Standard Guide for Locating Abandoned Wells[1]

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INTRODUCTION

This guide for locating abandoned wells, provides general procedures and suggestions for identifying the locations of wells that are installed for the purposes of oil and gas exploration or production, or for groundwater exploration, supply, monitoring, remediation, or injection, and subsequently have been abandoned. Not all areas require documentation of such abandonment; thus, this guide has been prepared to provide direction for determining the locations of those abandoned wells.

1. Scope

1.1 This guide provides an approach to selecting and implementing a program to identify the locations of abandoned wells. This guide provides descriptions of methods to be used as starting points in the search for these locations. It is not intended to be a step-by-step procedure to conduct the search program.

1.2 The described methods are approaches that have been used at many sites in the past. Other methods may be appropriate. Typically, several approaches are used to obtain acceptable confirmation of well locations. This guide is not limited to specific wells. The method chosen should be appropriate for the size of the area being searched and the type of well being located. Some well types and construction materials may preclude their detection by any of the methods described.

1.3 This guide offers an organized collection of information or series of options and does not recommend a specific course of action. This guide cannot replace education and experience and should be used in conjunction with professional judgment.

1.4 *This guide does not purport to address all aspects of exploration and site safety. It is the responsibility of the user of this guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations before its use.*

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D5092 Practice for Design and Installation of Groundwater Monitoring Wells

D5299 Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities

3. Terminology

3.1 *Definitions*—For definitions of common technical terms in this standard, refer to Terminology D653.

4. Significance and Use

4.1 Millions of oil and gas wells, water supply wells, and wells installed for environmental monitoring and remediation purposes, have been abandoned. The need to determine the locations of these abandoned wells is based on safety and

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

threats to the environment. Improperly constructed or abandoned wells may pose a safety threat to humans and animals, may be sources of brines and other undesirable fluids coming to the surface, may be conduits for transport of contamination from the surface to the substrate, or may cross-contaminate water-bearing zones in the subsurface. All states do not require documentation of the abandonment of wells and may not have specific requirements for abandonment procedures.

5. Methods for Locating Abandoned Wells Whose Locations Have Been Recorded, Observed, or Marked at the Surface

5.1 *Records Search*—Information regarding the potential location, type, age, method of abandonment, and other pertinent information about wells often can be determined by a thorough review of local, state, or federal records. Many governmental agencies have reporting requirements for both the installation and abandonment of all types of wells. Typically, oil and gas wells are controlled by separate agencies from water and environmental wells. With the recent proliferation of environmental studies, the number of agencies that may maintain these records has increased.

5.2 *Local Agencies*—Local (city and county) agencies typically retain records of oil and gas leasing agreements, tax records, plat maps, property ownership maps, and other related information. Information on municipal wells often is retained in local courthouses.

5.3 *State or Regional Agencies*—Most states or regions have several agencies that maintain records of drilled wells. Some maintain sophisticated computer databases, others maintain paper records. Location information also varies by jurisdiction and can be by township, range and section, state plane coordinate system, UTM coordinates, or latitude and longitude. Drilling logs, installation diagrams, production records, mechanical integrity testing reports, and other information often are available. Injection wells information typically also is available.

5.3.1 A starting place for well record information is a Geological Survey agency. If they do not maintain well records, they typically can provide direction to the proper agency.

5.3.2 Water well records are required in most jurisdictions. The sophistication of record keeping and location detail is variable. Health agencies often maintain records for public water supply wells.

5.3.3 Within the areas that produce oil and gas, a specific agency usually has been given the responsibility for maintaining well information.

5.4 Environmental monitoring wells have become more prolific within the last decade. Agencies typically require documentation of the installation of these wells.

5.4.1 Refer to Practice D5092 as it lists the minimum amount of information required for documentation of each installation. Guide D5299 lists information required to document the abandonment of wells.

5.5 *Interviews*—Conversations or interviews with local property owners, longtime residents, and drilling contractors often provide information about the locations of abandoned wells. Property owners often can identify specific well locations. Drilling contractors often maintain internal records of well locations. A careful explanation of the need for locating certain wells is necessary sometimes to obtain access to these proprietary data. The initial purpose for conducting the interview should dictate the type and format of interview documentation.

5.6 *Reconnaissance*—Actual site visits may identify the locations of abandoned wells whose surface locations have been marked or whose installation or abandonment have left soil disturbances that are identifiable as well-related.

6. Airborne and Space-Based Photographic and Other Methods for Locating Abandoned Wells Whose Locations Are Unknown

6.1 *Aerial Photographs*—Aerial photographs may be used to detect the surface disturbance associated with well drilling activities or the actual surface equipment. Historical photographs may document the actual drilling of now-abandoned wells. Aerial photographs may be available at many different scales and from many different sources.

6.1.1 The larger the scale of the aerial photograph, the easier it is to identify features. Photographs usually are available at a low cost. Photographs, however, may not be available for a given area or may not be at an appropriate scale. Interpretation of the photographs should be performed by trained personnel.

6.1.2 *Sources of Aerial and Satellite Photographs*—Many local and state or regional governmental agencies have archives of aerial photographs of their area of jurisdiction. In addition, a review of the local telephone directory listing of companies that provide aerial photographic services may provide sources of aerial and satellite photographs.

6.2 *Other Remotely Sensed Data*—Surface disturbances, associated either with the original well installation or with leaking fluids from an improperly abandoned well, may be detectable using various remotely sensed data. These data include, but are not limited to spectral, radar, and color infrared data acquired by satellite or aircraft. Spectral imagery may be used to detect vegetative stress resulting from either drilling activities or from the presence of saline or contaminated water leaking from an abandoned well. Thermal infrared imagery may be used to detect temperature anomalies resulting from the presence of metal casing. Spectral, color infrared, and radar imagery also may be used in textural analysis to deduce surface disturbances that may have resulted from drilling and well installation activities.

6.2.1 Most of these data are available only in digital format. Appropriate computer hardware and software, as well as personnel trained in image processing, may be necessary to use these data. Relative costs per unit aerial coverage for data acquisition and processing may be high for small search areas but low for large search areas. Ground verification of wells is necessary.

7. Geophysical Methods for Locating Abandoned Wells Whose Locations Are Unknown

7.1 In general, metal detectors and magnetometers can be used to detect metallic wells casing at various depths. Electromagnetic and resistivity methods can be used to detect both metallic well casings and fluids leaking from abandoned wells. Ground penetrating radar may be used to locate uncased wells or wells with nonmetallic casings.

7.2 *Metal Detectors*—Metallic well casings (ferrous or nonferrous) can be detected using portable metal detectors. The response of a metal detector us proportional to the area of a metal target. The larger of diameter of the buried casing, the easier it is to detect. Response also is inversely proportional to the depth of the target. The coil of the metal detector must pass directly over the buried casing in order for the casing to be detected, therefore, a closely spaced survey grid is necessary. Depth of detection for these metal detectors is usually 1 to 3 ft. Equipment usually is inexpensive and little training is required to operate it.

7.2.1 A special type of time domain electromagnetic sensor that uses relatively small loop transmitters functions as a metal detector with a greater depth of investigation and the ability to detect larger objects than convectional metal detectors.

7.3 *Magnetometers*—Ferrous metal well casings can be detected by a magnetometer survey. The response of a magnetometer is proportional to the mass of the target and is inversely proportional to the target's depth. A magnetometer may detect a buried casing that is off the side of a survey line and may detect a casing that has been cut off below the surface.

NOTE 1—The magnometer dose not have to pass directly over the target as in the case of a metal detector.

Depth of detection using a magnetometer is much greater than for any other method described. Large diameter deep well casings, such as those used in the oil and gas industry, commonly are detected by airborne magnetometer surveys. Equipment is easy to use.

7.3.1 Surface magnetometer surveys can be used to detect wells that contain ferrous metal casing at or near the surface.

7.3.2 A downhole (borehole) magnetometer may be used when the upper portion of the casing in an abandoned well is at a depth greater than the resolution of a surface survey, and there is an opening in which to lower the probe.

7.3.3 Airborne magnetometer surveys are used for general reconnaissance of an area. This method works best to locate large diameter wells, These surveys require ground verification of detected anomalies. They usually are more expensive than ground-based surveys.

7.3.4 *Sources of Airborne Magnetic Survey*

7.4 *Electromagnetic Methods*—Magnetic anomalies caused by the presence of conductive materials at the surface and in the shallow subsurface may be detected at the surface, from boreholes in the subsurface, or sometimes from the air. These methods may be used to detect either metallic casing or saline water associated with a leaking abandoned well. Measured anomalies may be small, and there may be interference from cultural sources of electromagnetic energy. Also, surveys may require close line spacings. Electromagnetic methods include both frequency and time domain methods, which require interpretation by trained personnel.

7.4.1 Frequency domain electromagnetic methods (conductivity surveys), measure the connectivity of subsurface materials by using a transmitter coil to generate an electromagnetic field that induces an electrical current in the earth. The induced current generates a secondary electromagnetic field that can be detected by a receiver coil. The magnitude of the induced current is a function of the composition and porosity of the soil and the conductivity of pore fluids. Since metallic well casing usually is more conductive than the surrounding soil, its presence may be detected by this method. Saline fluids leaking from abandoned wells often are more conductive than surrounding materials and may be detectable. Direct contact with the soil is not required for this method, and as a result, survey times may be rapid. Conductivity surveys should be conducted and interpreted by trained personnel.

7.4.2 Time domain electromagnetic methods are based on the principle that currents induced in the ground decay rapidly, producing a secondary magnetic field proportional to the conductivity of the subsurface material. By measuring the time decay of the secondary magnetic field as the induced current diffuses downward, a vertical electrical profile of the subsurface can be obtained. Depth of measurement depends on the primary (induced) field strength and range from a few meters to more than a kilometer. This method is useful especially for detecting conductive fluids, such as saline fluids leaking from an abandoned wellbore. These surveys must be conducted and interpreted by trained personnel.

7.5 *DC Resistivity*—This method may be used to detect saline water associated with a leaking abandoned well. The resistivity method is used to measure the resistance of subsurface materials to the flow of electricity. Since saline fluids are less resistance to electrical current flow than the surrounding soil, their presence can be inferred by this method, which requires interpretation by trained personnel.

7.5.1 Resistivity surveys must be correlated with known subsurface information. The indirect detection of fluids coming from an abandoned wells may be easier than the detection of the actual well casing using this method.

7.6 *Ground Penetrating Radar (GPR)*—It may be possible to locate uncased wells or wells with nonmetallic casings using ground penetrating radar (GPR). The GPR method uses high frequency radio waves to measure the transmission of electromagnetic energy through the subsurface, and its reflection by interfaces in the subsurface at which electrical properties vary. Variations in electrical properties result from changes in moisture content, bulk density, grain size, and clay content.

7.6.1 GPR is suited to detecting the disruption of subsurface layering associated with well construction or for situations in which and uncased abandoned well contains void space or homogeneous fill. Well casing also may be detected as a point reflector in a GPR survey record if the radar antenna is pulled directly over the well. Radar surveys should be conducted and interpreted by trained personnel.

8. Report

8.1 When an abandoned well, which has not been previously located, has been identified, the location and other pertinent data should be forwarded to the local, state, federal, or regional agency having jurisdictional control of the well location.

9. Keywords

9.1 abandoned wells; aerial photography; decommissioned wells; geophysical methods; remote sensing; well location

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