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EVALUATION OF REMOTE SENSING AND SURFACE GEOPHYSICAL METHODS FOR LOCATING UNDERGROUND STORAGE TANKS

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PURPOSE AND SCOPE

Delaware Code, Title 7, Chapter 74, Section 7415 states in part: "The Delaware Geological Survey shall investigate the feasibility of utilizing aerial photographs and other new advanced techniques for locating abandoned tanks." In response to this charge, the Delaware Geological Survey has completed a survey of currently available remote sensing and geophysical tools to determine which methods may be utilized to locate underground storage tanks. Limited preliminary field testing has been performed.

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METHODOLOGY

Information regarding the various methods was obtained by researching current literature, soliciting comments from experts, and applying in-house experience. Each method was evaluated using these criteria: appropriate scale, on-site or remote, technical applicability, and potential cost. The appropriate scale criterion is used to eliminate those methods that cannot be used because their resolving power is not adequate for the problem under consideration. The on-site or remote criterion is used to separate surface geophysical methods, which must be used on-site, from remote sensing methods, which operate from a distance. The technical applicability criterion takes into account the scale and on-site or remote criteria, and how a particular tool is used to detect an underground storage tank. The potential cost considers both the cost of equipment and the cost of an individual survey. The result is a list identifying the potential methods for locating underground storage tanks and a discussion of strategies for their employment.

DISCUSSION

A computerized cartographic information data base in preparation at the DGS Cartographic Information Center shows that remote sensing data adequate for the purpose of defining likely locations of underground storage tanks are available at governmental offices in Delaware. The acquisition of new remote sensing data or the development of new remote sensing techniques do not appear to be practical for the sole purpose of locating underground storage tanks. If, however, another current problem requires remote sensing data and the data needs are similar, then the acquisition of new data should be considered.

Table 1 lists the available methods and evaluations of their applicability to this problem. Methods designated not applicable were judged so because they will not identify likely sites of underground storage tanks. For example, available satellite imagery, side-looking airborne radar, and other such remote sensing techniques cannot adequately resolve candidate facilities or, of course, tanks. The surface geophysical methods judged not applicable with some qualification are methods that have the potential for locating likely underground storage tanks, but, for a variety of reasons, are not the most effective methods.

Table 1. Evaluation of methods.

Method	Appropriate Scale	On-site (O-S)/ Remote (R)	Technical Applicability
Remote Sensing Methods			
Satellite based remote sensing methods	No	R	No
Aerial Photography (Black and white/ Color/color infrared)	Yes*	R	Yes
Side-looking air-borne radar	No	R	No
Surface Geophysical Methods			
Ground Penetrating Radar	Yes	O-S	Yes
Electromagnetics	Yes	O-S	Yes
Resistivity	Yes*	O-S	No*
Seismic Refraction	Yes*	O-S	No*
Metal Detectors	Yes	O-S	Yes
Magnetometers	Yes	O-S	Yes

*some qualification needed
Sources of information: Dobrin (1976), Sabins (1978)

Aerial Photography Analysis

Analysis of aerial photography, especially of a sequence of photographs taken over a period of time, has advantages that make it a powerful tool for helping to locate underground storage tanks:

(1) The analysis can identify many of the facilities likely to have buried tanks and the possible tank locations (e.g., gasoline stations, industrial facilities, bus or truck terminals, auto dealerships.

(2) Relatively inexperienced investigators can be trained in a short period of time.

(3) The required photographs are public information and can be found at federal, state, county, and local governmental agencies.

(4) Analysis of the entire State could be completed by one person in 12-18 months.

However, there are disadvantages:

(1) Analysis of aerial photographs can only identify sites likely to have buried tanks and areas where tanks may be buried. The tanks themselves are not visible. Each likely site identified by analysis of aerial photographs must be field checked to ascertain its current condition. Preliminary field surveys have found that many abandoned facilities and probable tank locations can be identified in the field without the aid of aerial photographs.

(2) Many farms, homes, and other buildings have buried tanks for motor fuel or heating oil. Because tanks usually are buried several feet and have no surface expression, analysis of aerial photographs cannot discriminate between suspicious facilities that have buried tanks and those that do not.

Aerial photographs are best used as a tool to locate facilities most likely to have buried tanks and areas where tanks may be buried.

Surface Geophysical Methods

These methods include metal detectors, magnetometers, ground penetrating radar, and electromagnetic devices. Surface geophysical methods are used on-site and can identify likely locations of buried objects with fair to good accuracy. Metal detectors and magnetometers detect only metallic objects (magnetometers detect ferrous metals only). It is important to realize that surface geophysical methods generally do not identify the type of object (e.g., pipe, tank, buried debris), although a highly skilled equipment operator may sometimes be able to determine the shape and composition of a buried object. Further, if there is a buried tank, its condition usually can not be determined.

For all of these methods it is important that in-the-field investigations be conducted by qualified personnel. Day-to-day operation of the equipment should be assigned to only a few people so that they become familiar with the performance characteristics of a particular equipment item. The chance for error is greatly reduced by this practice.

The preparation and analysis of field data are important procedures. The field data have to be accurately recorded (± 10 feet) on accurate maps or site plans and/or survey points need to be staked out on site if excavation does not immediately follow the survey.

Of these four techniques, the metal detector is the least expensive to purchase and operate. Equipment costs are in the range of hundreds of dollars, and extensive personnel training is not required. An individual site survey can usually be completed in one hour or less.

Magnetometers are somewhat more expensive to purchase and operate. Equipment costs are in the range of $6,000-9,000, and minor personnel training is required to operate the equipment and analyze the data (David L. Pasciznyk, personal communication). An individual site can usually be investigated in one hour or less.

Electromagnetic methods, specifically terrain conductivity meters, are fairly expensive to purchase and operate. Equipment costs are in the range of $10,000 to $25,000, and extensive personnel training is required to operate the equipment and analyze the data (Kari G. Andres, personal communication). An individual site can usually be investigated in one hour or less.

Ground penetrating radar is likewise expensive to purchase and operate, with equipment costs in the range of $16,000-30,000 (Patricia Corbo, personal communication). Extensive personnel training is required to operate the equipment and analyze the data. An individual site investigation can usually be completed in one or two hours.

EFFECTIVE USES OF REMOTE SENSING METHODS

Remote sensing and surface geophysical methods can be used to locate facilities likely to have underground storage tanks and the areas where a tank may be buried. Remote sensing and surface geophysical methods can be employed either before (prevention) or after (liability) a problem occurs. Considering the costs and inherent limitations, it does not appear to be reasonable to use remote sensing and surface geophysical methods to attempt to locate every buried tank in the State because the potential costs of damage caused by leaking underground tanks will not be equal everywhere in the State. Further, certain areas are more vulnerable to damage than others. The most cost effective uses of remote sensing and surface geophysical methods for locating underground storage tanks appear to be (in order of priority):

(1) Where a problem exists and the source or sources cannot be identified. In this case, analysis of aerial photography is a standard procedure for locating potential sources. On-site surface geophysical methods can then be used to evaluate individual sites.

(2) As a preventive measure:

   (a) In the area surrounding a well or well field that could be damaged by leaking underground tanks or areas where a leaking underground tank problem would pose the threat of explosion or fire to buildings.

   (b) In an area to be set aside for future large scale ground-water development.

   (c) In aquifer recharge areas or areas where the problem will quickly affect wildlife or people.

   (d) All other areas.

FUTURE RESEARCH

If it is agreed that remote sensing methods can be helpful to the State's Underground Storage Tank program, then a test study should be performed. It is suggested that this procedure be followed:

(1) Pick two small areas (one urban and one suburban or rural 7.5-minute area) in preventive measure category 2(a).

(2) Identify those sites likely to have buried tanks by analyzing aerial photographs.

(3) Field check each site. While checking, determine if analysis of aerial photographs was required to identify the site.

(4) Compare the cost effectiveness of aerial photograph analysis and checking each site. Determine the number or percentage of sites that were not identified by each method.

(5) Determine the more effective method for each type of area.

CONCLUSIONS

The main constraint on using remote sensing and surface geophysical methods to locate buried storage tanks is that these methods do not actually locate buried storage tanks. Remote sensing and surface geophysical methods only identify those facilities or areas likely to have buried storage tanks. Even after a probable tank location is determined by remote sensing or surface geophysical methods, its condition can be accurately determined only by excavation.

Considering equipment and investigative costs, the presently available remote sensing and surface geophysical methods appear to be best suited to cases where pollutants from a suspected buried tank are affecting the surrounding environment. The methods are marginally useful as a preventive measure. Remote sensing and surface geophysical methods might be used in specific areas of the State where leaking underground storage tanks present the greatest potential threat to water resources, people, or wildlife. A suggested procedure for evaluating the effectiveness of remote sensing methods is presented, if it is agreed that they can be helpful to the State's Underground Storage Tank Program.

REFERENCES

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Sabins, F. F., 1978, Remote sensing: W. H. Freeman and Company, San Francisco, 426 p.