Buried Oil Detection by Canines in Northern Prince William Sound

(K9-SCAT)

1-3 May 2017

OSRI Contract No. 17-10-03

Prepared for:

Oil Spill Recovery Institute, Cordova, AK

By:

Owens Coastal Consultants, Bainbridge Island WA

31st August 2017

Table of Contents

Executive Summary

A series of beach surveys were conducted with a canine (Pepper) trained for subsurface oil detection at five (5) sites in three (3) locations in northern Prince William Sound, AK, in May 2017; three (3) of these sites were known to have subsurface oil based on multiple surveys in recent years. The survey team, the SCAT Team Lead and the canine handler, had no prior knowledge regarding the location of the subsurface oil at four (4) sites located in the Northwest Bay of Eleanor Island and on Smith Island.

- At the four (4) Northwest Bay and Smith Island sites where oil was known or suspected to be present:
  - Pepper made 44 alerts.
  - Pit observations verified 13 of the subsurface oil alerts.
  - Eight (8) subsurface alerts were logged as NOO in pits that reached the water table.
  - 23 subsurface alerts were unverified as no pits or incomplete pits were dug at these locations.

- In the controlled test on Shoup Bay Spit that had no known prior oiling:
  - Pepper made nine (9) alerts.
  - She detected and delineated five (5) out of the six (6) oiled target pots that had been buried in a rectangular configuration.
  - Two (2) alerts were given near the water line at the farthest west end of the spit during a clearance survey and most likely were surface oil from an unknown (vessel/boat) source.
  - Two (2) alerts are discounted due to human error (probable cross-contamination from field equipment).
  - Two (2) outlier pots, one buried and one on the surface were not identified; the surface pot in the lower intertidal zone was most likely overlooked due to distractions caused by slippery cobbles and sharp barnacles.

The study demonstrated that a trained canine can quickly and accurately detect and delineate subsurface oil on a beach. Two thirds (64%: 18 out of 28) of the subsurface oil alerts were verified by pit observations where pits were dug to the water table. Alerts were not verified as pits were not dug or not completed at 25 out of 51 (49%) of the alerts because of the challenges associated with digging pits in the very large, coarse sediments that typify these beaches in Prince William Sound.

1. Overview

1.1. Project Summary

The focus of this project was to validate and better understand the capabilities of oil detection canines to locate and delineate subsurface stranded oil. With current technology, the investigation of subsurface oil on beaches is very labor intensive and has a low probability of success due to spot sampling methods (API 2013). The results of the study have a high probability of immediate, short-term applications and long-term real benefits in the design and implementation of shoreline assessment (SCAT) surveys for stranded oil. A technology that offers the potential to detect and delineate subsurface oil more rapidly and with a higher level of confidence than current pitting or trenching practices provides potential support benefits to traditional SCAT programs.

1.1.1 Previous Studies

- The first investigations using detection canines for oil were undertaken by SINTEF in Norway (Brandvik and Buvik 2009; Buvik and Brandvik 2009). Subsequently, the American Petroleum Institute (API) funded a study in 2013 to investigate the potential to improve subsurface oil detection and delineation on beaches (API 2013).
- In 2015, API continued the funding to support field trials for one of the promising techniques, oil detection canines, which resulted in the development of Guidelines for the potential application of canines to support SCAT surveys (API 2016a, 2016b).
- In 2016, Environment and Climate Change Canada (ECCC) funded a limited-scope field study in Chedabucto Bay, Nova Scotia, to search beaches for surface and subsurface oil stranded from a release from the sunken tanker "M/T Arrow" (K2 Solutions 2016, OCC 2016, Owens et al. 2017).
- Detection canines were then used successfully in a different role, following a pipeline spill, to locate surface, subsurface and shallow submerged oil over wide areas in the North Saskatchewan River in August through October 2016, and again through the summer of 2017.

These recent experiences provide a high level of confidence that trained detection canines supported by experienced canine handlers and experienced SCAT Field Team Leads can locate oil in subsurface sediments and on surfaces obscured by debris and vegetation.

1.1.2 Study Design

The study was designed to investigate the ability of a trained canine to detect and delineate subsurface oil deposits on known sequestered subsurface oil in Northern Prince William Sound (e.g. Owens et al. 2008; Taylor and Reimer 2008; Michel et al. 2011). Canines have proven the ability to locate low concentrations of surface oil during a recent (2016) river spill response and to locate single point concentrations during controlled field trials (2015). This study was designed to better understand the capabilities of oil detection canines to support SCAT field surveys to evaluate how well the K9-SCAT Team can delineate the extent of known subsurface oil deposits. To ensure the validity of the tests, a "double blind" test protocol was applied so that the information on the known locations of the subsurface oil deposits was not shared with the K9-SCAT Field Team Lead and the Canine Handler.

The study design was developed in the context of:

- the presence of known subsurface oil deposits in northern Prince William Sound at depths ranging between 10 and 25 cm below the beach surface and up to 20 cm thick in places,
- the known distribution of these deposits which are predominantly, but not all, located in the middle/upper intertidal zone, between 2.5 and 3.5 m above MLLW,

- GPS coordinates of some of the deposits that enabled the field work to focus on known locations,
- the beach character, predominantly coarse sediments, which favors odor transport from subsurface to the beach surface,
- the positive experience with oil detection canines on the coarse-sediment beaches of Chedabucto Bay investigated in 2015, and
- a study team that had many years of field SCAT experience, particularly in northern Prince William Sound, and professional canine handlers with field experience with oil detection canines.

1.2 Study Locations

The study involved five (5) beach segments at three (3) locations in northern Prince William Sound (Table 1.1 and Figure 1.1).

Table 1.1 Location of K9-SCAT Survey Segments

Segment	Area	Latitude	Longitude
EL-056C	Northwest Bay, Eleanor Island	60.550574°	-147.579629°
EL-057	Northwest Bay, Eleanor Island	60.558896°	-147.578496°
SM-006B	NW Smith Island	60.524933°	-147.391181°
SM-006C	NW Smith Island	60.519114°	-147.405608°
SB-001	Shoup Bay Spit	61.116268°	-146.587286°

Figure 1.1 Location of the three study sites in northern Prince William Sound

1.3 Survey Objectives

The objectives of the K9-SCAT surveys were to conduct a real-world test of the ability of a canine to detect surface and/or subsurface oil, and to communicate an alert for:

- K9-SCAT Wide Area Search (WAS) "Clearance" Surveys, where No Oil is Detected (No Detectable Oil – NDO),
- K9-SCAT Wide Area Search (WAS) Surveys where oil is detected, and the canine signals an alert(s), and
- K9-SCAT Delineation Surveys, where the canine signals an alert, and then is directed to conduct an on-leash search to delineate the odor cloud, or footprint, of the oiling.

All surveys were "double-blind", that is, neither the canine/handler team nor the K9-SCAT Team Lead knew where the oil might be located.

Two project team members (Drs. Ed Owens and Elliott Taylor) and the OSRI Program Manager (Dr. Scott Pegau) were familiar with past oiling in this area and therefore had prior knowledge of locations where the team would likely find residual oil. However, this knowledge was not shared with the rest of the team until after the K9-SCAT survey for each segment.

2 K9-SCAT Team

2.1 K9-SCAT Team Organization

The K9-SCAT Team in the field was organized as shown in Figure 2.1.

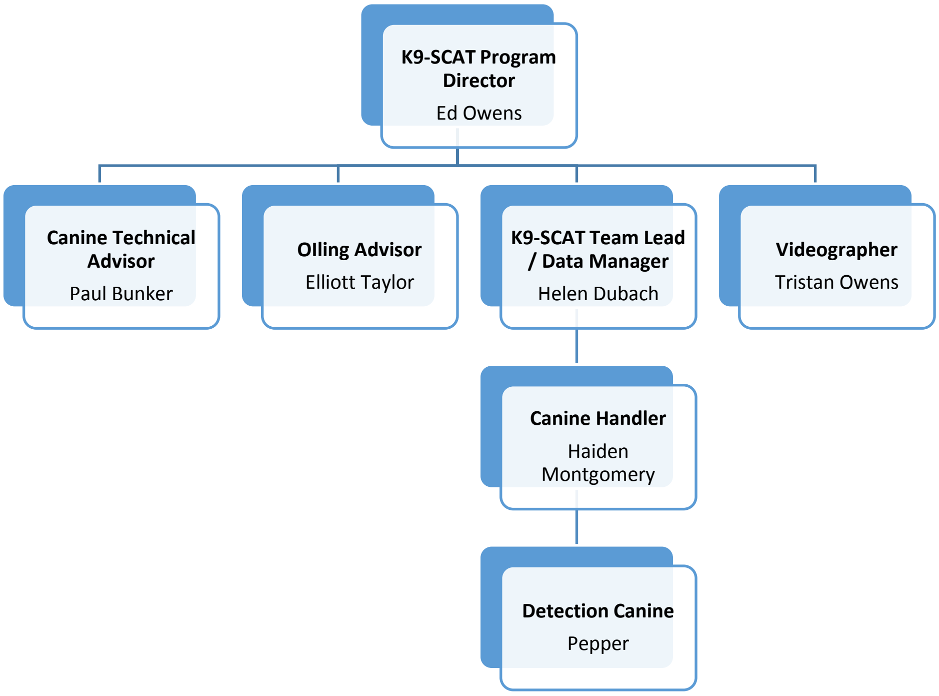


Figure 2.1 K9-SCAT Field Team Organization

In addition, the field program benefitted from the support of the OSRI Program Manager (Dr. Scott Pegau) and observers who accepted an open invitation to participate: Catherine Berg (NOAA), Dr. Tom Coolbaugh (ExxonMobil: 2nd and 3rd May), Dr. Maria Hartley (Chevron: 2nd and 3rd); Lt. Kate Hays (USCG, Valdez: 3rd), John Leclerc (RCAC: 2nd and 3rd), Lt. Jason Scott (USCG, Valdez: 1st), Gary Shigenaka (NOAA), and Lt. Chris Wallis (USCG, Valdez: 3rd); and who also volunteered to participate in the traditionally challenging pit digging activities that are a well-known feature of beach surveys in this region.

2.2 Roles and Responsibilities of K9-SCAT Team Members

The roles and responsibilities of the project participants are summarized in Table 2.1.

Table 2.1 Roles and Responsibilities of K9-SCAT Team Members

Role	Responsibilities
Program Director	• Manage and direct the K9-SCAT program • Determine and prioritize the segments to be surveyed • Define the area to be searched, i.e. the boundaries of the Wide Area Search
Canine Technical Advisor	• Provide canine technical input during planning and field surveys • Maintain links with veterinary services • Generate a field report to: o document the activities with respect to the canine(s) and the Handler, o document the behaviour of the canine with respect to the environmental and duty conditions, o identify any issues that arise, along with potential mitigating options, and o recommend improvements that could be applied to the survey design or the operating procedures.
K9-SCAT Team Lead	• Conduct a daily safety brief and ensure that all personnel understand and sign the JSA • Follow the Survey Checklist (see Section 3.5) • Act as a Safety "Spotter": highlight any safety concerns ahead or around the location, as the Canine Handler is focused on the canine activity • Communicate closely with the Canine Handler • Decide (with the Canine Handler) an appropriate search pattern design (Wide Area Search and Delineation) for the specific scenario • Fit the GPS tracking collar on the canine, or ensure the Canine Handler fits the GPS collar correctly • Ensure full area coverage using a handheld GPS and/or moving map display, directing the Canine Handler to unsurveyed or missed sections • Record data for each segment, including: o complete the K9-SCAT survey form o mark (with GPS) and flagging any alert sites, and record those on the survey form
Oiling Advisor	• Advise on local conditions and logistics • Advise on oiling conditions in a segment after the K9-SCAT survey is complete • Record oiling/pit data • Conduct subsurface investigation to confirm alerts
Videographer	• Document the survey with videos and/or photographs
Canine Handler	• Responsible for the health and welfare of the canine • Imprint the canine on the specific oil odor for the job • Direct the canine according to the search pattern(s) agreed with the K9-SCAT Team Lead • Follow direction from the K9-SCAT Team Lead to ensure full area

	coverage • Determine maximum working distances and times (duty cycle) to ensure that the canine is not overworked • Monitor the energy and enthusiasm of the canine • Identify the needs for a reward target or a rest • Reward the canine following an alert or an NDO survey • Identify risk and safety factors with respect to the canine
Data Manager	• Collect and collate field data • Download and process GPS data and photographs • Conduct QA/QC of incoming data • Produce summary reports, maps and tables, as required
Observers	• Observe the surveys • Conduct subsurface investigation to confirm alerts

3 K9-SCAT Program

3.1 Logistics and Schedule

Access to the sites was gained by a charter vessel ("Kimberlin's Cat", Figure 3.1); a 45-foot, aluminum, shallow draft catamaran jet boat with a drop bow that allowed direct and safe access to the beaches. The vessel transited out of the Port of Valdez each day and had a capacity for up to 20 passengers.

Figure 3.1 "Kimberlin's Cat" and photography set up in Northwest Bay (EL-056C)

3.2 K9-SCAT Missions

The project was timed based on the ability to conduct beach surveys with suitable low tide water levels during daylight hours. The survey dates for this project were May 1 to 3, 2017, which satisfied the daylight criterion and which had predicted low tides below +0.5m each day (Figure 3.2).

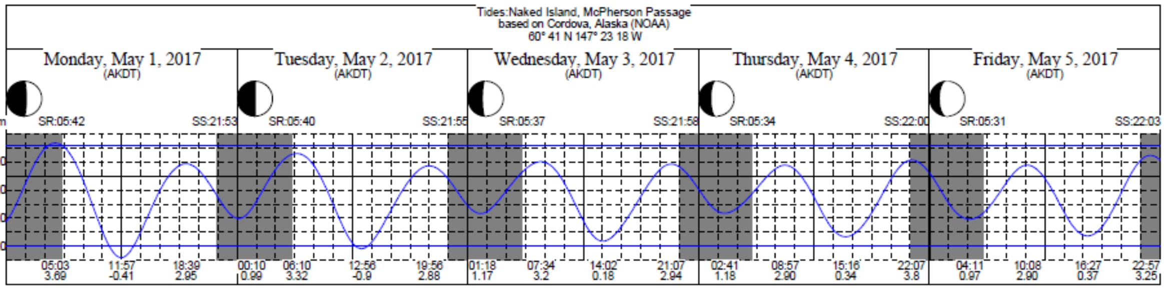


Figure 3.2 Tide graph for Naked Island, May 1-5, 2017

Table 3.1 Mission Activities

Date	Segments Surveyed	Low Tide	Time of Low Tide
1 May 2017	Eleanor Island: EL-056C, EL-057	-0.41m	11:57
2 May 2017	Smith Island: SM-006C, SM-006B	-0.9m	12:56
3 May 2017	Shoup Bay Spit SB-001	+0.18m	14:02

3.3 Survey Design

The two primary survey objectives for the projects were:

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

3.3.1 Survey Times

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. The project design was to limit the time of continuous searching to 120 minutes, ensuring that the canine could rest between surveys.

Previous studies indicate that a canine can cover a survey area at a range of 5-10 km hour. Given that the maximum segment length is less than 500 m, the 120-minute limit was not reached during any of the searches (see Table 6.9). The canine was able to rest while the team dug pits to verify the alerts.

3.3.2 Reward Targets

If a 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, 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). A reward target was available but not necessary during this project due to short segments and sufficient alerts.

3.3.3 Search Patterns

Depending on the width of the shoreline and the wind speed and direction, a canine search pattern may be linear (typically for survey widths less than 10m) or rectilinear. Given the shoreline widths encountered (30m or more) during the surveys, a rectilinear search pattern was employed (Figure 3.1). In this example, the wind direction was out of the east-northeast (see Table 6.1). Figure 3.1 also shows the location of the way points that mark the alerts provided by Pepper at the buried pots target area. As a rule of thumb, with low wind velocities, as was the case in this instance, the typical search pattern is based on a 10-m spacing between cross tracks.

Figure 3.3 Example of rectilinear search pattern (SB-001) from west to east into the wind

3.3.4 Delineation

Once the canine alerts on an odor from subsurface oil, a delineation survey is conducted to fully define the odor footprint. The team works into the wind to the degree possible, and monitors wind speed and direction periodically. An example delineation search pattern is described below:

1. The first alert location is recorded, flagged and a waypoint taken (Figure 3.2: Step 1).
2. The canine team then moves an agreed distance (depending on the wind, e.g. 5m) perpendicular to the first alert, and searches parallel to the initial search direction. Any alerts are recorded and flagged. This pattern continues until no alerts are recorded along a search line; this establishes the first “box” line for the delineation (Figure 3.2: Step 2).
3. The survey then continues at set distances perpendicular to the first “box” line. Any alerts are recorded and flagged until no alerts are recorded along two search lines on either side of the alert sites (Figure 3.2: Step 3).

4. The survey then moves perpendicular to the two new box lines to establish the fourth and final box line along which no alerts are recorded (Figure 3.2: Step 4).
5. The alert sites and box lines can then be sketched to delineate the odor footprint (Figure 3.2: Step 5).
6. If additional detail is required, the canine can be bounced around the delineated shape between the recorded alert sites flags.

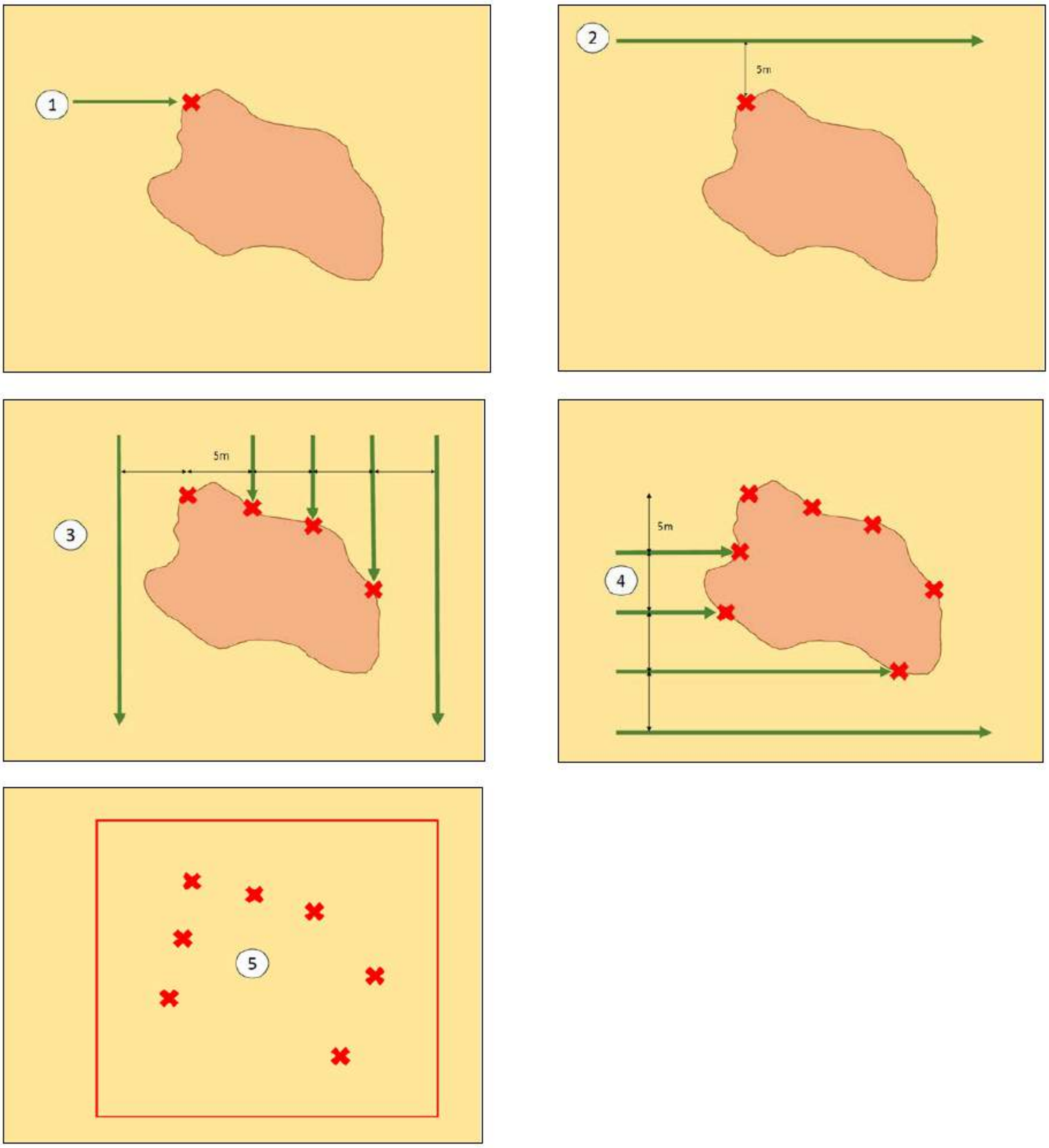


Figure 3.2 Delineation survey steps

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

3.4 Confirmation Testing/Vertical Delineation

Confirmation testing of any alerts and the vertical delineation and characterization of subsurface oil was conducted by the K9-SCAT team and the observers.

For each segment, the Oiling Advisor documented the oiling observed in each pit (Section 4).

3.5 Survey Checklist

The K9-SCAT Survey Checklist (Table 3.2) was followed by the K9-SCAT Team Lead.

Table 3.2 K9-SCAT Survey Checklist

K9-SCAT SURVEY CHECKLIST	
PRE-SURVEY	
	Evaluate canine and personnel safety risks associated with oil and/or the survey environment, and mitigation actions
	Set up the portable weather station
	Define the survey area (polygon) with the Program Director
	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
SURVEY	
	Record general (1), team (2), segment (3), and shoreline (4) information on K9-SCAT Survey Form
	START SURVEY (note time on form)
	If the CANINE ALERTS: Flag and note waypoint/coordinates on form, and commence delineation
	Flag and record all delineation alerts on survey form
	Continue search until the survey area has been fully covered
	Ensure canine and other team members get necessary rest, shelter, water, and food
	Conduct verification testing (pits) if required (record pit data on SOS or supplemental pit form)
	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 tracklines, and create map(s) of tracklines
	Download photos/videos
	Collect and collate forms/data

4 Data and Reporting

4.1 Forms and Documentation

The K9-SCAT PWS Survey Form (Figure C.1) was designed specifically for this project, and used to document the surveys and any alerts made by the canine. Data Output

The raw data from the project include:

- Completed K9-SCAT survey Forms (Attachment C.1)
- Canine Collar GPS tracklines (e.g. Figure 3.1 and Attachment A)
- Waypoints (start of segment, end of segment, alerts, pits)(e.g. Figure 3.1)

- Micro-meteorological data (wind, temperature, barometric pressure, humidity) (Table 6.1)
- Photographs (showing segment information, environmental conditions, alerts, pit oiling, etc.) (e.g. Attachment B)
- Survey Videos

5 Safety

5.1 Morning Safety Brief

A morning brief was conducted prior to each survey day to ensure that all participants and observers were fully aware of the objectives for the day, and of any safety concerns and issues. Everyone involved was required to read and sign the Job Safety Analysis (JSA) at this time each day.

5.2 Job Safety Analysis (JSA)

Potential human and canine risks associated with the vessel and with the field surveys were identified, and were used to develop a project-specific JSA that included both human and canine health and safety (Attachment D).

6 Survey Data

6.1 Environmental Data Summary

Table 6.1 summarizes the local meteorological data collected at 0.5 m above the ground surface at the study sites.

Table 6.1 Summary of Near-Ground Meteorological Data

Date 2017	Segment	Weather	Air Temp (° F)	Wind Direction (° True North)	Wind Speed (miles/h)	Barometric Pressure (mmHg)	Humidity %	Tide Stage
1-May	EL-056C	Cloudy	40	45	5	30	80	Low slack
1-May	EL-057	Cloudy	40	270	5	30	80	Low rising
2-May	SM-006C	Cloudy	42	5	4	30	83	Low slack
2-May	SM-006B	Cloudy	42	45	4	30	83	Low rising
3-May	SB-001	Cloudy	51	70	5	29	64	Low rising

6.2 Site Descriptions

Eleanor Island: EL-056C

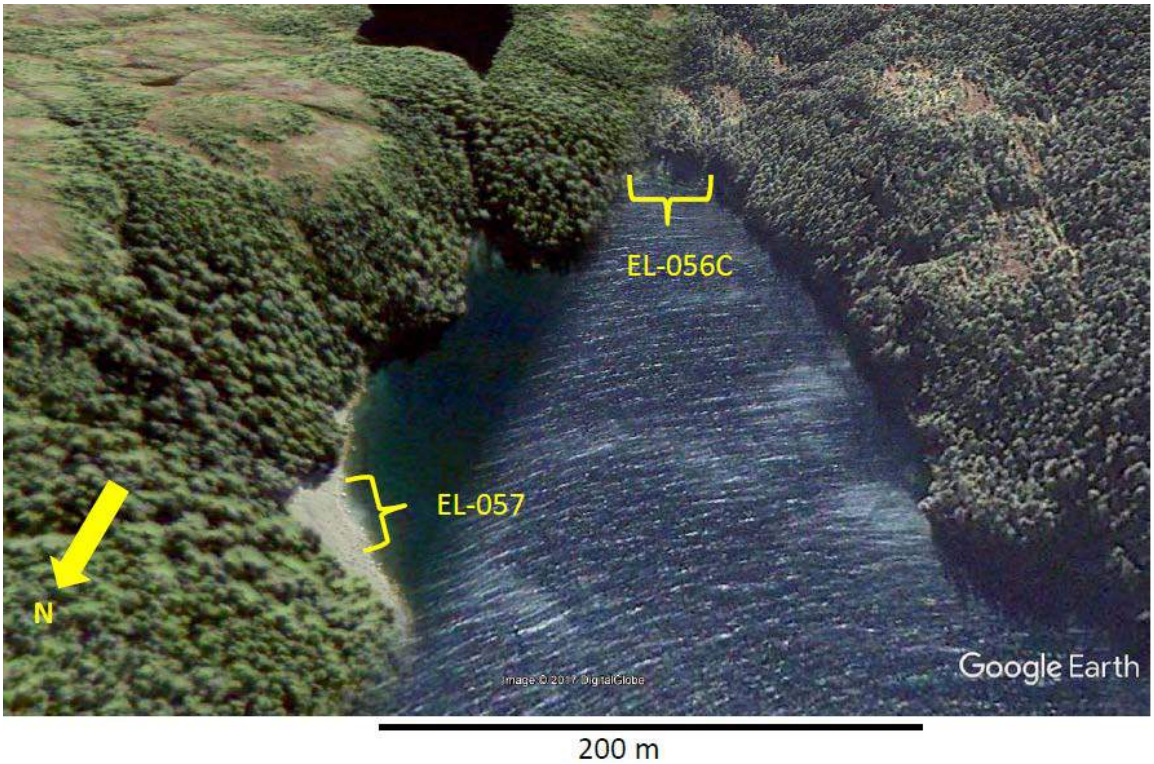


Figure 6.1 Location of surveyed segments on Eleanor Island (see Figure 1.1)

Segment EL-056C was visited on 1 May 2017. This site is a small, very sheltered, north-facing pocket beach at the head of Northwest Bay on Eleanor Island (Figures 3.1 and 6.1). The moderate angle intertidal beach is characterized by:

- a surface cobble and pebble cover over pebble, sand and cobble mixed sediments in the middle to supratidal zone along the central portion of the site (Figure 6.2 – Left),
- bedrock with a boulder and cobble cover along the steeper flanking shorelines and in the lower intertidal zone, and
- stream runoff that crosses the beach along the western portion of the site (at left facing landward (Figure 6.2 – Right).

Segment Length	Average Width	K9 Surveyed Length	K9 Surveyed Width
70 m	45 m	50 m	45 m

Sequestered EVOS SSO (Exxon Valdez Oil Spill – SubSurface Oil) was documented previously along the two sides of the beach where massive boulders cover shell hash and sandy fines, typically near the 0.00m MLLW. At these locations the SSO coated the bottom sides of cobble clasts and was trapped within interstitial sandy fines and shell hash.

Figure 6.2 EL-056C Left: Upper-middle intertidal zone. Right: Lower intertidal zone

Eleanor Island: EL-057

Segment EL-057 was visited on 1 May 2017. This site is a small, semi-protected, west-facing pocket beach northeast of EL-056C, near the head of Northwest Bay on Eleanor Island (Figure 6.1). The moderate angle beach is characterized by:

- a surface cobble and pebble cover over pebble, sand and cobble mixed sediments along most of the intertidal zone (Figure 6.3),
- bedrock outcrops with boulder cobble cover mid-site and along the south flank, and
- a stream runoff that crosses the beach along the bedrock edge at the south end of the beach.

Segment Length	Average Width	K9 Surveyed Length	K9 Surveyed Width
85 m	30 m	50 m	25 m

Post-EVOS monitoring surveys did not identify sequestered EVOS oil on this beach segment.

Figure 6.3 EL-057 Left: Upper-middle intertidal zone. Right: Middle intertidal zone

Smith Island: SM-006C

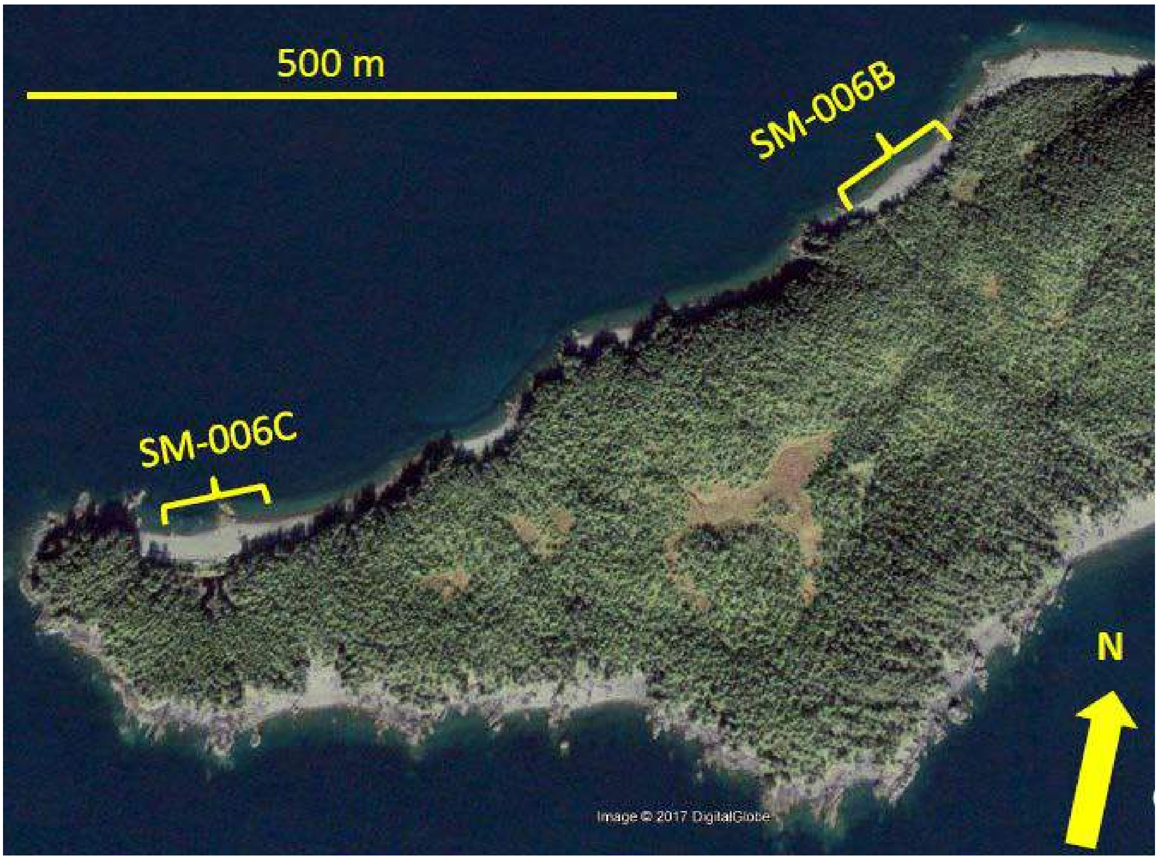


Figure 6.4 Location of surveyed segments on Smith Island (see Figure 1.1)

Segment SM-006C was visited on 2 May 2017. The beach is on the north-facing, exposed shoreline near the west end of Smith Island (Figure 6.4). The moderate angle, mixed coarse-sediment shoreline is characterized by:

- bedrock outcrops and cobble cover throughout most of the intertidal zone (Figure 6.5 – Right), underlain by mixed cobble, pebble, granule and sand
- a predominately boulder cover that characterizes the lower to middle intertidal zones in the eastern portion of the site where, in places, the underlying bedrock layer forms low relief ridges and swales that provide localized sheltering for the base layer of finer sediment.

The area surveyed is predominately the western portion of the full segment (Figure 6.5 – Left).

Segment Length	Average Width	K9 Surveyed Length	K9 Surveyed Width
500 m	60 m	140 m	40 m

Sequestered EVOS SSO was documented previously as generally located in the center (eastern portion) of the site among the large boulder rubble where HOR (Heavy Oil Residue) and MOR (Moderate Oil Residue) occurrences were commonly associated with a fine sediment layer under the granule matrix below the coarse cobble boulder cover.


Figure 6.5 SM-006C Left: Western end of beach. Right: Middle intertidal zone

Smith Island: SM-006B

Segment SM-006B was visited on 2 May 2017. The beach is on the northwest-facing, exposed shoreline east of SM-006B (Figure 6.4). The moderate angle, mixed coarse-sediment shoreline is characterized by:

- a rounded to subangular cobble surface cover in the upper to supratidal zone (Figure 6.6 – Left),
- large subangular surface boulders in the middle to lower intertidal zone (Figure 6.6 – Right).

The surface cover is underlain by mixed cobble, pebble, granule and sand.

Segment Length	Average Width	K9 Surveyed Length	K9 Surveyed Width
280 m	60 m	170 m	35 m

This segment was heavily oiled during EVOS. A 2002 SSO map is provided in Figure 6.13.


Figure 6.6 SM-006B Left: Upper-middle intertidal zone. Right: Lower intertidal zone

Shoup Bay Spit: SB-001

Figure 6.7 Location of Shoup Bay Spit (see Figure 1.1)

This beach was visited on 3 May 2017. The location is the south-facing, exposed shore of a long spit that has grown westward to enclose Shoup Bay (Figure 6.7). The moderate angle, mixed coarse-sediment beach is characterized by:

- a rounded pebble-cobble surface cover in the middle to supratidal zone (Figure 6.8), and
- large surface boulders on a wide low-tide terrace.

The surface cover is underlain by mixed cobble, pebble, granule and sand.

Site Length	Average Width	K9 Surveyed Length	K9 Surveyed Width
900 m	35 m	450 m	25 m

The area of Shoup Bay and the spit was not oiled during EVOS.

Figure 6.8 View to east on SB-001 with blank targets (#1 & #2 pot) in foreground

6.3 Eleanor Island EL-056C Survey

This beach had been surveyed by EVOS-SSO related studies.

On the first day on this first beach of the study, the handler was asked to start at the western end of the segment. Pepper had a Change of Behavior as soon as she stepped off boat but was instructed to continue and in fact crossed an area of previously known (to one observer) subsurface oil (the area of Waypoint 8 in Figure 6.9). On hindsight, the preferred method would have been to allow Pepper to scout by herself and then have the handler direct her focus. This approach was discussed and adopted in the subsequent surveys.

Pepper was directed to conduct a series of alongshore searches (track lines are provided in Attachment A: Figure A.1) which resulted in five (5) alerts (Figures 6.9 and A.1, Table 6.2).

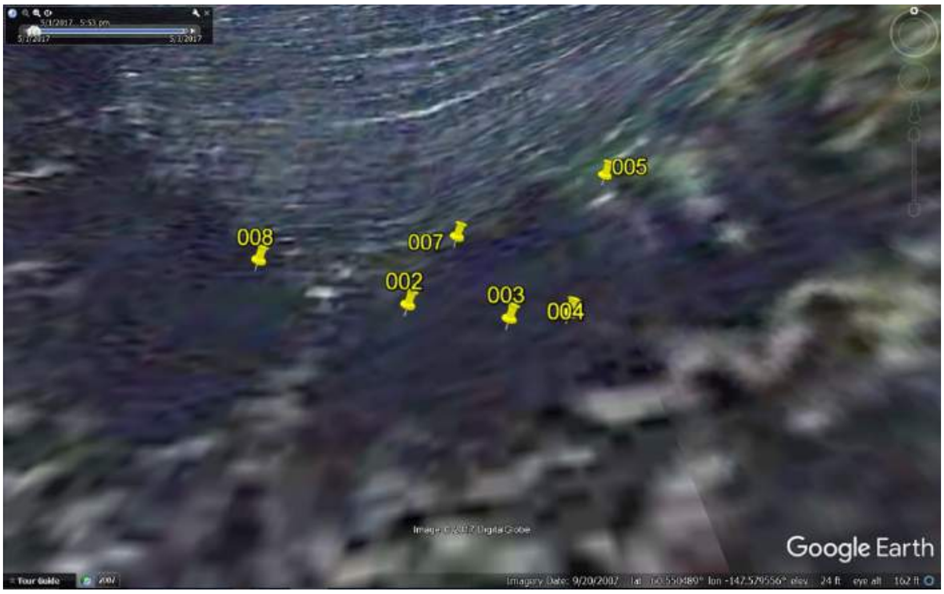


Figure 6.9 Alert waypoints in EL-065C (Table 6.2)

Table 6.2 EL-056C Alerts

Alert #	Wpt #	Verified?	Location	Pit Depth (cm)	Water Level in Pit (cm)	Observation	Comment
1	2	V	MTZ	45	20	silver sheen	several alerts in $3m^2$ area; 3 pits dug, sheen observed in one
2	3	-	UTZ	50	-	NOO	pit behind log, did not dig to water level: significant amounts of organics in pit
3	4	-	UTZ	50	-	NOO	did not dig to water level: significant amounts of organics in pit
4	5	V	LTZ	18	2	silver sheen	Figure B.6
5	7	V	LTZ	30		brown oil	sampled: #EL56-2017-01
N/A	8	N/A	LTZ			brown oil	pit dug at known location - oil used to imprint canine: Figure B.7

NOTE: In each Alert table:

- ***"V" and grey shading** indicate that an "alert" was Verified by visual observation*
- ***"N" and tan shading** indicate that a pit was dug to the water table but no oil observed (NOO, in which case the Alert was documented as Not Verified*
- ***("-") and no shading** indicate that either (a) a pit did not reach the water table, (b) a pit was not dug, or (c) that the data is not applicable (as explained in the "Comments")*

RESULTS:

- Three (3) alerts of subsurface oil in the middle and lower intertidal zones were verified by pits ("V")
- Two (2) alerts in the upper intertidal zone were unverified; the pits were incomplete as they did not reach the water table, and were logged as No Observed Oil (NOO) ("-")

6.4 Eleanor Island EL-057 Survey

This beach had not been surveyed by EVOS-SSO related studies.

Pepper was directed to conduct a series of across-shore searches (track lines are provided in Attachment A: Figure A.2) which resulted in four (4) alerts (Figure 6.10, Table 6.3).

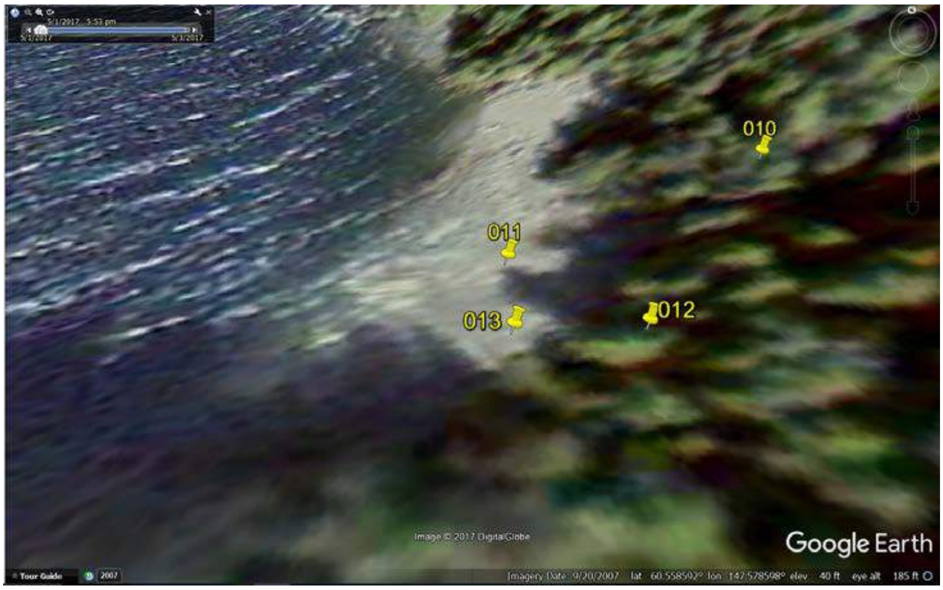


Figure 6.10 Alert waypoints in EL-057 (Table 6.3)

Table 6.3 EL-057 Alerts

Alert #	Wpt #	Verified?	Location	Pit Depth (cm)	Water Level in Pit (cm)	Observation	Comment
1	10	N	UTZ	35	12	NOO	pit to bedrock, with water table
2	11	V	LTZ	40	2	light silver sheen	sheltered by bedrock outcrop (Figure B.8)
3	12	-	UTZ	-	-	no pit	Ran out of time
4	13	N	MTZ	25	10	NOO	Figure B.9

RESULTS:

- One (1) subsurface oil alert in the lower intertidal zone was verified by a pit ("V")
- Two (2) alerts, one in the upper intertidal zone and one in the mid-intertidal, were not verified and were logged as NOO ("N")
- no pit was dug at the fourth alert ("-")

6.5 Smith Island SM-006C Survey

This beach had been extensively surveyed by EVOS-SSO related studies.

Pepper was directed to conduct a series of searches beginning with a swath in the upper/supra intertidal zones followed by a series of across-beach lines (track lines are provided in Attachment A: Figure A.3) which resulted in 18 alerts (Figure 6.11, Table 6.4).

Figure 6.11 Alert waypoints in SM-006C (Table 6.4)

Table 6.4 SM-006C Alerts

Alert #	Wpt #	Verified?	Location	Pit Depth (cm)	Water Level in Pit (cm)	Observation	Comment
1	16	-	MTZ				No pit
2	17	V	MTZ	12	10	light silver sheen	Figure B.10
3	18	N	UTZ	20	17	NOO	
4	19	N	High UTZ	23	19	NOO: organic sheen	
5	20	-	High UTZ	-	-	No pit	

6	21	V	STZ	28	25	light sheen	at logs
7	22	-	UTZ	-	-	No pit	in front of boulder
8	23	N	UTZ	18	15	NOO: organic sheen	
9	24	V	UTZ	32	28	brown oil	
10	25	V	MTZ	15	3	brown oil	
11	26	V	MTZ			rainbow sheen	sheen observed in pool on surface
12	27	-	UTZ	-	-	No pit	
13	28	V	MTZ	30	27	sheen	Figure B.11
14	29	-	MTZ	-	-	No pit	
15	31	-	LTZ	-	-	No pit	
16	32	V	LTZ	20	15	brown oil	
17	33	-	LTZ	-	-	No pit	
18	34	-	LTZ	-	-	No pit	

RESULTS:

- Seven (7) of the 18 subsurface oil alerts were verified by pits ("V")
- Three (3) alerts in the upper intertidal zone were not verified by pits and logged as NOO ("N")
- No pits were dug at eight (8) locations ("-")

6.6 Smith Island SM-006B Survey

This beach had been extensively surveyed by EVOS-related studies (Figure 6.12).

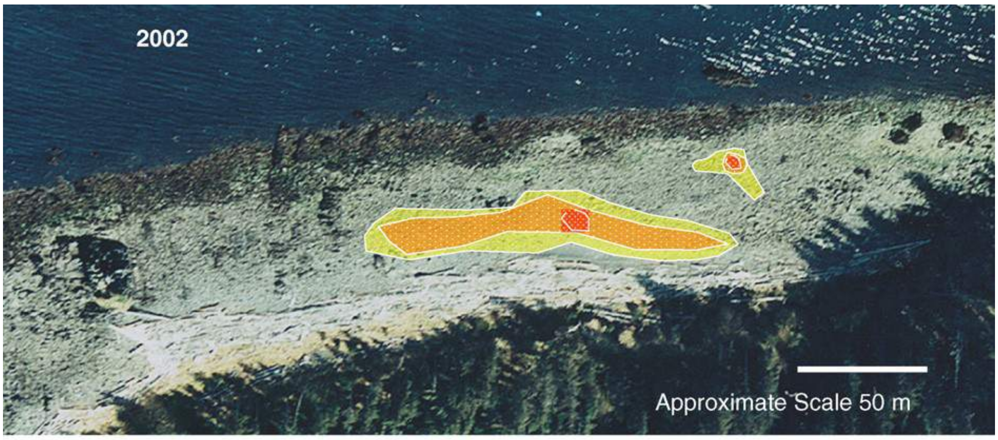


Figure 6.12 Subsurface oil observed from pits in SM-006B in 2002 (from Owens et al. 2008)

Pepper was directed to conduct a series of searches beginning with a swath in the upper/supra intertidal zones (tracklines are provided in Attachment A: Figure A.4) which resulted in 7 alerts (Figure 6.13, Table 6.5).

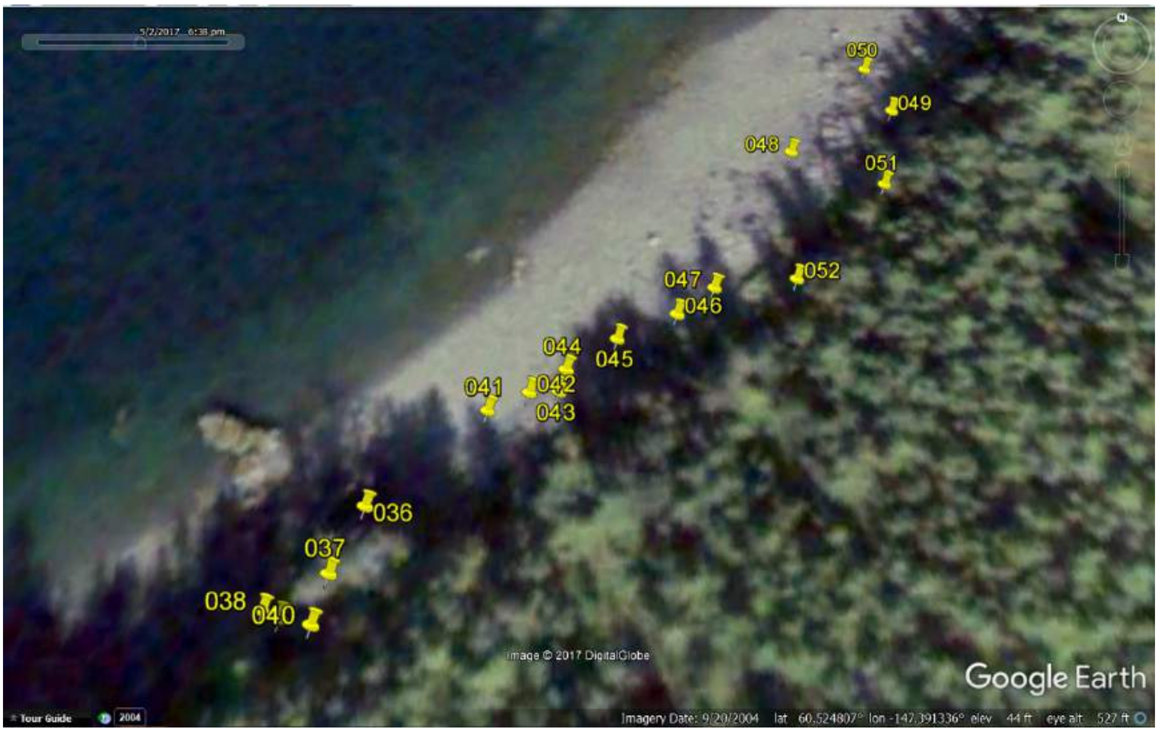


Figure 6.13 Alert waypoints in SM-006B (Table 6.5) (see also Figure 6.16)

Table 6.5 SM-006B Alerts

Alert #	Wpt #	Verified?	Location	Pit Depth (cm)	Water Level in Pit (cm)	Observation	Comment
1	36	N	MTZ	22	19	NOO	sheltered by bedrock outcrop
2	37	-	MTZ	45	-	NOO	pit did not reach water
3	38	-	MTZ	-	-	No pit	
4	39	-	UTZ	-	-	No pit	
5	40	V	STZ			engine oil filter on surface	artificial
6	41	-	MTZ	31	-	NOO	pit did not reach water: Figure B.12
7	42	-	MTZ	-	-	No pit	
8	43	-	MTZ	-	-	No pit	
9	44	N	MTZ	27	24	NOO	
10	45	-	MTZ	-	-	No pit	
11	46	-	UTZ	-	-	No pit	
12	47	-	MTZ	-	-	No pit	
13	48	N	MTZ	30	10	NOO	
14	49	-	UTZ	-	-	No pit	near bedrock outcrop
15	50	V	MTZ	30	27	rainbow sheen	Figure B.13
16	51	-	UTZ	-	-	No pit	
17	52	-	STZ	?	-		pit did not reach water: rebar in backshore

RESULTS:

- Two (2) of the 17 subsurface oil alerts were verified by pits ("V")
- Three (3) pits dug to the water table in the middle intertidal zone had NOO ("N")
- Nine (9) alerts were not verified as no pit was dug ("-")
- Three (3) pits did not reach the water table ("-")
- Six (6) middle intertidal zone alerts (#s 41 through 47; Figures 6.13 and 6.16) were in a straight line parallel to the water line; only two (2) pits were dug on these alerts; one had NOO (# 44) and one was incomplete as it did not reach the water table (# 41)

6.7 Shoup Bay Spit SB-001 Survey

This beach was not oiled by the EVOS.

The specific objective of this site study was to conduct a Wide-Area Clearance survey on a beach where there was no known oil, followed by a detection/delineation test with buried target oil pots.

Eleven (11) target pots were placed on the beach, eight (8) of which contained a trace amount of oil on sorbent material.

- Two blank pots were deployed west of the target area; one (#1) was empty and the second (#2) was placed 1-m away and contained unoiled sorbet material.
- An outlier oiled target pot (#3) was placed farther 20-m alongshore to the east.
- Six (6) pots (#s 4 through 9) were buried in a rectangular pattern in the upper intertidal zone spaced 2-m apart across-shore and 6-m apart alongshore (Figures B.14 and B.15).
- One outlier pot (#10) was placed 4-m past the farthest east of the rectangle upper corner.
- One additional pot (#11) was located on the surface in the lower intertidal zone near the target area.

Pepper was directed initially to conduct a wide area search at the western end of the spit, some 200 m away from target area (track lines are provided in Attachment A: Figure A.5). She was then directed to search in an across-beach pattern at an approximately 10-m spacing (see Figure 3.1).

Figure 6.14 Alert waypoints at the Shoup Bay Spit site (Table 6.6)

Figure 6.15 High resolution of the target alert waypoints at the Shoup Bay Spit site

Table 6.6 Shoup Bay Spit Alerts

Alert #	Wpt #	Verified?	Location	Pit Depth (cm)	Water Level in Pit (cm)	Observation	Comment
1	54	-	LTZ	5	5	NOO	No pit
2	55	-	LTZ	5	5	NOO	No pit
3	56	V	UTZ			NOO	*At used pin flag, probably oiled by prior use*
4	57	V	MTZ			Target pot #4	dry pit on burial
5	58	V	MTZ			Target pot #7	wet pit on burial
6	59	V	LTZ			NOO	*At video-camera tripod, probably oiled by prior use*
7	60	V	MTZ			Target pot #6	dry pit on burial
8	61	V	MTZ			Target pot #8	dry pit on burial
9	62	V	MTZ			Target pot #5	wet pit on burial: Figure B.15

NOTE: The waypoint #s 57 through 62 do not reflect the sequence of the alerts. The waypoints were taken after the search had been completed.

RESULTS

- Pepper did not alert on either of the two (2) blank pots (#s 1 and 2).

- At the start of the search at the western end of the spit, Pepper alerted at two (2) locations in the very low intertidal zone (wps #s 54 and 55). These two (2) alerts at the west end of SB-001 are not included in the total alerts as there were believed to be surface oil from a random unknown (vessel/boat) source.

- Moving east, before she reached the target area, she alerted in the supratidal zone (wp # 56) at a pin flag placed by the team that likely had been used earlier on a previous beach and was oiled. This supratidal pin flag indicated the area where blanks pots had been buried in the intertidal zone. Pepper also alerted on a camera tripod (wp # 59) outside of the target area which had been set up earlier on a previous beach where oiling had been present.

- Pepper alerted on five (5) of the six (6) pots in the rectangle (Table 6.6). She did not alert initially on the upper middle pot as she searched upwind and kept moving towards the farthest source of the odor plume. When redirected back to the middle area she alerted on the middle pot in the upper row (pot # 6; wp #60).

- Pepper did not locate the outlier (#3), one of the rectangle corners (pot #9), nor the lower tidal zone outlier (pot #11). In this latter area she had difficulty moving across the beach sediment and was clearly distracted during the search because of the sharp barnacles and slippery cobbles.

6.8 Summary of Alerts

A summary of the total numbers of alerts and verified alerts from the five (5) beaches is provided in Table 6.7. The same data sorted according to the tidal zone are provided in Table 6.8.

Table 6.7 Summary of Alert and Pit Data

Segment	Alerts	Pits that Reached the Water Table	Subsurface Oil Alerts Verified ("V")	Comments
EL-056C	5	3	3	2 incomplete pits as did not reach water level and logged as NOO ("-")
EL-057	4	3	1	2 pits were logged as NOO ("N"): 1 alert with no pit ("-")
SM-006C	18	10	7	3 pits logged as NOO ("N"): 8 alerts with no pits ("-")
SM-006B	17	5	2	3 pits logged as NOO ("N"): 2 pits did not reach the water table and 10 alerts had no pits ("-")
SB-001	9	7	5	5 buried target pots detected ("V"): 2 alerts unverified ("N"); 2 alerts were due to probable human error
TOTAL	51*	28	18	

* *Two (2) alerts at the west end of SB-001 are not included in this total as they were believed to be surface oil from an unknown (vessel/boat) source.*

Table 6.8 Summary of Verified and Unverified Alerts by Tidal Zone

Tidal Zone	Total Alerts	Subsurface Oil Alerts Verified ("V")	NOO (pits met water level) ("N")	Incomplete Pits (pits did not meet water level) ("-")	Alerts with No Pit ("-")
Supra	4	2	0	1	0
Upper	14	1	4	2	8
Middle	25	11	4	5	9
Lower	10	4	2	0	2
TOTAL	53	18	10	8	19

- Almost three quarters (73%) of the subsurface oil alerts where pits were dug to the water table were verified by pit observations (18 out of 28 alerts)
- Ten (10) of the 28 pits that reached the water table did not verify the alert with observed oil
- Twenty seven alerts (27) were not verified either because the pit did not reach the water table or no pit was dug at the alert
- Almost half (47%) of the subsurface oil alerts were in the middle intertidal zone and a further 26% were in the upper intertidal zone
- Only one (1) upper intertidal zone subsurface oil alert was verified and nine (9) alerts had no pit or were incomplete
- The large proportion of pits not dug or that were incomplete at the alerts (50%; 27 out of 53 alerts) is a result of the challenges associated with digging pits in the very coarse sediments that typify these beaches in Prince William Sound.

6.9 Discussion of Alert and Pit Data

The key element of any detection process for subsurface oil that is based on surface sampling is the ability to verify that the subsurface oil is present at the location that is identified. A canine continuously samples the air above the ground to detect odors that are released from a subsurface oil deposit and that have migrated to the surface. There are several challenges associated with the process to verify the surface "sampling" (that is, a canine alert of "change of behavior"):

- The odors may drift away from the source so that the alert may be indicated at a location one or several meters away from that source.
- The pit may be not directly located above the odor source.
- The pit may not be sufficiently deep.
- The pit may be filled with water and no oil or sheen is visible if the oil is dissolved and so is below visual detection limits

A total of 51 alerts were documented as follows:

- 19 subsurface oil alerts were verified by pit observation
- Nine (9) subsurface alerts were logged as NOO in pits that reached the water table
- 22 subsurface alerts were unverified as no pits were dug at these locations
- Two (2) alerts were due to human error (cross-contamination)
- One (1) surface oil target was missed probably due to distractions caused by slippery cobbles and sharp barnacles
- Two (2) buried pots were missed

These are a number of possible reasons why an alert was not verified by a pit observation:

- a “false negative”: the canine alerts on a non-hydrocarbon target, or
- the pit was not sufficiently deep to reach the subsurface oil, or
- the pit was dug at a location that was not directly above the source of the odor, or
- the oil concentration in the water in a pit was below visual detection limits (i.e. dissolved).

At the SM-006B site, Pepper alerted seven (7) times along a 50-m straight line in the middle of the beach face slope (Figures 6.12 and 6.16). These alerts were not random and, as the dog does not work on visual cues and has no spatial awareness, this straight line of alerts has a definite significance even though no oil was observed in either of the two pits (31 and 27 cm deep respectively) that were dug on this line. The pit at wp 41 (37 cm depth) did not reach the water table (Figure B.12); the pit at wp 44 reached the water table at 24 cm with no observed oil. This mid-beach location is frequently where the groundwater table intersects the beach-face slope. One possibility is that Pepper alerted on a set of very low oil-in-water concentrations that were associated with leaching from an extensive (50-m long) subsurface source. However, she displayed no changes of behavior or alerts in the higher or lower tidal zones. This possible interpretation would imply that the odors from the sources that she detected were below visual detection limits and could be an expression of dissolved hydrocarbons or that the source(s) were too deep to be verified by pits. This topic is discussed further in Attachment E on page E-8

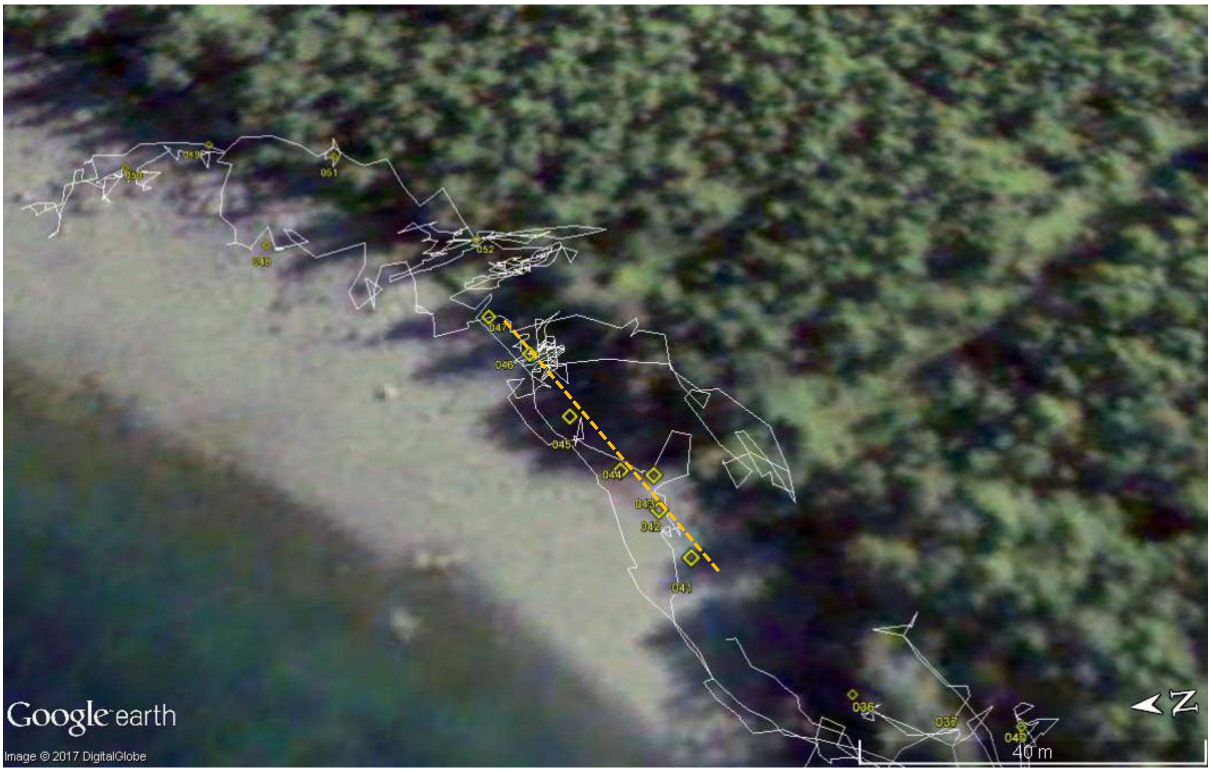


Figure 6.16 Detail of canine track at mid-site SM-006B showing the straight-line set of alerts identified by waypoints 041 through 047

6.10 Survey Tracks and Speeds

A summary of the search track lengths and times for each of the five (5) beach surveys is provided in Table 6.9. Track-line speed is derived directly from the Garmin data and relates to the “operating” speed of the canine. The alongshore coverage is based on overall distance and time. This information demonstrates the area and speed at which a canine can support a subsurface oil detection SCAT survey with effectively 100% coverage.

Table 6.9 Summary of Time and Distance Data

Segment	Time On	Time Off	Beach Length (m)	Beach Width (m)	Canine Trackline Length (m)	Average Canine Trackline Speed (km/hr)	Maximum Canine Trackline Speed (km/hr)	Approx. Alongshore Coverage Speed (km/hr)
EL-056C	13:13	13:31	60	35	2,200	3	15	0.2
EL-057	14:37	14:53	70	30	650	4	8	0.3
SM-006C	13:05	13:48	130	35	1,400	3	9	0.2
SM-006B	14:31	15:25	170	30	1,600	2.5	6	0.3
SB-001	13:24	14:25	450	30	2,700	4.5	17	0.5

Other field surveys have provided similar canine trackline speeds of 3 to 6 km/hour and alongshore coverage rates of 0.7 to 2.4 linear km/hour, depending on the beach type, intertidal zone width, and substrate character (Owens *et al.* 2017). The alongshore coverage rates are low in the four (4) pocket beaches of this study due to a number factors, including the small areas involved and the associated density of the track lines.

7 Conclusions

The study achieved the primary objective as Pepper was able to detect, on multiple occasions, subsurface oil that had been in place for over 25 years. On the Shoup Bay Spit, she detected and delineated a set of subsurface oil targets that had been placed in a rectilinear pattern. She also detected surface oil, most likely from recent boating activity, at two locations within the surveyed shorelines.

Due to the challenges associated with digging pits in the very coarse sediments that typify these beaches in Prince William Sound, only 28 of the 53 alerts were investigated; eighteen (18) of these alerts were verified by the presence of subsurface oil in the pits and there were ten (10) pits that were dug to the water table where no oil was observed.

The verification process for real-world detection confidence levels is considerably more difficult to achieve compared to controlled tests. In the 2015 API fields tests that tested canine’s abilities to detect subsurface hyrdocarbons, 704 oiled and non-oiled targets were deployed of which 684 were correctly identified by the canines, 18 were attributed or explained as experimental or design issues, so that only two (2) remained unexplained (API 2106a). The success rate in these controlled field tests was 99.7%, yielding a very high level of confidence in the ability of the canines to detect subsurface oil and not to alert on false positives or miss targets (“false negatives”). Clearly, the effort to corroborate the canine alerts under actual field conditions can be very time consuming, yet with the high canine alert success rate that verification effort can be refined.

“False positives” (alerts that are made but the presence of subsurface oil is not verified) may simply reflect a canine detection threshold that is less than visible oil or the inability to dig a pit that is sufficiently deep to encounter the oil. “False negatives” (no alert is made where subsurface oil exists) are more challenging to decipher and can result from a number of factors, including the search instructions given to the canine by the handler of SCAT Team Lead. The canine may not be directed to an area and so does not survey that location and detect the odor, or may be instructed to proceed when in fact the canine is in the process of "investigating", or may be a result of over-exposure, in which the canine has an abundance of widespread oil (no specific target or diminishing rewards).

The Shoup Bay Spit test was an ad hoc field test design and very little time was allowed (less than 3 hours) for the odors to migrate through a very small hole in the lid of the container and through the sediments and/or water to the surface. Nevertheless, Pepper detected five (5) of the six (6) subsurface targets that had been placed in a rectangular pattern in the upper intertidal zone.

The ability of a trained detection canine to outperform the standard manual subsurface digging strategy by sensing near-ground odors from subsurface oil was demonstrated by:

- The size of the areas that were searched by the canine and the short time required for each search (Section 6.10; Table 6.9).
- The length of time that was required for the support team, which typically involved up to six (6) pit diggers, to attempt to verify the alerts; pits were dug at only 24 of 44 of the alerts on the Eleanor and Smith Island beaches.
- All but one of the pits were dug only at the alerts so that the human support team did not “survey” any other sections of those beaches; typically, in subsurface oil detection pit/trench/auger surveys, the “detected oil” to “no observed oil” ratio in pits and trenches is on the order of 1:3 to 1:7 on a coarse- spacing design (that is, pits located tens to hundreds of meters apart) with at most some tens of pits per day (Owens *at al*. 2016).

Pepper was uncomfortable and distracted on the Shoup Bay Spit beach lower intertidal zone platform where she was directed to work in an area with slippery cobbles and sharp barnacles. In this area she did not detect a target pot that had been placed between boulders. Similarly, Pepper’s tasking was curtailed toward the end of work on SM-006B given the very angular, barnacle-covered boulders (Figure B.4) that predominated within the MITZ as the survey progressed eastward.

As is typical with a developing technology, many questions remain. The particular challenge for this subsurface oil detection and delineation strategy is the non-verbal communication between animal and human, and the skill that is required in the interpretation of the canine’s behavior by the handler. No sampling technique on beaches is perfect. However, this and other recent studies provide proof that a trained canine can locate subsurface oil and can achieve this detection and delineation with a better efficiency and greater accuracy (high confidence, low risk) compared to traditional manual or mechanical excavation based on spot samples (low confidence, high risk).

References

API, 2013. *Subsurface Oil Detection and Delineation in Shoreline Sediments: Phase 1 – Final Report*. American Petroleum Institute, Technical Report 1149-1, Washington DC, 46 pp. http://www.oilspillprevention.org/~/media/oil-spill-prevention/spillprevention/r-and-d/shoreline-protection/1149-1-subsurface-oil-detection-report.pdf

API, 2014. *Subsurface Oil Detection and Delineation in Shoreline Sediments: Phase 2 – Final Report*. American Petroleum Institute, Technical Report 1149-2A, Washington DC, 26 pp. http://www.oilspillprevention.org/~/media/oil-spill-prevention/spillprevention/r-and-d/shoreline-protection/1149-2a-subsurface-oil-detection-guide.pdf

API, 2016a. *Canine Oil Detection: Field Trials Report*. American Petroleum Institute, Technical Report 1149-3, Washington DC, 48 pp.

API, 2016b. *Canine Oil Detection (K9-SCAT) Guidelines*. American Petroleum Institute, Technical Report 1149-4, Washington DC, 81 pp.

Brandvik P.J. and T. Buvik, 2009.*Using dogs to detect oil hidden in snow and ice. Results from field training on Svalbard April 2008*. JIP-Report No: 14. SINTEF Report No. F12273, Trondheim, Norway, 19 pp.

Buvik, T. and P.J. Brandvik, 2009.*Using dogs to detect oil hidden in beach sediments. Results from field training on Svalbard, September 2008 and on the west coast of Norway. (Fedje/Austreheim), June 2009*. SINTEF Report No. F12274, Trondheim, Norway, 20 pp.

Furton, K.G. and L.J. Myers, 2001.The scientific foundation and efficacy of the use of canines as chemical detectors for explosives. *Talanta*, 54, 487-500.

Garner, K.L., L. Busbee, P. Cornwell, J. Edmonds, K. Mullins, K., Rader, J.M. Johnston and J.M. Williams, 2001. *Duty Cycle of the Detector Dog: A Baseline Study*. Report FAA Grant #97-G-020, Institute for Biological Detection Systems, Auburn Univ., AL, 49 pp.

K2 Solutions, 2016. *Canine Oil Detection Tasking Nova Scotia, Canada - Final Report*. Unpublished report by K2 Solutions, Inc. submitted to Environment Canada and Climate Change, Ottawa ON, 8 pp.

Michel, J., Nixon, Z., Hayes, M. O., Irvine, G. and Short, S., 2011. The Distribution of lingering subsurface oil from the Exxon Valdez Oil Spill. *Proceedings International Oil Spill Conference*, American Petroleum Institute: Washington, DC, 1–27.

Owens, E.H., Bunker, P., Dubach, H.C. and Castle, R.W., 2016. Guidelines for Canine Oil Detection Teams to Support SCAT Surveys (K9-SCAT). *Proceedings of the Thirty-ninth AMOP Technical Seminar*, Environment and Climate Change Canada, Ottawa ON.

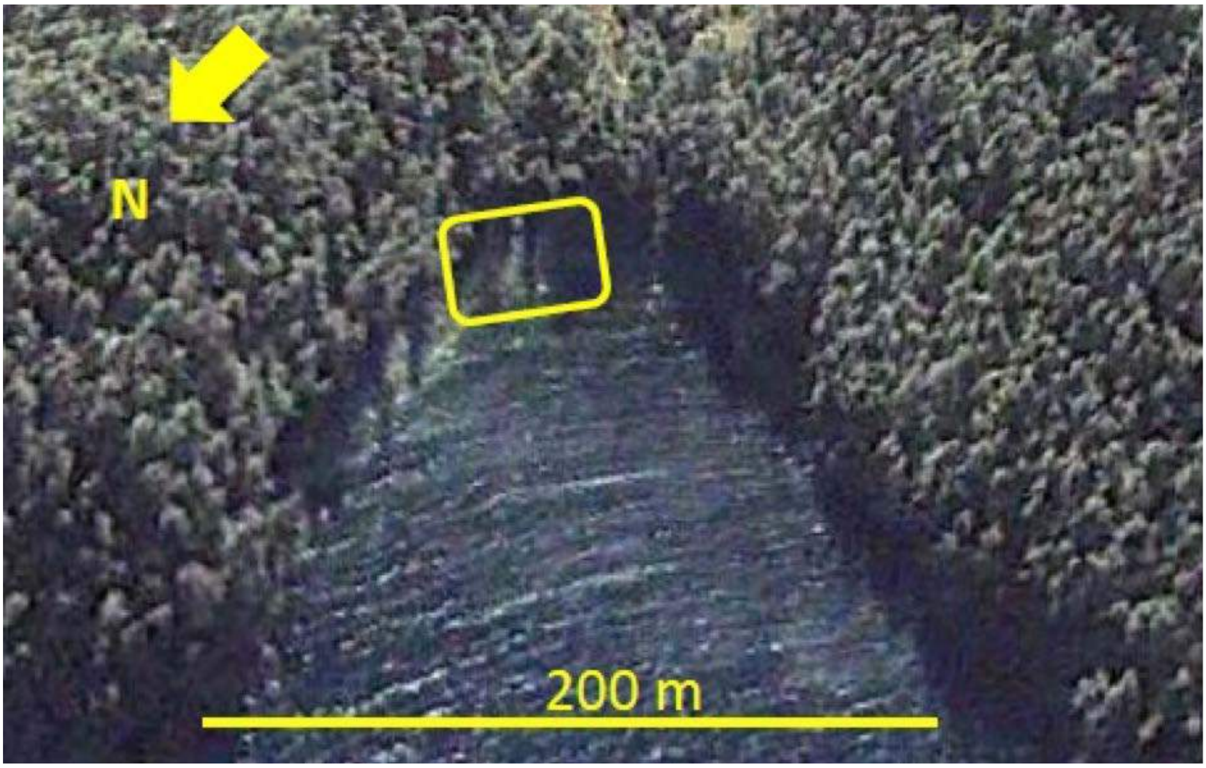
Owens, E.H, Dubach, H.C., Bunker, P, MacDonald, S., Yang, Z., Lambert, P. and LaForest, S., 2017. Canine Oil Detection (K9-SCAT) following 2015 Releases from the T/V *Arrow* Wreck. *Proc. Int. Oil Spill Conf.,* American Petroleum Institute, Washington DC.

Owens, E.H., Taylor, E. and Humphrey, B., 2008. The Persistence and Character of Stranded Oil on Coarse-sediment Beaches. *Marine Pollution Bulletin*, 56(1), 14-26.

OCC, 2016. *K9-SCAT: T/V "Arrow" Survey Report*. Unpublished report by Owens Coastal Consultants (OCC) submitted to Environment Canada and Climate Change, Ottawa ON, 55 pp.

Taylor, E. and Reimer, D., 2008. Oil persistence on beaches in Prince William Sound: A review of SCAT surveys conducted from 1989 to 2002. *Mar. Pollut. Bull., 43*, 458–474.

Attachment A - Canine Tracklines



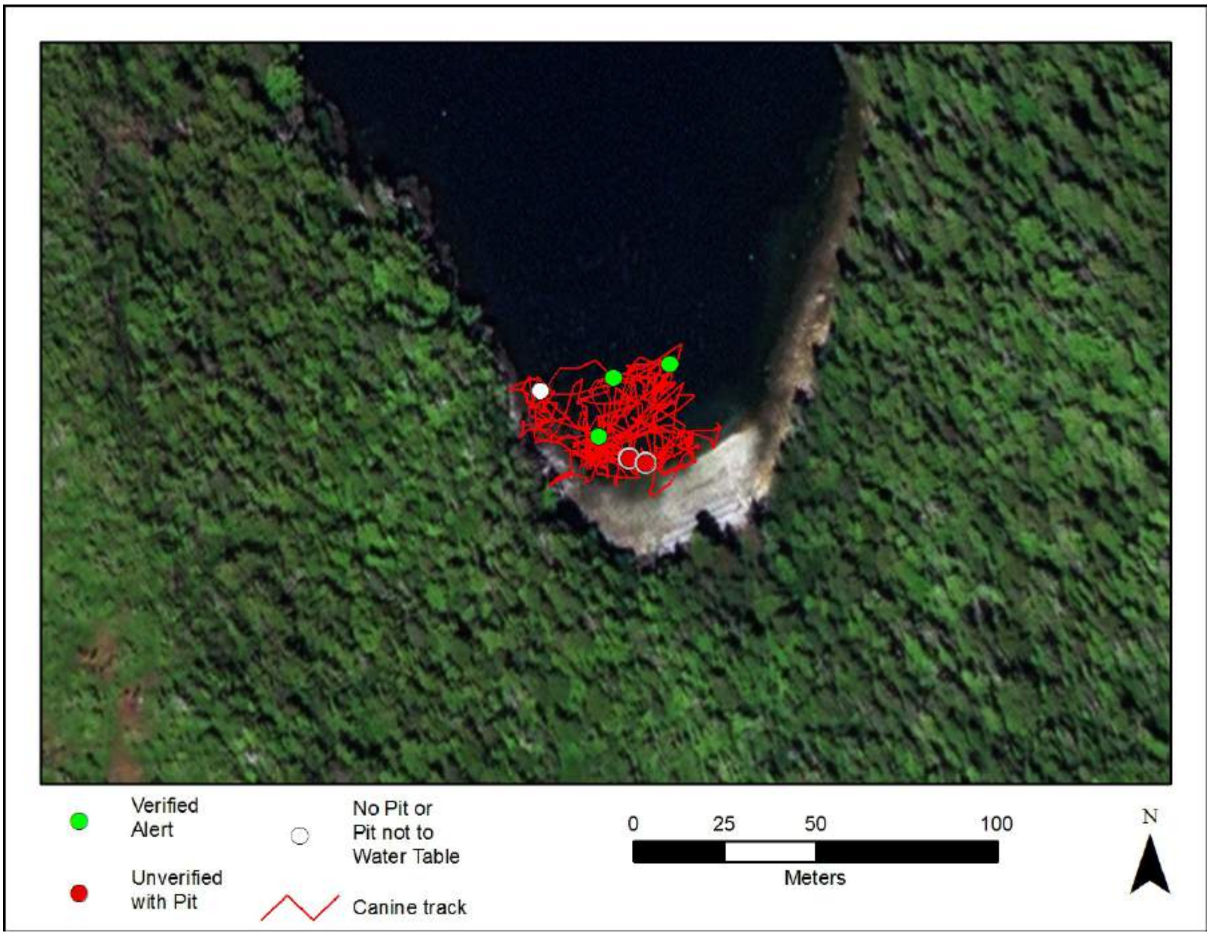
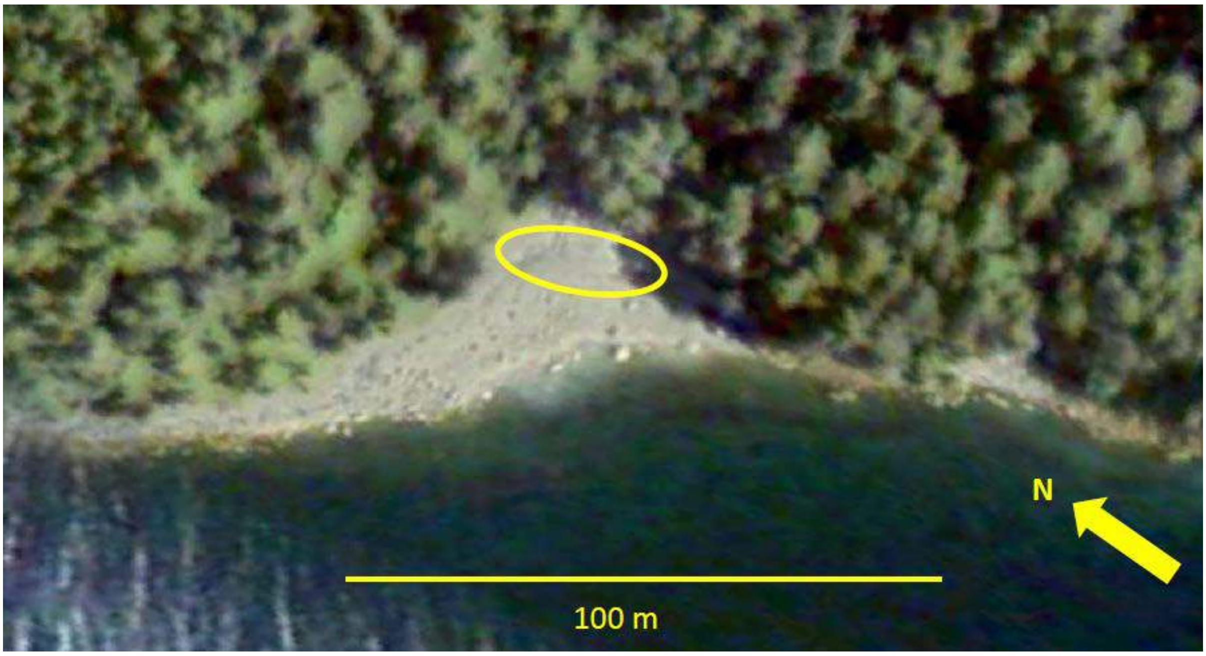


Figure A.1 Canine tracklines on EL-056C



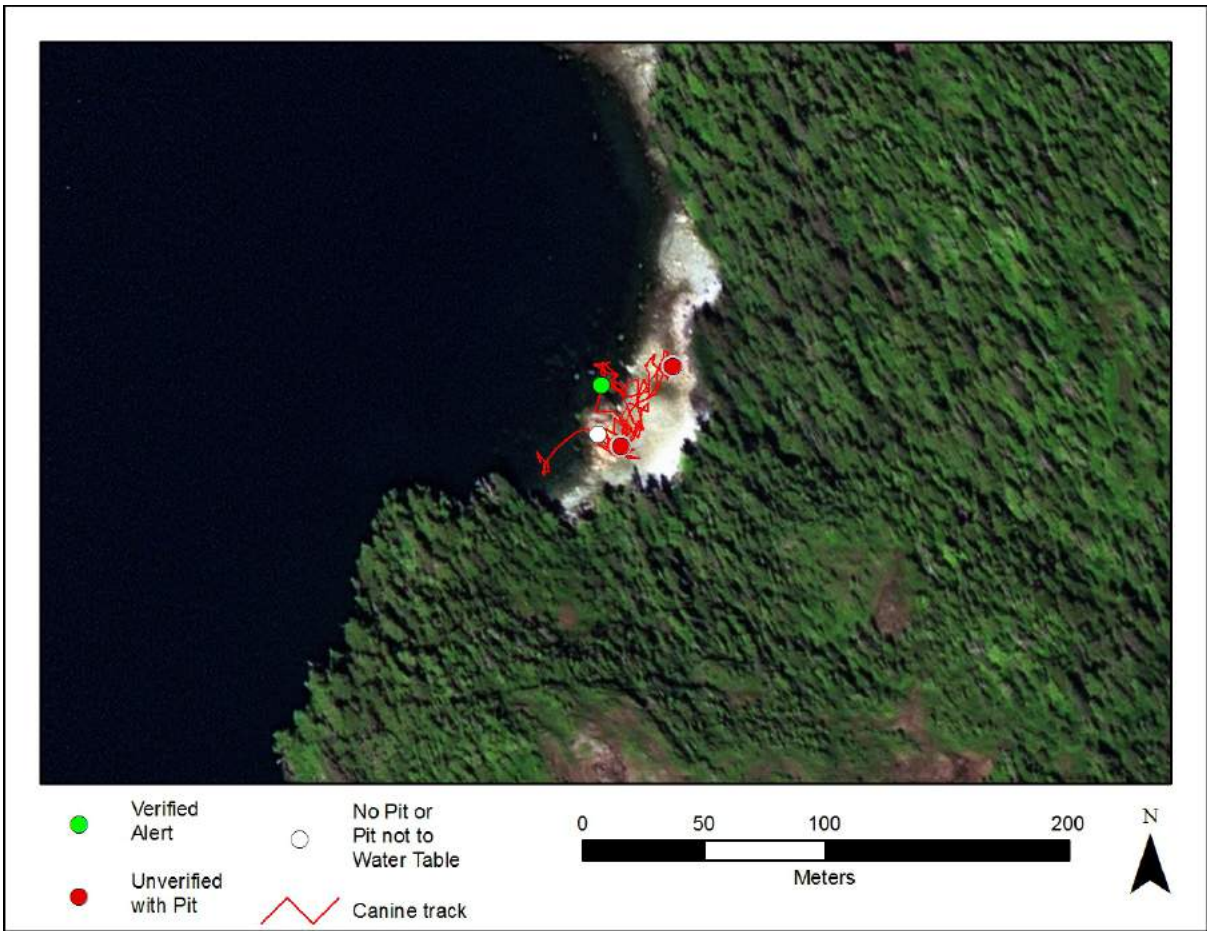
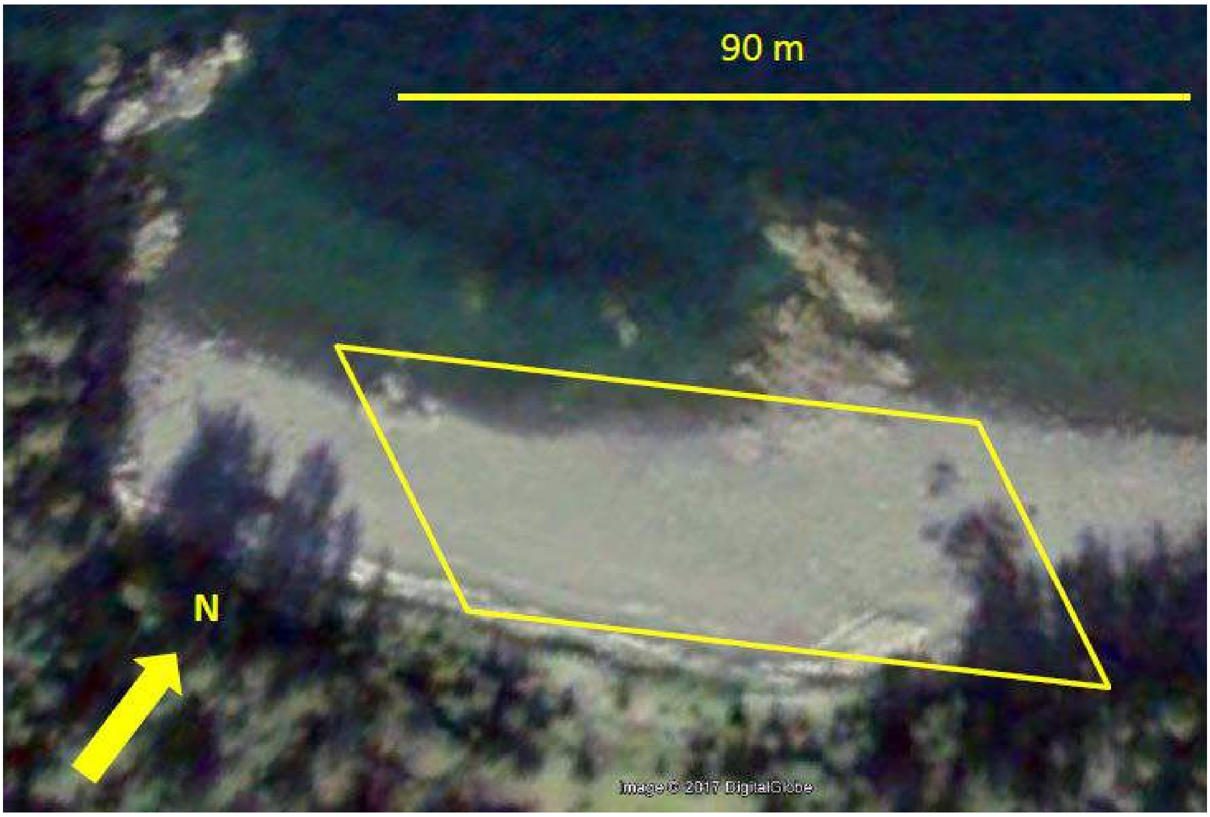


Figure A.2 Tracklines EL-057

Figure A.3 Tracklines SM-006B



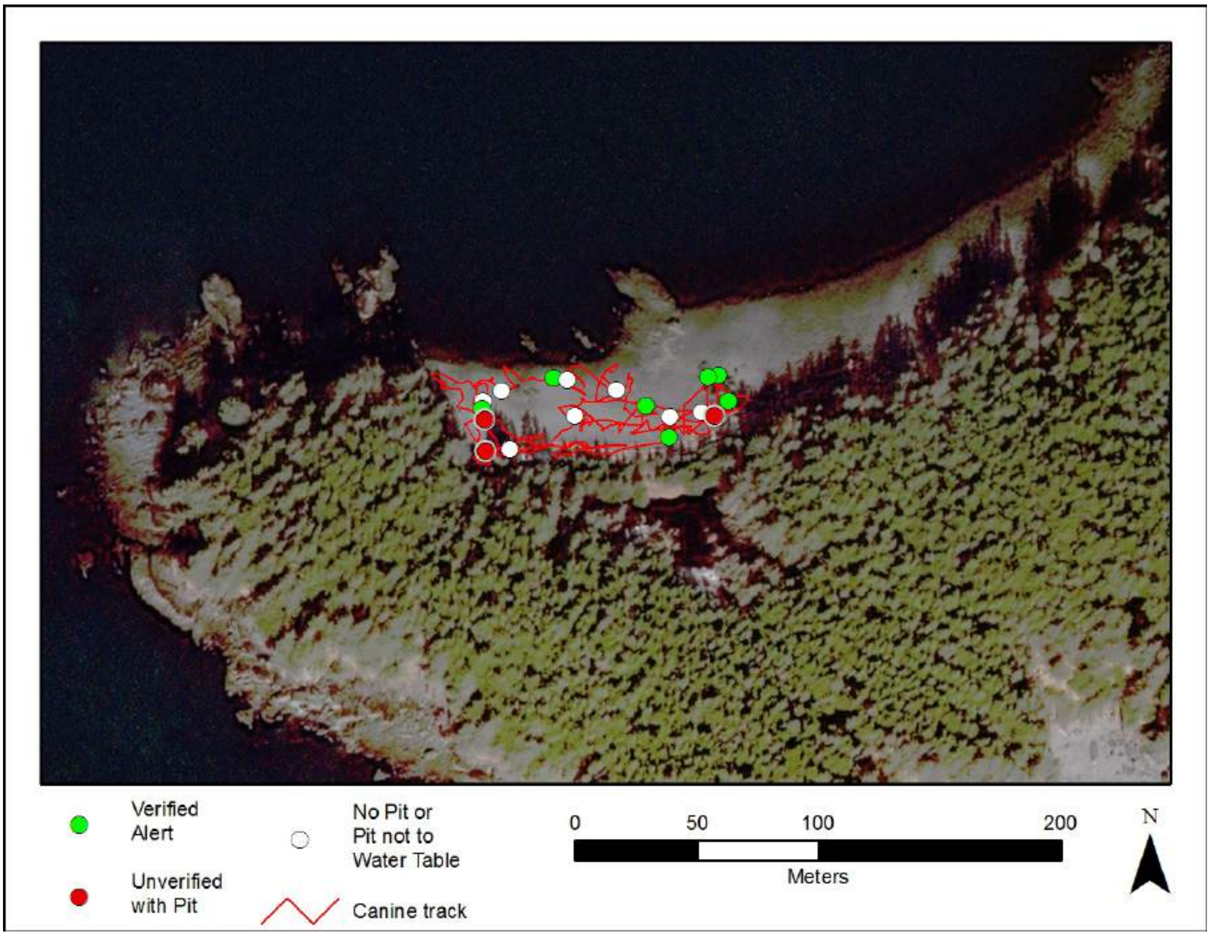


Figure A.4 Tracklines SM-006C

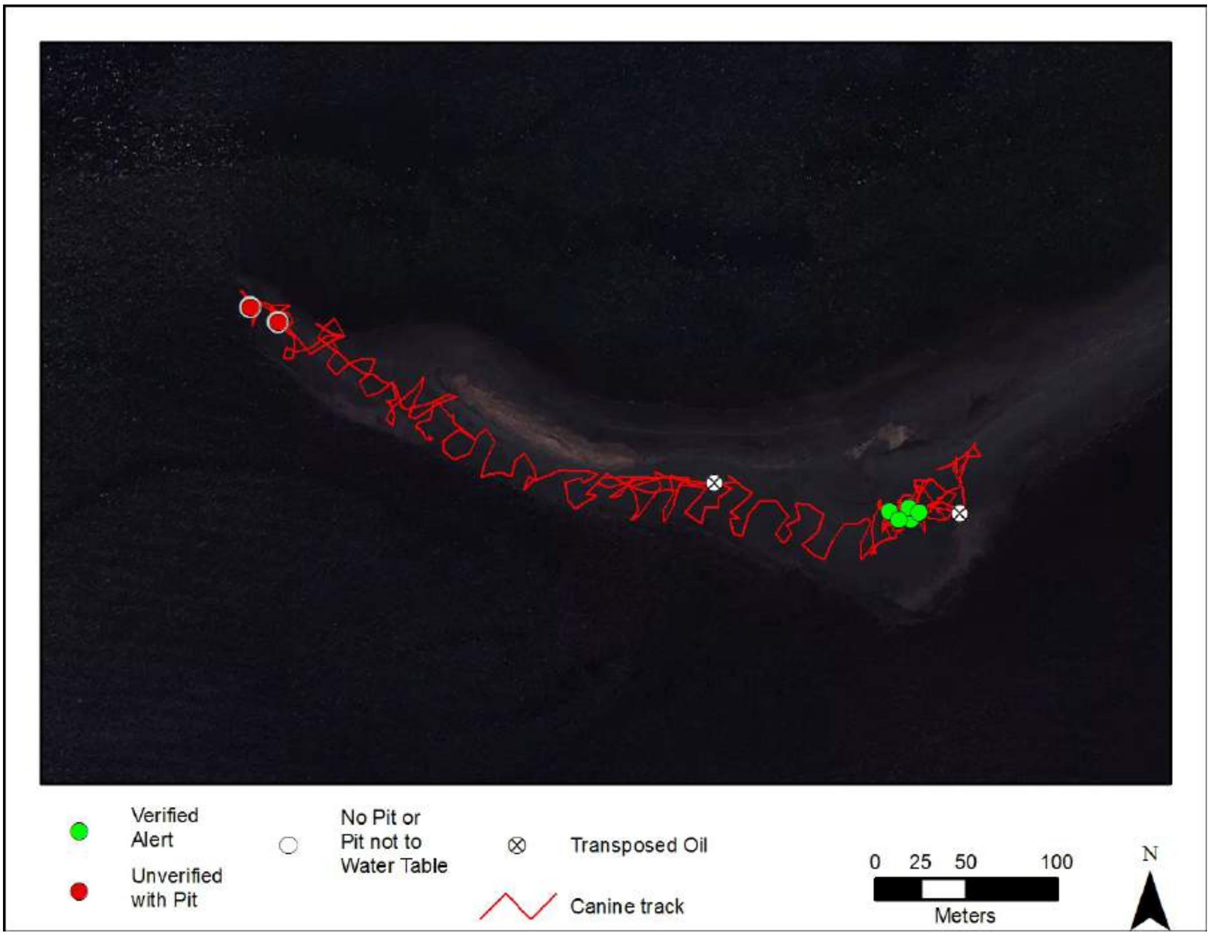


Figure A.5 Tracklines SB-001

Figure A.6 Close up of tracklines and alert way points at target area

Attachment B – Photography & Videography

B.1 Photography & Videography Equipment

The surveys were documented with both photographs and videos from multiple cameras on all dates of the project. Cameras were selected based upon location, activity and the specific environment.

Cameras used during this project included:

- Canon EOS 6D Mark II DSLR (239 images; 58 video clips)
- Canon EOS 7D Digital SLR (617 images; 81 video clips)
- GoPro Hero III Silver Sport Camera (7 video clips)
- Canon Vixia HFG20 HD Video Camera (47 video clips)

Total still images recorded: 856 images

Total video clips recorded: 193 video clips

Approximately 400 additional still photographs were taken by Owens, Dubach and Taylor, primarily of the alert locations and completed pits.

B.2 Media Products

Media products exclusively created for this project for the PWSSC Oil Spill Recovery Institute include:

Video

- "Buried Oil Detection by Canines in Northern Prince William Sound (K9-SCAT)"
- "Oil Detection by Canines (K9-SCAT)"
- Video library of all footage collected during the project available upon request

Photography

- Selection of still Photos from the Buried Oil Detection by Canines
- Video library of all photographs collected during the project available upon request

Mixed Media

- Digital flyer summarizing the project including select photographs and a brief text overview

B.1 Camera Positioning & Framing

Cameras were positioned at varying angles and places for each location, based upon the planned activity and the specific environment of the location. For example, during the Shoup Bay testing, four (4) cameras were set up to provide accurate coverage of the canine and handler's movements and the canine's alerts to pre-positioned hydrocarbon samples.

Camera position was based on several factors, including:

- Activity
- Area of location
- Ground Surface
- Accessibility
- Lighting
- Perspective of focus

Camera framing was selected to capture specific attributes of each scene including the K9-SCAT process, canine behavior during survey, and an overview of the overall operation. Capturing the breadth of the canine's search pattern and the canine's behavior when alerting was weighted with importance. All pits were photographically documented and georeferenced.

Figure B.1 Wide Frame: To provide a greater situational and complete operational overview, by encompassing the full breadth of the test area, including the search pattern covered by the canine (Segment SB-001)

Figure B.2 Full Frame: Larger view of the survey area and pit digging operations, provides an overview of the study sites (Segment SM-006B)

Figure B.3 Medium Frame: Tighter focus on the canine team and the SCAT survey process, including handling of the canine the search pattern and the canine change of behavior/alerts (Segment SM-006B)

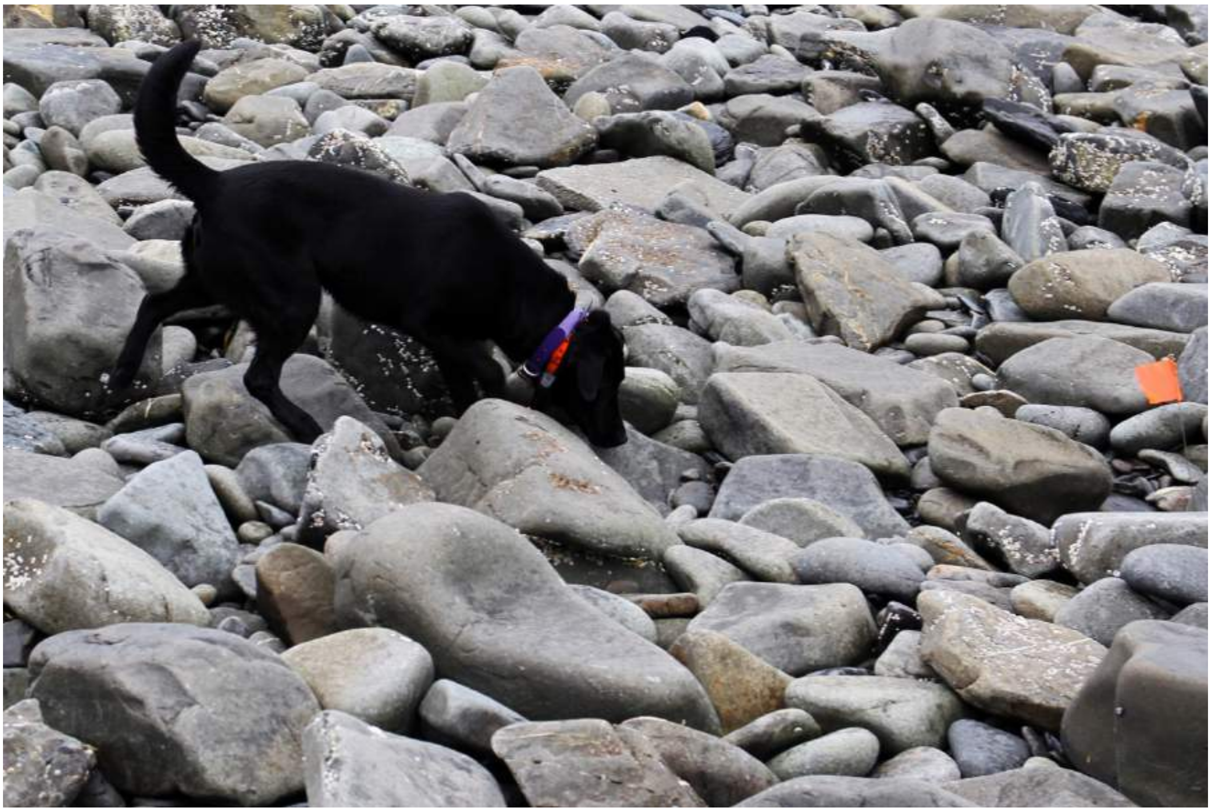


Figure B.4 Close-up (CU): Primarily used to capture the alert behavior of the canine and the alert area (segment SM-006B)

Figure B.5 Extreme Close-up to capture the pits, especially where oil was observed (segment SM-006B)

B.2 Still Photography Pit Examples

Figure B.6 EL-056C pit at WP 5 with traces of silver sheen

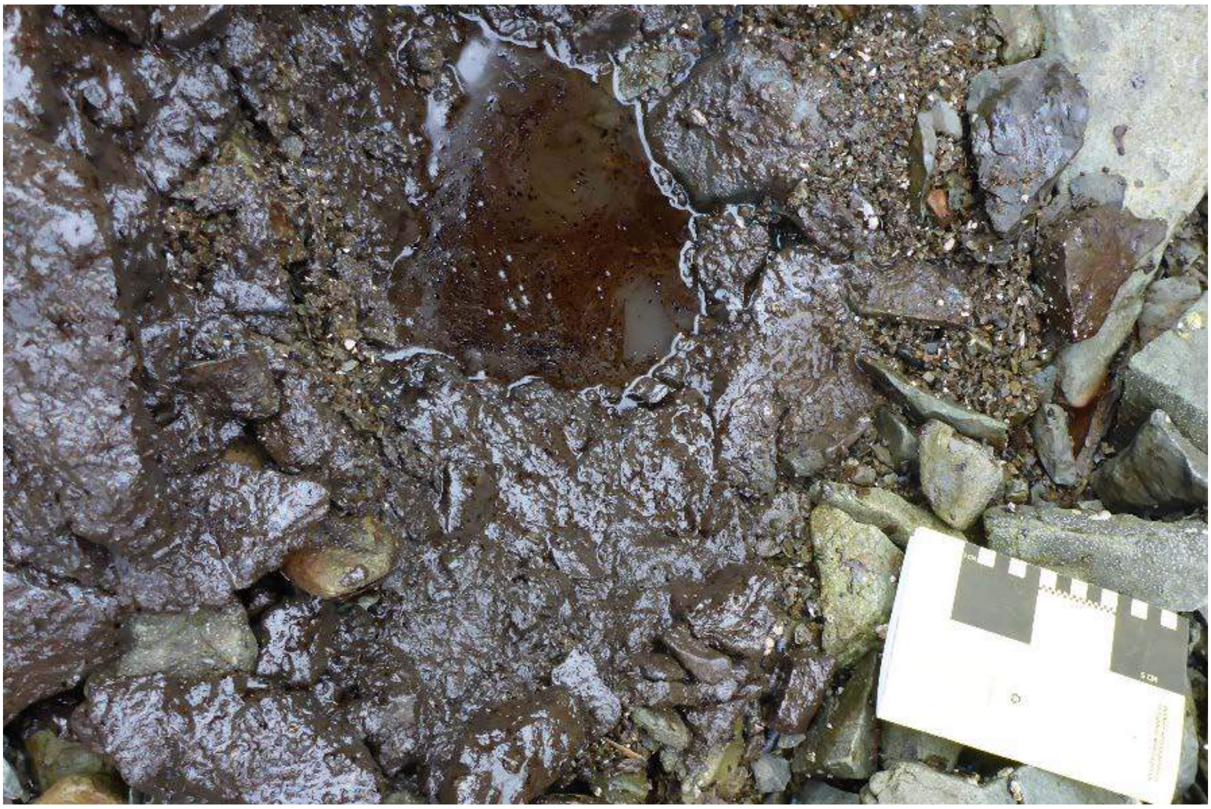


Figure B.7 EL-056C pit at WP 8 with brown oil

Figure B.8 EL-057 pit at WP 11 with silver sheen traces

Figure B.9   EL-057 pit at WP 13 with NOO

Figure B.10 SM-006C pit at WP 17 with 2mm silver sheen speck

Figure B.11   SM-006C pit at WP 28 with metallic and silver sheen, plus 4-5 brown flecks

Figure B.12   SM-006B pit at WP 41 with NOO

Figure B.13 SM-006B pit at WP 50 with 15% rainbow/silver sheen

Figure B.14 SB-001 placing target into pit at MHW

L

Figure B.15   SB-001 placing target # 5 (WP 62) into wet upper intertidal zone pit

Attachment C – SCAT Field Forms

K9-SCAT SURVEY FORM - PWS

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
Search Method:	Wide Area Search / Delineation	**Tide:**	High / Medium / Low ________m Rising / Falling / Low Slack / High Slack		

2. K9-SCAT TEAM

K9-SCAT TL:		**Handler:**	
Canine:		**Tracking Collar/GPS ID:**	

3. SEGMENT DATA

Total Length:	_______ meters	**Trackline Length:**	_______ meters	**Datum:**	
Survey Start GPS:	**WP:**	**LAT:**		**LONG:**	
Survey End GPS:	**WP:**	**LAT:**		**LONG:**	

4. 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			

5. COMMENTS

OIL DETECTED?	Yes / No				
Photographs?	Yes / No	**Video?**	Yes / No	**Completed By:**	

REVISION DATE: 12 April 2017

Figure C.1 K9-SCAT Survey Form

C.1 Completed K9-SCAT Survey Forms

K9-SCAT SURVEY FORM - PWS

1.GENERAL INFORMATION					
Date: (dd/mm/yyyy)	01/05/17	Weather:	Sun / (Clouds) / Fog / Rain / Snow (circle)	Air Temp:	40 °F
Time Start: (24hr EST)	13:13	Humidity:	80 %	Wind Direction:	NE / 45°
Time End: 24hr (EST)	13:31	Pressure:	30 "Hg ~~mb~~ rising / falling (circle)	Wind Speed:	5 mph
Location:	Eleanor Island	Segment ID:	EL-056C	Survey by:	(Foot) / Boat
Search Method:	(Wide Area Search) / Delineation	Tide:	High / Medium / (Low) ____ m; Rising / Falling / (Low Slack) / High Slack		

2. K9-SCAT TEAM			
K9-SCAT TL:	Helen Dubach	Handler:	Haider Montgomery
Canine:	Pepper	Tracking Collar/GPS ID:	K9-1

3. SEGMENT DATA					
Total Length:	60 meters	Trackline Length:	2200 meters	Datum:	WGS84
Survey Start GPS:	WP: 1	LAT:	—	LONG:	—
Survey End GPS:	WP: 6	LAT:	—	LONG:	—

4. POSITIVE ALERTS

Alert #	Wpt #	Verified? Y/N	Comment	Alert #	Wpt #	Verified?	Comment
1	2	Y	MTZ - several alerts	11			
2	3	N	UTZ - behind log	12			
3	4	—	UTZ	13			
4	5	Y	LTZ	14			
5	7	Y	LTZ	15			
6	8	Y	LTZ	16			
7				17			
8				18			
9				19			
10				20			

5. COMMENTS

(2) 3x pits 30-40cm (to shell hash), silver sheen observed in one

(3) & (4) - alerts in a line (~3m apart) N00, pit not dug same location, to w/1, lots of organics.

(5) Light s. sheen in pit, no odor (30cm)

(7) Brown oil in pit, to 30cm. Sampled

(8.) Pits dug & used to imprint canine - brown / rainbow sheen.

OIL DETECTED?	(Yes) / No				
Photographs?	(Yes) / No	Video?	(Yes) / No	Completed By:	H. Dubach

REVISION DATE: 12 April 2017

K9-SCAT SURVEY FORM - PWS

1.GENERAL INFORMATION					
Date: (dd/mm/yyyy)	01/05/17	**Weather:**	Sun / (Clouds) / Fog / Rain / Snow (circle)	**Air Temp:**	40 °F
Time Start: (24hr EST)	14:37	**Humidity:**	80 %	**Wind Direction:**	270°
Time End: 24hr (EST)	14:53	**Pressure:**	30 ~~mb~~ Hg rising / falling (circle)	**Wind Speed:**	5 mph
Location:	Eleanor Isle	**Segment ID:**	EL - 057	**Survey by:**	(Foot) / Boat
Search Method:	(Wide Area Search) / Delineation	**Tide:**	High / Medium / (Low) ______ m; (Rising) / Falling / Low Slack / High Slack		

2. K9-SCAT TEAM			
K9-SCAT TL:	Helen Dubach	**Handler:**	Haiden Montgomery
Canine:	Pepper	**Tracking Collar/GPS ID:**	K9-1

3. SEGMENT DATA					
Total Length:	70 meters	**Trackline Length:**	650 meters	**Datum:**	WGS84
Survey Start GPS:	WP: 9	**LAT:**	—	**LONG:**	—
Survey End GPS:	WP: 14	**LAT:**	—	**LONG:**	—

4. POSITIVE ALERTS

Alert #	Wpt #	Verified? Y/N	Comment	Alert #	Wpt #	Verified?	Comment
1	10	N	UTZ	11			
2	11	Y	LTZ behind bedrock	12			
3	12	-	UTZ in log line	13			
4	13	N	MTZ	14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

5. COMMENTS

(10) Noo in pit (not dug to w/l)

(11) Light sheen in pit @ 30cm.

(12) out of time to dig.

(13) Noo in pit @ 25cm.

OIL DETECTED?	(Yes) / No				
Photographs?	(Yes) / No	**Video?**	(Yes) / No	**Completed By:**	H. Dubach

REVISION DATE: 12 April 2017

K9-SCAT SURVEY FORM - PWS

1. GENERAL INFORMATION

Date: (dd/mm/yyyy)	02/05/17	Weather:	Sun / **(Clouds)** / Fog / Rain / Snow (circle)	Air Temp:	42 °F
Time Start: (24hr EST)	13:05	Humidity:	83 %	Wind Direction:	S °
Time End: 24hr (EST)	13:48	Pressure:	30 mb Hg rising / falling (circle)	Wind Speed:	4 mph
Location:	Smith Island	Segment ID:	SM-006C	Survey by:	**(Foot)** / Boat
Search Method:	**(Wide Area Search)** / Delineation	Tide:	High / Medium / **(Low)** ____ m Rising / Falling / **(Low Slack)** / High Slack		

2. K9-SCAT TEAM

K9-SCAT TL:	Helen Dubach	Handler:	Haiden Montgomery
Canine:	Pepper	Tracking Collar/GPS ID:	K9-1

3. SEGMENT DATA

Total Length:	130 meters	Trackline Length:	1400 meters	Datum:	WGS84
Survey Start GPS:	WP: 15	LAT: —	—	LONG:	—
Survey End GPS:	WP: 36	LAT: —	—	LONG:	—

4. POSITIVE ALERTS

Alert #	Wpt #	Verified? Y/N	Comment	Alert #	Wpt #	Verified?	Comment
1	16	Y	MTZ } close	11	26	Y	MTZ - sheen in pool
2	17	Y	MTZ }	12	27	—	UTZ under wp# 21
3	18	N	UTZ	13	28	Y	MTZ
4	19	N	UTZ high	14	29	—	MTZ
5	20	—	UTZ high	15	31	—	LTZ
6	21	Y	STZ @ logs	16	32	Y	LTZ
7	22	—	UTZ in front of boulder	17	33	—	LTZ
8	23	N	UTZ	18	34	—	LTZ
9	24	Y	UTZ	19			
10	25	Y	MTZ	20			

5. COMMENTS

(16)(17) light silver sheen in pit.

(18) NOO

(19)(23) NOO, organic sheen.

(20)(22)(27)(29)(31)(33)(34) - No pits?

(21) light silver sheen in pit.

(24)(25) Brown sheen in pit

(26) sheen observed on surface pooling (no pit)

(28) Rainbow sheen in pit

(32) Brown oil in pit

OIL DETECTED?	**(Yes)** / No				
Photographs?	**(Yes)** / No	Video?	**(Yes)** / No	Completed By:	H. Dubach

REVISION DATE: 12 April 2017

K9-SCAT SURVEY FORM - PWS

1.GENERAL INFORMATION					
Date: (dd/mm/yyyy)	02/05/17	Weather:	Sun / (Clouds) / Fog / Rain / Snow (circle)	Air Temp:	42 °F
Time Start: (24hr EST)	14:31	Humidity:	81 %	Wind Direction:	45°
Time End: 24hr (EST)	15:25	Pressure:	30 Hg rising / falling (circle)	Wind Speed:	4 mph
Location:	Smith Island	Segment ID:	SM-006B	Survey by:	(Foot) / Boat
Search Method:	(Wide Area Search) / Delineation	Tide:	High / Medium / (Low) ____ m; (Rising) / Falling / Low Slack / High Slack		

2. K9-SCAT TEAM			
K9-SCAT TL:	Helen Dubach	Handler:	Haiden Montgomery
Canine:	Pepper	Tracking Collar/GPS ID:	K9-1

3. SEGMENT DATA					
Total Length:	170 meters	Trackline Length:	1600 meters	Datum:	WGS 84
Survey Start GPS:	WP: 35	LAT:	—	LONG:	—
Survey End GPS:	WP: 52	LAT:	—	LONG:	—

4. POSITIVE ALERTS

Alert #	Wpt #	Verified? Y/N	Comment	Alert #	Wpt #	Verified?	Comment
1	36	N	MTZ - behind bedrock	11	46	—	UTZ
2	37	N	MTZ - mid beach	12	47	—	MTZ
3	38	—	MTZ	13	48	N	MTZ
4	39	—	UTZ	14	49	—	UTZ
5	40	Y	oil filter!	15	50	Y	MTZ - buzzing / 3 alerts
6	41	N	MTZ	16	51	—	UTZ
7	42	—	MTZ	17	52	N	STZ
8	43	—	MTZ	18			
9	44	N	MTZ	19			
10	45	—	MTZ	20			

5. COMMENTS

(36) (37) (41) (44) (48) (52) NOO

(40) oil filter stranded in UTZ.

(50) rainbow sheen in pit.

Remainder of alerts not investigated due to incoming tide & loss of boat landing area.

OIL DETECTED?	(Yes) / No				
Photographs?	(Yes) / No	Video?	(Yes) / No	Completed By:	H. Dubach

REVISION DATE: 12 April 2017

K9-SCAT SURVEY FORM - PWS

1.GENERAL INFORMATION

Date: (dd/mm/yyyy)	03/05/17	**Weather:**	Sun / (Clouds) / Fog / Rain / Snow (circle)	**Air Temp:**	51 F
Time Start: (24hr EST)	13 24	**Humidity:**	64 %	**Wind Direction:**	70°
Time End: 24hr (EST)	14:25	**Pressure:**	29 mb rising / falling (circle)	**Wind Speed:**	5 mph
Location:	Sheep Bay	**Segment ID:**	SB-001	**Survey by:**	(Foot) / Boat
Search Method:	Wide Area Search → (Delineation)	**Tide:**	High / Medium / (Low) ______ m; (Rising) / Falling / Low Slack / High Slack		

2. K9-SCAT TEAM

K9-SCAT TL:	Helen Dubach	**Handler:**	Haidee Montgomery
Canine:	Pepper	**Tracking Collar/GPS ID:**	K9-1

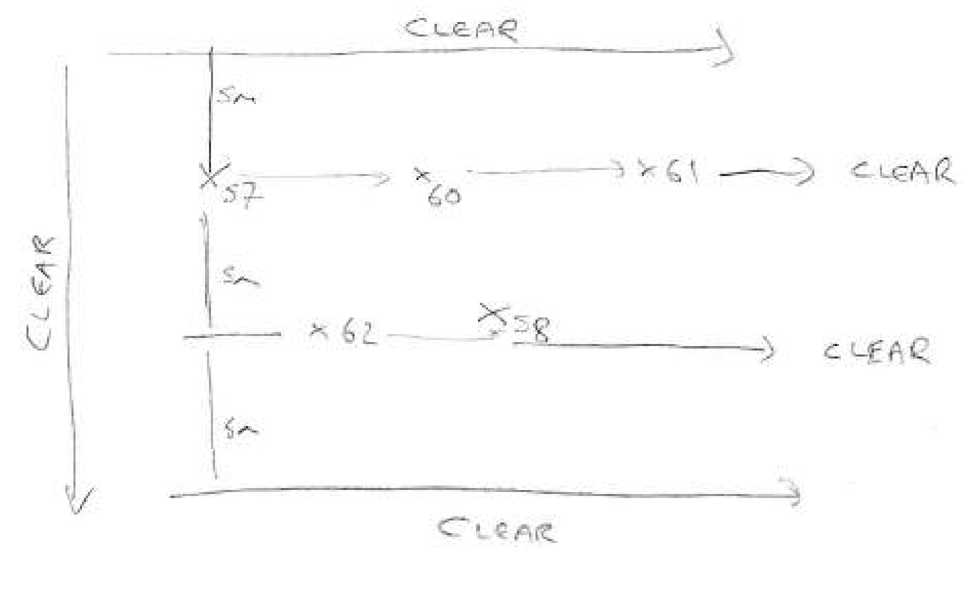
3. SEGMENT DATA

Total Length:	450 meters	**Trackline Length:**	2700 meters	**Datum:**	WGS84
Survey Start GPS:	WP: 53	**LAT:**	—	**LONG:**	—
Survey End GPS:	WP: 62	**LAT:**	—	**LONG:**	—

4. POSITIVE ALERTS

Alert #	Wpt #	Verified? Y/N	Comment	Alert #	Wpt #	Verified?	Comment
1	54	N	MTZ - end of spit	11			
2	55	N	MTZ - end of spit	12			
3	56	Y	MTZ - contaminated bag	13			
4	57	Y	MTZ	14			
5	58	Y	MTZ	15			
6	59	Y	LTZ - contaminated tripod	16			
7	60	Y	MTZ	17			
8	61	Y	MTZ	18			
9	62	Y	MTZ	19			
10				20			

5. COMMENTS



OIL DETECTED?	(Yes) / No				
Photographs?	(Yes) / No	**Video?**	(Yes) / No	**Completed By:**	H. Dubach

REVISION DATE: 12 April 2017

Attachment D - JSA and Field Checklists

JSA PWS K9-SCAT Surveys

JOB SAFETY ANALYSIS	TEAM:	SUPERVISOR:	LOCATION:	DATE:
SPECIFIC JOB TASK/WORK ACTIVITY:				
REQUIRED PERSONAL PROTECTIVE EQUIPMENT:				

	Sunglasses		Closed-toes sturdy shoes		Hat		Sunscreen		Insect Repellent
	Ear Protection		Personal Flotation Device		Rain gear				
	CANINE PPE:		Canine Boots		Canine goggles		Canine coat		Canine Hi-Vis

SEQUENCE OF BASIC JOB STEPS	POTENTIAL HAZARDS	CONTROL MEASURES *Hierarchy: elimination, substitution, re-engineering, warning signs & systems, training/ procedures, & PPE*
1. Transfers: Dock to boat. Boat to dock.	Falling overboard; Slips, Trips and Falls; Pinch Points; Wind exposure; poor dock/pier condition. Abrupt boat handling; bumping dock too hard on approach; dangerous wave height and/or direction; insecure ladders/brows.	Approved PFD must be worn at all times, Follow direction of vessel Captain and crew at all times, Maintain three point hold on boat at all times (i.e., two hands, one foot), Keep hands and feet clear of pinch points, motors, and other moving equipment.
2. Transfers: Boat to shore. Shore to boat.	Falling overboard; Slips, Trips and Falls; Pinch Points; excessive bow to ground height; insecure ladders/brows.	Approved PFD must be worn at all times, Follow direction of vessel Captain and crew at all times, Maintain three point hold on boat at all times (i.e., two hands, one foot), Keep hands and feet clear of pinch points, motors, and other moving equipment, hand personal equipment to crew; if needed ensure approved ladders/brows are properly secured.
3. Transits	Falling overboard, Slips, Trips and Falls, Pinch Points, Mechanical – Motor, Weather - Sudden Storms, Fog. Grounding; striking submerged objects.. Heavy river traffic.	Approved PFD must be worn at all times, Follow direction of vessel Captain and crew at all times, When working outside cabin, Wear proper foul-weather PPE if working outside of cabin, personnel remain seated on permanently affixed seat inside cabin while vessel is in-transit, Maintain three point hold on boat at all times (i.e., two hands, one foot), ensure all equipment is securely stowed, Keep hands and feet inside boat until docked and secured, Keep hands and feet away from motors or other moving equipment, Maintain radio communications, Keep alert for changes in weather, Seek shelter if adverse weather threatens.
4. Transportation on foot / Beach Surveys	Slips, Trips and Falls; Soft/uneven ground; High Temperature, strong sun, high winds; Sudden Storms, Fog; Fatigue; Muscle strains; Injury; Potential dehydration; Wildlife; Insects; Marine life; Trash (broken glass, etc.), Sharps (hypodermic needles)	Stay away from the water's edge (unless wearing approved PFD), Maintain line of sight; Keep alert for changes in weather, Wear appropriate clothing for conditions; Seek shelter if adverse weather threatens; Scan area for trip hazards and soft/uneven ground, and eliminate or avoid area; Use proper body positioning; Wear proper footwear for task (closed-toe sturdy shoes); Watch footing; Be aware of surroundings; Take breaks as needed or as conditions warrant; Work at least in pairs (two person teams); Rehydrate, at least one bottled water an hour; Avoid all wildlife and marine life; Use Insect repellents as necessary; stay away from / do not handle trash, sharps
5. Subsurface investigation of segment (using shovels/pry-bars)	Back injuries. Foot injuries. Abrasions, blisters to hands.	Always use proper digging technique - Use your legs. Wear proper footwear (boots with ankle support, puncture proof, etc). Wear proper PPE for the task (e.g., gloves).
6. Canine: Oil contamination of body	Oil contamination being absorbed via pads or ingestion cleaning fur.	Utilize canine booties in areas containing surface oil contaminates. Wash canine on completion of task with approved shampoo. Complete full body inspection of canine on completion of task.
7. Canine: Drinking water from inlets, pools or sea	Canine may drink available water source which could contain contaminates as well as salt	Train dog to only accept water from handler. Carry fresh water supply available for use by canine. Control canine and correct any behavior of drinking from natural water sources.

1

JSA PWS K9-SCAT Surveys

Safety Brief Checklist	
	Project objectives
	Current and forecasted weather
	Weather safety
	Clothing/PPE Requirements
	Food and water
	Sanitary facilities
	Communications
	Review vessel plan with captain/crew
	Request Safety concerns from Participants – and mitigate
	Get everyone to sign the certification sheet

JSA PWS K9-SCAT Surveys

JSA/TAILGATE SAFETY BRIEFING CERTIFICATION SHEET

PRINT NAME:	CERTIFYING SIGNATURE:	CELL NUMBER:	DATE:

3

Attachment E – K2 Solutions, Inc. Final Report

Oil Detection Canine Tasking
Prince William Sound, Alaska
Final Report

Issued to:

Owens Coastal Consultants

Prepared and Submitted by:
Paul Bunker

Project Manager, Oil Detection Canines
K2 Solutions, Inc.

11 July 2017

Table of Contents

1 EXECUTIVE SUMMARY

Owens Coastal Consultants requested K2 Solutions, Inc. (K2)'s support for a trial to detect sub-surface oil located in the area of northern Prince William Sound, Alaska. From May1-3, 2017, K2 deployed a trained Oil Detection Canine Team to Valdez to demonstrate the capability and feasibility to detect subsurface oil. Searches were conducted on islands within the northern Sound, and the results, observations, and lessons learned are detailed in this report.

2 OBJECTIVE

To conduct a beach survey of selected island areas within the Prince William Sound, Alaska:

a. Survey selected island beaches within Prince William Sound for the presence of any residual shoreline oil.
b. Evaluate the capabilities of an Oil Detection Canine Team using the Shoreline Cleanup Assessment Technique (K9 SCAT) in a real-world oiled shoreline situation.
c. Investigate the delineation capabilities for subsurface oil deposits on known sequestered subsurface oil in Prince William Sound.

Canines have proven their ability to locate single point surface and subsurface oil concentrations during controlled field trials (API, 2016) and to detect low concentrations of surface oil during a beach survey in Nova Scotia (K2 Solutions, 2016). This phase of learning was designed to better understand the capabilities of oil detection canines to support a Shoreline Cleanup Assessment Technique (SCAT) program.

3 METHODOLOGY

In 2015 K2 trained two Oil Detection Canines for a research trial in support of Owens Coastal Consultants and the American Petroleum Institute (API). The project included training canines in systems of search as well as imprinting on target oils. The API research trial demonstrated a concept capability that canines can be trained and utilized to consistently and efficiently detect sub- surface oil. A follow-on field deployment to Nova Scotia in 2016 gave K2 the opportunity to demonstrate and assess the canine detection capability in a real world scenario. Results from Nova Scotia demonstrated the canine's capability to detect aged subsurface target oil (K2 Solutions, 2016).

4 DEPLOYMENT

K2 has protocols for both national and international travel, which were utilized for the Oil Detection Canine Team deployment:

Handler:	Jessica Haiden Montgomery
Canine:	M539 Pepper

Though Alaska has limited requirements for accepting canines into the state, as part of K2's process, a veterinarian examined and cleared the canine prior to travel. Travel was via commercial airline from Raleigh-Durham International Airport, North Carolina, to Valdez, Alaska on April 29-30, 2017. Road transportation via a rental vehicle was then utilized by the team to Valdez. The canine team deployed to survey sites via boat.

5 SEARCH TASKINGS

Monday 1st May, 2017

Eleanor Island EL-056C, EL-058B
Weather: 44 degrees F, 80% humidity,
5mph
Terrain: Small pebble/cobble beach, flat sand with cobble at water's edge

EL-056C 6 alerts, 4 verified Start Time: 1313 End Time: 1331

Several alerts in $3m^2$ area. 3 x pits dug, sheen observed in one; brown oil, silver sheen found in dug pits.

Pepper giving an indication at location of target odor

Pepper was worked at the furthest point on the beach starting on boulders and searching into the wind. Pepper was at first confused as what to do once off the boat, looking at her handler for directional and guidance. She eventually began to gain confidence and slowly alerted onto the cobble sediments. After that first find with a reward, she began to pick up and find further target odor locations; some along the upper intertidal zone wood line, and others further down near the water's edge. After reporting the indication locations and marking with pin flags, pits were dug and confirmation of oil was established. Pepper was taken to an open pit and given an opportunity to fully imprint onto the new odor.

After this initial island, we moved to a location in which oil was not known to exist as the site had not been surveyed in recent years. Pepper alerted and oil was confirmed to be found near the water's edge underneath the cobbles.

EL-058B 4 alerts, 1 verified Start Time: 1437 End Time: 1453

Light silver sheen found sheltered by bedrock outcrop; ran out of time to dig other pits to verify due to incoming high tide.

Indication location is marked by the handler with a pin flag

Tuesday 2nd May, 2017

Smith Island SM-005, SM-006C
Weather: 51 degrees F, 83% humidity, 4mph, light rain,
cloudy Terrain: Boulders with mixed pebbles

Pepper was worked off-leash into the wind with more confidence with just two others accompanying this time. She began covering a pebble surface in which a pit was dug to confirm her find. She eventually worked to the edge of the trees and covered on an abandoned oil filter and then moved on to the wider beach area. From this area, Pepper covered an additional 16 times in various places such as the upper tidal zone, middle tidal zone, and at the water's edge.

SM-005 18 alerts, 5 verified from pits. Start Time: 1305 End Time: 1348

Light silver sheen found at logs and in front of boulder, brown oil found 28 cm pit depth, with a water level of 25cm as well as another 15cm pit depth with 2cm water level; rainbow sheen observed in pool on surface, brown oil 25 cm pit depth.

SM-006C 17 alerts, 1 verified from pit. Start Time: 1431 End Time: 1525

Oil found sheltered by bedrock outcrop, alerted on an oil filter as well near top of the woody debris line.

Wednesday 3rd May, 2017

Shoup Bay Spit (SB-001)
Weather: 41 degrees F, 44% humidity, 4mph wind, cloudy
Terrain: Coarse sediment, sediments ranging from pebbles to boulders that were too large to walk upon, sand, barnacles

Trial setup:

Pepper was worked on an area of approximately 1 acre. The odor was placed in jars with a holes pierced in the lids and sealed. The jars were then buried 2 feet underground beneath cobble and pebbles. The setup also contained empty jars and disturbed ground.

Pepper was initially worked on the opposite side of the beach, away from where the trial was placed, this was used to settle her into the environment and offer an opportunity for a quick find if oil was present. She alerted twice, but her indications could not be checked and verified as positive due to time. The area is a shipping lane for the Valdez Terminal and many small commercial and recreational vessels transit the site each day so that it would not be unusual to expect the canine to detected small amounts of stranded oil.

Jessica gives Pepper a directional cue during Wide Area Search

Pepper indicated near a pin flag on what was assumed to have been oiled from the previous day, as it had been used to mark oil within Smith Island. An alert on a camera tripod was likely previously oiled as well as it had been deployed within the oiled area of Eleanor and Smith Islands.

Pepper was worked on-leash to delineate from a flagged alert, which produced a line of finds.

9 alerts, 6 verified. Start Time: 1324 End Time: 1425

Found 4 target pots.

Thursday 4th May 2017

Departed Valdez, Alaska to Vancouver, Canada and redeployed to Saskatchewan, Canada for a follow-on tasking. No issues/concerns to report.

6 RESULTS/FINDINGS:

i. Terrain

The terrain proved to be a challenge to the canine at times, with the biggest issues being barnacles and slippery bedrock and boulders (for example, Figure B.4). The team considered canine booties to address the barnacle problem, but determined that these offer reduced grip. With the slippery surface, the team determined that the potential risk of injury from a fall outweighed any possible utility. We will investigate whether Kevlar booties with a grip surface on the sole would be better suited to the task for future deployments. Additionally, beginning at least two weeks prior to future deployments, the canine should have “Mushers Secret” applied to its pads daily.

ii. Access

The canine team should be allowed first, undisturbed access to the search area. This will prevent the canine being walked through areas of target odor on a leash and not being able to respond. In addition, any surface oil is potentially disturbed and spread through the search area on the soles of footwear of people walking about.

iii. Target Odor Thresholds

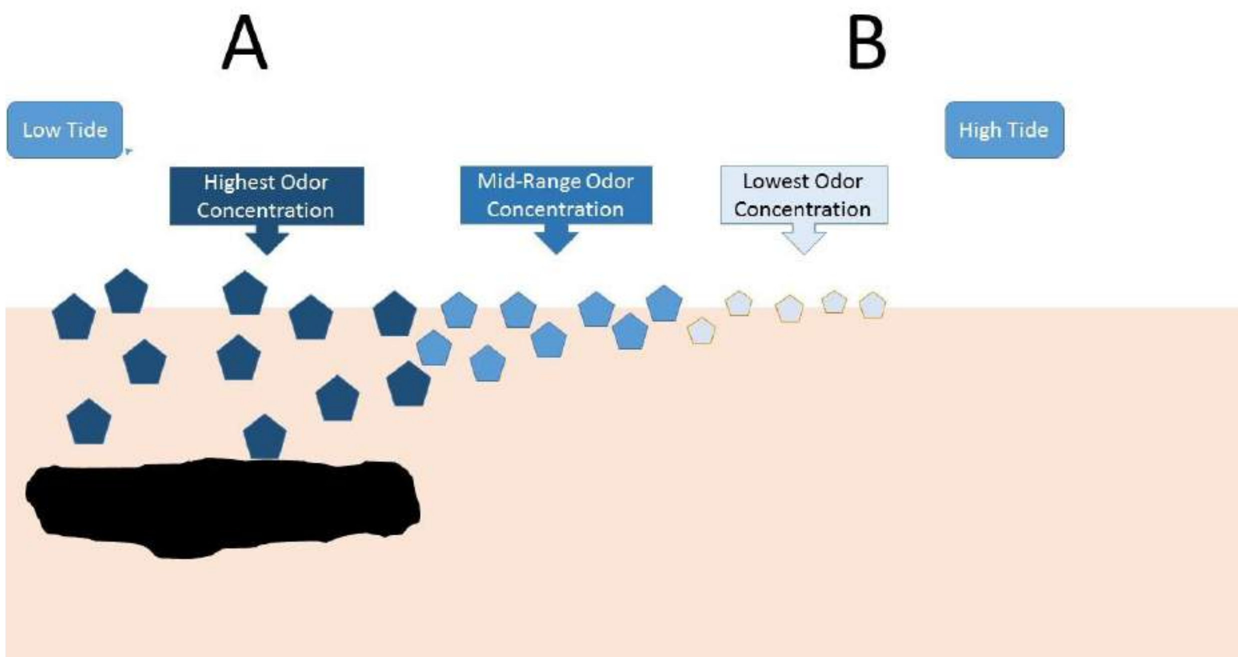
Pepper, the Oil Detection Canine utilized for this task, was selected because she had been imprinted and trained on sub-surface target oils. However, she has been trained using a process developed for these canines where oil is mixed with water and left to sit for 24 hours. The liquid is then filtered so all visible oil is removed. The resulting liquid is clear and can be used on the ground to train canines in signature oil footprint detection.

With this imprinting and training methodology the canines learn to detect and indicate the presence of oil molecules dissolved in water, meaning that the canine can detect much lower levels of trace oil than can be observed by a human. This means the canine can also accurately detect the target odor at a considerable distance from the source within a shoreline situation - as encountered at Prince William Sound.

Traditional detection canine training, such as Explosive or Narcotics Detection Dogs, are trained to follow the odor footprint to the source by discriminating the difference between the concentration levels of the molecules. Molecules are more dense at the source and become weaker in concentration the further they are transported away from the target.

With Oil Detection Canines we utilize methods learned through the training of Landmine Detection Dogs. That is, we train the dogs to indicate at the first instance of target molecules being encountered. We do not train them to follow the trail of odor to the source. The diagram below illustrates this concept.

The molecules are strongest above the target and grow weaker as they are transported up the shore through tidal and wave action. A traditional detection dog would be expected to indicate the presence of the target at point “A”, the strongest odor location. An Oil Detection Canine is trained to detect and indicate the point of delineation between target molecules and unoiled ground (sand, soil, gravel etc.). It was observed that Pepper gave indications in a straight line in the middle intertidal zone on Smith Island beach (Section 6.9; Figure 6.16). This is surmised to be due to her detecting the molecules of oil that have been dissolved in the sea water at source location and deposited further up the beach.



Concentration of oil molecules along a beach profile

Another consideration is the pebble/cobble//gravel makeup of the beaches in Prince William Sound. The canines have been trained primarily to respond to spills within sand/soil/sediment types of subsurface. These materials reduce the flow of molecules and filter them out of the water so that the footprint remains very close to the source. As the water is moving through these densely packed subsurface materials at a slow rate, molecules attach to the structure materials and remain there until dislodged. In the case of Prince William Sound we see that the tidal water is very free flowing through the more open (porous) subsurface sediments. This means the molecules within the tidal water are more easily transported farther without attaching to subsurface materials. When the tide starts to ebb, water collects in small rock pools, crevices, and sea weed. This results in oil molecules remaining along the tidal line and available for detection by a canine.

To prevent the canine detecting trace molecules dissolved in tidal water in future, a canine would be trained to detect only target odor source locations and to a level of concentration expected to be encountered at source. This would mean training a canine specifically to support Prince William Sound surveys, but is achievable in concept.

iv. Weather

The weather was no issue for the canine. As the ground warms up it will release higher concentrations of target odor molecules. The weather encountered during the surveys, however, was not detrimental to the canine's working capabilities. Wind direction has a large bearing on target location source from the indication. This is true not only for placing the canine in productive areas, but also to help the SCAT team with investigation upon indications.

v. Wildlife

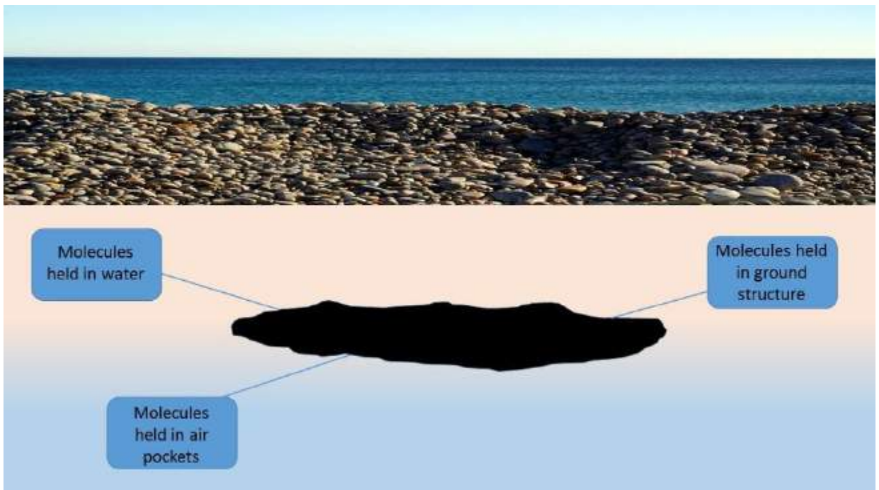
Seals, sea lions, and shoreline birds were observed during searches and were no issue or distraction for the canine.

vi. Imprinting

A sample of target oil for odor imprinting prior to deployment would be an advantage. It is understood this is not always possible and therefore we use many variants of oil in training in order to replicate the actual target oils as much as possible. For future research, it would be beneficial to have samples of the oil as it has aged and mixed with the local environment. By imprinting the canine only on the Exxon-Valdez oil that was aged and had been in the environment, it can be assured that the canine will be trained for the specific task as required.

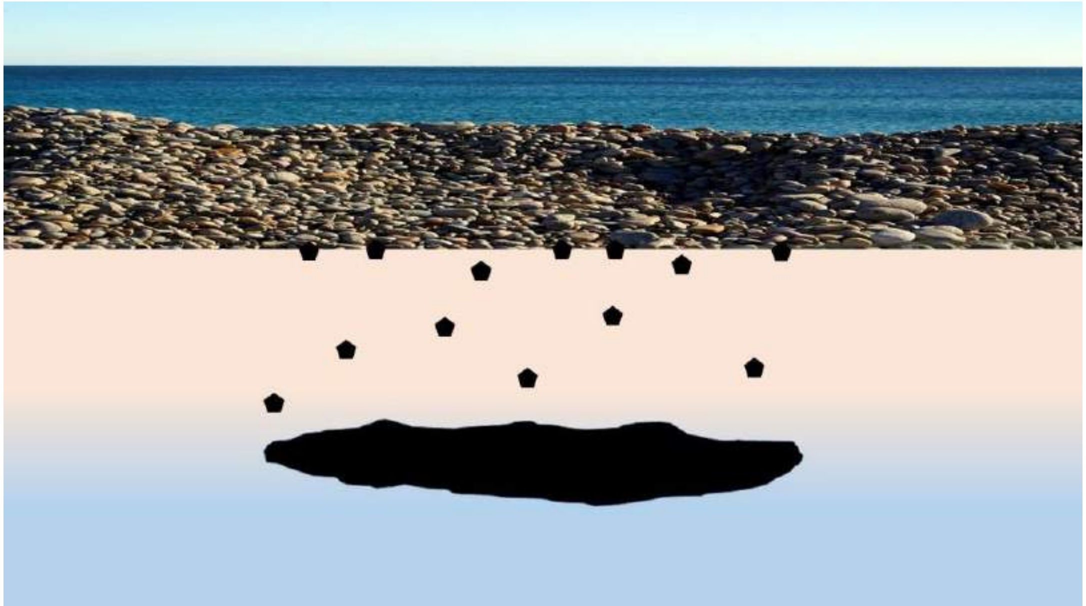
vii. Training

Canines must be taught using the buried target odors rather than airborne scent during training. Airborne scent is too easy to locate and therefore results in a degradation of the system of search. By teaching buried odor, it was found the canines would concentrate on the ground odor footprint and work the area in more detail due to the nature of the target. Subsurface oil is located within the terra firma structure in three ways: within air pockets, attached to the soil/sand/sediment etc., or within the moisture content.



Oil molecules are located in 3 areas in sub-surface material

It is the molecules within the moisture content that the canines are trained to detect. These dissolved molecules move through the soil structure by the action of water movement, tides, rain, dew, and the action of heat from the sun. This constant process of transportation through the soil forms a footprint of molecules on the surface. These molecules attached themselves to the surface structure and, if possible, can be released by either the action of the elements (sun, rain, wind), or their own self ability to become volatile.



Molecules are transported by moisture/water through the ground to form an odor footprint

Because of this, any target placed out for training needs to be aged within the environment to allow the natural processes of molecule transfer to take place. Due to Oil Detection Canines being used in areas where pits and trenches are often dug, they are taught to ignore disturbance. This is a reason the process of oil/water mixture, as described above, was developed: that a footprint of molecules can be replicated without any ground disturbance or the need to age the target for training.

viii. Utilization

During operational searches the handler never knows the start of the oiled area for delineation unless the canine previously indicated the location of target odor during a Wide Area Search (WAS), or if the handler was shown a start location based on a K9-SCAT assessment. In both cases, the team has a known start point for delineation. In the field deployment it was sufficient to mark the location of oil detected in a WAS and not delineate. The speed of search and accuracy of detection enables the SCAT survey to concentrate efforts in high productive areas rather than on areas with no oil. During the search of Smith Island, the Oil Detection Canine Team provided a clear delineation line along the high water mark, despite using the Wide Area Search technique. Canines have no concept of spatial awareness in relation to the straight line along the high water line, and this confirmed to the Canine Technical Advisor that the detected and marked straight line was a delineation. As described above, it is believed this was the point at which diluted molecules were located, and therefore the canine gave its trained response. By training a canine to higher thresholds, it is conceivable that a delineation of target oil source is achievable in the Wide Area Search role.

7 DISCUSSION

In conclusion, this study proved that trained Oil Detection Canine Teams are capable of locating surface and subsurface target odor in operational deployments. By deploying canines using systematic search patterns, teams are able to cover large areas effectively, efficiently and accurately. It is important that the Oil Detection Canine Team is viewed as a useful tool in the SCAT toolbox. There are limitations, such as those posed by large boulders and by areas that are overly oiled, which result in the canine not being able to pinpoint just one source location. The canine demonstrated it has the capability to transition effectively and efficiently from training to operational searches. Experiencing aged oil targets, as well as being able to imprint the canine on the aged oil aged from a specific area, will result in faster field deployment and utilization. By implementing lessons learned, a capability-specific to Prince William Sound is achievable and would be effective and efficient at locating and delineating subsurface target oil.

8 RECOMMENDATIONS

There are opportunities to further develop the canine capability through detailed research.

The integration of the Oil Detection Canine Team is a proven asset as a detection capability and will provide an accurate time and manpower saving capability. This will result in reductions in both the cost and, more importantly, time, in locating subsurface oils. The overall benefit is a reduction in the environmental impact both in the short-and long-term. This advanced detection capability also provides the community a tool that is easy to deploy in a quality assurance role after clean-up, and as confirmation that the end of clean-up operations were met, or as a survey tool for monitoring further impact of the spill months/years later.

Further research into the capability may include:

- deployments in winter conditions
- threshold odor targets
- detection of target oils at deeper depths
- discrimination between “old” spills/nature seeps and target odor

9 ACKNOWLEDGEMENTS

K2 Solutions, Inc. wishes to acknowledge and thank the members of Owens Coastal Consultants (OCC), Oil Spill Recovery Institute; Scott Pegau and the observers: NOAA; Catherine Berg, Gary Shigenaka, Chevron; Maria Hartley, ExxonMobil; Tom Coolbaugh and the United States Coast Guard representatives.

10 REFERENCES

API, 2016. Canine Oil Detection: Field Trials Report. American Petroleum Institute, Technical Report 1149-3, Washington DC, 48 pp.

K2 Solutions, 2016. Canine Oil Detection Tasking Nova Scotia, Canada - Final Report. Unpublished report by K2 Solutions, Inc. submitted to Environment Canada and Climate Change, Ottawa ON, 8pp.