Taking a geophysical approach to risk reduction

EM Induction equipment is ideal for carrying out basic utility locating. However, it cannot be used to detect non-conductive features such as concrete or plastic pipes.

By Kevin Vine

Just last May, a 21 year old man was seriously injured when a gas main burst into flames at a shopping plaza in Sydney, Australia. Parts of the Plaza, known as Lane Cove, were under construction, and the main was accidentally struck during the course of a regular work day. Closer to home, in 2011, crews were repairing a broken watermain on Woodroffe Avenue in Ottawa that had caused pavement to collapse while impacting the water supply of almost 11,000 homes. During the repair, a gas line was severely damaged, creating major project delays and road closures.

There is little doubt that awareness of safe digging practices has vastly improved over the last decade: the recent passing of Bill 8 which mandates that all public utilities become part of the ON1Call system is evidence of this growing awareness. However, the stats remain fairly dim. The 2012 DIRT Report produced by the Common Ground Alliance revealed that over 200,000 incidents of damage to underground infrastructure had occurred in the previous year across North America.

Part of the issue lies in a general lack of awareness about the range of technologies and techniques that are available to accurately locate almost any type of buried or embedded structure. By leveraging only basic locating equipment, difficult-to-find subsurface utilities and other features regularly remain undetected by the locate industry.

Contrary to popular belief, no single technology can locate utilities effectively for all site conditions where utility composition and depth varies. The solution lies in applying a range of geophysical techniques, matching the right technology to the task and ensuring that data is captured and interpreted by trained, technical experts. Here's a look at some of the tools and techniques available today and when they should be applied to mitigate project risk.

With GPR, an embedded object can be located by scanning only one side of the concrete. This differs from X-Ray which requires access to both sides and is hence limited to elevated concrete slabs.

Electromagnetic (EM) induction

Ideal for basic utility locating

This common locating equipment operates by sensing either a background signal or a signal introduced into the utility line using a transmitter. It works by connecting directly to a piece of utility hardware and sending a signal down that is then returned to the transmitter, setting up an electric circuit.

An induction clamp can also be used which is placed around conduits or exposed cables. Coils of wire in the clamp are energized by the transmitter and produce a magnetic field that is transferred onto the cable which must be fully grounded at both ends of the line. Typical applications of EM Induction include locating metal conduits related to water, electricity, telephone and communication cables.

EM Induction is ideal for basic locating, but has several limitations. It's only effective if the subsurface utilities are composed of electrically conductive material or are equipped with tracer wires. It cannot be used to detect non-conductive materials such as PVC or concrete. Furthermore, a direct connection to the utility is required to perform the locate which is not always possible to achieve. It also does not provide detailed data on the depth of underground plant. Projects that require deeper analysis should incorporate more sophisticated surveying tools such as ground penetrating radar.

Ground penetrating radar (GPR)

The solution to finding "un-locatable" buried infrastructure

GPR is a non-destructive technology that works by transmitting high-frequency radio waves into the ground or structure and analyzing the reflected energy to create a profile of the subsurface features. The reflections are caused by a contrast in the electrical properties of subsurface materials which can be indicative of water content, void spaces in the ground, buried concrete, PVC and other utilities as well as geophysical properties such as bedrock and changes in material layers.

The technology is able to detect anomalies deep below the surface that indicate both metallic and non-metallic features. It can also provide detailed data regarding the depth and position of underground plant for projects that require information above and beyond the marked locations of utilities. It's an ideal solution for sites that may contain non-conductive utilities such as concrete sewers, watermains and storm drains that can't be identified with basic locating equipment. Or simply, in cases where tracing wire has shifted or corroded due to frost or age. GPR is also ideal for project sites where there's no access to the buried plant because the technology does not require a direct connection. With more and more utilities being comprised of durable PVC materials, the use of GPR is steadily increasing among civil construction and engineering projects.

GPR is also increasingly replacing X-Ray techniques for identifying buried features in concrete. A typical challenge with X-Ray is that it is limited to elevated concrete slabs because technicians require access to both sides of an object. In contrast, a GPR scan can be conducted on a single side of the concrete and can also detect anomalous features such as void spaces in new concrete construction pours.

GPR has few limitations but the depth of penetration can be affected by soil conditions and this should be considered on a project-by-project basis. For example, project sites com-

A GPR scan picks up on anomalies deep below the surface that are indicative of both metallic and non-metallic features, providing detailed data on depth and position.

prised of dry soil with little salt content yield excellent results, but heavy clay-based soils can be difficult to penetrate.

Time domain electromagnetic (TDEM)

For identifying conductive materials over large swaths of land

TDEM survey equipment functions like a large metal detector and is well suited for locating assets such as metal pipelines or buried underground storage tanks across a vast project area, (though it is only suited to identifying electrically conductive materials). It works by generating an electromagnetic field that induces a current in the earth which in turn causes the subsurface to create a magnetic field. By measuring this magnetic field, subsurface properties and features can be revealed.

It's highly effective at detecting shallow and deep-buried metal objects, both large and small. For example, a single buried 55-gallon drum can typically be detected to a depth of three metres. This makes it ideal for projects that might require underground storage tanks and other buried metallic features to be uncovered across a large property. Because no contact with the ground is required, TDEM can cover a large area quickly. Once data is collected, it can be mapped to show subsurface anomalies indicative of metallic features within the site.

However, much like GPR, the effectiveness of TDEM can also be affected by soil conditions. For example a project site comprised of clay could prevent the ability to energize the earth. In this case, there are a range of other surveying options available including seismic techniques which propagate acoustic vibrations into the earth that are reflected back to the surface in order to depict subsurface features. Another option is magnetometry which detects ferrous metal buried tanks, utilities, drums and other objects by sensing distortions generated by the earth's magnetic field. This technology does not require the charging or sending of electromagnetics or sound into the subsurface.

A final thought

Construction is booming in Canada with more than $4 trillion worth of assets currently being repaired and maintained. Across the board, every project big and small struggles to maintain its projected schedule while operating safely. The biggest problems are usually the most unexpected such as a cut conduit, damaged gas line or burst water main.

The simple truth is, if a buried asset exists within a project area, it must be accurately located prior to construction, no matter the material, or there's no telling what the outcome could be: from construction delays, to project redesign to a dangerous accident. As such, it's often necessary to extend beyond basic EM induction to leverage geophysical methods that allow for complex data recording during the field survey. This captured data supports informed evaluation prior, during and after a project, as well as more advanced interpretation of subsurface features not otherwise possible.