Use of the FIDLER Scintillation Probe for the Characterization of Subsurface Radionuclide Contamination
IAEA/SM-359/P-8

Michael E. Murray
Robert L. Coleman

Life Sciences Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

ABSTRACT

The Measurement Applications and Development Group at the Oak Ridge National Laboratory has used a FIDLER to characterize a site where numerous localized and dispersed concentrations of uranium had been previously discovered beneath a poured concrete floor. The thick floor impeded the evaluation of the distribution of regions containing uranium without boring numerous holes through the concrete. The purpose of this study was to perform a radiological assessment of the building in preparation for remediation of the site. Integrated counts were taken with the FIDLER probes fixed in place on a systematic grid across the area to be evaluated. The results were then superimposed on a drawing of the area of evaluation. This approach allowed the boundaries of the regions with subsurface contamination to be resolved much better than by using standard survey techniques and decreased the number of borehole samples and subsequent analyses. The study demonstrated that this survey technique provides rapid and essential characterization information and reduces sampling, analytical, and remediation costs.

1. INTRODUCTION

A simplistic approach was deployed to map contaminants by observing the low-energy radiation emanating through cover material in order to characterize the distribution and concentration of radioactive contaminants beneath dirt-filled areas and poured concrete floors. Most of the radiation surviving the traverse through the cover material is scattered photons, therefore the measurement of the low-energy band, from 30 to 700 keV, is an efficient manner to detect the presence of subsurface contamination. This approach will aid the decision making process for discerning the number and location of subsequent samples. A Field Instrument for the Detection of Low-Energy Radiation (FIDLER) probe[1] has been used because of its high sensitivity to low-energy gamma and x-ray radiation, portability, and directional bias. The detector has a sodium iodide (NaI) crystal 1.6 mm in thickness and 13 cm in diameter. The detector has a 2-mm-thick beryllium window and uses a quiet photomultiplier tube with low noise characteristics. The

[1] Model G5 FIDLER , BICRON Corporation, Bodegraven, The Netherlands

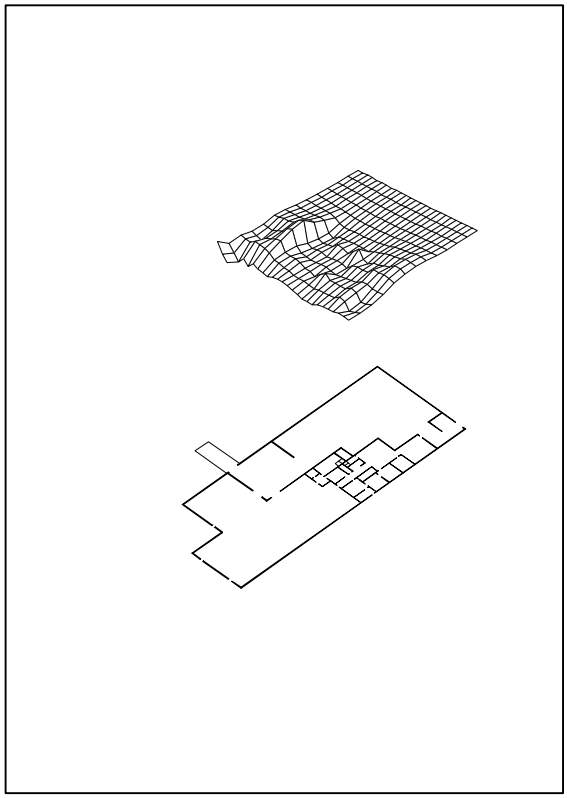
detector geometry makes it highly suitable for detecting low-level, low-energy gamma radiation both in full spectrum and spectroscopic applications.

To evaluate the potential viability of the FIDLER to detect subsurface contaminants, a site near Pittsburgh, Pennsylvania was selected because it was in the planning stages for remediation, and it had subsurface uranium contamination as determined by a limited radiological survey [1]. One core sample indicated ^{238}U in concentrations up to 740 Bq/g, mostly in a 6-cm layer under 10 to 25 cm of concrete. The facility was an operating business and the FIDLER survey attempted to delineate the extent of the contamination, minimize the number of core samples required and thus reduce the impact on normal business operations.

2. METHODOLOGY AND DISCUSSION

A radiological survey team from the Measurement Applications and Development Group of ORNL conducted a thorough investigation of the site following standard protocol [2]. The survey included the use of NaI scintillation detectors (4.4 cm by 3.8 cm diameter) typical area scans and exposure correlation measurements, Geiger-Mueller pancake probes for beta/gamma surface contamination, and ZnS scintillation detectors for alpha contamination. The results were similar to previous efforts; the highest exposure rate was ~45 **m**R/h.

The FIDLER survey was based on a 1.5 m by 1.5 m grid and timed counts of 2-minute duration. The detectors were placed on each grid point with the beryllium window about 1cm from the concrete surface. The results were entered into a database, normalized to account for differences in detectors, and overlaid onto a building floor plan. The measurements are graphically given in a relief map as shown in Figure 1. The areas of highest exposure are obvious and correlate to previous data. Areas where the FIDLER measurements showed minor variations were not recognized by typical walkover scanning surveys and were candidates for sampling.



The FIDLER results were reviewed and formed the basis for subsequent core samples through the concrete. Ten locations coinciding with the FIDLER results were bored to a maximum depth of 76 cm. Samples were collected every 6 cm. The samples were analyzed at ORNL for the uranium isotopes and their decay progeny. Table I compares the results of the FIDLER measurements and analytical concentrations of ^{238}U. The depth and thickness

TABLE I. Comparison of FIDLER results with ^{238}U analytical results.

FIDLER results, cpm above background	Maximum ^{238}U concentration, Bq/g	Depth of contamination layer below concrete, cm
500	2.4	15-46
1000	0.1	15-30
1000	0.15	15-30
1000	.2	15-30
1000	5.6	15-45
1000	8.6	15-61
2000	11	15-45
3000	185	15-60
4000	12	30-45
17000	740	31-46

of each contaminated layer is also given. The comparison of the results illustrates that measurements greater than background using the FIDLER usually indicated elevated concentrations of contaminants; however, the converse cannot be inferred. The absence of elevated exposure rates could not be used to infer the absence of contaminants.

As the site was being remediated, the FIDLER data served as a guide to expected contamination levels, an estimation of the volume of soil to be removed, and other remediation logistics. The use of the FIDLER probes has been demonstrated at other sites [3] [4] with equal success in predicting subsurface contamination.

3. CONCLUSIONS

The FIDLER detector probes were successfully demonstrated to provide an indication of subsurface contamination when gamma-emitting nuclides are present. The mapped FIDLER measurements clearly delineated areas of elevated gamma radiation within the facility, even when conventional NaI detectors had only indicated background. Based on the results of this evaluation (and others cited), it is believed that FIDLER detection systems can be a valuable tool to help guide conventional sampling and site remediation. By obtaining integrated counts recorded on a fixed grid across the area of interest, use of the FIDLER detector will likely provide insight into the location of subsurface contaminants.

Disadvantages of the FIDLER detectors are the relative cost per detector, fragility and relative weight. Because of these concerns, it is not expected that the FIDLERs will replace the more compact, rugged, and less expensive scintillation probes commonly used for gamma radiation scanning survey applications when searching for relatively high-energy gamma and x-ray emitters. When faced with the prospect of evaluating the potential presence of subsurface contamination, however, it is believed that the use of this technique enhances the detection sensitivity beyond using the standard NaI systems.

It should be noted that as with any other detection method where the contaminant to detector geometry is questionable, observations equal to the detector background cannot be interpreted to mean that no contamination exists; rather, it simply means that nothing out of the ordinary was observed. It should also be mentioned that although the FIDLER measurements clearly documented areas of higher gamma radiation levels, they cannot unambiguously be related to the uranium concentration levels or the volumes of these concentrations. This is because neither the thickness nor exact composition of the floor and subsoil, nor the distribution of the uranium in the soil, can be accurately known.

4. REFERENCES

[1] Foley, R.D., Cottrell, W.D., Crutcher, J.W., Results of the Radiological Survey at Conviber Inc., 644 Garfield Street, Springdale, Pennsylvania (CVP001), Oak Ridge National Laboratory, ORNL/RASA-89/18 (1991).

[2] Coleman, R.L., Murray, M.E., Brown, K.S, Results of the Supplementary Radiological Survey at the Former C. H. Schnoor and Company Site, 644 Garfield Street, Springdale, Pennsylvania (CVP001), Oak Ridge National Laboratory, ORNL/RASA-94/3 (1995).

[3] Murray, M.E., Johnson, C.A., Results of the Independent Radiological Verification Survey of the B Ditch at Du Pont Chamber Works, Deepwater, New Jersey (DNJ001V), Oak Ridge National Laboratory, ORNL/RASA-97/12 (1998).

[4] McKenzie, S.P., Uziel, M.S., Results of the Independent Radiological Verification Survey of Remediation at Building 31, Former Linde Uranium Refinery, Tonawanda, New York (LI001V), Oak Ridge National Laboratory, ORNL/RASA-96/10 (1998).