILIZATION TIME** | |
| | Trained canine(s) and handler(s) ready to mobilize 24/7 within 24 hours |
| | Imprinting time |
| **PRIOR EXPERIENCE** | |
| | Air/ground detection |
| | Subsurface odor detection |
| | Oil detection |
| | Working with SCAT teams |
| **QUALIFICATIONS** | |
| | Canine Training Logs and Certifications |
| | Handler Certifications |
| | HAZWOPER Certification |
| | Canine Standards |
| **CANINE WELFARE** | |
| | Canine health management |
| | Vaccinations/medications |
| | Veterinary support |
| | Healthy diet |
| | Appropriate shelter, crates, kennels |
| | General care and concern |
| **SCAT EXPECTATIONS OF THE DETECTION CANINE PROVIDER** | |
| | Ability to imprint the canine and successfully pass a pre-deployment assessment test with the target oil (Section 4.4) |
| | Ability to work as part of a team |
| | Basic understanding of the SCAT process |
| | Understanding of safety requirements for a response and likely expectations/questions |

**Table 4.2—Information Required by the Detection Canine Provider**

| | |
|---|---|
| **LOGISTICAL SUPPORT** | |
| | Accommodation for handler and canine |
| | Transportation arrangements |
| **RELEVANT INCIDENT INFORMATION** | |
| | General information on the incident (location, time, source) |
| | Survey location |
| | Size of survey area |
| | Survey environment/terrain |
| | Survey type (WAS/Delineation/Clearance) |
| | Oil type |
| | Potential depth of oil (if known) |
| | Potential amount/concentration of oil (if known) |
| **SAMPLE FOR IMPRINTING** | |
| | Suitable sample of the target oil for imprinting (consider degree of weathering, concentration, depth) |
| **SAFETY DATA** | |
| | Safety Data Sheet (SDS) of the oil |
| | Air monitoring data (if available from site) |
| | Personal Protective Equipment (PPE) requirements for personnel (with recommendations for canine PPE) |

When time allows, a canine team is assessed on detection and deployment protocols immediately prior to attending an operational tasking. This evaluation could be completed by an independent assessor to a defined standard as detailed in the Standard Operational Procedures (SOP) for Canine Oil Detection Teams (IMAS, 2013b,c).

Once deployed to a response location, the canine would be exposed to the target odor and local terrain utilizing the provider's own imprinting protocols. This process can be as short as a 4-hour block of training to ensure the canine is calibrated to the new environment and target odor. The K9-SCAT Team Lead should arrange for and conduct an assessment test with the target oil to determine that the operational capability has been achieved prior to field deployment (Figure 4.2). Throughout the tasking, the canine may require random exposure to target odors to maintain canine efficiency and interest, if live targets are not being encountered (Annex B).

**Figure 4.2—Canine Imprinting Test (Trondheim Hundeskole/SINTEF)**

# 5 K9-SCAT Roles and Responsibilities

- A K9-SCAT team would function in the same manner as other SCAT field teams.
- An experienced SCAT Team Lead would manage and direct a K9-SCAT survey to support the handler and to ensure full area coverage and document survey data.
- A successful field survey requires training, experience, coordination, and good communication between the K9-SCAT Team Lead and the handler, and between the handler and the canine.
- The handler controls and rewards the canine and is responsible for the health and welfare of the animal.

## 5.1 Introduction

K9-SCAT fits into the response organization within the Environmental Unit, with the K9-SCAT Team managed by the SCAT Coordinator (Figure 5.1). The roles and responsibilities within a traditional SCAT team are described in IPIECA (2014) and summarized in Table 5.1. K9-SCAT teams function exactly the same as any other SCAT field team. The roles of, and interactions with, the SCAT Logistics Coordinator, SCAT-Ops Liaison Coordinator, and SCAT Data Manager are the same as for traditional SCAT field teams. Section 6.2 provides additional logistical considerations, and Section 8 summarizes additional data management requirements for a K9-SCAT program.

A K9-SCAT team typically consists of:

- K9-SCAT Team Lead,
- canine(s) with canine handler(s),
- participating Team Members (e.g. agency representatives, land owners, land managers).

K9-SCAT requires close interaction between the K9-SCAT Team Lead and the canine handler, and requires a high level of understanding of each other's roles, expectations, protocols, and skills in order to communicate effectively and develop a good working relationship. An effective and successful K9-SCAT Team must fully integrate the two very different disciplines of SCAT and canine detection, with inter-disciplinary training, cooperation, and calibration.

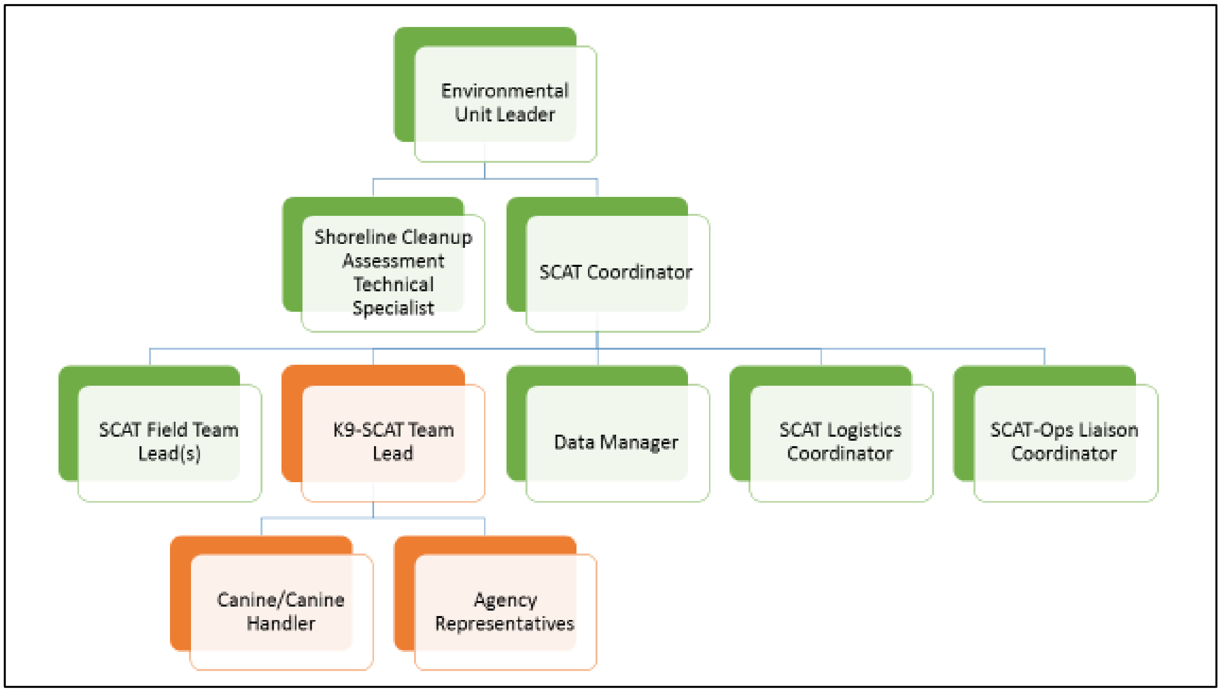



**Figure 5.1—K9-SCAT in the Environmental Unit**

## 5.2 K9-SCAT Roles and Responsibilities

The roles and responsibilities of a traditional (non-K9) SCAT team are well established and documented (e.g. IPIECA, 2014). Table 5.1 summarizes the key roles and responsibilities in a traditional SCAT program, and this section describes the additional responsibilities required for a K9-SCAT team.

### 5.2.1 SCAT Coordinator

The SCAT Coordinator is responsible for managing and directing the SCAT program and for coordinating the field teams. The SCAT Coordinator evaluates the need for K9-SCAT, and recommends mobilization to the Environmental Unit Leader and Incident Command. S/he must therefore have a good understanding of:

- the advantages and limitations of K9-SCAT,
- the scenarios in which a canine oil detection survey can be effectively and successfully conducted,
- specific requirements for the K9-SCAT team, such as:
  - time required for imprinting the target oil,
  - team calibration,
  - typical distances covered by a K9-SCAT team in the survey environment,
  - logistical requirements for the canines.

In coordination with the Shoreline Cleanup Assessment Technical Specialist and/or the Environmental Unit Leader, the SCAT Coordinator determines: the segments/reaches/areas to be surveyed by K9-SCAT teams, survey prioritization, and the agency representation on each K9-SCAT team. The SCAT Coordinator also prepares the K9-SCAT Plan (see Annex A), either within the overall SCAT Plan or as a stand-alone document.

### 5.2.2 K9-SCAT Team Lead

The role of the K9-SCAT Team Lead is equivalent to that of a traditional SCAT Team Lead, and requires the same experience and training as a traditional SCAT Team Lead, but with additional canine detection experience and understanding. The K9-SCAT Team Lead has the following additional responsibilities.

- Conducting an assessment test prior to deployment (Section 4.4).
- Communicating closely with the canine handler.
- Defining the area to be searched, i.e. the boundaries of the Wide Area Search.
- Deciding (with the canine handler) an appropriate search pattern design (Wide Area Search and Delineation) for the specific scenario (Section 7.5).
- Fitting the GPS tracking collar on the canine, or ensuring the canine handler fits the GPS collar correctly (Section D.1).
- Ensuring full area coverage using a hand held GPS and/or moving map display, directing the canine handler to unsurveyed or missed sections (Section D.5).
- Recording data, including:
    - completing the survey form(s) (Annex C),
    - photography,
    - marking (with GPS) and flagging any alert sites, and recording those on the survey form.
- Safety “Spotter”: highlighting any safety concerns ahead or around the location, as the canine handler is focused on the canine activity.
- Ensuring compliance with BMPs/ESA Section 7/NHPA Section 106 requirements
- Ensuring the agency representatives understand the search area and pattern(s), and recognize how the canine communicates an alert (Figure 2.9 left)
- Ensuring that the unprocessed GPS field data is provided to the SCAT Data Manager.

**Table 5.1—Summary of Key Roles in a Traditional SCAT Program**

| |
|---|
| **ENVIRONMENTAL UNIT LEADER** |
| • Determines the need for an oiling survey, and activates the SCAT team<br>• Acts as a conduit for information and communications between SCAT and the Planning Section<br>• Chairs any committees or Technical Working Groups, such as the Shoreline Treatment TWG |
| **SHORELINE CLEANUP ASSESSMENT SPECIALIST** |
| • Provides technical and scientific input during key decision making processes, such as the selection of appropriate treatment techniques and Treatment Endpoints |
| **SCAT COORDINATOR** |
| • Directs the SCAT program and manages the team's activities<br>• Sets SCAT program objectives and plans<br>• Serves as the primary point of contact within the Incident Management Team for SCAT activities<br>• Coordinates with the SCAT logistics coordinator to set daily field team missions<br>• Coordinates the development of treatment recommendations and cleanup endpoints for Command approval<br>• Coordinates the evaluation of the effectiveness of treatment methods and endpoints, and modifies them as necessary<br>• Determines the number of field teams required, and ensures all teams are fully represented by the relevant parties |
| **FIELD TEAMS** |
| • Represent relevant stakeholders (e.g. Responsible Party, agencies, land owners/managers)<br>• Gather oiling and site character data in the field<br>• Gather other data as necessary, e.g. safety, logistics, ecological, cultural, socioeconomic concerns<br>• Complete necessary forms and reports<br>• Make recommendations for treatment<br>• Liaise with Operations to ensure a shared understanding of Shoreline Treatment Recommendations (STRs), endpoints, and operational limitations (could be conducted by a separate SCAT-Ops Liaison role for a larger incident)<br>• Conduct Shoreline Inspection (SIR) surveys, comparing oiling conditions with agreed endpoints and making recommendations for signoff/completion |
| **DATA MANAGER/TEAM** |
| • Collects and collates field data<br>• Downloads and processes GPS data and photographs<br>• Conducts QA/QC of incoming data<br>• Enters data into SCAT GIS database<br>• Produces summary reports, maps, and tables, as required<br>• Produces field maps and maps for reports<br>• Maintains an archive for all SCAT data<br>• Generates summary data tables and maps ("dashboard") |
| **SCAT LOGISTICS COORDINATOR** *(this role could be filled by the SCAT Coordinator on a small, localized incident)* |
| • Develops daily missions for field teams in consultation with the SCAT coordinator<br>• Ensures that all teams have the necessary transportation to complete their missions<br>• Ensures that all teams have the necessary equipment (including PPE) to safely complete their missions<br>• Produces the SCAT Safety Plan and Job Safety Analysis (JSA)<br>• Maintains communications with teams in the field<br>• Tracks field teams throughout the day until they return<br>• Maintains SCAT planning tables<br>• Facilitates daily briefs and debriefs |

### 5.2.3 Canine Handler

The canine handler must be fully familiar with, and understand the needs of, the canine(s) on his/her team. Handlers are responsible for:

- the health and welfare of the canine(s) (Section 6.4),
- imprinting the canine(s) on the specific oil odor for the job.

During a search, the handler:

- directs the canine according to the search pattern(s) agreed with the K9-SCAT Team Lead,
- follows direction from the K9-SCAT Team Lead to ensure full area coverage,
- determines maximum working distances and times (duty cycle) to ensure that the canine is not overworked,
- monitors the energy and enthusiasm of the canine,
- identifies the needs for a reward target or a rest,
- rewards the canine following an alert or an NDO survey.

The Canine handler is responsible for generating a daily field report that:

- documents the activities with respect to the canine(s) and the handler,
- documents the behavior of the canine with respect to the environmental and duty conditions,
- identifies any issues that arise, along with potential mitigating options, and
- recommends improvements that could be applied to the survey design or the operating procedures.

### 5.2.4 Team Members

Team Members, such as agency, landowners, or land manager representatives, may join the K9-SCAT team to observe the search process and to confirm alerts or “NDO” (No Detected Oil) in a segment or search area on behalf of their agency/ies. Team Members are not involved in the direction of the search, rather they have passive participation to ensure that the relevant stakeholders observe the survey together, and report the same outcomes.

Team Members may not have previously worked with K9-SCAT; therefore, a training or orientation session may be necessary to ensure that all team members are familiar with the abilities and limitations of K9-SCAT teams.

# 6 K9-SCAT Survey Planning

- A K9-SCAT survey should be planned and managed in the same manner as other field SCAT missions.
- Suitable accommodation and travel arrangements take into account the needs of the animal and the handler.
- The SCAT Safety Plan would cover the K9-SCAT field deployment and include a canine health and safety plan, and provision for direct access to a canine veterinarian.

## 6.1 Mobilization

Once the need for K9-SCAT has been determined by the SCAT team, several key pieces of information are required for approval and planning. These include the ability of the K9-SCAT team to work in the specific environment/terrain, deployment and imprinting time, and the availability of a sample of the target oil for imprinting the canine(s). A checklist for mobilization for a K9-SCAT team is provided in Table 6.1.

## 6.2 Logistics

The SCAT Logistics Coordinator (or SCAT Coordinator for small-scale incidents) typically arranges for the accommodation of SCAT personnel, and for their transportation by land, water or air to survey sites, as well as any local transportation and equipment requirements for the survey. The Logistics Coordinator is also responsible for maintaining good communications with the field team(s) at all times and for ensuring that the teams have sufficient food and water. Additional logistical requirements, primarily relating to the canine(s), are required for a K9-SCAT team. The canine, handler, and the K9-SCAT Team Lead would provide information for their local transport and support needs.

### 6.2.1 Accommodation

The accommodation provided for SCAT personnel is typically a hotel room, although apartments may be more cost-effective for longer term incidents, and live-aboard vessels/barges may be used to house personnel in remote areas. In either case, the accommodation must allow working canines, and provide sufficient indoor space for a canine crate or bed, as well as an outdoor area for exercise and relief. The canine handler would be consulted to ensure that the accommodations are adequate for the health, safety, and comfort of the canine(s).

**Table 6.1—K9-SCAT Mobilization Checklist**

| K9-SCAT MOBILIZATION CHECKLIST | |
|---|---|
| ☐ | The SCAT Coordinator determines the need for K9-SCAT support |
| ☐ | The SCAT Coordinator seeks approval from the Environmental Unit Leader, Planning Section Chief, and Incident Command |
| ☐ | The SCAT Coordinator evaluates, selects, and contacts the K9-SCAT provider |
| ☐ | The SCAT Coordinator provides the following information to the K9-SCAT provider:<br>• Location of the incident<br>• Spill environment:<br>  • land or on water<br>  • lake, pipeline, river, shoreline, stream, terrestrial<br>• Survey terrain<br>• Oil type<br>• Approximate length or area of segments/reaches to be surveyed<br>• Estimated length of deployment time required<br>• Contact details (name, phone and email address) for the SCAT Coordinator |
| ☐ | The SCAT Coordinator requests the following information from the K9-SCAT provider:<br>• Deployment time to the Command Post or site<br>• Proposed staff by job title to be placed on Standby<br>• Estimated imprinting time<br>• Volume of oil required for imprinting<br>• Contact details (name, phone, and email address) for the K9-SCAT primary contact |
| ☐ | The SCAT Coordinator requests a sample of the spilled oil for imprinting |
| ☐ | The K9-SCAT provider is placed on STANDBY until the mobilization of K9-SCAT resources are approved by either (a) the Planning Section Chief via ICS form 213RR, or (b) email from the Responsible Party |
| ☐ | Once mobilization is approved, the EUL or designee provides the following information to the K9-SCAT provider:<br>• Copy of the completed and signed 213RR for SCAT personnel, or other formal notice of approval (such as an e-mail message)<br>• Command Post contact information<br>• Required on-site arrival date/time<br>• If appropriate, travel and accommodation information |
| ☐ | Once approved, the SCAT Coordinator contacts and coordinates the mobilization of the approved K9-SCAT personnel and resources to the ICP and/or other relevant site. |

### 6.2.2 Transportation

Transportation for SCAT teams is typically arranged by the SCAT Logistics Coordinator; however, the K9-SCAT provider may have their own preferred methods of transporting their canines and may provide suitable kennels or crates. The canines are always accompanied by their handler(s). For any mode of transportation, consideration must be given to:

- general comfort of the canine,
- cleanliness,

- freedom of movement,
- ventilation,
- access to clean drinking water,
- temperature control,
- shelter from the elements (sun, rain, wind),
- protection from fumes, dust, wind-blown sand,
- ease of entry – canines should always be lifted in and out of vehicles,
- regular breaks to allow exercise, relief, water, food, etc.

If the travel involves a significant change in climate, after deployment to a new area, canines should be allowed a recovery period of at least two days to allow for acclimatization to the new environment (IMAS, 2013d).

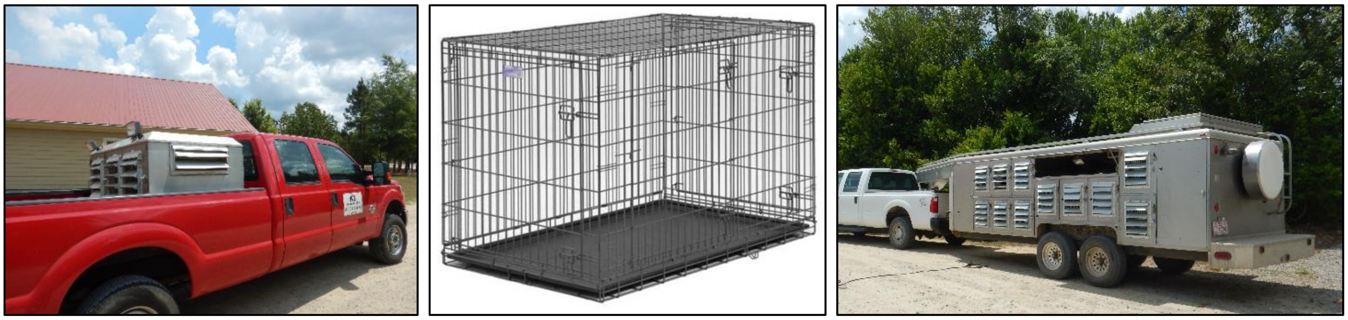
#### 6.2.2.1 International Transportation

With regard to international deployments, the United States Department of Agriculture defines the requirements for importing commercial animals (USDA, 2016). International health certificates for the export of animals from the United States are completed by an accredited veterinarian and must be endorsed by a Veterinary Services area office (e.g. the USDA, Albany, NY) in order to be valid. Certification can be completed as part of routine animal care, so that no deployment time is lost. The United States has minimal requirements for animals to be exported to other countries. Each country would have their own specific health requirements for entry of animals and also have their own certificate format. There is no single source that provides import/export requirements for foreign countries. To obtain the requirements for each country, the interested party in the country of destination would have to apply for an Import Permit at the appropriate government department, often the Ministry of Agriculture. This Import Permit should identify the specific requirements for the import of canines.

#### 6.2.2.2 Road Transportation

For road transportation of canines, the key concern is for the safety and comfort of the canines. Kennels or crates are typically used to prevent the canines from sliding around during transportation, and to prevent them from distracting the driver. Road transportation of a canine team might consist of:

- 1 to 3 kennels on the back of pickup truck (Figure 6.1a),
- 1 to 2 crates inside a large vehicle (e.g. SUV) (Figure 6.1b),
- a kennel or crate on the back of a UTV,
- a kennel trailer for a large team (Figure 6.1c).



a) b) c)

**Figure 6.1—Canine Transportation: a) Kennel on Pickup Truck, b) Typical Dog Crate, c) Kennel Trailer**

#### 6.2.2.3 On-water Transportation

A kennel or crate may be placed on a vessel, ideally inside the cabin, where there is shelter from the elements and temperature control. Consideration should be given to the comfort of the canine, and its acclimatization to the movement of the vessel on water.

#### 6.2.2.4 Air Transportation

The International Air Transportation Association (IATA)'s Live Animals Regulations (LAR) is the global standard for transporting canines by commercial airlines, and specifies airline and government requirements for the transport of live animals (IATA, 2015).

Individual airlines should be contacted in advance to understand their requirements for canine transportation, including the use of travel crates. There may be animal travel restrictions during the hottest or coldest times of the year, so planning ahead of time can alleviate delays.

Consideration should be given to the acclimatization of canines to air travel, especially if transporting between sites by helicopter. Canines may require some rest time after a flight to recover from the unsteady motion.

### 6.2.3 Shelter On-site

Shelter should be available for the canine(s) at the survey site for regular breaks from the survey, and when canines/canine teams work on a rotation. This shelter may be a crate or kennel on/in a truck, car, UTV, or vessel, where the temperature can be controlled and the canine can shelter from the elements (sun, rain, wind, etc.), and be able to rest.

## 6.3 The Public and Response Personnel

Depending on the location of the survey(s), and any ongoing response operations, canines may come into contact with members of the public and/or response personnel. Public access should be restricted during K9-SCAT surveys, and domestic dogs should be restricted from the survey area, if at all possible and practical. Trained canines should not be distracted by humans and other domestic dogs. They are trained to be non-aggressive; however, the behavior of the public, and other animals, cannot be predicted.

Operational briefs may be appropriate to ensure that response personnel are made aware of the presence and purpose of the K9-SCAT team, and of how they should behave around the canines.

## 6.4 Canine Health and Safety

Good physical and mental health is essential for all working canines. Strength, resistance to disease, fitness, liveliness, endurance, motivation, and the ability to learn are fundamental requirements, which depend on the health of the canine (IMAS, 2013d).

The handler is responsible for the health, safety, and welfare of the canine(s), including:

- daily health checks (before and after each operation);
- monitoring canine health, condition, and energy during surveys;
- assessing the duty cycle and the hours of work per canine per day;
- ensuring the canines have the necessary:
    - food,
    - water,
    - routine medications,
    - shelter,
    - comfort;
- grooming and parasite control;
- ensuring the canines have:
    - clean and comfortable accommodation when not working,
    - clean and comfortable transportation to the survey site, and
    - clean and comfortable shelter/kenneling during breaks from surveys;
- managing exposure to:
    - sun,
    - hot/cold temperatures,
    - wind,
    - rain/snow,
    - wind-blown sand/dust;
- minimizing and mitigating oil exposure (limiting survey times if necessary) due to:
    - contact,
    - inhalation,
    - ingestion;

- avoiding heavy machinery: it may be necessary to plan surveys in areas where Operations are not working, or to notify Operations of the need to pause during surveys near heavy machinery;
- avoiding wildlife hazards, where present;
- avoiding domestic animals, where present;
- Emergency First Aid;
- Canine PPE (Table 6.2);
- obtaining immediate veterinary support when necessary.

**Table 6.2—Canine PPE**

| RISK | PPE |
|---|---|
| Oil Contact | Dog boots (Figure 6.2a) |
| Wind-blown sand/dust | Dog goggles (“Doggles”) (Figure 6.2b) |
| Low temperature | Dog boots, coat |
| Dense vegetation, thorns, etc. | Dog boots, coat |
| Heavy machinery, vehicles | Hi-vis clothing (Figure 6.2c) |

a) b) c)

**Figure 6.2—Examples of Canine PPE: a) Boots (K2 Solutions), b) “Doggles” (K2 Solutions), c) Hi-vis Coat (www.canineconcepts.co.uk)**

Information on potentially harmful components of the target oil, plus any air monitoring data obtained from the survey site, should be used by the Safety Officer and supporting canine veterinarian to evaluate potential health risks to the canine due to the oil (i.e. inhalation, ingestion, or contact). Harmful components include Volatile Organic Compounds (VOCs), Polycyclic Aromatic Hydrocarbons (PAHs) and Hydrogen Sulfide ($H_2S$). For fresh and/or light oils, VOCs may be elevated, and therefore consideration should be given to personal air monitoring. As a general rule of thumb, a site/activity that is identified as unsafe for response personnel would be unsafe for a canine. Human Health and Safety information for selected harmful substances, including occupational exposure limits are provided in ExxonMobil (2014).

The SCAT Safety Plan would cover the K9-SCAT field deployment and include the protocols for the handler to monitor the health and wellbeing of the animal and provision for direct access to a canine veterinarian.

The Job Safety Analysis (JSA) would include all matters, risks, and mitigations associated with the deployment of a K9-SCAT team.

## 6.5 Equipment Checklist for a K9-SCAT Survey

Table 6.3 provides a checklist of equipment and support that can be used prior to daily field deployments.

**Table 6.3—Equipment Checklist for a K9-SCAT Survey**

| | |
|---|---|
| **RECORDING DEVICES** | |
| □ | Handheld GPS |
| □ | Moving map display (recommended for Wide Area Searches) |
| □ | GPS tracking device fitted to canine collar |
| □ | Camera |
| **DOCUMENTATION** | |
| □ | Smart phone with local weather information (recommended) |
| □ | K9-SCAT Survey Form |
| □ | Notebook (waterproof) |
| □ | Pens/pencils |
| □ | Flags for marking alerts |
| **SAFETY (PERSONNEL)** | |
| □ | Communications (cell phone, radio, sat phone) |
| □ | Sturdy footwear (e.g. hiking boots) |
| □ | Sunglasses |
| □ | Hat |
| □ | Foul/Cold weather gear |
| □ | PPE |
| □ | First aid kit |
| □ | Water and food |
| **CANINE REQUIREMENTS** | |
| □ | Water and food (in cooler, if necessary) |
| □ | Rewards |
| □ | Shelter |
| □ | Harness/leash/long line |
| □ | Canine PPE |
| □ | K9 care equipment (bowls, grooming, towels, first aid, etc.) |
| □ | Reward target (if necessary) |

# 7 K9-SCAT Survey Design Guidelines

- Wide Area Searches, off leash and under favorable conditions, can cover between 4 and 8 ha/hour (10 and 20 acres/hour) at speeds between 5 and 10 km/hour (~3 and 6 miles/hour). On-leash delineation search speeds are slower: 1 to 5 km/hour (0.5 to 3 miles/hour).
- K9-SCAT planning includes the design of a search pattern that is best suited to the mission objective(s).
- An off-leash Wide Area Search or a pipeline ROW survey typically involves a rectilinear “ladder” pattern.
- An on-leash subsurface oil delineation survey typically follows a “bounce” pattern to define the boundaries of the deposit, after it has been located.
- The objective of delineating a continuous or discontinuous subsurface oil deposit is to provide location information so that a SCAT team can excavate pits or trenches at the site and in the immediately adjacent area to determine the character of the oil and the exact vertical and horizontal dimensions.
- Detection canines are trained to locate specific targets by imprinting with an oil sample from the area.
- In planning a K9-SCAT program, the team should be aware of potential “background” or non-target oils in a survey area. Canines may be trained to ignore non-target oils during the imprinting process.
- Confirmation, characterization and vertical delineation of subsurface oil would be conducted by an accompanying SCAT team or at a later time.

SCAT program missions typically involve a phased approach with initial reconnaissance observations to define areas for subsequent, more detailed, ground surveys. A K9-SCAT team can support the initial reconnaissance surveys and the ground inspection surveys. In subsequent phases of a SCAT program, a K9-SCAT team can provide support for inspection missions.

## 7.1 Survey Objectives

Table 7.1 identifies three primary survey objectives for K9-SCAT missions:

- clearance of an area for No Detected Oil (NDO),
- oil detection and delineation, and
- completion verification.

## 7.2 Strategic Information Required for K9-SCAT Survey Planning

The development of a K9-SCAT Plan requires the acquisition of a range of information that is used to set survey objectives and design a survey strategy. Table 7.2 identifies key information and data that are necessary for the development of the Plan.

## 7.3 Design Decisions Required to Develop a K9-SCAT Plan

The development of a K9-SCAT Plan involves evaluating and selecting appropriate survey tactics for each type of mission. Table 7.3 identifies the typical set of decisions that are required as part of the survey planning process.

**Table 7.1—K9-SCAT Mission Objectives**

| K9-SCAT SURVEY OBJECTIVE | APPLICATION | ASSOCIATED SCAT PROCESS |
|---|---|---|
| **CLEARANCE – NO DETECTED OIL (NDO)** | During an initial SCAT phase where surface, hidden, or subsurface oil is not anticipated, but confirmation is required, for example:<br>• A survey in an area not believed to have been oiled<br>• Routine pipeline inspection | Reconnaissance or initial SCAT (SOS) survey |
| **OIL DETECTION (WITH DELINEATION)** | During an initial SCAT phase where hidden or subsurface oil possibly exists, and where either confirmation, location (detection) and delineation is required, or the area is cleared as No Detected Oil (NDO), for example:<br>• A survey where oil is suspected to have penetrated into, or been buried by, sediment or snow<br>• A survey where oil is suspected to be present in a boulder, wetland, or scrub area and cannot be directly observed from the air or ground, or where human traffic in a wetland can be avoided, or in difficult terrain (Figure 2.8a)<br>• Rapid segment surveys to locate buried oil on a shoreline in support of active cleanup<br>• A resurvey following a high water level or a significant event such as a storm that would be expected to remobilize and redistribute oil<br>• A routine pipeline survey following a leak warning and/or third-party report<br>The objective of delineating a continuous or discontinuous subsurface oil deposit is to provide location information so that a SCAT team can excavate the site and the immediately adjacent area to determine the character of the oil and the exact vertical and horizontal dimensions. | Initial SCAT (SOS) survey |
| **CONFIRMATION OF ENDPOINT ACHIEVEMENT** | As part of a post-treatment survey where the location of oiling is known, and either:<br>• recommended treatment has been completed, or<br>• a suitable period of natural recovery has transpired | Post Treatment Assessment (PTA), Shoreline Inspection Report (SIR) survey, or monitoring survey |

**Table 7.2—Information Required for K9-SCAT Survey Strategic Planning**

<table>
<tr><td colspan="2">OIL INFORMATION</td></tr>
<tr><td></td><td>Oil type</td></tr>
<tr><td></td><td>Estimated volume of spilled oil (if known)</td></tr>
<tr><td></td><td>Potential depth (if known, e.g. pipeline depth or beach profile data)</td></tr>
<tr><td></td><td>Length of time since oil was spilled/stranded/deposited, degree of weathering</td></tr>
<tr><td colspan="2">SURVEY INFORMATION</td></tr>
<tr><td></td><td>Size of the survey area</td></tr>
<tr><td></td><td>Terrain type within the survey area</td></tr>
<tr><td></td><td>Survey objective and mission type</td></tr>
<tr><td colspan="2">LOGISTICS</td></tr>
<tr><td></td><td>Access locations</td></tr>
<tr><td></td><td>Transportation to and within survey area</td></tr>
<tr><td></td><td>Access and transportation constraints</td></tr>
<tr><td colspan="2">WEATHER AND CONDITIONS</td></tr>
<tr><td></td><td>Weather forecast:<br>• Temperature<br>• Humidity<br>• Wind speed and direction<br>• Barometric pressure<br>• Precipitation (rain, snow)</td></tr>
<tr><td></td><td>Presence of ice/snow</td></tr>
<tr><td></td><td>Tide/water levels:<br>• High water level, Low water level, range<br>• Tide times<br>• Rising, falling, slack water</td></tr>
<tr><td colspan="2">SAFETY</td></tr>
<tr><td></td><td>Risk identification – general and specific for K9-SCAT field activities, mitigation actions</td></tr>
<tr><td></td><td>Oil inhalation toxicity and air VOC monitoring data</td></tr>
<tr><td></td><td>Segment specific safety issues</td></tr>
</table>

**Table 7.3—Survey Design Tactical Decisions**

| DECISION | CONSIDERATIONS |
|---|---|
| **SURVEY LOCATION ("WHERE")** | • segment location<br>• size/shape of area segment/polygon<br>• start point (consider access and wind direction) |
| **SURVEY TIMING ("WHEN")** | • tides/water levels<br>• temperature, humidity, winds<br>• work day schedule<br>• duty cycle |
| **SURVEY DESIGN ("HOW")** | • search pattern<br>• suitable quartering spacing for WAS rectilinear or "ladder" design<br>• suitable "bounce" sizes for delineation |
| **SURVEY PARTICIPATION ("WHO")** | • how many teams<br>• how many canines per team (rotating for fatigue, cold, heat etc.)<br>• team members/agency participation |
| **SURVEY DURATION** | • estimated time to complete survey (in terms of hours and days) |
| **SAFETY** | • risk prevention (avoidance/elimination) measures, and/or<br>• risk mitigation (reduction) measures<br>• PPE requirements for people/canine(s) |

The "Duty Cycle" is the amount of time that a canine works without observed deterioration in detection performance. Garner et al. (2001) indicate that an effective duty cycle under moderate working conditions is in the range of 90 to 120 minutes of continuous searching, although extreme conditions of temperature or humidity may reduce this time. Planning a duty cycle may include multiple animals and handlers who can alternate during a search.

### 7.3.1 Reward Targets

If the survey is expected to involve long periods (i.e. several hours) of searching without any detection of oil, for example during clearance surveys of large areas, the canine may benefit from the placing of a "reward target." This is a simulated target, using the target oil, which may be hidden/buried by a team member to allow the canine to "find" the oil, communicate an alert (Figure 2.9 left), and receive a reward. This action maintains the canine's enthusiasm for the search, and enables longer searches in areas with No Detected Oil (NDO). Instructions for making a subsurface reward target are provided in Annex B.

## 7.4 Scenario Planning Considerations

The current state-of-knowledge for canine oil detection is based on a relatively small set of research and real-world experiences. However, there is a reasonable expectation that the applications of K9- SCAT are much broader than current tested scenarios based on knowledge and experience gained from a wide range of detection applications over many years.

In designing a search pattern for surface oil during a large area clearance survey or in wetlands, dense undergrowth or rough terrain where pedestrian movement is difficult or undesirable, a detection canine senses for an airborne odor cloud working toward the potential or suspected oil source. The canine may use a combination of air and ground scenting as s/he approaches the source of hidden oil, or in low wind conditions.

In a search for potential or suspected subsurface oil, a detection canine senses for an airborne odor cloud that has migrated to the surface from the source through sediment, snow, and/or water to create an odor “footprint.” The canine typically uses a combination of air and ground scenting as s/he approaches the odor footprint, or in low wind conditions. The objective of delineating a continuous or discontinuous, lens-type subsurface oil deposit is to provide location information so that a SCAT team can excavate the site and the immediately adjacent area to determine the character of the oil and the exact vertical and horizontal dimensions.

Search speeds vary depending on a wide range of environmental, vegetation and terrain factors. The 2015 API field trails were conducted in favorable conditions with open terrain with no environmental constraints (Figure 2.6) (API, 2016). Off-leash WAS speeds ranged between 6 and 11 km/hour (4 and 7 miles/hour) and the calculated areal coverage rates ranged between 4 and 8 ha/hour (10 and 20 acres/hour) for continuous searching without breaks. Buvik and Brandvik (2009) report a range of on-leash search speeds between 1 and 5 km/hour (0.5 and 3 miles/hour) over more difficult terrain. Avalanche dogs are reported to search at rates on the order of 2 ha/hour (5 acres/hour) for a “coarse” pattern survey and 0.5 to 1 ha/hour (1.25 to 2.5 acres/hour) for “fine” search patterns (Alderson, nd; Mountain Yahoos, nd; Gilmore, nd).

Delineation speeds are slower than during an off-leash WAS and, under the favorable conditions of the 2015 API field trials (Figure 2.7), the on-leash search speed range was 1.6 to 3.5 km/hour (1 to 2 miles/hour).

Table 7.4 provides a range of survey rates for planning purposes, for favorable search conditions, based on information from the Norwegian and API field trials.

**Table 7.4—Typical Survey Speeds and Coverage Times for Planning K9-SCAT Missions**

| SURVEY TYPE | PLANNING SURVEY SPEED RANGE: km/hour (miles/hour) | PLANNING SURVEY COVERAGE RANGE: ha/hour (acres/hour) |
|---|---|---|
| **WIDE AREA SEARCH – off leash** | 5–10 (3–6) | 4–8 (10–20) |
| **DELINEATION – on leash** | 1–5 (0.5–3) | 0.5–1 (1.2–2.5) |

In considering the potential applications for K9-SCAT, Tables 7.5 and 7.6 identify some of the environmental and operational factors and the potential risks that should be evaluated in the development of a K9-SCAT Plan.

## 7.5 Search Patterns

An appropriate search pattern should be designed in order to ensure full survey coverage during a Wide Area Search (WAS). A rectilinear, or “ladder”, search pattern (Figures 2.6, 7.1, and 7.2) would be appropriate in all but the narrowest environments, where a linear or straight search pattern would be sufficient to cover the width of the area (Figures 7.3 and 2.8a). Many canines naturally quarter, or orbit, when scenting; therefore, the handler only needs to direct the canine to ensure the canine’s movements fully cover the survey area, with the assistance of the K9-SCAT Team Lead’s GPS tracking and/or moving map display (Section D.5, Figure D.3).

The distance between quarters, or the determination of what constitutes “narrow”, depends on the reach of the odor carried by the near-surface air under the prevailing wind and environmental conditions at the time of the survey. Under favorable conditions, air odor from a subsurface oil footprint can easily reach, and be detected, at 15 m to 20 m distance. Odor from large surface oil deposits has been detected at ranges on the order of hundreds of meters (Section 2.3.1).

**Table 7.5—Scenario Planning Considerations**

| ENVIRONMENT | SURVEY SHAPE | SURVEY PATTERNS | POSSIBLE TERRAIN TYPES |
|---|---|---|---|
| **LAKE (ON SHORE)** | Linear, along the lake shoreline (width dependent on prior and current water levels) | >10 m wide: Rectilinear "ladder" search<br><br><10 m wide: Straight down the center line | • dry: sand, pebble/cobble, boulder, bedrock, grass, shrub, forest<br>• wetland: pond, fen, bog, swamp, reeds, tundra<br>• snow/ice |
| **PIPELINE** | Linear along the ROW | Rectilinear "ladder" search | • dry: grassland, desert, shrub, forest<br>• wetland: pond, fen, bog, swamp, reeds, tundra<br>• snow |
| **RIVER** | Linear, with consideration of channels, two banks per channel, channel bars and shallow waters | >10m wide: Rectilinear "ladder" search<br><10m wide: Straight down the center line or mid bank | • dry: sand, pebble/cobble, boulder, bedrock, grass, shrub, forest<br>• wetland: pond, fen, bog, swamp, reeds, tundra<br>• snow/ice |
| **SHORELINE** | Linear, along the shoreline (width dependent on tides) | >10m wide: Rectilinear "ladder" search<br><10m wide: Straight down the center line | • dry: sand, pebble/cobble, boulder, bedrock, grass, shrub, forest<br>• wetland: pond, fen, bog, swamp, reed, tundra<br>• snow/ice |
| **STREAM** | Linear, typically covering both banks as well as shallow waters | Straight down the center of each bank<br>If very narrow (<10 m) and shallow, can cover both banks with one winding linear line survey | • dry: sand, pebble/cobble, boulder, bedrock, grass, shrub, forest<br>• wetland: pond, fen, bog, swamp, reed, tundra<br>• snow/ice |
| **TERRESTRIAL** | Polygon | Rectilinear "ladder" search | • dry: grassland, desert, shrub, forest<br>• wetland: pond, fen, bog, swamp, reed, tundra<br>• snow |
| **ON WATER (SHALLOW)** | Polygon | Rectilinear "ladder" search | • on boat<br>• on ice |

**Table 7.6—Operational Considerations and Potential Risks for Planning**

| ENVIRONMENT | OPERATIONAL CONSIDERATIONS | POTENTIAL RISKS |
|---|---|---|
| **WATER** | • Ability of canine/handler team to indicate and recognize the direction of an odor plume<br>• Ability of boat operator to follow handler directions<br>• Alert verification (underwater techniques (e.g. viewing tubes, snorkel) | • Boat operations: embarking and disembarking<br>• Working on water: waves, currents, white water<br>  ◦ Mitigation: human and canine Personal Floatation Devices (PFDs) required |
| **LAND:**<br>**DENSE VEGETATION** | • Difficulty maneuvering through vegetation, e.g. dense undergrowth or shrubs<br>• Potential difficulty for maintaining sight and control of the canine during a Wide Area Search | • Slips, trips and falls (branches, roots, etc.)<br>• Cuts or punctures from branches thorns, etc.<br>• Mitigation: may require human and canine protective clothing |
| **LAND:**<br>**WETLANDS** | • Bearing capacity for personnel, canines, and verification equipment<br>• Avoiding trampling/damage of wetland vegetation | • Sinking into soft sediment<br>• Slipping on wet sediment |
| **LAND:**<br>**SOFT SEDIMENT** | • Bearing capacity for personnel, canines, and verification equipment | • Sinking into soft sediment |
| **LAND:**<br>**UNSTABLE TERRAIN** | • Difficult and slow maneuvering, for example through boulders, riprap, or on steep slopes | • Slips, trips, and falls |
| **ICE** | • Ice thickness and load bearing<br>• Difficulty maneuvering across ice<br>• Alert verification (e.g. coring through ice) | • Cold environment – consider duty cycle, clothing (human and canine) and shelter requirements<br>• Slippery walking surface |
| **SNOW** | • Difficulty maneuvering through soft snow/powder | • Cold environment – consider duty cycle, clothing (human and canine) and shelter requirements<br>• Slippery walking surface |

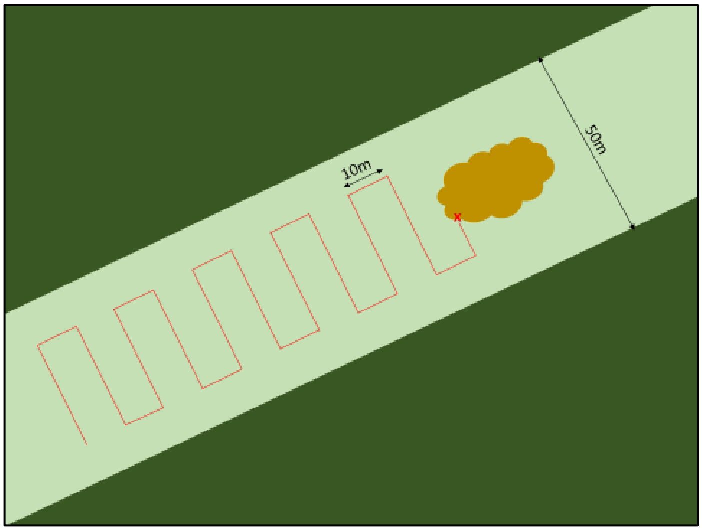



**Figure 7.1—WAS: Straight Rectilinear ("Ladder") Search Pattern (e.g. Pipelines, Straight Shorelines)**


**Figure 7.2—WAS: Dynamic Rectilinear Search Pattern (e.g. Non-straight Shorelines, Meandering Rivers)**


**Figure 7.3—WAS: Straight or Linear Search Pattern (e.g. Narrow Shorelines, Riverbanks)**

Once the canine has alerted on an odor from subsurface oil (Figure 2.9 left), a Delineation Survey is conducted to fully delineate the odor footprint (Figures 2.7 and 2.9 right).

- The first alert location (Figure 2.9 left) is recorded, flagged, and a waypoint taken.
- The team should work with the wind to the degree possible, and monitor wind speed and direction periodically.
- The canine team then begins to "bounce" around the footprint.
- The canine is directed away from the alert location, and returned at an angle (Figure 7.4).
- Subsequent alerts are recorded, flagged and waypoints taken.
- The "bounces" are repeated until the odor footprint is fully delineated.

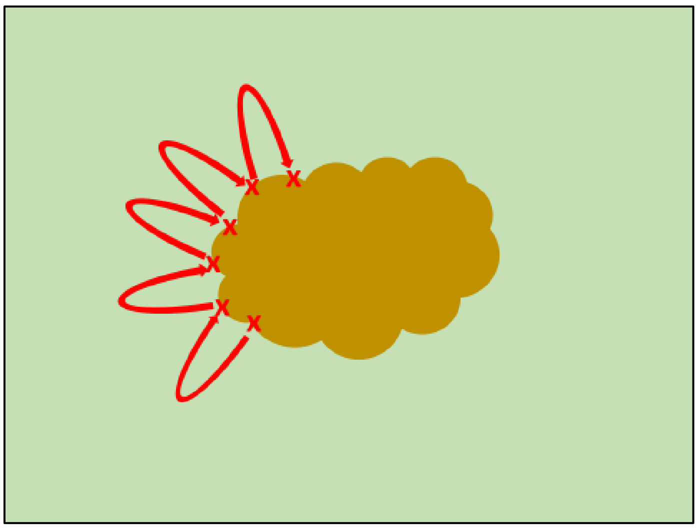



**Figure 7.4—Subsurface Oil Delineation Survey: "Bouncing" around the Odor Footprint**

This bouncing pattern defines the size of the continuous or discontinuous oil deposit, which may be on the order of meters wide and maybe meters or tens of meters long, or may be small (up to 1 m diameter) patch(es) or lens(es). Once this delineation has been completed, the WAS pattern is resumed.

The tactical delineation decisions at this stage involve close coordination between the K9-SCAT Team Lead and the canine handler.

Once the approximate boundary of a continuous or discontinuous deposit has been delineated, excavation is used to characterize the vertical distribution and horizontal character.

## 7.6 Potential Confounding Issues or Sources of Misidentification

Detection canines are trained to locate specific targets by imprinting with an oil sample from the area, and they are able to detect target odors even when a non-target odor is orders of magnitude higher in concentration, and overwhelming to humans (Johnston, 1999). In planning a K9-SCAT program, the team should be aware of potential "background" or non-target oils in a survey area. For example:

- <u>Natural Seeps</u>: Stranded oil from marine or land seeps are well documented in the Gulf of Mexico, Santa Barbara region, CA, northern Gulf of Alaska and Prince William Sound, AK, and the North

Slope of Alaska. Oil from the Santa Barbara seeps is routinely documented 280 miles (500 km) to the north of the source area on the Pacific Coast beaches adjacent to San Francisco.

- Pelagic Tar Balls: Tar balls are common on all coasts globally, to greater or lesser degrees, either from terrestrial sources (rivers), ship or offshore petroleum activity sources, or distant seeps, and are typically heavily weathered so that they have lost most, if not all, of the odor-producing fractions.

- Spill Residues: in Prince William Sound, AK, as well as several natural seep areas, there are known oil residues in shoreline sediments from both the 1964 earthquake Valdez tank farm spills and the 1989 T/V *Exxon Valdez;* and in Chedabucto Bay, NS, from the 1970 T/V *Arrow* and possibly the 1979 T/V *Kurdistan* spills. Doubtless there are other, less well documented, cases.

- Industrial Sources: In many coastal and inland sites, former industrial activities have resulted in undocumented spills, some of which may date back decades and have not been cleaned or treated (e.g. Wooley, 2002).

- Vehicle Sources: Fuel/oil in vehicle or vehicle leaks in the survey area.

Canines are able to discriminate between odors from different oils, and can therefore be trained to ignore non-target oils. Oils are composed of many different vapor compounds. It is understood that, during imprinting on a target substance, a canine can be trained to recognize a few of the odor components comprising the target substance and that different canines may learn to recognize different odor components from the same substance (Johnston, 1999). If any of the components that the canine has learned to recognize are also found in a non-target substance, it is possible that the canine may alert on that substance. It is therefore necessary to use non-target substances expected in the survey area during imprinting to train the canine(s) to ignore those substances, and alert only on the target odor.

During the response to the Refugio spill in California in May 2015, the potential deployment of a K9-SCAT team was evaluated to locate subsurface oil. A number of potentially confounding factors weighed against a successful deployment that included, primarily, the known presence of weathered and fresh oil from nearby marine and land seeps from the same reservoirs as the leaked oil from the pipeline. Other factors included the presence of surface oil from the leak within the target area and the small size of the target area (4,000 $m^2$), so that manual excavation was a reasonable option; therefore, the canine team was not mobilized (see Table 2.2).

## 7.7 Confirmation Testing and Vertical Delineation

Confirmation testing of alerts and the vertical delineation and characterization of subsurface oil is conducted by SCAT teams. SCAT teams may either:

- shadow the K9-SCAT team, and excavate pits or trenches immediately after the K9-SCAT team has completed delineation of a deposit (this may be useful in remote locations), or

- survey the area at a different time, using the K9-SCAT team’s flags, maps, and coordinates of the alerts.

If stranded oil on shorelines or river banks has been, or is suspected to have been, remobilized and redistributed by wave and/or current action, then repeat surveys by K9-SCAT with a rapid data turnaround time should be considered to confirm the continued presence of that oil or to locate any remobilized and redistributed oil.

Trenches or pits, excavated manually (with shovels) or mechanically (with augers, backhoes, etc.), document the boundary and interior of the oiled area that has been delineated at the surface alert sites. The SCAT team completes the relevant Shoreline Oiling Survey (SOS) form to document their observations (see http://shorelinescat.com/Forms%20Oiling.html). The SCAT Team Lead may decide to dig additional pits/trenches outside the boundary of the horizontal oil footprint that has been delineated in order to confirm the absence of oil in the adjacent area.

# 8 Data Collection and K9-SCAT Data Management Guidelines

- The K9-SCAT Team Lead is responsible for documenting the location and extent of oil or potential oil targets, and documenting the scope, purpose and completeness of survey coverage.
- K9-SCAT surveys are documented on a K9-SCAT Survey Form.
- Standard procedures are followed to provide photographic or videography coverage of a K9-SCAT survey.
- Track lines accurately document the canine survey coverage.
- Ideally, the K9-SCAT Team Lead has a real-time, GPS-based moving-map display to direct the handler during the search.
- Waypoints document locations where oil has been detected and also may be used to delineate the outer boundary of a large area with subsurface oil.

K9-SCAT activities are documented and the data and information collected during a survey are reviewed (QA/QC) and managed using the same protocols as traditional SCAT surveys. This section discusses only those aspects of data collection and management that are specific to a K9-SCAT program.

## 8.1 K9-SCAT Survey Checklist

The checklist in Table 8.1 provides a tool for planning and conducting a K9-SCAT field survey.

## 8.2 Field Survey Documentation Forms

All SCAT survey missions are documented, and K9-SCAT Survey Forms enable consistent documentation and recording of essential survey information, including: date, time, location (segment number, waypoints/coordinates), team members, environmental conditions, canine alert locations, and other observations.

Forms, provided in Annex C, have been developed for a range of survey environments:

- lake,
- pipeline,
- river,
- shoreline,
- stream,
- terrestrial.

The appropriate form should be chosen according to the survey environment and climate, and a form must be completed for each K9-SCAT survey, as described in Table 8.1. Forms should be completed by the K9-SCAT Team Lead and submitted to the SCAT Data Manager for QA/QC, database input, and documentation control.

**Table 8.1—K9-SCAT Survey Checklist**

| K9-SCAT SURVEY CHECKLIST | |
|---|---|
| **PLANNING** | |
| | Evaluate canine and personnel safety risks associated with oil and/or the survey environment, and mitigation actions |
| | Define the survey area (polygon) |
| | Select the appropriate K9-SCAT Survey Form (Annex C) and revise as necessary |
| | Identify team participation:<br>• Canine/handler<br>• K9-SCAT Team Lead<br>• Team members (agency representatives, specialists) |
| | Evaluate optimum survey date and time based on weather forecast, last water level, and environmental conditions |
| | Arrange logistics for all team members, and complete communication plan |
| **SURVEY** | |
| | Handler evaluates the weather and determines start point and search pattern |
| | Synchronize the times on tracking GPS(s) and camera |
| | Attach GPS tracking device to Oil Detection Canine, note device number |
| | Record general (1), team (2), segment (3), and shoreline (4) information on Survey Form |
| | START SURVEY (note time on form) |
| | If CANINE ALERTS: flag and note waypoint/coordinates on form (Section 5), and commence delineation |
| | Flag and record all delineation alerts on survey form (Section 5) |
| | Continue search until the survey area has been fully covered |
| | Ensure canine and other team members get necessary rest, shelter, water, and food |
| | If NO ALERTS: note on form |
| | END SURVEY (note time on form) |
| | In comments box (6), note observations, and photographs/videos taken. |
| **POST SURVEY** | |
| | Download GPS device track lines, and create map(s) of track lines |
| | Download photos/videos |
| | Collect and collate forms/data |
| | Report any alerts and their locations to the SCAT Coordinator |

## 8.3 Photography-Videography Guidelines

K9-SCAT survey photographs are valuable for documentation purposes, and can be taken to:

- record segment information, e.g. shoreline type, backshore character, sediment type, vegetation cover, etc. This is particularly useful if a traditional SCAT team has not recently surveyed the segment;
- record the environmental conditions, e.g. high tide/water, ice, snow, fog, etc.;
- record the location of any alerts, together with taking a GPS waypoint, recording the coordinates and flagging the alert spot;
- provide a general overview of the survey area. Videography may also record the areal coverage and search patterns, and to document any alerts or No Detected Oil (NDO) reports.

Photograph times, and/or video numbers/minutes, should be noted on the K9-SCAT survey form. Additional information regarding georeferencing of photos is provided in Section D.3. Photographs and videos are submitted to the SCAT data manager for database input, georeferencing, and documentation control.

## 8.4 Survey Coverage and Track Lines

The collection of GPS data, track lines, and waypoints has become a standard SCAT survey practice and is an expected SCAT team data deliverable along with survey forms and photographs. Current SCAT survey forms include space to record latitude and longitude coordinates and/or waypoints. All photographs taken on SCAT surveys must be georeferenced and/or appropriate GPS data collected to allow post-survey photo processing (Section D.3).

SCAT data management systems (databases) and related GIS mapping systems are now the standard for all but small spills. The timely creation of spill data for the Environmental Unit, Unified Command, Operations, and stakeholders requires field data to be in a format that can be quickly incorporated into the database and GIS, i.e. digital track lines and waypoint data related to the location of shoreline features, oiling, and survey coverage.

Two important considerations in the survey design are to:

- ensure that the K9-SCAT Team Lead has access to real-time track line data during a WAS to ensure complete coverage of the survey area (Section D.5, Figure D.3), and
- the data management system should be designed to process the K9-SCAT survey track line and waypoint data to produce confirmation or re-survey maps on a rapid turnaround basis (Sections 7.7 and 8.6).

### 8.4.1 SCAT Team Lead and Canine GPS

Traditional SCAT surveys are typically conducted using a single hand-held GPS unit. SCAT survey teams generally consist of three or more persons who can spread out across a shoreline or survey path covering a wide swath (Figure 2.1b) represented by a single GPS track line.

K9-SCAT surveys can be best conducted by attaching a GPS unit to the canine’s collar (Figure 8.1) to continuously record the animal’s location and track within the survey area, and to waypoint any alerts. There are also remote canine tracking GPS devices available that use phone/wifi connections, which may be useful in areas with good phone coverage (Annex D).

Ideally, the K9-SCAT Team Lead has a real-time moving-map display to show the actual coverage in order to direct the handler during a search (Section D.5).

Annex D provides guidelines on GPS equipment and usage.

**Figure 8.1—Canine Fitted with GPs Tracking Collar and Cameras (K2 Solutions)**

## 8.5 Data Management

There are two principal purposes for the data collected during a SCAT survey:

- document the location and extent of oil or potential oil targets, and
- document the scope, purpose, and completeness of survey coverage.

The data sets collected by a K9-SCAT team are not significantly different from traditional SCAT surveys, (forms, photos, waypoints, and track lines). However, subsurface K9-SCAT surveys require the following additional considerations for the SCAT data management team to process and produce relevant data products for the response.

- SCAT database programs could be adapted to take into account new categories related to subsurface oiling evaluations beyond the standard SCAT pit and trench documentation.
- New mapping protocols could be developed to provide subsurface oiling maps and summary tables to indicate areas of potential oil targets (alerts), verified oil from a traditional SCAT survey, NDO (No Detected Oil) based on a K9-SCAT survey (as opposed to a No Observed Oil “NOO” result from a traditional ground SCAT survey), or other observations, as appropriate.
- Segment status tables and maps or subsurface status maps could be adapted to include the K9-SCAT survey categories “Alert” and NDO.
- Individual segment maps showing track lines may be required as attachments to the K9-SCAT team forms and field maps to provide a complete data set for documentation.

- Database designs and input fields could be adapted to include K9-SCAT team members (K9-SCAT Team Lead, canine, and handler names) and other data parameters relevant to K9-SCAT surveys to ensure complete documentation for SCAT data archives.

## 8.6 Reporting

Typically, the SCAT Data Team generates a summary of the survey information in the form of a set of tables and/or maps, often referred to as a "Dashboard." With regard to a K9-SCAT survey, the regular (daily) reports to the Incident Management Team for K9-SCAT data could include:

- K9-SCAT survey coverage (km),
- location of alerts (maps and coordinates),
- segments with NDO versus segments with alerts (maps and tables), and
- follow-up confirmation testing and vertical delineation (pits/trenches) reports.

Shoreline Cleanup Operations teams rely, to a large degree, on the segment oiling maps produced by the SCAT program. If a K9-SCAT survey has been undertaken to confirm the presence of oil immediately prior to Operations beginning to work in a segment, the data management system should be designed to process the K9-SCAT survey track line and waypoint data to produce these maps on a rapid turnaround basis. This type of support is particularly valuable in dynamic situations where oil may have been remobilized and redistributed since the ground survey upon which the cleanup activities have been based.

## References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## Websites

K9-SCAT resources: www.K9SCAT.com

SCAT resources: www.shorelineSCAT.com

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## ANNEX A—K9-SCAT Survey Plan Outline

- At the outset of a response, the SCAT Coordinator, with the assistance of the EUL (or designee) and the Shoreline Response Technical Advisor, develops a Plan for Shoreline Response and SCAT.
- The Plan defines the objectives, management structure, scope and scale of response necessary to implement comprehensive shoreline response activities.
- The introduction of K9-SCAT requires additional information, which may be compiled as a separate Plan, or as an addendum to the Shoreline Response and SCAT Plan.
- The following outline presents recommended information requirements for a K9-SCAT Plan.

### SECTION 1 OVERVIEW

- Program objectives
- Location of areas identified for K9-SCAT surveys
- Description of shoreline or terrain, and expected oiling
- Survey objectives and priorities
- Survey constraints and limitations
- Regulatory requirements, permit / permission requirements
- Safety issues

### SECTION 2 K9-SCAT TEAM

- K9-SCAT Team organization and structure within the Environmental Unit
- Roles and Responsibilities of key K9-SCAT Team Members
- Stakeholder representation
- Coordination within the IMT (Safety Officer, Environmental Unit, Operations, Planning, Logistics)
- Canine and manpower providers

### SECTION 3 K9-SCAT PROGRAM

- K9-SCAT phases and missions
- Logistics plan and tasking
- Equipment and support requirements
- Survey design
- Search patterns
- Calibration
- Forms and documentation
- Data Management/GIS
- Reporting
- Confirmation testing/vertical delineation
- Safety Plan and Job Safety Analyis (JSA)
- Communications Plan
- Animal Health and Welfare Plan

## ANNEX B—Creating and Using a Calibration and Reward Target

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- Section 7.3.1 identifies the importance of an oiled target for the purpose of either canine calibration or for rewarding the canine when no oil is detected during a survey.
- This Annex provides an informal instruction for creating and using subsurface oil targets.

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<u>Equipment required:</u>

- Sample of target oil
- Local sediment
- Nitrile gloves
- PVC pipes (1.5 in. diameter), closed at one end
- Measuring tape
- Cutting tool
- PVC caps for 1.5 in. diameter tube
- Shovel

1. Nitrile gloves should be used to handle oil and oiled sediment.
2. If the sample oil is fresh, it may be appropriate to allow the oil to weather. This may be achieved by leaving the oil in the open for a certain time period (24 hours, 48 hours, 1 week, etc.), depending on the expected degree of weathering of the target subsurface oil.
3. Mix the sample oil with the local sediment, ideally the same sediment that is present in the survey area, to a concentration appropriate for the expected subsurface oil; for example, an oil:sediment ratio of 1:20, 1:10, 1:5 etc. (see Figure B.1).
4. Estimate the likely depth of any suspected subsurface oil within the survey area. Use this depth to determine a suitable depth for the calibration or reward target.
5. Measure and cut the PVC tube to this depth, ensuring that one end is closed and sealed.
6. Load the bottom 5 cm (2 in.) of the PVC pipe with the oiled sediment.
7. Fill the remainder of the pipe with clean, unoiled sediment.
8. Cap the open end of the pipe. Keep the target capped during storage, deployment and recovery to prevent spillage (Figure B.2).

9. Label the PVC tube with:

    a. oil name/type,

    b. oil:sediment ratio,

    c. depth of oiled sediment,

    d. sediment type,

    e. date created.

10. During deployment, carry the oil target using clean nitrile gloves to a random location within the segment, away from the sight of the canine and handler.

11. Remove the cap, and bury the tube vertically until the top is flush with the land surface.

12. The open end of the tube and disturbed sediment/vegetation should be hidden and/or camouflaged as much as possible.

13. Record a GPS waypoint of the site of the buried target, so that it can be located and recovered later.

14. Ideally, personnel planting the tube should not use a direct line to the site and should return to the start point by a different route to prevent the canine from picking up on the human scent.

15. Allow the odor to “soak” for a few minutes, before starting the search.

16. Once the target has been located, recover the target tube and cap.

17. Replace any disturbed sediment and/or vegetation.

**Figure B.1—Target Oil in 1:10 Sediment Mix**

**Figure B.2—Capped and Labeled Oil Target Tube (with Wheelbarrow Containing Clean Local Sediment)**

## ANNEX C—K9-SCAT Survey Forms

K9-SCAT Survey forms should be selected and modified as necessary, according to the mission type and environment. This section provides example K9-SCAT Survey forms for:

- lake,
- pipeline,
- river,
- shoreline,
- stream,
- terrestrial.

**K9-SCAT SURVEY FORM - LAKE**

**1.GENERAL INFORMATION**

| | | | | | |
|---|---|---|---|---|---|
| **Date:** (dd/mm/yyyy) | | **Weather:** | Sun / Clouds / Fog / Rain / Snow (circle) | **Air Temp:** | °C |
| **Time Start:** (24hr EST) | | **Humidity:** | ____% | **Wind Direction:** | |
| **Time End:** 24hr (EST) | | **Pressure:** | ______ mb rising / falling (circle) | **Wind Speed:** | mph |
| **Location:** | | **Segment ID:** | | Survey by: | Foot / Boat |
| **Purpose of Survey:** | SOS / SIR / Other________ | **Water Level:** | Low / Mean / High / Flood ________m | | |
| **Search Method:** | Wide Area Search / Delineation | | Rising / Steady / Falling | | |

**2. K9-SCAT TEAM**

| | | | |
|---|---|---|---|
| **Dog Name/ # :** | | **Handler Name:** | |
| **K9-SCAT TL:** | | **Tracking Collar/GPS ID:** | |
| **Team Members:** | | | |

**3. SEGMENT DATA**

| | | | | | |
|---|---|---|---|---|---|
| **Total Length:** | ______ meters | **Trackline Length:** | ______ meters | **Datum:** | |
| **Survey Start GPS:** | WP: | LAT: | | LONG: | |
| **Survey End GPS:** | WP: | LAT: | | LONG: | |

**4. SHORELINE INFORMATION** *Circle and check boxes as appropriate. P = Primary, S = Secondary, T = Tertiary*

| SHORELINE CHARACTER | | Lower | Upper | Supra | BACKSHORE CHARACTER | Fringe | Inland |
|---|---|---|---|---|---|---|---|
| Physical | Width | m | m | m | Width | m | m |
| | Slope | L / M / H | L / M / H | L / M / H | Slope | L / M / H | L / M / H |
| Bedrock | Shelf / Ramp / Cliff | | | | Cliff / Bank | | |
| Unconsolidated | Bluff / Cliff / Talus | | | | Cliff / Hill | | |
| | Mud | | | | Beach | | |
| | Sand | | | | Dune | | |
| | Mixed Fine | | | | Flat / Lowland | | |
| Beach / Flats | Mixed Coarse with sand | | | | Wooded / Vegetated | | |
| | Pebble - Cobble | | | | Agricultural Fields | | |
| | Boulder / Rubble / Riprap | | | | Tidal Channel / Inlet | | |
| | Peat / Organics | | | | Lagoon / River | | |
| | Marsh / Swamp | | | | Estuary / Delta | | |
| Wetlands | Bog / Fen | | | | Marsh / Wetland | | |
| Manmade | Permeable | | | | Permeable | | |
| | Impermeable | | | | Impermeable | | |
| Ice/snow | Ice / Snow | | | | Ice / Snow | | |

**5. POSITIVE ALERTS**

| Alert # | Wpt # | Verified? Y/N | Comment | Alert # | Wpt # | Verified? | Comment |
|---|---|---|---|---|---|---|---|
| 1 | | | | 11 | | | |
| 2 | | | | 12 | | | |
| 3 | | | | 13 | | | |
| 4 | | | | 14 | | | |
| 5 | | | | 15 | | | |
| 6 | | | | 16 | | | |
| 7 | | | | 17 | | | |
| 8 | | | | 18 | | | |
| 9 | | | | 19 | | | |
| 10 | | | | 20 | | | |

**6. COMMENTS**

| | | | | | |
|---|---|---|---|---|---|
| **OIL DETECTED?** | Yes / No | *Draw sketch if oil is found and delineated* | | | |
| **Photographs?** | Yes / No | **Video?** | Yes / No | **Completed By:** | |

REVISION DATE: 12 January 2016

**K9-SCAT SURVEY FORM - PIPELINE**

| **1.GENERAL INFORMATION** | | | | | |
|---|---|---|---|---|---|
| **Date:** (dd/mm/yyyy) | | **Weather:** | Sun / Clouds / Fog / Rain / Snow (circle) | **Air Temp:** | °C |
| **Time Start:** (24hr EST) | | **Humidity:** | ____% | **Wind Direction:** | |
| **Time End:** 24hr (EST) | | **Pressure:** | _______ mb rising / falling (circle) | **Wind Speed:** | mph |
| **Location:** | | **Segment ID:** | | **Survey by:** | Foot / Boat |
| **Purpose of Survey:** | SOS / SIR / Other__________ | **Surface Water:** | **Present?** Yes / No | | |
| **Search Method:** | Wide Area Search / Delineation | | Standing / Flowing | | |

| **2. K9-SCAT TEAM** | | | |
|---|---|---|---|
| **Dog Name/ # :** | | **Handler Name:** | |
| **K9-SCAT TL:** | | **Tracking Collar/GPS ID:** | |
| **Team Members:** | | | |

| **3. SEGMENT/PIPELINE DATA** | | | | | |
|---|---|---|---|---|---|
| **Total Length:** | _______ $m^2$ | **Trackline Length:** | _______ meters | **Datum:** | |
| **RoW Width** | _______ $m^2$ | **Pipeline Depth:** | Average _________m | Max: __________m Min: __________m | |
| **Survey Start GPS:** | **WP:** | **LAT:** | | **LONG:** | |
| **Survey End GPS:** | **WP:** | **LAT:** | | **LONG:** | |

**4. TERRAIN INFORMATION** *Circle and check boxes as appropriate. P = Primary, S = Secondary, T = Tertiary*

| TERRAIN TYPE | | |
|---|---|---|
| Physical | Slope | <5° / 5 - 15° / 15 - 30° / >30° |
| Dry | Desert | |
| | Grassland | |
| | Shrub | |
| | Forest | |
| Wetland | Pond | |
| | Fen | |
| | Bog | |
| | Swamp | |
| | Tundra | |
| Manmade | Permeable | |
| | Impermeable | |
| Ice/snow | Ice / Snow | |

**5. POSITIVE ALERTS**

| Alert # | Wpt # | Verified? Y/N | Comment | Alert # | Wpt # | Verified? | Comment |
|---|---|---|---|---|---|---|---|
| 1 | | | | 11 | | | |
| 2 | | | | 12 | | | |
| 3 | | | | 13 | | | |
| 4 | | | | 14 | | | |
| 5 | | | | 15 | | | |
| 6 | | | | 16 | | | |
| 7 | | | | 17 | | | |
| 8 | | | | 18 | | | |
| 9 | | | | 19 | | | |
| 10 | | | | 20 | | | |

**6. COMMENTS**

| | | | | | |
|---|---|---|---|---|---|
| **OIL DETECTED?** | Yes / No | *Draw sketch if oil is found and delineated* | | | |
| **Photographs?** | Yes / No | **Video?** | Yes / No | **Completed By:** | |

REVISION DATE: 12 January 2016

**K9-SCAT SURVEY FORM - RIVER**

| **1.GENERAL INFORMATION** | | | | | |
|---|---|---|---|---|---|
| **Date:** (dd/mm/yyyy) | | **Weather:** | Sun / Clouds / Fog / Rain / Snow (circle) | **Air Temp:** | °C |
| **Time Start:** (24hr EST) | | **Humidity:** | ____% | **Wind Direction:** | |
| **Time End:** 24hr (EST) | | **Pressure:** | ________ mb rising / falling (circle) | **Wind Speed:** | mph |
| **Location:** | | **Segment ID:** | | **Survey by:** | Foot / Boat |
| **Purpose of Survey:** | SOS / SIR / Other__________ | **Water Level:** | Low / Mean / Bankfull / Overbank | | |
| **Search Method:** | Wide Area Search / Delineation | | Falling / Steady Rising | | |

| **2. K9-SCAT TEAM** | | | |
|---|---|---|---|
| **Dog Name/ # :** | | **Handler Name:** | |
| **K9-SCAT TL:** | | **Tracking Collar/GPS ID:** | |
| **Team Members** | | | |

| **3. REACH DATA** | | | | | |
|---|---|---|---|---|---|
| **Total Length:** | ________ meters | **Trackline Length:** | ________ meters | **Datum:** | |
| **Survey Start GPS:** | WP: | LAT: | | LONG: | |
| **Survey End GPS:** | WP: | LAT: | | LONG: | |

**4. REACH INFORMATION** *Circle and check boxes as appropriate. P = Primary, S = Secondary, T = Tertiary*

| RIVERBANK CHARACTER | | Upper | Lower | OVERBANK CHARACTER | Fringe | Inland |
|---|---|---|---|---|---|---|
| Physical | Width | m | m | Width | m | m |
| | Slope | L / M / H | L / M / H | Slope | L / M / H | L / M / H |
| Bedrock | Platform / Ramp / Cliff | | | Platform / Ramp / Cliff | | |
| Unconsolidated | Bank / Cliff / Talus | | | Bank / Cliff / Talus | | |
| | Mud | | | Flat / Lowland | | |
| | Sand | | | Dune | | |
| Beach / Flats | Mixed Fine | | | Wooded / Forest | | |
| | Mixed Coarse with sand | | | Vegetated: Grass / Shrub | | |
| | Pebble - Cobble | | | Agricultural Fields | | |
| | Boulder / Rubble / Riprap | | | Inlet / Channel | | |
| | Peat / Organics | | | Delta | | |
| | Vegetated / Wooded Bank | | | Lagoon | | |
| Wetlands | Marsh / Swamp | | | Marsh | | |
| | Reed Beds | | | Wetland | | |
| Manmade | Permeable | | | Permeable | | |
| | Impermeable | | | Impermeable | | |
| Ice/Snow | Ice | | | Ice / Snow | | |

**5. POSITIVE ALERTS**

| Alert # | Wpt # | Verified? Y/N | Comment | Alert # | Wpt # | Verified? | Comment |
|---|---|---|---|---|---|---|---|
| 1 | | | | 11 | | | |
| 2 | | | | 12 | | | |
| 3 | | | | 13 | | | |
| 4 | | | | 14 | | | |
| 5 | | | | 15 | | | |
| 6 | | | | 16 | | | |
| 7 | | | | 17 | | | |
| 8 | | | | 18 | | | |
| 9 | | | | 19 | | | |
| 10 | | | | 20 | | | |

**6. COMMENTS**

| | | | | | |
|---|---|---|---|---|---|
| **OIL DETECTED?** | Yes / No | *Draw sketch if oil is found and delineated* | | | |
| **Photographs?** | Yes / No | **Video?** | Yes / No | **Completed By:** | |

REVISION DATE: 12 January 2016

**K9-SCAT SURVEY FORM - SHORELINE**

**1.GENERAL INFORMATION**

| | | | | | |
|---|---|---|---|---|---|
| **Date:** (dd/mm/yyyy) | | **Weather:** | Sun / Clouds / Fog / Rain / Snow (circle) | **Air Temp:** | °C |
| **Time Start:** (24hr EST) | | **Humidity:** | ____% | **Wind Direction:** | |
| **Time End:** 24hr (EST) | | **Pressure:** | ______ mb rising / falling (circle) | **Wind Speed:** | mph |
| **Location:** | | **Segment ID:** | | **Survey by:** | Foot / Boat |
| **Purpose of Survey:** | SOS / SIR / Other__________ | **Tide:** | High / Medium / Low ________m | | |
| **Search Method:** | Wide Area Search / Delineation | | Rising / Falling / Low Slack / High Slack | | |

**2. K9-SCAT TEAM**

| | | | |
|---|---|---|---|
| **Dog Name/ # :** | | **Handler Name:** | |
| **K9-SCAT TL:** | | **Tracking Collar/GPS ID:** | |
| **Team Members:** | | | |

**3. SEGMENT DATA**

| | | | | | |
|---|---|---|---|---|---|
| **Total Length:** | ______ meters | **Trackline Length:** | ______ meters | **Datum:** | |
| **Survey Start GPS:** | WP: | LAT: | | LONG: | |
| **Survey End GPS:** | WP: | LAT: | | LONG: | |

**4. SHORELINE INFORMATION** *Circle and check boxes as appropriate. P = Primary, S = Secondary, T = Tertiary*

| SHORELINE CHARACTER | | Lower | Upper | Supra | BACKSHORE CHARACTER | Fringe | Inland |
|---|---|---|---|---|---|---|---|
| Physical | Width | m | m | m | Width | | m |
| | Slope | L / M / H | L / M / H | L / M / H | Slope | L / M / H | L / M / H |
| Bedrock | Platform / Ramp / Cliff | | | | Platform / Ramp / Cliff | | |
| Unconsolidated | Bank / Cliff / Talus / Tundra | | | | Bank / Cliff / Talus / Tundra | | |
| | Mud | | | | Beach | | |
| | Sand | | | | Dune | | |
| | Mixed Fine | | | | Forest | | |
| Beach / Flats | Mixed Coarse with sand | | | | Grass/Shrubs | | |
| | Pebble - Cobble | | | | Agricultural Fields | | |
| | Boulder / Rubble / Riprap | | | | Tidal Channel / Inlet | | |
| | Peat / Organics | | | | Lagoon / River | | |
| Wetlands | Saltmarsh / Mangrove | | | | Estuary / Wetlands / Delta | | |
| Manmade | Permeable | | | | Permeable | | |
| | Impermeable | | | | Impermeable | | |
| Snow / Ice | Snow / Ice | | | | Snow / Ice | | |

**5. POSITIVE ALERTS**

| Alert # | Wpt # | Verified? Y/N | Comment | Alert # | Wpt # | Verified? | Comment |
|---|---|---|---|---|---|---|---|
| 1 | | | | 11 | | | |
| 2 | | | | 12 | | | |
| 3 | | | | 13 | | | |
| 4 | | | | 14 | | | |
| 5 | | | | 15 | | | |
| 6 | | | | 16 | | | |
| 7 | | | | 17 | | | |
| 8 | | | | 18 | | | |
| 9 | | | | 19 | | | |
| 10 | | | | 20 | | | |

**6. COMMENTS**

| | | | | | |
|---|---|---|---|---|---|
| **OIL DETECTED?** | Yes / No | *Draw sketch if oil is found and delineated* | | | |
| **Photographs?** | Yes / No | **Video?** | Yes / No | **Completed By:** | |

REVISION DATE: 12 January 2016

**K9-SCAT SURVEY FORM - STREAM**

| 1.GENERAL INFORMATION | | | | | |
|---|---|---|---|---|---|
| Date: (dd/mm/yyyy) | | Weather: | Sun / Clouds / Fog / Rain / Snow (circle) | Air Temp: | °C |
| Time Start: (24hr EST) | | Humidity: | ____% | Wind Direction: | |
| Time End: 24hr (EST) | | Pressure: | _______ mb rising / falling (circle) | Wind Speed: | mph |
| Location: | | Segment ID: | | Survey by: | Foot / Boat |
| Purpose of Survey: | SOS / SIR / Other__________ | Water Level: | Low / Mean / Bankfull / Overbank | | |
| Search Method: | Wide Area Search / Delineation | | Falling / Steady Rising | | |

| 2. K9-SCAT TEAM | | | |
|---|---|---|---|
| Dog Name/ # : | | Handler Name: | |
| K9-SCAT TL: | | Tracking Collar/GPS ID: | |
| Team Members | | | |

| 3. REACH DATA | | | | | |
|---|---|---|---|---|---|
| Total Length: | _______ meters | Trackline Length: | _______ meters | Datum: | |
| Survey Start GPS: | WP: | LAT: | | LONG: | |
| Survey End GPS: | WP: | LAT: | | LONG: | |

**4. REACH INFORMATION** *Circle and check boxes as appropriate. P = Primary, S = Secondary, T = Tertiary*

| STREAM CHARACTER | | Left Bank | Right Bank | OVERBANK CHARACTER | Left Bank | Right Bank |
|---|---|---|---|---|---|---|
| Physical | Width | m | m | Width | m | m |
| | Slope | L / M / H | L / M / H | Slope | L / M / H | L / M / H |
| Bedrock | Platform / Ramp / Cliff | | | Platform / Ramp / Cliff | | |
| Unconsolidated | Bank / Cliff / Talus | | | Bank / Cliff / Talus | | |
| | Mud | | | Flat / Lowland | | |
| Beach / Flats | Sand | | | Dune | | |
| | Mixed Fine | | | Wooded / Forest | | |
| | Mixed Coarse with sand | | | Vegetated: Grass / Shrub | | |
| | Pebble - Cobble | | | Agricultural Fields | | |
| | Boulder / Rubble / Riprap | | | Inlet / Channel | | |
| | Peat / Organics | | | Delta | | |
| | Vegetated / Wooded Bank | | | Lagoon | | |
| Wetlands | Marsh / Swamp | | | Marsh | | |
| | Reed Beds | | | Wetland | | |
| Manmade | Permeable | | | Permeable | | |
| | Impermeable | | | Impermeable | | |
| Ice/Snow | Ice | | | Ice / Snow | | |

**5. POSITIVE ALERTS**

| Alert # | Wpt # | Verified? Y/N | Comment | Alert # | Wpt # | Verified? | Comment |
|---|---|---|---|---|---|---|---|
| 1 | | | | 11 | | | |
| 2 | | | | 12 | | | |
| 3 | | | | 13 | | | |
| 4 | | | | 14 | | | |
| 5 | | | | 15 | | | |
| 6 | | | | 16 | | | |
| 7 | | | | 17 | | | |
| 8 | | | | 18 | | | |
| 9 | | | | 19 | | | |
| 10 | | | | 20 | | | |

**6. COMMENTS**

| | | | | | |
|---|---|---|---|---|---|
| OIL DETECTED? | Yes / No | *Draw sketch if oil is found and delineated* | | | |
| Photographs? | Yes / No | Videos? | Yes / No | Completed By: | |

REVISION DATE: 12 January 2016

**K9-SCAT SURVEY FORM - TERRESTRIAL**

**1.GENERAL INFORMATION**

| | | | | | |
|---|---|---|---|---|---|
| **Date:** (dd/mm/yyyy) | | **Weather:** | Sun / Clouds / Fog / Rain / Snow (circle) | **Air Temp:** | °C |
| **Time Start:** (24hr EST) | | **Humidity:** | ____% | **Wind Direction:** | |
| **Time End:** 24hr (EST) | | **Pressure:** | ______ mb rising / falling (circle) | **Wind Speed:** | mph |
| **Location:** | | **Segment ID:** | | **Survey by:** | Foot / Boat |
| **Purpose of Survey:** | SOS / SIR / Other_________ | **Surface Water:** | Present? Yes / No | | |
| **Search Method:** | Wide Area Search / Delineation | | Standing / Flowing | | |

**2. K9-SCAT TEAM**

| | | | |
|---|---|---|---|
| **Dog Name/ # :** | | **Handler Name:** | |
| **K9-SCAT TL:** | | **Tracking Collar/GPS ID:** | |
| **Team Members:** | | | |

**3. SEGMENT/POLYGON DATA**

| | | | | | |
|---|---|---|---|---|---|
| **Total Area:** | ______ $m^2$ | **Trackline Length:** | ______ meters | **Datum:** | |
| **Survey Start GPS:** | WP: | LAT: | | LONG: | |
| **Survey End GPS:** | WP: | LAT: | | LONG: | |

**4. TERRAIN INFORMATION** *Circle and check boxes as appropriate. P = Primary, S = Secondary, T = Tertiary*

TERRAIN TYPE

| | | |
|---|---|---|
| Physical | Slope | <5° / 5 - 15° / 15 - 30° / >30° |
| Dry | Desert | |
| | Grassland | |
| | Shrub | |
| | Forest | |
| Wetland | Pond | |
| | Fen | |
| | Bog | |
| | Swamp | |
| | Tundra | |
| Manmade | Permeable | |
| | Impermeable | |
| Ice/snow | Ice / Snow | |

**5. POSITIVE ALERTS**

| Alert # | Wpt # | Verified? Y/N | Comment | Alert # | Wpt # | Verified? | Comment |
|---|---|---|---|---|---|---|---|
| 1 | | | | 11 | | | |
| 2 | | | | 12 | | | |
| 3 | | | | 13 | | | |
| 4 | | | | 14 | | | |
| 5 | | | | 15 | | | |
| 6 | | | | 16 | | | |
| 7 | | | | 17 | | | |
| 8 | | | | 18 | | | |
| 9 | | | | 19 | | | |
| 10 | | | | 20 | | | |

**6. COMMENTS**

| | | | | | |
|---|---|---|---|---|---|
| **OIL DETECTED?** | Yes / No | *Draw sketch if oil is found and delineated* | | | |
| **Photographs?** | Yes / No | Video? | Yes / No | **Completed By:** | |

REVISION DATE: 12 January 2016

# ANNEX D—GPS Guidelines

- GPS track lines are essential to document all K9-SCAT surveys to ensure that the desired coverage has been accomplished.
- Track lines are an important part of the SCAT database.
- Ideally, the K9-SCAT Team Lead has a real-time moving map display to direct the handler during the search.
- Waypoints document locations where oil has been detected and also may be used to delineate the outer boundary of a large area with subsurface oil.
- The time interval for track recording should be set based on the anticipated speed of travel of the canine and the anticipated length of the survey.

## D.1 GPS Devices

There are two types of device available that may be used to track a K9-SCAT survey:

**GPS data-loggers**

- Small, stand-alone GPS data loggers are commercially available that can be easily mounted to the canine's collar, and set to continuously record throughout a survey.
- The track record can be downloaded at the end of the survey or the day by the Team Lead or data management team, and used to plot the canine's track line and survey coverage.
- The disadvantage of this system is that the K9-SCAT Team Lead must determine the completeness of coverage in the field and rely only on visual and/or systematic survey methods.

**GPS radio transmitters**

- Canine training and tracking GPS devices are commercially available, and consist of a GPS collar for the canine with a radio transmitter and a special GPS receiver unit that can continually receive the collar transmissions and record the canine's track (Figure D.1).
- The track line is displayed on the screen of the receiver unit, or on a mini moving-map-display, and can be used by the K9-SCAT Team Lead to review the completeness of coverage during a survey, and/or before leaving a search area.
- This method can be used with multiple canines at the same time.

**Figure D.1—Typical GPS Tracking Collar**

## D.2 Calibration

The different settings and features of the equipment utilized during a survey must be understood in order to ensure consistency across a field program.

- Dates and times on GPS devices, cameras, and watches should be set to the same, correct time and time-zone at the start of a survey (Figure D.2).

- Times written on forms and notes must match the waypoint and photo information recorded on the device. This attribute is critical for georeferencing cameras that do not have built-in GPS.

- If more than one GPS is used during the survey, the team should choose a “designated GPS” for the recorded survey information, including survey waypoints.

- It is good practice to conduct a cross-device calibration to compare the different units. This can be achieved by placing each GPS and/or GPS-enabled camera at the same location for a minute and recording the coordinates. This information can be used to compare the distance offset between the devices and to adjust measurements, if required, or to indicate that a device may be malfunctioning or providing un-reliable coordinate information.

- Another useful calibration technique is to take daily waypoints at a location that can be seen on satellite imagery or web-based mapping systems, such as Google Earth: for example, a corner of a building. Plotting these waypoints can provide reference and offset correction data for mapping.

- Ideally, all cameras used in the field would be equipped with a built-in GPS and electronic compass to expedite post-survey processing.

- If built-in GPS devices are not available, a photo of the GPS showing the current time (hh:mm:ss) must be taken at the start of each survey.

    - This photograph is necessary to provide an offset time between the photo time data and the GPS track-line time data for georeferencing photos during post-survey processing.

    - It is important in this situation that the GPS used for the camera processing is carried by, or near to, the person taking the photos.

- It is good survey practice to always take a pre-survey photo of the GPS, even if using GPS enabled equipment, as a safety backup and crosscheck. GPS coordinates recorded by cameras generally should not be used for positioning features or potential oil targets as often these do not have the same accuracy levels as dedicated GPS devices which may have access to additional positioning services.


**Figure D.2—Time and Date Calibration**

## D.3 Track Recording

GPS track lines are essential to document a Wide Area Search to ensure that the desired coverage has been accomplished.

- GPS units should be set to record track coordinates on a **time interval** (not "Distance" or "Automatic"), in order to record regular coordinate fix intervals that can be used to link track line data in post survey applications and other datasets, such as the location of photographs.

- The GPS units should be set to an appropriate time interval for the survey method and duration.

  - A 5–10 second interval is considered reasonable for a walking survey.

  - An interval of 3–5 seconds would be recommended for canine GPS units in order to more accurately record abrupt changes in direction and speed that are typical of canine movements.

  - For a Wide Area Search, a canine may be able to survey at a speed of between 5 and 10 km/hour (API, 2016). Table D.1 indicates the approximate travel distances between recorded fixes for different GPS time interval settings at three typical survey speeds.

  - The selected time interval depends in part on the memory capacity of the individual GPS device and the expected duration of the survey. For example, most Garmin field GPS units can store 10,000 fixes in "active or current" memory, (10,000 / 5 seconds = 13+ hours) (Table D.2).

- The GPS should be set not to overwrite when full; otherwise, that data is automatically moved to secondary memory when the "current" track is full before overwriting.

- GPS units have an option to "Save" track lines. Care should be taken with this option as some GPS devices average the track data to reduce file size and, in so doing, only save a portion of the recorded information needed for photo linking.

- Newer GPS units have an "archive" feature that saves the entire track line data to secondary GPX files that can be downloaded from the unit. This type of GPS unit can be set to "archive" on a daily basis, or when the "current" track memory is full.

- The current day's track line should be downloaded and provided to the SCAT data management team at the end of each day of surveys.

- The "active or current" track line should be cleared before starting the next day's surveys.

**Table D.1—Approximate Distances Traveled Between Location Fixes**

| TIME INTERVAL (seconds) | 1 | 3 | 5 | 10 |
|---|---|---|---|---|
| Distance (m) at 2 km/hr | 0.6 | 2 | 3 | 6 |
| Distance (m) at 5 km/hr | 1.5 | 4.2 | 7 | 14 |
| Distance (m) at 10 km/hr | 3 | 8 | 14 | 28 |

**Table D.2—Available GPS Memory**

| TIME INTERVAL (seconds) | 1 | 5 | 10 |
|---|---|---|---|
| Hours of recording | 3 | 14 | 28 |

Figure D.3 provides an example of a canine track line recorded during a Wide Area Search field trial. In this example the search objective was to clear an area and no target oil was deployed. The search was conducted under favorable conditions over easy terrain with one canine and lasted 5 minutes (Figure 2.6). The search covered approximately 0.5 ha (1.24 acres) and the track line length is 720 m (~800 yards) with a calculated average survey speed of 8.64 km/hour (5.4 miles/hour) (API, 2016).

## D.4 Waypoints

Waypoints provide coordinates of targets identified by the canine and are an important part of the SCAT database.

- Typical field GPS units have a waypoint capacity of 500 to 2,000.
- Waypoint capacity should be monitored and older survey waypoints cleared as necessary.
- It is often useful to save important waypoints/coordinates, such as segment boundaries, in the GPS unit for future surveys.
- If waypoints are kept for reference it is useful to rename them so as to avoid any confusion.
- Each waypoint is recorded with a date and time so the data management team can associate waypoint numbers with survey form dates and times. The waypoint GPS files provided to data management for the survey should be those used to record waypoints on forms and in notes.

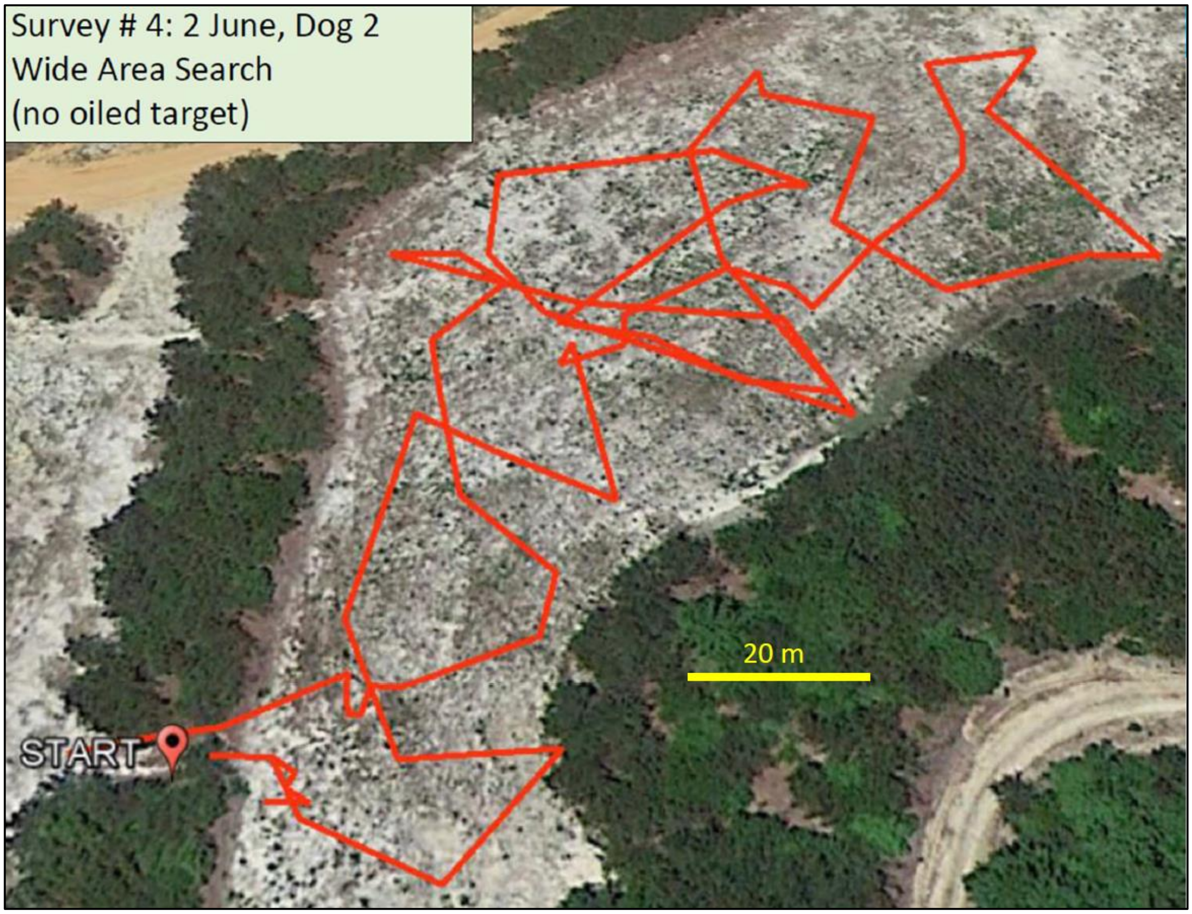


**Figure D.3—Example of a Track Line from a 5-Minute WAS Survey**

## D.5 Secondary and Moving Map Displays

GPS and electronic survey equipment, along with computers, smart phones, and tablet apps, are continuously evolving as new technologies and services become available. The use of these technologies can be adapted to SCAT survey procedures and methods in a multitude of ways depending on the specific applications, requirements, and user preferences. Importantly, map displays can use any of these technologies to provide real-time displays of position and track lines for canine survey coverage.

Electronic survey mapping displays can be grouped into two main categories: direct and remote.

- **Direct Displays**: indicate the geographic position of the user, for example, a hand-held GPS, smart-phone, tablet, etc., and the device essentially shows and records the location of itself.
- **Remote Displays:** indicate and record the geographic position of devices separate and at different locations from the displaying device: for example, radio transmitting canine collars, and locational GPS transmitters that are used to track persons, vehicles, boats, etc.

### D.5.1 Direct Displays

There is an ever increasing availability of direct display locational devices that can provide real-time direct moving map coordinates. These include smart phones, tablets, computers, car navigation systems, cameras, hand-held GPS devices, and wearable devices such as watches. Each of these has advantages and disadvantages depending on the purpose and expected data requirements of the survey (Table D.3).

### D.5.2 Remote Displays

Remote map displays can provide location and tracking information for GPS devices within range of the display "base-station."

- The range of individual systems depends on the communication methods used, for example local radio transmissions, cellular networks, or global satellite communication systems.
- These types of system are typically used to track equipment such as vehicles and boats; however, they can also be used to track persons, canines, and other GPS-enabled devices.
- Remote GPS tracking systems can be used to relay not only location information but also any other types of data that can be collected and transmitted, such as photos and video, e.g. captured by a drone.
- Remote moving-map displays typically are not used during traditional SCAT field surveys, however, remote display systems can be used to track the path of the canine to ensure full coverage of the survey area during a K9-SCAT survey
- Remote tracking may also be used to track the location of individual SCAT teams for team coordination and safety.
- Remote tracking stations are often set up as base-stations connected to computers and larger displays, i.e. at command centers; however, they can be established using laptops, tablets, phones, or specially equipped GPS devices.

### D.5.3 Interactive Display Systems

In addition to direct displays and remote displays, there are abundant navigation systems and software applications that can be run on computers, laptops, tablets and phones that can interact with other GPS devices to control or transfer recorded datasets.

- For example, a field hand-held GPS could be connected via cable or wirelessly to a laptop kept in a survey vehicle to quickly review track line and waypoint information at the end of the survey on a larger screen with better resolution and with more detailed base-map imagery, before leaving the site.
- A canine tracking GPS system could be connected directly to software running on a laptop at a field station to display a canine's location and track line information independent of the canine handler's or K9-SCAT Team Lead's field unit(s).
- Some newer GPS receivers can communicate directly with other devices, such as phones, to transfer more accurate GPS receiver data to apps, or, for example, to receive data alerts from a phone that is kept safely out of the elements, or to share a location if in range of a cell tower.

**Table D.3—Direct Display Locational Devices**

| DEVICE | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| **HAND-HELD GPS DEVICES** | • Dedicated GPS navigation devices traditionally provide more reliable and consistent positioning, with potential access to more reliable satellite and correction data.<br>• Do not need any external data connections to function to full capacity. | • Display screens are small.<br>• Mapping base imagery needs to be individually loaded prior to surveys.<br>• Limited external communication to other devices. |
| **AUTOMOBILE NAVIGATION SYSTEMS** | • Not typically directly used for SCAT surveys, can be useful for finding land access points.<br>• Typically have medium-sized displays and navigation support.<br>• Have built-in street map base.<br>• Do not need any external data connections for base navigation. | • Not practical for remote survey use.<br>• Typically do not have track recording capabilities.<br>• Only include street map base. |
| **GPS MODULES** | • Provide GPS capabilities to devices that do not typically have built-in GPS, for example computers and laptops that often are able to run more sophisticated navigational and GIS software applications for tracking and mapping.<br>• Rugged computer systems are available that could be used for field applications and several high-end SLR cameras can accept GPS module input.<br>• Do not need other external data transmission connections to function to full capacity. | • Not typically used for direct ground field survey work due to the size of computers and laptops; however, they are often used in aerial survey or boat based applications.<br>• Requires a data connection to the secondary device, i.e. Bluetooth or cable from GPS module. |
| **CONVERGED DEVICES** | • The most prolific type of new device available, including a wide range of phones, tablets, and cameras.<br>• Have built-in GPS, customizable navigation and mapping applications (apps), track and waypoint recoding, GPS photo, remote connection capabilities.<br>• Often have an Assisted (A-GPS) functionality. | • Positional data typically not as accurate as dedicated GPS devices; however, some newer devices are providing support for other available satellite data such as GLONASS.<br>• Most software applications require either a Wi-Fi, cell, or satellite communication connection to download map bases. |
| **WEARABLE TECHNOLOGY** | • Devices such as smart-watches are convenient and always quickly accessible.<br>• Screens may be too small to be used for moving map displays showing extended track lines; however, could be useful for quick location checks. | • Most wearable technology does not have built-in GPS, relying on connections to phones or other GPS devices to provide this support. |

## ANNEX E—K9-SCAT Fact Sheet

This table provides a brief summary of the key points following the sequence of the sections in the Guide. The relevant section numbers are included in each heading.

| **OVERVIEW (EXECUTIVE SUMMARY)** |
|---|
| • Canine detection searches involve a rapid, straightforward, proven concept that is based on sound scientific principles. Research has demonstrated that the canine sense of smell is at least as sensitive as commercial gas analytical instruments. |
| • A trained K9-SCAT detection team that includes a canine, handler, and K9-SCAT Team Lead can provide an efficient, versatile, rapid, reliable, cost-effective and real-time support tool for a SCAT program to locate surface and subsurface oil in a wide range of environmental settings. |
| • Imprinting of a trained detection canine with the target oil is quick (hours) so that an experienced and prepared team can be deployed rapidly during a spill response with minimal additional training. |
| • Surface oil searches can survey large areas rapidly or can search in wetlands, dense undergrowth and rough terrain where pedestrian movement is difficult or undesirable, or the oil is hidden in boulders, riprap, or vegetation. A detection canine senses for an airborne odor cloud working towards the potential or suspected oil source. The canine may use a combination of air and ground scenting as s/he approaches the source of hidden oil, or in low wind conditions. |
| • In a search for potential or suspected subsurface oil, a detection canine senses for an airborne odor cloud that has migrated to the surface from the source through sediment, snow, and/or water to create an odor “footprint.” The canine typically uses a combination of air and ground scenting as s/he approaches the odor footprint, or in low wind conditions. |
| • Locating a subsurface or hidden oil deposit is not a challenge for a canine in many scenarios. Successful delineation of the surface footprint of a continuous or discontinuous (including lens-type) subsurface oil deposit requires training, experience, coordination and good communication between the K9-SCAT Team Lead and the handler, and between the handler and the canine. |
| • The objective of delineating a subsurface oil deposit is to identify areas for excavation and investigation by a SCAT team who then determine the character of the oil and the exact vertical and horizontal dimensions. |
| • The combination of the fast survey speed with real-time GPS tracking is a valuable strategy to search large areas rapidly and to quickly re-survey areas in dynamic situations where oil may be remobilized and redistributed. |
| • A K9-SCAT Team can rapidly clear large shoreline/inland areas or pipeline corridors with a high-confidence, low-risk survey to ensure that oil is not present in those areas. This type of survey would be time-consuming for a traditional ground observation and excavation team. |
| • A skilled and attentive handler is essential to ensure that the safety, health, and welfare of the animal are the first priority at all times. |
| **INTRODUCTION (SECTION 1)** |
| • The purpose of these guidelines is to provide information on when and how detection canines can be used to support a shoreline or inland oiled area assessment (SCAT) program. This information includes: |
| ○ How oil detection dogs work and what they can do to locate and delineate surface and subsurface oil, |
| ○ The current state of knowledge regarding situations and types of surveys that a K9- SCAT team can undertake as part of a SCAT program, and |
| ○ How to plan and design a K9-SCAT survey and collect the appropriate data to document that survey. |

| **BACKGROUND: CANINE OIL DETECTION (SECTION 2)** |
|---|
| • Current oil detection practices are based on physical observations and can be slow and, for subsurface oil, typically provide only a partial (<0.01%) coverage. |
| • Canine surveys for surface oil detection can support ground SCAT teams in difficult or heavily vegetated terrain. |
| • Canine surveys can rapidly and reliably “clear” large areas with no surface or subsurface oil within the affected area. |
| • The positive attributes of canine subsurface oil surveys (speed, versatility, reliability, real-time data generation, and cost effectiveness for low-risk, high-confidence horizontal detection) and of excavation tactics (accurate characterization of the oil and the horizontal and vertical dimensions) do not overlap, but rather are complementary. |
| **CURRENT ACCEPTED SCAT SURVEY DETECTION PRACTICES (SECTION 2.1)** |
| • The current practice is for experienced observers to locate surface oil and to excavate to detect subsurface oil. |
| • Typically, this is a slow and time-consuming process. |
| • Aerial observations can detect only relatively large oil deposits so that ground surveys are required to locate and characterize smaller concentrations; even detecting large deposits on the ground may be difficult in heavily vegetated areas. |
| • The primary detection method for subsurface oil is spot sampling by manual or mechanical excavation. |
| • Spot sampling has a limited potential for success, with a high probability of non-detection, particularly for horizontally discontinuous or lens-type oiling. |
| **SURFACE OIL SURVEYS (SECTION 2.1.1)** |
| • The current SCAT practice is for experienced observers to locate surface oil. |
| • Visual aerial surveys usually can detect and define Heavy and Moderate Oiling Categories but may not be able to detect low oil concentrations (Light, Very Light, or Trace Oiling Categories). |
| • Visual ground surveys may not be able to locate oil hidden by vegetation in wetlands or river banks, or between boulders or riprap. |
| Ground-based survey teams may be very slow in rough and difficult terrain, such as irregular bedrock and coarse sediment (cobble-boulder or riprap) environments, dense vegetation, or snow conditions. |
| • In certain environments, such as wetlands, pedestrian movement may be undesirable. |
| • Typically, a considerable portion of the survey effort involves a ground-based determination that no oil is present (No Observed Oil – NOO). |
| **SUBSURFACE OIL SURVEYS (SECTION 2.1.2)** |
| • The current practice involves manual or mechanical excavation tactics to survey for and locate subsurface oil. |
| • This is a labor-intensive and time-consuming tactic. |
| • This spot sampling technique typically covers only a fraction of the area being surveyed (<0.01%), and has a high probability of non-detection for horizontally discontinuous, or lenses of, subsurface oil. |
| **CANINE AIR DETECTION THEORY AND TECHNIQUES (SECTION 2.2)** |
| • Canines can be trained to investigate, analyze, discriminate and signal the presence of a substance that the animal has been trained to recognize. |
| • The presence of subsurface oil can be detected as molecules are released and move upwards through sediment, water, or snow. The canine uses either ground or air scent to detect the target odor. |
| • The canine can be trained to signal the presence of an odor plume or follow that plume to the source (the odor ground footprint). |
| • Wide Area Search off-leash patterns are used to survey large areas rapidly whereas on-leash techniques are used to delineate an odor footprint. |

| CANINE OIL DETECTION FIELD EXPERIENCE (SECTION 2.3) |
|---|
| • Field research studies conducted with oil detection dogs in Norway and the USA provide proof of concept for a range of situations. |
| • Large surface oil deposits have been detected at distances over 1,000 m (0.6 mile). |
| • Subsurface oil has been detected at depths of 90 cm (36 in.) in sediments and 30 cm (12 in.) in packed snow. |
| • Apart from the Norwegian research, field experience on actual spills is limited to anecdotal information. |
| **APPLICATIONS, CONSTRAINTS: CURRENT STATE-OF-KNOWLEDGE (SECTION 2.4)** |
| • Detection dogs are versatile and reliable and can locate small surface oil deposits during Wide Area Searches and at depths up to 90 cm (36 in.) in sediments, based on research and experience to date. |
| • Detection dogs have a wider application, as yet untested, to detect oil at greater depths in sediments and snow as well as sunken oil in shallow water, based on research results and experience with detection dogs in other applications. |
| • Pre-deployment field trials are important to validate that a detection team can meet the survey application and expectations. |
| • Implementation of a detection team survey is less straightforward than with human observers or analytical instruments as animal/human behavioral factors must be considered and a successful deployment requires an experienced SCAT Team Lead and an interactive Team Lead, handler, and canine partnership. |
| **PEOPLE, CANINES, AND MACHINES: A COMPARISON (SECTION 2.5)** |
| • Humans observe and document; canines and gas instruments detect, analyze, and communicate. |
| • Surface oil detection and documentation surveys can be conducted from the air for Heavy and Moderate category oil concentrations, but have the risk of not detecting small amounts of oil, or oil hidden in vegetation or between boulders/riprap. |
| • Ground canine searches can cover large areas quickly and reliably to detect small amounts of surface and/or subsurface oil. |
| • The combination of human observational skills and canine detection/delineation skills are highly complementary. |
| • Aerial observations provide rapid coverage for locations with high surface oil concentrations, whereas canines provide rapid ground coverage in areas with low oil concentrations or with thick vegetation that are hard to observe and detect by humans. |
| • Canines reliably and rapidly generate real-time data and provide a low risk, high confidence strategy to detect and delineate hidden or subsurface oil deposits or to clear areas with No Detected Oil (NDO). |
| **THE DECISION PROCESS TO DEPLOY K9-SCAT (SECTION 3)** |
| • A SCAT program design typically includes several survey techniques as part of a multi-phased operation. A K9-SCAT component may be appropriate: |
| ○ During the initial phase in areas where the expectation of surface oiling is low, |
| ○ After surface oil has been removed or in the absence of surface oil, if subsurface oil is suspected or expected, |
| ○ In dynamic environments when oil may have been remobilized and redistributed after a reconnaissance or ground SCAT survey, |
| ○ During inspection surveys to confirm that treatment targets are achieved, and |
| ○ During routine pipeline inspections. |
| • An element of the evaluation process would be a field trial prior to full deployment to ensure that the survey expectations can be achieved. |

| CANINE PROVIDERS (SECTION 4) |
|---|
| • SCAT program managers typically have little or no experience with canine providers or detection canines. This section summarizes some of the parameters that should be considered in the evaluation and selection of service providers. |
| • The service provider should, at a minimum: |
| ○ be a professional organization that trains detection canines, |
| ○ have a staff of certified and experienced handlers, |
| ○ be able to conduct imprinting after mobilization in the field prior to deployment, |
| ○ understand the importance and purpose of SCAT missions, |
| ○ have an animal health and welfare protocol that is implemented by the handler, and |
| ○ be supported by a canine veterinarian(s). |
| **K9-SCAT ROLES AND RESPONSIBILITIES (SECTION 5)** |
| • A K9-SCAT team would function in the same manner as other SCAT field teams. |
| • An experienced SCAT Team Lead would manage and direct a K9-SCAT survey to support the handler and to ensure full area coverage and document survey data. |
| • A successful field survey requires training, experience, coordination and good communication between the K9-SCAT Team Lead and the handler, and between the handler and the canine. |
| • The handler controls and rewards the canine and is responsible for the safety, health and welfare of the animal. |
| **K9-SCAT SURVEY PLANNING (SECTION 6)** |
| • A K9-SCAT survey should be planned and managed in the same manner as other field SCAT surveys. |
| • Suitable accommodation and travel arrangements take into account the needs of the animal and the handler. |
| • The SCAT Safety Plan would cover the K9-SCAT field deployment and include a canine health and safety plan, and provision for direct access to a canine veterinarian. |
| **K9-SCAT SURVEY DESIGN GUIDELINES (SECTION 7)** |
| • Wide Area Searches, off leash and under favorable conditions, can cover between 4 and 8 ha/hour (10 and 20 acres/hour) at speeds between 5 and 10 km/hour (~3 and 6 miles/hour). On-leash delineation search speeds are slower: 1 to 5 km/hour (0.5 to 3 miles/hour). |
| • K9-SCAT planning includes the design of a search pattern that is best suited to the mission objective(s) and the configuration of the search area. |
| • An off-leash Wide Area Search or a pipeline ROW survey typically involves a rectilinear “ladder” pattern. |
| • An on-leash subsurface oil delineation survey typically follows a “bounce” pattern to define the boundaries of the deposit, after it has been located. |
| • The objective of delineating a continuous or discontinuous subsurface oil deposit is to provide location information so that a SCAT team can excavate pits or trenches at the site and in the immediately adjacent area to determine the character of the oil and the exact vertical and horizontal dimensions. |
| • Detection canines are trained to locate specific targets by imprinting with an oil sample from the area. |
| • In planning a K9-SCAT program, the team should be aware of potential “background” or non-target oils in a survey area. Canines may be trained to ignore non-target oils during the imprinting process. |
| • Confirmation, characterization and vertical delineation of subsurface oil would be conducted by an accompanying SCAT team or at a later time. |

| **DATA COLLECTION AND K9-SCAT DATA MANAGEMENT GUIDELINES (SECTION 8)** |
|---|
| • The K9-SCAT Team Lead is responsible for documenting the location and extent of oil or potential oil targets, and documenting the scope, purpose, and completeness of survey coverage. |
| • K9-SCAT surveys are documented on a K9-SCAT Survey Form. |
| • Standard procedures are followed to provide photographic or videographic coverage of a K9-SCAT survey. |
| • GPS track lines accurately document the canine survey coverage. |
| • Ideally, the K9-SCAT Team Lead uses a real-time, GPS-based moving map display to direct the handler during the search. |
| • Waypoints document locations where oil has been detected and also may be used to delineate the outer boundary of a large area with subsurface oil. |

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