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Project Summary

Evaluation of Abatement Alternatives Through the Use of Remote Sensing Devices

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Several remote sensing techniques (ground-penetrating radar, electrical resistivity, metal detection, and seismic refraction) were employed to investigate the subsurface location of buried drums and chemical contamination at an uncontrolled hazardous waste site in Rhode Island. The techniques were used in conjunction with direct sample collection to support the selection of a long-term abatement alternative for the site. The advantages and limitations of the four remote sensing techniques are given, and an approach for accomplishing systematic investigations at other abandoned hazardous waste sites are recommended.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research projects that are fully documented in separate reports (see Project Reports ordering information at back).

Introduction

This summary describes how several remote sensing techniques can be used in conjunction with direct sample collection at an uncontrolled hazardous waste site to (a) determine the extent and nature of the buried drum and subsurface chemical contamination (plume) problem and (b) support the selection and design of a long-term abatement approach. The use of the following remote sensing techniques was demonstrated:

- ground-penetrating radar
- metal detection
- electrical resistivity
- seismic refraction

The focus here is on the techniques and their results and the selection of the preferred abatement alternative.

The uncontrolled hazardous waste dump site is located in Coventry, Rhode Island, approximately 20 miles southwest of Providence. This site encompasses approximately 7.5 acres of cleared ground surrounded by woods and wetland in a relatively rural area of the state. An undetermined quantity of chemicals had been placed into the ground both by burying 55-gallon drums in five separate locations and by discharging into trenches directly (Figure 1). A swamp, located northwest of the site, is the surface discharge area of chemicals leaching from the dump. This swamp discharges to a small pond which is a source of irrigation water for a cranberry bog located approximately 1 mile from the swamp's outlet. To date, no evidence of chemical contamination in the pond has been found, based on sampling conducted by the Rhode Island

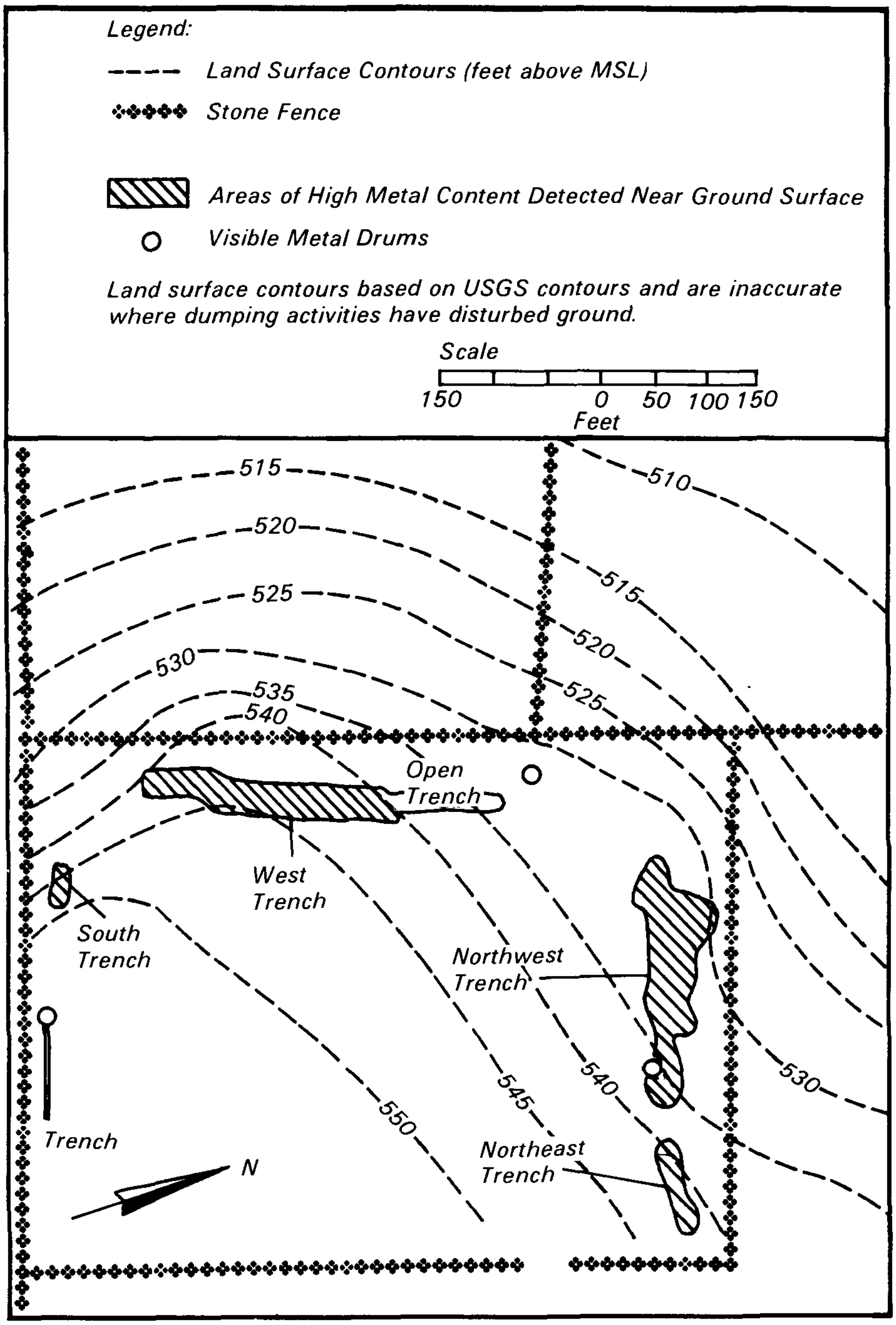

Figure 1. *Outline of trench locations at the Coventry site as determined by metal detection.*

Department of Environmental Management (DEM) and the U.S. Environmental Protection Agency (EPA), Region I.

State of Rhode Island officials were alerted to the dumping activities by a fire and explosion in September 1977. A court order issued in November 1977 prohibited the property owner from continuing dumping activities or otherwise altering the site. From the end of 1977 to mid-1979, the DEM conducted field investigations to quantify the seriousness of the situation.

The investigation at the Coventry site was conducted in two separate phases.

Site Investigation

The ultimate purpose of the Phase I and Phase II investigations was to support the selection of one of the following long-term abatement methods:

- site encapsulation
- leachate collection and treatment
- drum removal and chemical disposal
- "no action" alternative

The techniques employed for data collection during the Phase I effort were: electrical resistivity; metal detection; installation of monitoring wells; and chemical analysis of soil, groundwater, and surface water. The field methods employed, the data collected, the conclusions drawn, and the recommendations made to the DEM are documented in the Phase I report, along with the abatement options, the additional information needed, and the recommendations for immediate and near-term actions to protect the public health. ("Hazardous Waste Investigation: Picillo Property, Coventry, Rhode Island," R. W. Pease et al., MITRE Technical Report 80W00032, the MITRE Corporation, Bedford, Massachusetts. 142 pp. 1980.)

Although the extent of the problem was defined and abatement options were preliminarily evaluated in Phase I, key pieces of information were needed concerning the presence of fracturing or contamination of the bedrock and the condition and number of the buried drums before a permanent solution could be selected. The reports summarized here describes the advantages and disadvantages of the four remote sensing techniques and how they were used to define the extent of the buried drum problem and evaluates the alternatives and make recommendations for permanent abatement (Table 1).

Remote Sensing Techniques

Ground-Penetrating Radar

The technique of ground-penetrating radar involves the repetitive propagation of short-time duration pulses of electromagnetic energy in the radio frequency range downward into the ground from a broad bandwidth antenna on (within a few inches of) the surface. Reflections from subsurface interfaces are received by the antenna during the off period of the pulsed transmission, processed electronically, and recorded to yield a continuous profile of subsurface conditions as the antenna/transmitter-receiver unit is moved across the ground surface. The depth d to an interface, or the surface of a "target" such as a metal drum, is calculated from

Table 1. Techniques Used in Phase II to Provide Information Needed to Select an Abatement Alternative

Alternative	*Additional Information Required to Select Alternative*	*Technique to Obtain Information**
1. No Action	● *condition of source (drums)* ● *state of nearby pond* ● *contaminant underflow at swamp* ● *ultimate disposition of all pollutants*	● *radar, exploratory excavation* ● *additional wells, chemical analysis of soils and water samples*
2. Drum Removal and Disposal (excavation, testing, and proper disposal of drums and contents, and contaminated soils)	● *condition of source (drums)* ● *condition of soil*	● *radar, exploratory excavation* ● *exploratory excavation, chemical analysis of soil samples*
3. Site Encapsulation (construction of impermeable barriers around source of pollutants)	● *condition of source (drums)* ● *condition of bedrock*	● *radar, exploratory excavation* ● *seismic refraction, core drilling, deep wells*
4. Leachate Collection and Treatment		
a. Limited Option (interceptor trenches constructed adjacent to site walls)	● *condition of source (drums)* ● *condition of bedrock*	● *radar, exploratory excavation* ● *seismic refraction, core drilling, deep wells*
b. More Complete Option (interceptor trenches constructed 600 feet downgradient of site walls)	● *same as above*	● *same as above*

**Metal detection had previously been used to locate trenches; electrical resistivity to delineate leachate plume. Radar could have been employed in lieu of or in conjunction with metal detection, as recommended for other sites; potential radar effectiveness was not known at the time of the initial survey.*

d = (vt)/2, where v is the wave velocity equal to $c/\sqrt{\varepsilon_r}$, where c is the velocity of light and ε_r is the relative dielectric constant of the material in which the wave is propagating) and t is the pulse travel time.

Ground-penetrating radar has been used in such applications as archeological surveys, locating sewer lines and buried cables before construction activities, and profiling lake and river bottoms. The application to locating buried drums of chemical wastes is relatively new, and further refinements both in the technology and in data interpretation are anticipated.

Using their Surface Interface Radar System 7*, the equipment manufacturer, Geophysical Survey Systems, Inc. (GSSI), conducted the field survey. The survey of the trench areas, representing approximately 2 acres, took 2 days. Following experimentation with two alternative antennas and center frequencies, GSSI Model 3105AP operating at a center frequency of 300 MHz and GSSI Model 3102 operating at 600 MHz, the latter was chosen for most of the survey because of its improved spatial resolution at shallower depths.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The operating depth varies approximately as the inverse square of the frequency, all else being equal.

One large trench (labeled the West Trench in Figure 1) located by the metal detection survey was surveyed with the 300 MHz antenna set at a nominal depth of 25 feet, later calibrated at 24.4 feet, based on average soil conditions. The other trenches (labeled Northwest, Northeast, and South) were subsequently surveyed using the 600 MHz antenna set at a nominal depth of 12.5 feet. The survey was conducted according to a rectangular grid. All trenches were surveyed longitudinally by using parallel radar transects at spacings of 10 feet. Transverse transects, or crosscuts, were made at intervals of 20 feet for the Northeast and South trenches and 40 feet for the West and Northwest Trenches. The antenna unit was pulled along each transect manually, and the data were recorded by wire connection with equipment located in a stationary van on the site, which also served as the power source. The major equipment components were a control unit with cathode ray tube display, a tape recorder, a graphic (chart) recorder, and a solid state inverter.

The radar beam has a spread of ±45° in the fore and aft directions, and ±20° laterally. Any target detected within this beam will be recorded as being directly below the point of the surface where the signal is transmitted and received, and signals are reflected only from surfaces perpendicular to the direction of the signal. The use of a 10-foot grid spacing thus resulted in a sampling approach, as opposed to full coverage of the subsurface volume. Even with a very fine grid, however, a fraction of the buried drums would be missed by the radar because of (a) their orientation or (b) their being "shielded" by metal drums closer to the surface, since metal is a near-perfect reflector of radar energy.

Metal Detection

The entire 7.5 acre site was surveyed with a Fisher M-Scope (Model TW-5) metal detector. This equipment is designed for locating buried metal objects by inducing an electromagnetic field around the object in response to radiation from a transmitter. The average depth of detection for metal objects is dependent on the amount of background "noise." Thus, in areas free of buried metal, the probable depth of detection is approximately 6 to 8 feet. Because the sensitivity setting of the instrument had to be cut back in areas of buried drums, the potential depth of metal detection was approximately 4 to 5 feet. In areas where buried drums were suspected, based on disturbed ground or the initial gross scan of the overall site, the survey was conducted by traversing closely-spaced grid lines.

Electrical Resistivity

The electrical resistivity of a geological formation depends on the conduction of electric current through the particular subsurface materials. Since most of the geologic formations that contain water have high resistivities, the electrical resistivity of a saturated rock or soil is primarily a function of the density and porosity of the material and the concentration of the conducting ions within the saturating fluid. In a resistivity survey, an electric current is passed into the ground through a pair of current electrodes and the potential drop is measured across an inner pair of potential electrodes. The "apparent resistivity" is determined by the equation, $R_a=2\pi A(V/I)$, where A is the electrode spacing, V is the potential difference and I is the applied current. The depth of penetration is controlled by the distance between the electrodes (called the A-spacing) and is approximately equal to half of this distance. Varying the A-spacing allows resistivity measurements to be taken in the form of either lateral or depth profiling.

Both types of profiling methods were conducted at the hazardous waste site in Coventry using a Bison Instruments Model 2350B Earth Resistivity meter powered by a 90 volt battery. A fixed A-spacing of 20 feet was used for the lateral profiles in the areas of the trenches and the swamp where the depth of groundwater contamination was suspected as being shallow. Two lateral profiles using a fixed A-spacing of 50 feet were also conducted approximately 2000 feet west and north of the immediate site walls, where it was suspected that the contamination might be detected at greater depths.

Seismic Refraction

The seismic refraction method is based on the principal that elastic waves (mechanical rather than electromagnetic) travel through different subsurface strata at different velocities. Elastic waves are introduced to the ground surface by an energy source, usually a small explosion or a hammer blow on a steel plate for shallow investigations. The refracted waves are detected by small seismometers (geophones) located on the surface at various distances from the energy source. A seismograph records the travel time between the vibration and the arrival of the elastic wave at the geophones. Plotting arrival time versus distance from the energy source to geophone from a series of seismograph records enables the strata depths and their seismic velocities to be determined through the use of simple refraction theory.

Seismic refraction profiling of approximately 2,850 linear feet was done in 2 days of field work. A Geometrics/Nimbus Model ES1210F Multichannel Seismograph was used to record and collect the voltage outputs from 12 geophones spaced at 20-foot intervals for each refraction spread. The energy source used to initiate each record and shock wave was a 30-pound weight drop or 10-pound sledge hammer blow on a steel plate with an attached impact start switch.

Results of Field Studies

Plume Delineation

When the information needed to evaluate the long-term abatement alternatives was determined, the Phase I investigation was planned. A principal component of the site investigation was the installation of shallow monitoring wells to collect soil and water samples and to determine groundwater elevations.

Because natural conditions at the site were such that measurement of electrical resistivity was expected to be successful, a lateral profiling survey was performed to facilitate placing the monitoring wells. In addition, a depth profiling survey was conducted to determine vertical contamination patterns.

The western plume, which was defined primarily with the use of the 20-foot A-spacing, appeared to be generally within 10 feet of the surface. Most of the plume moving toward the north was defined with the 50-foot A-spacing and appears generally deeper than 20 feet below the surface. Some shallow contamination, however, is also apparent along the northern border of the site near the trenches. Shallow bedrock off the northwest corner of the site was considered the most likely explanation for the high apparent resistivity values between the two plumes, although this explanation was later proven false (see next subsection). Hence the results of the resistivity survey suggested that additional monitoring wells be located to determine the existence of the shallow bedrock and to substantiate the presence of two separate plumes.

Additionally, discovery of a contaminant source along the partly grass-covered western edge of the site served to indicate how far south and west the monitoring well program ideally should extend. Locating this additional source of contamination may also have been possible using the radar technique based upon comparison of signal strength.

Following the lateral resistivity survey, 15 monitoring wells were installed. Refusal depths, tentatively assumed to reflect the approximate top of bedrock, did indicate a mound in the bedrock surface off the northwest corner of the site. Four wells in this vicinity were dry, which also gave credence to the results obtained from the resistivity survey, namely the existence and location of two plumes. In addition, soil samples taken from these same locations were much less contaminated than soil samples taken from borings located within the plume boundaries. Consideration of these factors seemed to indicate that groundwater flow was being diverted around a bedrock mound, and this had resulted in the detection of high apparent resistivity values in this area. Later (Phase II) bedrock drilling, seismic refraction survey, and chemical analysis of soil and groundwater showed that the bedrock mound did not exist and that contaminated groundwater was indeed traveling in this location. In general, the groundwater is at a greater depth below the surface in this region than the other surveyed areas; this resulted in the higher relative resistivity values and subsequent incorrect interpretation.

Determination of Bedrock Topography

Complete verification of the shallow bedrock off the northwest corner of the site was not possible until the bedrock coring and the seismic survey were done. The drilling showed that the refusal depths of the previous borings had actually been due to boulders and/or very dense till. At each boring location, the bedrock (a granite gneiss) was discovered to be 10 to 30 feet deeper than anticipated. The seismic survey indicated that the bedrock surface was gently rolling, varying from approximately 10 feet below ground surface near the swamp to approximately 70 feet below ground surface on top of the site.

The boring drilled in the area between the two plumes showed that the bedrock was highly weathered and fractured. A piezometer installed in the fractured bedrock indicates that the granite gneiss is hydraulically connected to the unconsolidated glacial deposits. Therefore, groundwater is not being diverted around a shallow bedrock mound, as had been inferred from the resistivity survey and Phase I drilling, but is actually moving over this area toward the swamp at depths greater than 20 feet. A groundwater sample taken from this well was found to contain a diverse assortment of volatile organic pollutants similar in concentration to samples taken from wells within the two plumes.

A seismic refraction profile was performed over the West Trench in an experimental attempt to determine the depth of the base of the buried drums. Neither ground-penetrating radar nor metal detection was able to show the lower boundary of drums, and resistivity depth profiles revealed no readily interpretable trends. Knowing the depth of trenches is critical for estimating the number of drums in each trench. A remote sensing method that can effectively determine depth of drums would greatly aid other similar investigations for the determination of drum number and cost estimates of abatement techniques.

Buried Drum Location and Number

The location and dimensions of the trenches, which were used to estimate the number of drums in each trench, were based on a combination of data from metal detection, ground-penetrating radar, and the exploratory excavation. The results from the seismic profiling of the West Trench were used to estimate the lower limit for the bottom of the trenches, even though these data have not been confirmed. In estimating the number of drums contained in the trenches, the angle of the vertical side walls was assumed to be 60°, the angle of the declining surface of drums 45°, and the angle of descent of the trench ends 45°. The angle of repose for disturbed site soil is approximately 45°, but excavated side walls were shown to maintain a steeper slope.

Since the radar probed to a depth of 12 feet, in contrast with the 4 to 6 feet in the vicinity of the trenches for metal detection, the radar would be expected to present a somewhat more accurate indication of trench boundaries. The radar found two trenches in the "Northeast Trench" instead of the single trench identified previously with metal detection; the explanation for this is not known. On the other hand, the radar data for the West Trench had to be supplemented by data from the metal detection.

The radar provided, in addition, some useful qualitative information on the way drums were placed and on the trench construction. For example, although there were isolated instances where drums appeared to be neatly stacked, this was the exception rather than the rule. Based on the radar data, the drums appeared, for the most part, to be randomly stacked, and at least the top 8 or so feet below the surface (where individual drums most clearly could be identified), the drums appeared to be present in clusters as opposed to being uniformly dense throughout a trench. Also, the top surface of the drums displayed an "angle of repose" from the sides to the center of the trench cross-section.

The radar was not able to detect the bottom of the trenches, partly because the upper drums masked what was beneath. Even in the West Trench, where a 25-foot nominal depth was probed, the trench bottom could not be located from the data. The radar data can often be used, however, to determine the interface between the sides of the trenches and the undisturbed soil. Radar signals from within the trench are generally stronger than signals from outside the trench. This contrast is attributed to the fact that the disturbed soil within the trench has a higher dielectric constant because it is more porous and has a greater moisture content than undisturbed soil. For future work at other sites, it is suggested that deep radar probing at and just outside a trench boundary may be successful in determining the maximum depth of drums, depending on the steepness of the side of the trench relative to the radar beam, the clarity of the radar signal at this depth, and the subsurface material at the given site.

To produce estimates for the number of drums remaining buried, a theoretical trench geometry described earlier was employed. It is assumed for the purpose of the drum estimates that a 2-foot layer of soil covered the top of the burial area and that two nominal trench depths of 14 and 22 feet were used to bracket the range determined from remote sensing and direct excavation. The bottom of the trenches are assumed to be level with no irregularities. Straight sides for the horizontal widths and lengths have also been assumed.

Two densities of drums (percent of volume of drums within trench volume below the cover layer of soil) were used for the drum number estimates: 90 percent and 50 percent. A drum density of 90 percent represents the closest packing arrangement possible for cylinders without regard to interferences imposed by the actual geometry of the trench boundaries. An actual drum density of 54 percent was calculated for the Northeast Trenches using the results obtained from the DEM site representative combined with the theoretical trench geometry. The calculated 54 percent density was rounded off to 50 percent for the lower limit calculations of the drum number estimates.

The number of buried drums was estimated by calculating the volume of each trench and multiplying the volume by the assumed drum density to yield the total volume of drums (Table 2). The estimate for the number of uncrushed, 55-gallon drums is provided by dividing the total volume by the volume of a single drum (7.35 ft^3). As Table 2 shows, the overall range varies by a factor of two and a half, from 16,700 to 44,700, whereas the more likely range based upon the observed depth of the Northeast Trenches, is less than a factor of two, from 25,000 to 44,700.

The above estimates are for whole, uncrushed 55-gallon drums. These numbers will necessarily increase if some of the drums are crushed, enabling closer packing. The drum number estimates can be corrected for the presence of crushed drums by multiplying by $g/(f + g - gf)$, in which f represents the fraction of crushed drums and g is equal to the ratio of the volume of a whole drum to the volume of a crushed drum. If $g = 2$ and $f = 0.3$, for example, as indicated by the exploratory excavation of the Northeast Trenches, there would be 18 percent more drums (whole plus crushed); however, there would be 17 percent fewer whole drums.

Table 2. Estimated Number of Buried Drums Based on Extrapolation of Best Available Data*

Trench Location†	Maximum Drum Density		Drums Randomly Stacked‡	
	Nominal Trench Depth, ft			
	14	22	14	22
Northwest	14,800	22,400	8,200	12,400
West	13,500	20,200	7,500	11,200
South	1,700	2,100	1,000	1,200
Total	30,000	44,700	16,700	25,000

**Drums are assumed to be uncrushed, 55-gallon drums.*
†The two Northeast Trenches had been excavated, and 2,300 drums were removed.
‡Random stacking (indicated by results of excavation of Northeast Trenches) approximated 50 percent drums, 50 percent earth by volume in the trench below a 2-foot cover, and an assumed trench geometry as described in the text.

Before the radar survey, an estimated range of the number of drums was substantially lower than the estimates presented here. The earlier analysis plausibly assumed that the trenches with buried drums were constructed similarly to that of an unfilled trench on the site. As a lesson for other similar sites, remember that without the benefit of more accurate information, the "worst case" corresponds to a steep sided trench (with angle of repose depending on local soils as well as the method of trench construction) with depth approximately equal to the water table, to bedrock, or to the maximum feasible excavation depth.

Conclusions and Recommendations

Uncontrolled or abandoned hazardous waste sites present varying degrees of difficulty to investigators. For example, abandoned sites that are large in area and rural (with hindering vegetation or that are in areas of complex geology and hydrology represent troublesome environments for investigation. Therefore, developing approaches for thorough, but rapid and cost-effective, assessments of these difficult situations is important. In most cases, a well-designed and executed investigative program will include remote sensing techniques in addition to direct measurement. Premature action to drill wells; collect and analyze various air, water, and soil samples; or perform excavation without careful planning and proper integration of available techniques may result in unnecessary, adverse exposure to hazardous conditions and in an inaccurate or incomplete understanding of the total problem.

Remote sensing techniques may be used to provide reasonably accurate assessments of subsurface contamination, the location and extent of buried drums, and other data needs for determining appropriate methods of abatement. Since each of the techniques has limitations, not all critical information, both theoretical and site-specific, can be obtained remotely. Consequently, direct sampling should be undertaken at every uncontrolled hazardous waste site.

Table 3 summarizes the purpose, advantages, and limitations of each of the four remote sensing methods used at the Coventry site. This type of information should be consulted before developing an investigatory program. Even with disadvantages inherent in each technique, proper sequencing and phased studies can potentially result in an overall optimized approach. As the study progresses, preliminary conclusions will necessarily be modified and the nature of direct sampling activities will need to be evaluated continuously. The final conclusions should not be drawn solely from the results of remote sensing methods.

To accomplish site investigations in the most efficient manner, a systematic approach is necessary to take advantage of the information that can be extracted from remote sensing methods. A systematic approach reduces the time and cost and increases the effectiveness of direct sampling.

In general, the following two objectives must be addressed by all investigations at uncontrolled hazardous waste sites:

- determination of the nature and extent of the problem and the resulting effects on public health and the environment (both actual and potential)
- determination of environmentally sound and cost-effective methods to effectively abate the problem (if abatement is deemed necessary).

In an investigation, specific data needed to meet each objective should first be identified. After this, the various techniques available for data acquisition, both remote and direct, can be evaluated with regard to the type of information that can be obtained from each in relation to the specific conditions at the site. Although not always the case, remote sensing techniques should be used before using the more direct data acquisition methods of borings or excavations. This is not intended to imply, however, that all direct sampling should be held in abeyance. Numerous instances exist in which emergency action depends on immediate results from air, water, and soil sampling; for such cases, remote sensing techniques should be used secondarily.

Both the selection and sequence of remote sensing and direct data collection techniques should be based on the specific needs and circumstances of the given site. Additionally, the limitations of the remote sensing techniques (Table 3) should be kept in mind. Even the best combination of results obtained remotely provides only an approximate representation of subsurface condition. Finally, since the cost of such site surveys tends to be only a very small fraction of the total cost of ultimate solutions, it is generally cost-effective to apply several overlapping techniques at a site to complement one another and refine the results to support implementation of the preferred long-term solution.

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Table 3. *Comparison of Remote Sensing Techniques*

Technique	Purpose	Advantages	Limitations
Electrical Resistivity			
Lateral Profiling	• *determine lateral extent of contaminated groundwater.*	• *procedure less expensive than drilling.*	• *limited ability to detect nonconductive pollutants.*
	• *facilitate placement of monitoring wells and optimize their number.*	• *procedure more rapid than drilling.*	• *technique unsuitable if no sharp contrast between contaminated and natural ground water*
	• *monitor changes in plume position and direction.*	• *equipment light-weight, able to be hand carried.*	• *interpretation difficult if water table is deep.*
		• *survey may be conducted in vegetated areas.*	• *interpretation difficult if lateral variations in stratigraphy exist.*
			• *interpretation difficult if radical changes in topography are not accounted for in choice of A-spacing.*
			• *technique unsuitable in paved areas or areas of buried conductive objects.*
Depth Profiling	• *indicate change in contamination with depth.*	*same as above*	*same as above*
	• *establish vertical control in areas of complex stratigraphy.*		
***Seismic Refraction** (Non-explosive Method)*	• *determine depth and topography of bedrock.*	• *procedure less expensive than coring or excavation.*	• *technique unsuitable if no sharp velocity contrast between units of interest (e.g., trench containing buried drums and surrounding soil).*
	• *determine depth of trench containing buried drums*	• *procedure more rapid than coring or excavation.*	• *survey requires access road for vehicle.*
		• *survey may be conducted in vegetated areas.*	• *depth of penetration varies with strength of energy source.*
			• *low velocity unit obscured by overlying high velocity units.*
			• *interpretation difficult in regions of complex stratigraphy*
Metal Detection	• *locate areas of high metal content (e g., buried drums)*	• *procedure less expensive than excavation or radar.*	• *technique unsuitable for the detection of nonmetallic objects*
		• *procedure more rapid than excavation or radar.*	• *technique unsuitable for objects below 5 feet.*
		• *equipment light-weight, able to be hand-carried.*	• *technique unsuitable for determining number of arrangement of buried objects.*
		• *survey may be conducted in vegetated areas.*	
Ground-Penetrating Radar	• *locate buried objects (e.g., buried drums).*	• *procedure less expensive than excavation.*	• *technique unsuitable for vegetated areas.*
	• *provide qualitative information regarding drum density.*	• *procedure more rapid than excavation.*	• *data requires sophisticated interpretation.*
	• *detect interfaces between disturbed and undisturbed soil (e.g., bottom of trenches).*	• *procedure deeper penetrating than metal detection.*	• *underlying objects obscured by those above.*
	• *detect plumes of high chemical concentration.*	• *procedure yields more information than metal detection*	• *survey requires access road for vehicle.*
		• *procedure may be used over paved areas.*	

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This Project Summary covers two reports, entitled:
"Evaluation of Pollution Abatement Alternatives: Picillo Property, Coventry, Rhode Island," by N. L. Cichowicz, R. W. Pease, Jr., P. J. Stoller, and H. J. Yaffee (Order No. PB 82-103 888; Cost: $10.50)
"Use of Remote Sensing Techniques in a Systematic Investigation of an Uncontrolled Hazardous Waste Site," (Order No. PB 82-103 896; Cost: $10.50)
will be available only from: (prices subject to change)

National Technical Information Service
5285 Port Royal Road
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