



Simple techniques for assessing impacts of oil and gas operations on public lands: a field evaluation of a photoionization detector (PID) at a condensate release site, Padre Island National Seashore, Texas

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Lakewood, Colorado

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Condensate has impacted at least 0.28 acres. The impacted area may extend northwest of the surveyed area.

INTRODUCTION

Land managers have increasing responsibilities to assess the nature and extent of environmental impacts of various activities on public lands and to determine the associated risks to human health and ecosystems. Often, the land manager has a large number of sites to evaluate, limited resources to perform remediation and assessments, and limited guidance on how to evaluate and prioritize sites. Because formal site assessments are lengthy and expensive (see, for example, ASTM, 1999a) and limited resources need to be used on those sites with the greatest problems, accurate prioritization is vital.

The generally remote location of oil and gas production sites on Federal lands has historically limited public concern regarding impacts on human health and ecosystems. More recently, oil and gas production sites on public and private lands have come under increased scrutiny as past production impacts are being noticed, impacts on fish and waterfowl are documented, use of surface and ground water supplies expands, rural areas are encroached upon by residential and commercial development, and recreational uses of producing areas increase.

For oil and gas production sites, the main sources of human health and ecosystem risk are hydrocarbons (especially that fraction that is dissolved in water), saline water co-produced with the hydrocarbons, and radionuclides, principally radium in the produced water or associated scale and sludge. Although a previous study by the authors examined techniques designed to evaluate all three of these contaminants (Otton and Zielinski, 2000), this study looked just at the detection of volatile hydrocarbons in soils and shallow ground water. The purpose of this study was to extend and modify soil gas sampling methods used in the previous study.

The method evaluated here to detect hydrocarbons has the advantage of being simple and cost-effective and extends the reach of the observer into the shallow subsurface. The method provides real-time field data. Using this method and simple site mapping, one or more locations a day may be assessed, depending on the level of detail required.

Knowledge of the site characteristics (geology, slope, drainage, topography, etc.) and site history enhances the ability to search for and recognize likely locations of contamination. Thus, these techniques are best used by, or in collaboration with, knowledgeable personnel.

The simple technique for site assessment described here uses a PID to detect volatile organic compounds in soil gas in auger holes at oil and gas production sites, whether spills are apparent or not. This approach has advantages in that readings are instantaneous and the sensitivity and range are excellent (0.1 to 10,000 ppm VOCs). The instrument can detect direct hydrocarbon contamination of soils, VOCs being given off by a non-aqueous-phase hydrocarbon layer on top of the water table, or hydrocarbons dissolved in the water. It thus allows personnel to evaluate contamination beyond the immediate area of obvious contamination. Understanding how far and in which direction hydrocarbons may have migrated beyond the immediate site is critical to assessing and prioritizing the site, especially if potential receptors (i.e. stream, pond, water well) may exist downgradient from the site.

Much work of this type has been done as the preliminary or screening phase of formal site assessments or to guide cleanup of hydrocarbon spills on an emergency basis (Hayden Truscott, Kinder Morgan, Inc., oral commun., 2001). Little of this work has been published, and experience with screening techniques is usually limited to oil and consultant company environmental, health, and safety personnel.

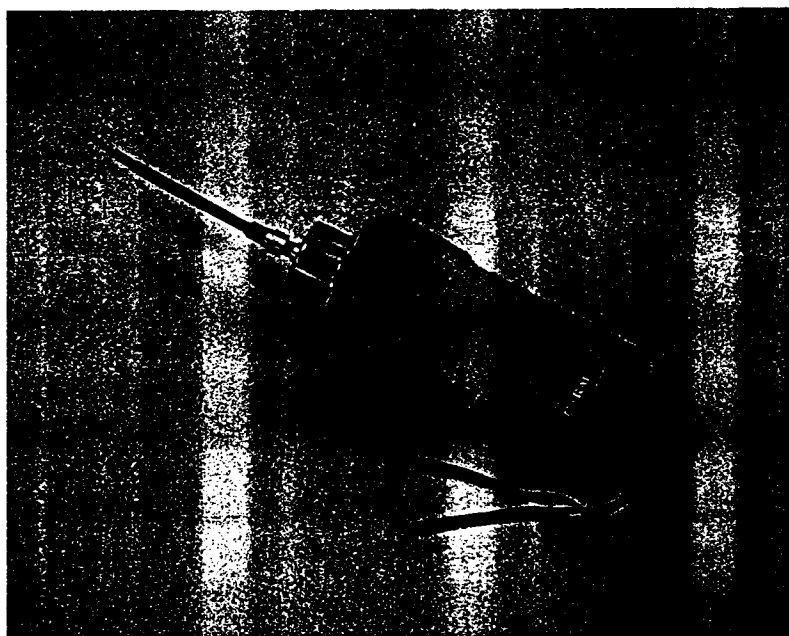


Figure 1- Photoionization detector (RAE Systems, appendix 1) used to determine the concentration of volatile organic compounds in air (either in soil gas in an auger hole or being given off by a soil sample to the headspace of a plastic sample bag).

In January 2001, the authors and personnel of the National Park Service visited the A-4 site, Dunn-McCampbell lease, in the Padre Island National Seashore, Texas. The site is located about 9 miles south of the Malaquite Beach Campground (fig. 2).

The main objectives were: 1) to establish what sampling techniques might be effective in the sandy soil and shallow-water-table conditions present in this area; and 2) delineate the probable area of condensate release at a known release site.

Site features

The site includes of a gas-and-condensate-processing unit placed on a 6-foot-high bulkhead adjacent to an area of low, vegetation-covered dunes (figs. 3, 4, and 5). The bulkhead is about 25 feet wide and 46 feet long. The long dimension of the bulkhead is oriented N. 50° E. Three pipelines extend from the bulkhead at its northeast end; one carries produced gas and fluids from a nearby well to the unit, and the other two carry natural gas and condensate product away from the bulkhead. A 2-foot by 4-foot sump is located on the northwest side of the bulkhead (fig. 5). Various oily fluids (lubricating oils, etc.) have seeped from the sump into the adjacent soil, leaving it slightly stained.

The site also includes an area where, in 1992 or 1993, a stream of condensate and natural gas was sprayed into the air northwest and west of the bulkhead. It was common practice in the 1980's and early 1990's for personnel working on equipment at such sites to vent pressurized lines to the atmosphere prior to working. Condensate landed on the nearby sandy soils and percolated into the ground. NPS personnel who visited the site after the event reported death of vegetation over an area of about 1/3 to 1/2 acre (Paul Eubank, National Park Service, oral commun., 2001). During subsequent visits, NPS personnel noted revegetation of the dead area. Only one such area of contamination has been documented by earlier observations of NPS personnel and data from this study, although other areas of condensate contamination in soils may be present at this site. The location of our sampling was based on the documented area.

During the three days of the 2001 visit, 29 shallow auger holes at 26 sites (fig. 3) were sampled. Data from these holes provide 1) information regarding the best approach to sampling VOCs in vadose-zone soil gases in sandy soils with a shallow water table, and 2) an

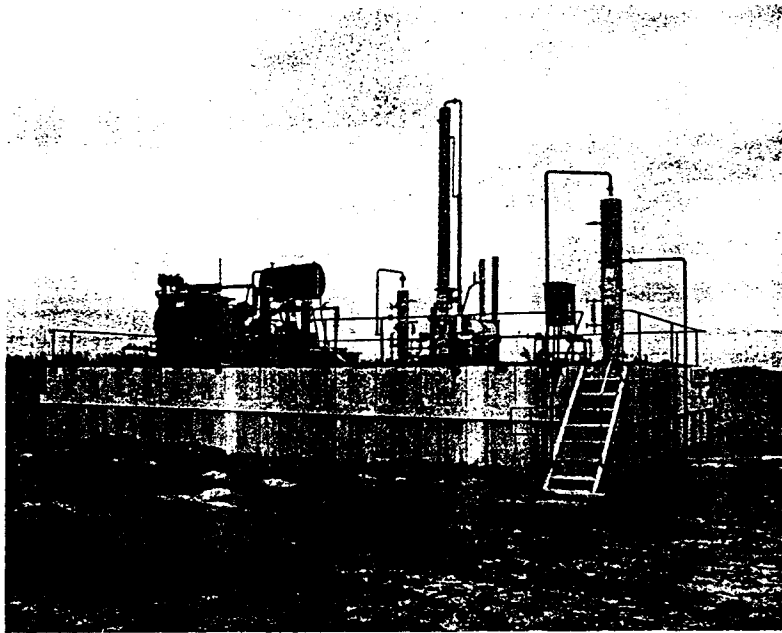


Figure 4- Gas-processing unit on bulkhead, A-4 site, Dunn-McCampbell lease. View from the east looking west. Note low dune area beyond the bulkhead.

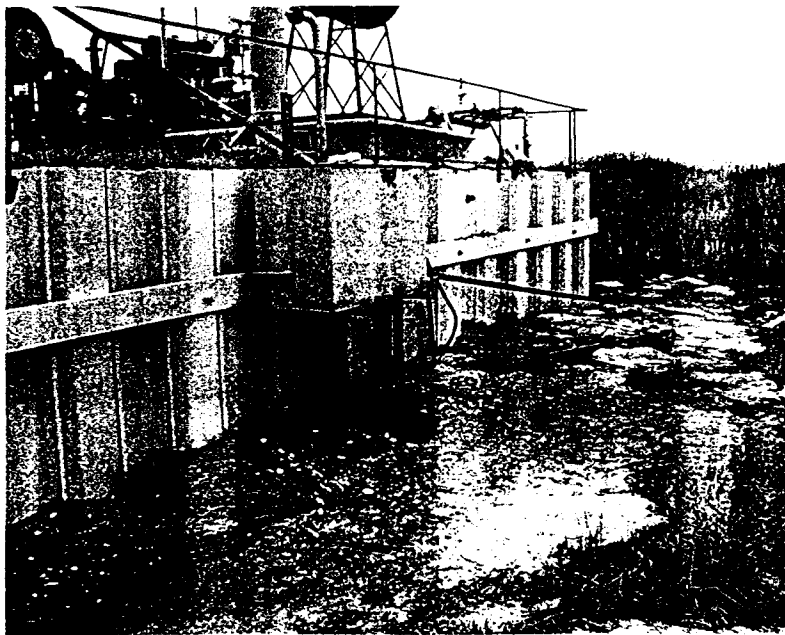


Figure 5- View of the sump on the northwest side of the bulkhead and the area of oil-stained soil adjacent to the sump. Note low dunes beyond bulkhead.



Figure 6- View, looking east, of the northeast part of the sampled area. The person in the photo is standing near site AH8. He is flanked to the northwest and southwest by the low dune ridges (fig. 3). The bulkhead and the parking area beyond are in a deflation flat.

SAMPLING METHODS

In a previous investigation in northeastern Tennessee (Otton and Zielinski, 2000), the authors sampled soil gas by augering 5-cm-diameter holes about 75-100 cm deep and then inserting a flexible Teflon tube into the hole to within a few centimeters of the bottom. The PID was then used to draw the sample from the bottom of the open hole through the tube. The highest reading using this technique was typically the initial value after pumping started, because ambient air is drawn into the hole and up the tube as sampling progresses and dilutes the soil gas in the open hole.

We tested the open auger hole technique at this site and compared it to an alternative technique in which a 5-cm-diameter, clear, hard plastic tube (capped at one end) is inserted into the open auger hole (fig. 7). The soil adjacent to the upper part of the hole (or soil removed during augering) is pushed against the walls of the tube at the top of the hole to form a seal (fig 8). The tip of the PID probe is inserted into a hole in the cap. However, a hole in the thick, rigid plastic cap would be a source of air leakage because it is difficult to get an airtight seal



Figure 7- Individual is inserting the 61 cm clear, rigid plastic tube into the open auger hole. The yellow instrument is the PID. The other instrument is a microRmeter, designed to check for naturally occurring radioactivity.



Figure 8- Site AH 16. Top of inserted tube with blue rigid plastic cap and duct tape. Note hand impressions from pushing soil down around the top of the tube to seal the soil. Also note the weak iron oxyhydroxide staining in soil surface layer.

droplets were probably drawn into the bottom of the tube from standing water or water-saturated sand in the bottom of the hole. Water condensation formed on the inner wall of the Teflon tube because the ground temperature was warmer than the air temperature by several degrees.

After pulling the Teflon tube from the hole, we attempted to get the tube back to ambient air VOC concentrations (0.0 ppm) by pulling air through the tube with the PID. The VOC readings did not decline readily and went above the bottom hole value (>20 ppm) initially. After several minutes the values still had not declined significantly. We believe that the walls of the Teflon tube and the water droplets on the walls had sorbed and were subsequently releasing substantial amounts of VOCs.

We switched to the 61-cm-long, 5-cm-ID rigid plastic tube. We calculated the approximate volume of our hole, which was 83 cm deep and 2.5 cm in radius (about 1600 cc) and determined that 5 minutes was an adequate sampling time. The maximum reading was 419 ppm of VOC during a 5-minute sampling period. This value is a factor of 20 higher than the value obtained with the Teflon tube in the open auger hole. After removing the probe from the hole we noted that the instrument read 4 ppm without any tube attached (presumably VOCs were sorbed to the inline water trap). It took several minutes to get the instrument down to ambient levels (0.0 ppm). We also pulled ambient air through the 61 cm tube to check for contamination. Initial readings were about 15 ppm, but after several minutes the levels dropped to less than 4.0 ppm.

Throughout the study, we noted that background readings should be checked on the tubes after moderately to highly contaminated sites (20-1000 ppm) have been measured. The tube can be cleaned of sorbed VOCs by removing the cap and swinging the tube through the air for a few minutes. Pushing a clean cloth through the length of the tube can also lower VOC readings. If the tube is used without getting the VOC concentrations down to ambient levels (0.0 ppm at this site), then the background reading on the tube should be recorded and subtracted from the results in the next reading. Background readings are used in table 1 to calculate the true VOC reading.

We sampled soil gas at Site AH8 and then returned to that site three days later and augered three additional adjacent holes (AH8B, AH8C, and AH8D, fig. 10). In hole AH8B (90 cm deep, measured 112 ppm with the rigid tube), we inserted the Teflon tube to various depths above the bottom of the hole (10, 20, and 30 cm, table 1). The maximum

(91 cm deep), respectively (table 1). The lower reading for AH8 may reflect the somewhat shallower depth of sampling; however the lower reading for AH8D cannot be explained by that. The readings for AH8B, AH8C, and AH8D reflect variability, but we are uncertain whether the variability is because of site, operator, or instrument.



Figure 10- Site AH8. Initial hole is marked by the orange flag (the flag is visible but not the metal wire inserted into the ground; the hole is beneath the meter stick). Adjacent locations, AH8B, AH8C, and AH8D, are marked by 10-penny nails tied with red flagging. The opening for one of these holes is visible, just to the right of the red flagging on the left side of the photo. The PID (yellow) and an open field notebook are visible.

EXTENT OF HYDROCARBON IN SOIL AT A-4

VOC analyses for the 26 sites are tabulated in Table 1 and portrayed in Figure 11. The highest reading (419 ppm at AH1) at the site was from the area of oil-stained soil adjacent to the sump (table 1, fig. 3, fig. 5). Outside of that area, the highest reading was 159 ppm in AH14 (table 1, fig. 3). The area of hydrocarbon soil contamination documented by the sampling (fig. 12) is 0.12 hectares (0.28 acres). The area of contamination is well constrained only at the northeast end and the southwest end where the edge of the area is bracketed by sample locations. The impacted area likely extends northwest of the surveyed area.

Table 1- VOC measurements at auger hole locations at the A-4 site

BG- background hole; RT-rigid tube; except where noted, the tube was 61 cm long; TT (XX)- Teflon tube, number of cm above bottom of hole; NA- not applicable; bg- no odor, no measurement, background value assumed; WT- water table.

Site #	Method	Date	Depth (cm)	Time of measurement (mins:secs)	Raw VOC reading, peak, if just one listed (ppm)	Raw minus background (ppm)
BG	RT	01/09	72	5:00	0.3	0.3
AH1	TT (2.5)	01/09	40	NA	7.1	7.1
	TT (2.5)	01/09	83	NA	19.2	17.9
	RT	01/09	83	5:00	419	419
AH2	RT	01/09	85	5:00	9.1	Unknown
AH3	RT	01/09	85	11:00	15.0	Unknown
AH4	RT	01/09	88	5:00	1.3	1.3
AH5	RT	01/09	88	4:00	1.2	1.2
AH6	RT	01/09	84	5:00	0.4	0.4
AH7	RT	01/09	66	5:00	76.7	76.7
AH8	RT	01/09	83	5:00	96.5	94.9
AH8B	RT	01/12	90	4:00	112	111
	TT (10)	01/12	90	NA	22	NA
	TT (20)	01/12	90	NA	24	NA
	TT (30)	01/12	90	NA	19	NA
AH8C	RT	01/12	91	4:00	112	111
AH8D	RT	01/12	91	4:00	88.1	85.4
AH9	RT	01/11	87	5:00	0.6	0.6
AH10	RT	01/11	88	5:00	70.4	70.4
AH11	RT	01/11	90	5:00	40.8	40.0
AH12	RT	01/11	88	5:00	12.1	11.0
			114	6:00	28.4	27.3
AH13	RT	01/11	104	5:00	2.7	0.7
			138	5:00	17.5	15.5
AH14	RT	01/11	88	5:00	159	159
AH15	RT	01/11	100	5:00	8.5	6.4
			156	4:00	90.4	89.2
AH15	RT (61cm)	01/12	159	5:00	83.9	83.9
	RT (30.5cm)	01/12	159	5:00	63.3	63.0
AH16	RT	01/12	134	4:00	57.0	56.6
AH17	RT	01/12	141	4:00	127	127
AH18	RT	01/12	160	1:00	131	131
				1:50	138	138
				3:00	127	127
				4:00	117	117
AH19	RT	01/12	121	1:55	102	102
				4:00	86.2	85.8
AH20	RT (30.5cm)	01/12	57 WT at 57	4:00	1.1	1.1

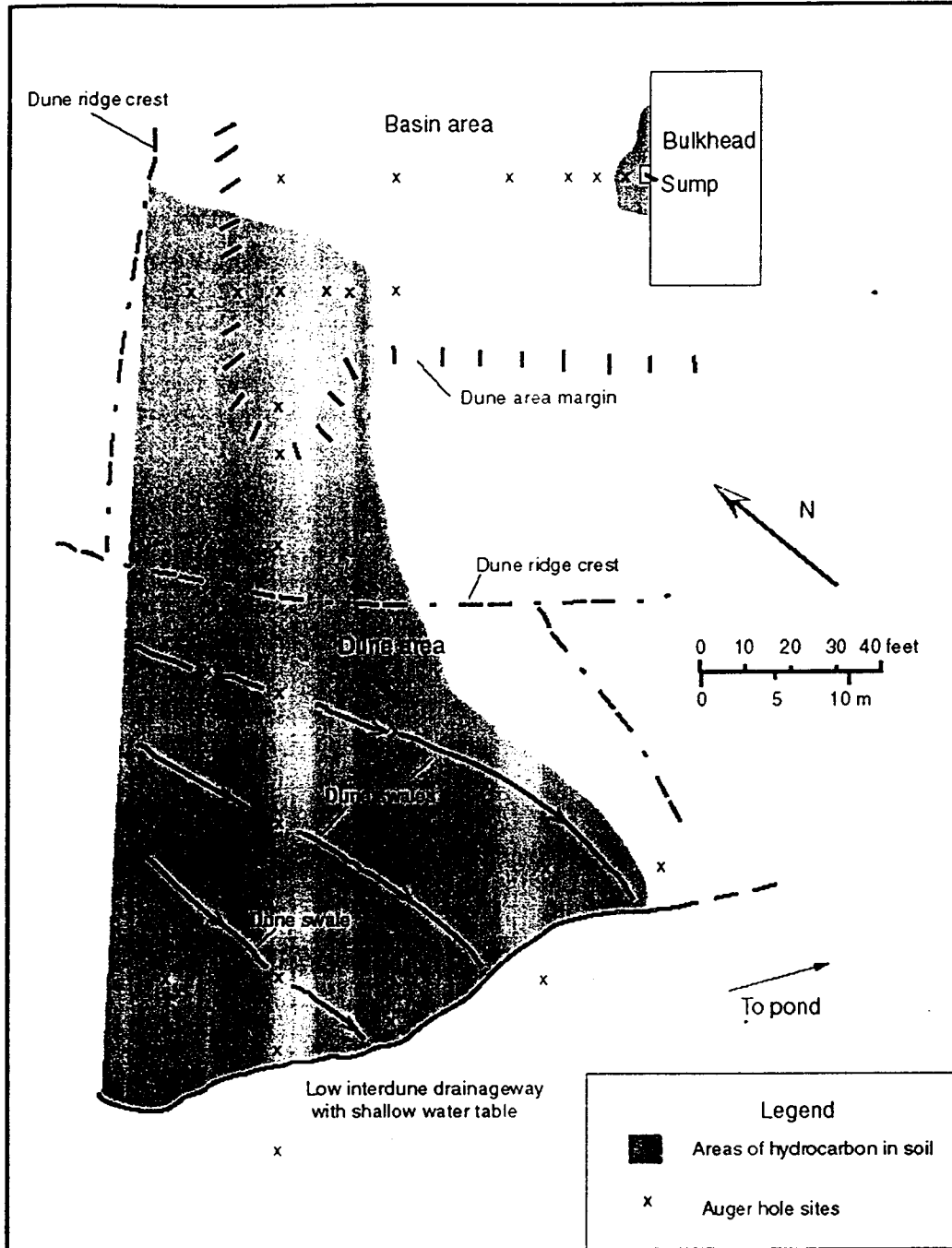


Figure 12- Areas where data suggest hydrocarbons are present at and near the water table. The larger area of hydrocarbons may extend to the northwest and is reasonably well delineated only at the northeast end and southwest end of the mapped area, where sample sites bracket the contact. The area near the sump is mapped based on one reading and the stained soil at the surface.

VOC data obtained using the rigid tube technique and the PID successfully delineate an area of condensate contamination near the bulkhead. The boundaries are best delineated where they are bracketed by sample locations. The area is open to the northwest, but VOC values in soil gas seem to be decreasing in that direction.

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Appendix- Field equipment used during this study*

1) RAE-2000 Photoionization Detector

RAE Systems
1339 Moffett Park Drive
Sunnyvale, CA 94089

2) Soil auger

2¼" diameter general-purpose soil auger- threaded, stainless steel bit, cross handle, and 3-foot extension rods

AMS Supplies
105 Harrison
American Falls, ID 83221

* Mention of equipment used during this study is for information only and does not imply endorsement by the U.S. Geological Survey. Instruments and equipment sold by other manufacturers may achieve the same results.