

Subsurface Utility Engineering: A Proven Solution

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Abstract

A lack of reliable information for the location of underground utilities can result in costly conflicts, damages, delays, utility service disruptions, redesigns, claims injuries and even lost lives during construction activities. While the location of subsurface utilities might be found on plans and records, experience has often shown that the utility locations are not exactly as recorded or the records do not fully account for the buried utility systems.

An engineering process known as subsurface utility engineering (SUE) has proven to be a welcome solution to providing this much-needed underground utility information. Combining geophysics, surveying, civil engineering and nondestructive excavation technologies, SUE can provide accurate mapping of existing underground utilities in three-dimensions during the design phase to avoid unnecessary relocations, eliminate unexpected conflicts with utilities, and enhance safety during construction.

The use of Subsurface Utility Engineering services has become a routine requirement on highway and bridge design projects in the United States, and is strongly advocated by the Federal Highway Administration (FHWA), American Society of Civil Engineering, American Association of State Highway and Transportation Officials and state departments of transportation. A study sponsored by the FHWA found that \$4.62 (approximately \$5.68 UAD) for every dollar spent on SUE was saved on overall project costs. This figure was quantified from studying 71 projects that had a combined construction value in excess of \$1 billion. Qualitative savings were non-measurable, but it is clear that those savings are also significant and may be many times more valuable than the quantifiable savings. In a similar study conducted in Canada commissioned by the Ontario Sewer and Watermain Construction Association, the University of Toronto's Centre for Information Systems in Infrastructure and Construction discovered an average savings of \$3.41, Canada, (\$3.79 AUD) for every dollar spent on SUE.

In addition to highway designs, SUE is gaining strong endorsement by other industries and market sectors involved with design of construction projects which affect underground utilities. The Federal Aviation Authority has developed a DVD, released in early 2009, entitled, "Underground Update" to explain the benefits of SUE to the airport industry.

What is Subsurface Utility Engineering?

Subsurface utility engineering is a highly-efficient, nondestructive engineering practice that combines geophysics, surveying, civil engineering and asset management technologies. Used appropriately and performed correctly, SUE identifies and classifies quality levels of existing subsurface utility data and maps the locations of underground utilities. The data allows for developing strategies and informed design decisions to manage risks

and avoid utility conflicts and delays. If a utility conflict does exist, viable alternatives can be found to resolve the conflicts before any damage is done.

In 2003, the American Society of Civil Engineers (ASCE) published the *Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data*. This standard formally defined SUE and set standard guidance for collecting and

depicting underground utility information, which elevated SUE to a new level.

The ASCE standard presents a system of classifying the extent of existing subsurface utility data gathered into quality levels. Such a classification allows project owners, engineers and constructors to develop strategies to reduce or allocate risks due to existing subsurface utilities. The standard closely follows concepts in place in the industry. This enables users of SUE to be “in compliance” with this standard through their use of SUE or through their inclusion of SUE specifications in their engineering contracts.

The Process

The three major activities of designating, locating, and data management can be conducted individually to meet the specific needs of a given project, but are most advantageously used in combination to create a complete three-dimensional mapping of a utility system. While the practice of SUE is tailored to each project, the process typically follows:

- The first step in the investigation is to gather utility records from all available sources. This may include as-built drawings, field notes, distribution maps and even recollections from people who were involved in the planning, building or maintenance of the utilities in question. All the data is then compiled into a composite drawing and labeled ASCE Quality Level D.
- A site visit is also made to find visible surface features of the existing underground utilities (e.g., manholes, pedestals, valves). This site visit may be conducted at the same time that the topographic survey is completed for the project. This information is added to the composite drawing completed during the ASCE Quality Level D record research and upgraded to ASCE Quality Level C.

- At this point a decision is made as to which utilities may have an impact on the proposed design and warrant further investigation. Using a variety of geophysical techniques (e.g., pipe and cable locators, ground penetrating radar), the horizontal position of these critical utilities is determined. This information is compiled into the utility drawing as ASCE Quality Level B data.
- By taking utility information from the Quality Level B data at this point and referencing it with the proposed design, utility conflict areas are identified and organized in a database known as a conflict matrix. The conflict matrix identifies conflicts (existing utilities crossing the path of the proposed design) and allows the designers to make educated decisions regarding relocation or redesign. When using the plans, be sure to not only use the plan views but the cross-sections, drainage profiles and staging plans as well. Many times, significant conflicts will appear on these sheets and not on the plan sheet by itself.
- Once conflicts are identified using the conflict matrix, the final step in the data collection process is to excavate test holes at key locations where the exact size, material type, depth and orientation of the utilities being investigated are identified. The test hole information is surveyed and included in the utility drawings, which are now ASCE Quality Level A.
- The additional data gathered from the completed test holes is added into the conflict matrix. At this point, designers are able to review all options the conflict matrix presents and decide the most economical course of action.

When utility owners and design teams work together, mutually-beneficial strategies can be applied. Besides significant cost savings and drastically reduced construction delays,

utility owners are more likely to complete relocations when presented with a utility conflict matrix. This demonstrates that all other options have been thoroughly investigated, rather than the previous method of forcing utilities to move facilities without much apparent forethought. Cooperation is yielding and more desirable results are obtained.

Not Just for Highways

The term "Subsurface Utility Engineering" was coined at the 1989 FHWA National Highway Utility Conference. The FHWA quickly accepted this term, adopted a prime advocacy position, and continues to promote the use of the Subsurface Utility Engineering process in all highway and bridge design projects. Today, through the efforts of the FHWA in documenting and promoting the significant return on any dollars invested in the Subsurface Utility Engineering process, over 40 State highway agencies are using Subsurface Utility Engineering on their projects.

In addition to highway design, Subsurface Utility Engineering is gaining strong endorsement by the FAA and the United States military for use in design of construction projects involving congested underground utilities. Typical applications include construction of underground utilities like sanitary force mains and petroleum oil and lubricant (POL) lines, upgrades to utilities on wharves, airfield runway/taxiway repairs, new site development, and utility system management.

The same technologies used in the Subsurface Utility Engineering process can also find more creative applications in environmental restoration programs. For example, the surface geophysical and nondestructive vacuum excavation technologies represent an alternate means to identify, expose, and possibly characterize buried objects such as underground storage tanks or objects in landfills that may be a source of environmental release or explosion if

disrupted by more aggressive excavation equipment. In cases where contamination is detected in subsurface holding tanks or catch basins, utility-locating technologies can be used to trace the various pipelines entering the tank/basin back to possible sources of the observed contamination. Vacuum excavation also provides an alternative for the highly controlled removal of soil around buried utilities or other sensitive structures such as security systems.

Whereas cost savings resulting from the avoidance of utility conflicts have been the primary driver for the use of the Subsurface Utility Engineering process in highway projects, many of the aforementioned applications at military installations may find their primary value in reduced construction time and in increased safety of workers and the public. Recognizing the level of importance placed on personnel safety and the degree of upfront planning and review typically carried out to assure a safe working environment, it would be of great advantage to know with certainty the location of potentially impacted utilities at the planning stage, prior to contract bidding and field mobilization.

For maximum effectiveness, the Subsurface Utility Engineering process should be incorporated early in the development of every project that may have an impact on underground utility facilities, particularly in built-up areas. When subsurface utilities are discovered during the construction phase, the costs of conflict resolution and the potential for catastrophic damages are at their highest. That is why the collection and systematic depiction of reliable data for existing subsurface utilities is critical if engineers are to make informed decisions and support risk management protocols regarding a project's impact on these utilities.

Allocation of Risk

The fact that readily available information on utility locations is often incomplete and

inaccurate has been a “given” among project owners, engineers, and contractors for decades. One can easily relate to the following scenario that has been played out on many military construction projects in response to this informational uncertainty and the associated risks:

- The project owner would initially assign responsibility for utility mapping to the design engineer by including general language in the scope of work. Typically, the standard of practice for the design engineer would be to compile utility information from the utility owner, local public works files, oral recollections of “old timers”, and other readily available sources of such data, and then to correlate this information with the site survey for the project. This information corresponds to ASCE Quality Levels D and C.
 - Recognizing the likelihood that utilities would either be missed or erroneously located through this process, the design engineer would include a disclaimer on the plans. In essence, the disclaimer would pass the responsibility for underground utilities on to the construction contractor. Either the project owner or the contractor would rarely challenge such disclaimers, and thus the design engineer would incur minimal risk for any errors related to utility depictions on the design plans.
 - Facing a bid competition, and recognizing that project owners are typically held responsible for delays and costs associated with “unknown” or “differing site conditions,” contractors would have no option other than to assume that the utility depictions on the plans were complete and accurate.
- At the start of construction, the “one-call” statutes would often result in utility owners coming into the field and marking expected utility locations during construction. These locations may or may not have coincided with the design plans.
 - As a result, the project owner would often face a situation in which: (1) the initial construction bids would likely have a contingency built in to account for the informational uncertainty surrounding underground utilities and the likelihood that claims would have to be developed and negotiated; (2) the contractor would secure a preferable position since any additional work would be negotiated and performed outside of a bid situation; (3) the financial risk would be magnified by the potential costs of construction downtime, schedule delays, redesign, and utility relocation; and (4) a worst-case scenario could develop that may involve utility damage, service outages, consequential damages, and injury to works and the public.

Over the years, four events began to change this scenario. First of all, the convergence of new equipment and data-processing technologies now allows for the cost-effective collection, depiction and management of existing utility information. These technologies encompass surface geophysics, surveying techniques, computer-aided design and drafting and geographic information systems, and minimally intrusive excavation techniques. Secondly, competition in the marketplace has allowed project owners to shift more responsibility and liability to the design engineers and contractors. Thirdly, there has been an overall growth in the litigious nature of society and the associated increase in risk to all parties involved in design and construction projects. And fourth, the birth of Subsurface Utility

Engineering in the 1980's as a distinct service. The subsurface utility engineer became the individual with the appropriate expertise and tools to allow construction activities to be planned away from high risk utilities when possible, to characterize the nature of utility conflicts before work begins in the field, to coordinate utility relocations and easements, and to develop utility "as built" that are complete and accurate.

The Value

University of Toronto Study: *Evaluating the use of Subsurface Utility Engineering in Canada*

The market for SUE in Canada is slowly following its U.S. counterpart. In Ontario, the market for SUE has seen rapid growth especially on large-scale municipal projects. The University of Toronto study presents the results of a 12-month study that investigated the challenges and opportunities facing SUE in Ontario. The study took an in-depth look at nine large municipal and highway reconstruction projects that utilized SUE to provide an enhanced depiction of buried utilities. Based on this analysis, a cost model for SUE utilization was proposed that takes into account both tangible and intangible benefits. This model was applied to gauge the expected cost savings due to SUE utilization on these nine projects. All projects showed a positive return-on-investment (ROI) that ranged from \$2.05 to \$6.59 (Canadian) for every dollar spent on SUE. Although these ROI figures should not be considered universal, they indicate that with careful scoping of SUE services, project risks can be appropriately reduced at reasonable cost.

Purdue University Study: *Cost Savings on Highway Projects Utilizing Subsurface Utility Engineering*

Purdue University's study was published and distributed in 2000. A total of 71 projects from Virginia, North Carolina, Texas and Ohio were studied. These projects involved a mix of interstate, arterial,

and collector roads in urban, suburban, and rural settings. Two broad categories of savings emerged: quantifiable savings and qualitative savings. An average of \$4.62 (U.S) in avoided costs for every dollar spent on SUE was quantified. Qualitative savings were non-measurable, but it was clear to the researchers that those savings were also significant and were possibly many times more valuable than the quantifiable savings. It was concluded that SUE was a viable technologic practice that reduced project costs related to the risks associated with existing subsurface utilities and should be used in a systemic manner.

Summary

The technology is now available to achieve a complete and precise three-dimensional mapping of subsurface utilities prior to or at the design phase of a project. If Quality Level A information is collected through the full use of the Subsurface Utility Engineering process, the project owner, design engineer, and contractor can proceed with confidence that utilities have been identified and categorized as to their horizontal location, depth, size, composition, and condition. The use of the Subsurface Utility Engineering process will continue to grow as project owners request higher quality levels of utility information to reduce and better manage their risks. In the end, the use of Subsurface Utility Engineering will tend to shift the risk of bad information to the party most capable of handling that risk – the subsurface utility engineer.

Related cost analyses have shown that the use of the Subsurface Utility Engineering process provides a significant return on investment. As a very rough rule of thumb, the cost of incorporating the Subsurface Utility Engineering process is about 10 percent of the total preliminary engineering cost, or about one percent of the total project cost. These costs are small when compared to the overall savings on projects where the Subsurface Utility Engineering process is used.

In this era of partnerships, Subsurface Utility Engineering represents a new way of doing business, in which the past adversarial relationship among project owners, design engineers, utility companies and contractors has been replaced by a cooperative effort to reach an appropriate balance between the risk of informational uncertainty and the associated cost of reducing that risk.