Surveys of Subsurface Utilities Can Reduce Risk in Plant Decommissioning

A. Edward Sciulli

Power-generating plants are being shut down, decommissioned, and demolished across the United States. This current move away from aging and less efficient power plants is largely being driven by changes in environmental and regulatory requirements, the high cost of modernizing infrastructure to meet new standards, new and more efficient power generation technology, and the current abundance of alternative cleaner fuels. When it is economically infeasible to retool existing plants to take advantage of new technology or alternate fuels, owners are electing to decommission and demolish these facilities.

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One of the many potential problems associated with decommissioning and demolition plans for long-standing power plants is the accuracy and completeness of existing plant information. This is particularly true regarding the documentation of subsurface utilities and other subsurface infrastructure. Power stations constructed in the 1950s and 1960s have usually gone through several stages of upgrades and additions to the original plant, which may have also included abandonment of older systems. In some cases, these upgrades and abandonments are well documented. However, in most instances, system modifications over the years are not well documented or existing documentation is incomplete.

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As will be discussed later, the existence and location of subsurface utilities and other subsurface infrastructure can be a significant risk factor in the planning and execution of a successful, safe, and cost-effective demolition and remediation project. Fortunately for plant owners, consultants, and contractors involved in the decommissioning and demolition process, standard guidelines exist for designating and locating existing subsurface infrastructure. Those involved in the planning and design of the demolition and remediation process should include an assessment of the subsurface infrastructure as part of the planning due diligence to decrease potential risk and, more importantly, provide for an increased measure of safety.

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WHY BE CONCERNED WITH SUBSURFACE INFRASTRUCTURE?

According to statistics compiled by Common Ground Alliance (CGA), an association of 1,700 individuals, organizations, and spon-

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sors in every facet of the underground utility industry, an estimated 335,000 subsurface utility damage incidents occurred as the result of excavations in the United States in 2013.[1] At a minimum, each incident most likely results in project delays and additional costs. However, more importantly, incidents can cause environmental contamination, hazardous material exposure, injury, or even death.

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- *Safety*—Always a top priority for any construction, demolition, or remediation project, unknown or improperly located subsurface utilities or other infrastructure can compromise worker safety during excavations or other subsurface-intrusive investigations. Specifically, active or abandoned pipelines, underground storage tanks, and electrical conduits all pose a safety hazard to excavation personnel if encountered and ruptured. Chemical exposure, fire, explosion, and electrocution are all potential risks when excavating at a power plant facility.

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- *Additional Sources of Contamination*—Operations at a power-generating facility involve the use of a number of hazardous chemicals: polychlorinated biphenyl–containing oil in equipment and pipelines; petroleum products in pipelines and storage tanks; and other hazardous materials that may be contained in wastewater, sludge, and ash transported through subsurface piping. If unknown subsurface infrastructure containing such hazards is ruptured, the potential exists for creating significant environmental impacts to facility soil, groundwater, and/or nearby surface waters. These potential impacts will most likely result in additional remediation costs and project delays.
- *Remediation Efforts*—Soil, groundwater, and other environmental media remediation could be a substantial portion of plant-decommissioning efforts, depending on the impacts generated over the life of the plant operation, regulatory requirements, or the site's planned future use (e.g., additional remediation efforts may be implemented if redevelopment is planned for future commercial/residential use). Planned remediation efforts are usually based on assessments or investigations of site soil, groundwater, and other environmental media. However, subsurface utility networks and structures can create potentially significant alterations to the site subsurface, which could influence local groundwater flow gradients and patterns, affect contaminant fate and transport, and possibly act as preferential pathways for contaminant migration. If these existing networks or portions of existing networks are unknown at the time of assessment, then identification of source areas, estimates of contaminant transport, or identification of migration patterns may not be accurate. Remedial actions conducted may result in incomplete remediation if they were based on assessments that did not take into account unknown underground storage tanks, preferential flow of groundwater, or vapors along a subsurface utility trench.
- *General Obstructions*—Whether it is demolition activities, site remediation efforts, or site redevelopment/construction, unknown subsurface utilities and other subsurface infrastructure can present a barrier, or at least a hindrance, to planned activity. At a minimum, encountering previously unknown subsurface infrastructure during these activities will likely result in project delays and additional costs due to the following: redesign of planned construction or remediation system installation, adjust-

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ments in means and techniques to complete the planned activity, unforeseen utility relocations, and possibly additional soil or groundwater remediation.

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WHAT SHOULD BE DONE TO REDUCE THESE RISKS?

It is important to understand that the above-referenced estimate of subsurface utility damage incidents includes excavation sites for which subsurface utility one-calls (811) and mark-outs were completed. Public utility locators responding to an excavation one-call are only required to mark out utility purveyor-owned lines, usually to a meter or specific valve servicing the private property. Public utility locators are not responsible for mark-out of privately owned utilities and would not possess drawings or plans that indicate the assumed location or layout of said utilities or other infrastructure. As the majority of subsurface infrastructure located beneath the power plant property is privately owned, it is the responsibility of the owner, or the owner's consultant/contractor, to assist in mitigating the above risks.

Given the magnitude of a general decommissioning and demolition project, owners, consultants, and contractors should consider engaging a consultant experienced in Subsurface Utility Engineering (SUE) to assist in locating and possibly identifying subsurface utilities and other subsurface infrastructure within the project site. SUE is a process that combines civil engineering, surveying, and surface geophysical remote sensing techniques. It was generally born from the need to apply more stringent guidelines and procedures to the collection and depiction of subsurface utility data for highway construction and renovation projects. The selected consultant should be able to demonstrate the following: a high level of competence demonstrated through knowledge and understanding of the SUE process, experience in successfully completing the process at other industrial sites, and expert knowledge regarding the proper application and limitations of the equipment used.

The SUE process has been adopted by many states' departments of transportation and has become a requirement for many federally funded projects. More recently, the SUE process has been gaining ground in applications for other construction and renovation projects, especially for industrial facilities, as the demand to limit risks (e.g., unanticipated costs) increases.

The SUE process allows engineers and other consultants to quantify the quality of the information, because the process follows a specific standard for collecting and depicting subsurface utility and other subsurface infrastructure information on construction, excavation, and remediation plans and drawings.

THE SUE PROCESS

The American Society of Civil Engineers (ASCE) published the current standard defining the SUE process in 2002.[2] In general, this document was produced to standardize the SUE process and define quality levels for depicting collected data.

The SUE process consists of several sequential steps. Depending on the project scope, which may require SUE across the entire plant or just specific excavation or remediation areas, all steps may not be conducted. Alternatively, steps may be combined.

In general, the SUE process consists of the following:

- *Research*—This step involves the review of existing plant information regarding subsurface utilities and other infrastructure. The research step generally includes a review of all available maps and drawings that contain information on subsurface utilities and infrastructure, including details and cross-sections. This information, which is usually only available in paper copies or scanned images, is sometimes digitized for later use in design, excavation, and remediation plans. This step may also include interviews with long-time plant personnel or others with knowledge of subsurface infrastructure at the facility. Data depicted to this level of accuracy are defined as Quality Level D.
- *Surveying*—The surveying step can be considered a "ground truthing" of the research step described above. Information is ob-

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tained from recent, existing surveyed mapping of the plant or from conducting project-specific surveying and plotting of visible and accessible above-ground utility features (manholes, storm water intakes, valves and valve covers, and other features). Information gathered during this stage is then correlated, using professional judgment, with the results of the research step discussed above. At this point, discrepancies between the existing record and actual "ground truthing" data can be identified. Data depicted to this level of accuracy are defined as Quality Level C.

- *Designating*—Designating under ASCE 38-02 is defined as the process of using surface geophysical (remote sensing) methods to interpret the presence of a subsurface utility and mark its horizontal position on the ground surface. The designating surveys generally employ specialized procedures and equipment to investigate relatively shallow objects (utilities) at discrete locations. Prior to initializing a survey, specific search area boundaries are established across the site and are posted on existing facility plans and maps. The search areas are delineated based on surface area, expected density of utilities, potential access restrictions, and/or completion priority. Once established, utility surveys proceed in a phased approach by search area or group of search areas, as appropriate. This approach assists in establishing priority areas across the facility and provides a vehicle to track survey progress and completeness.

  A combination of geophysical methods is usually employed to increase survey accuracy. Geophysical techniques typically include a combination of radio frequency (RF) surveys, ground-penetrating radar (GPR), and magnetic and/or electromagnetic (EM) methods. These techniques are nondestructive and only require surface measurements.

  - RF data are collected using an EM transmitter/receiver system. These devices operate in both a passive and active survey mode. The passive survey mode requires no signal transmitter. Existing electrical currents in buried utilities producing secondary magnetic fields in the 50/60 Hz range are detected with the RF receiver. The active survey mode requires the use of a signal transmitter designed to produce a voltage of known frequency and "signature," and the means of applying it to the target buried conductors. Two active modes are available: direct connection, where the signal generator is connected directly to a pipe or cable at an access point such as a valve, meter, or end of the conductor; and induction, where the signal transmitter sets up a magnetic field through the coil returning through the earth below.

    A conductor lying parallel to the coil is linked by this field. Therefore, it has a voltage induced in it. The RF receiver can detect secondary fields produced as the result of the direct connection or induced signal.
  - GPR systems radiate repetitive, short-time-duration, EM pulses into the earth from a broad-bandwidth antenna placed on the ground surface. Buried man-made objects or features produce dielectric discontinuities in the subsurface, which reflect transmitted pulses back to the surface antenna. Towing the surface antenna along profiles collects continuous data. GPR profiles are established at each search area based on the suspected density of utilities and the results of the RF survey described above. Data are usually collected in two perpendicular directions across each search area, as appropriate.
  - Magnetic and/or EM surveys may be used in select search areas containing very few surface structures. These methods are effective for covering large areas in a short time frame. However, these methods provide a greatly reduced target resolution relative to the RF and GPR methods described above. These methods are generally effective in searching for deeper, large-diameter utility lines or larger subsurface objects, such as underground storage tanks and foundations.

    A magnetometer/gradiometer makes magnetic measurements. This instrument simultaneously measures the amplitude of the earth's magnetic total field with a sensor affixed to the top of a staff and the vertical gradient of the total field between the top sensor and a lower one. Variations in the earth's magnetic field caused by ferrous metal objects are detected.

- A time-domain metal detector collects EM data. The transmitter generates a pulsed primary magnetic field into the soil, which induces secondary currents in nearby metallic objects. Decay of the induced currents produces a secondary magnetic field measured by the receiver coil. By recording data some time after the start of the decay process, the current induced into the ground is fully dissipated and only the current in the metal object is still producing a secondary field. The result is detection of only the conductive metal objects beneath the site.

The effectiveness of each geophysical technique depends on the target of interest, site geology/hydrogeology, surface cover, and potential interference from surrounding surface features. The final selection of techniques is usually made based on initial field testing, physical characteristics of individual search areas, and potential targets of interest.

Interpreted utility or other geophysical anomaly locations are marked on the ground surface using paint or other markers (flags, stakes, or other instruments). When possible, interpreted utilities are marked in accordance with the American Public Works Association Uniform Color Codes.[3] Markers are then surveyed using conventional survey techniques or global positioning systems (GPSs). Data depicted to this level of accuracy are defined as Quality Level B.

- *Locating*—Locating under ASCE 38-02 is defined as the process of exposing and recording the precise vertical and horizontal location of designated utilities and, when possible, providing the utility type, size, and configuration. In order to verify the existence and precise location of utilities interpreted from the geophysical survey conducted under the designating stage, test pits are excavated at designation stage markings. Interpreted utilities, identified critical utilities, potential utility conflict areas, and/or geophysical anomalies interpreted as possibly representing some other subsurface obstruction are investigated on an as-needed basis. The number and locations of excavations, if any, are determined jointly between the owner, the owner's design consultant, and the SUE consultant.

Test pits are generally excavated using nondestructive excavation techniques such as hydro excavation or air-knife. These techniques are a safe and efficient alternative to traditional mechanical excavation and provide a means to excavate soil and material with minimal risk of damage to underlying materials. Hydro excavation is a combination of high-pressure water jetting and high-volume vacuum. Air-knife excavation is a combination of high-pressure air jetting and high-volume vacuum. The selection of excavation techniques will depend on facility-specific characteristics and planned depth of excavation. Once test pits are opened and the subsurface utility is exposed, additional surveys are conducted to record the precise location and vertical position. Data depicted to this highest level of accuracy are defined as Quality Level A.

- *Data Management/Conflict Analysis*—The data management process consists of the correlation of data gathered during subsequent steps and transferring this information to project demolition, excavation, and remediation plans and drawings. Data are depicted by data quality designation indicated above (i.e., Quality Level D, C, B, or A) and should include all information gathered. At this time, a conflict analysis may be performed. The conflict analysis is an engineering process to evaluate and compare depicted utility information with proposed demolition, excavation, and remediation plans.

This step is completed to provide owners and design engineers with information regarding potential hazards associated with planned activities.

SO WILL THIS PROCESS ELIMINATE MY RISK?

As mentioned earlier, existing plant data depicting the locations and types of subsurface utilities existing beneath the site are usually dated and incomplete. Although useful, relying on this data alone does little to eliminate or even

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greatly reduce the risks of encountering undocumented subsurface facilities.

Relying on existing plant data alone does little to eliminate or even greatly reduce the risks of encountering undocumented subsurface facilities.

Implementing geophysical surveys to verify and supplement existing data can reduce the risks associated with unknown subsurface utilities. However, geophysical surveying, as with any remote sensing endeavor, is not an exact science, and results usually cannot be warranted or guaranteed. Several factors, including the proximity to surface noise features, subsurface soil chemistry, soil moisture, surface pavement, and the physical condition of subsurface targets, can negatively impact the effectiveness of geophysical and other remote sensing surveys. Depending on site conditions, the above-surface geophysical devices and techniques cannot necessarily detect or describe the precise size, location, and other characteristics of subsurface utilities and infrastructure.

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To verify the precise horizontal and vertical position of subsurface infrastructure with 100 percent accuracy, the only method currently available to owners and engineers is to expose the utilities in excavations and directly measure their positions. However, this method would generally be cost- and schedule-prohibitive when applied to a power plant decommissioning and demolition project.

SO WHAT ARE THE BENEFITS?

Owners and engineers should view the procedures and techniques described earlier as a due diligence step in the decommissioning and demolition process. Most importantly, implementing the SUE process, whether for specific project areas or across the entire project, can provide an additional level of safety relative to planned excavations associated with demolition or remediation activities.

The risk of environmental issues associated with unanticipated releases from the rupture of unknown subsurface utilities, storage tanks, or other facilities can be greatly reduced. Better understanding of the existence and location of these subsurface features would allow design engineers to plan proper mitigation procedures for managing possible hazardous materials or petroleum products.

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A more complete account of the existing subsurface utility network will provide environmental professionals involved in site remediation activities with a better understanding of the possible impacts to groundwater flow patterns, potential sources, and migration and preferential contaminant transport pathways. A more comprehensive understanding of these processes should lead to more complete and efficient remedial plans and actions.

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Finally, a more thorough and accurate understanding of the plant subsurface infrastructure should result in a reduction in contractor delays from encountering unknown subsurface features, unanticipated utility relocations as the result of excavations and remedial action implementation, and reduction in the potential need for delays due to redesign of excavation or remedial actions. As every owner, engineer, and contractor involved in plant decommissioning and demolition activities knows, reduced design and implementation delays directly equate to reduced overall project costs.

NOTES

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