YDiG?

BC's Magazine for Trenchless Construction

NASTT BRITISH COLUMBIA CHAPTER

2019

Trenchless Solutions for B.C. Infrastructure

Official Publication of the North American Society for Trenchless Technology • British Columbia Chapter

www.nastt-bc.org

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The Province of BC is the first regional government in the world to actively provide a mechanism to measure carbon reduction, using Trenchless Technology.

Trenchless technologies are viable and proven methods to install, repair and replace pipes with many advantages over open cut methods.

Early in 2019 final approval has been granted to use the Carbon Calculator, a tool developed by the Nastt-BC that allows for the calculation of carbon savings using trenchless over open cut methods.

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Y-DiG?

North American Society for Trenchless Technology - BC Chapter

FEATURED...

Sliplining

Rehabilitation of a section of aging steel pipe was the final phase of a Metro Vancouver project in Burnaby

Prepared

SUE data safeguards against unpleasant surprises that could endanger a project's prospects for success

On Track

One example of a project utilizing all aspects of SUE is the TTC Union Station Expansion in Ontario

ALSO...

COVER PHOTO: Metro Vancouver

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Ophir Wainer
NASTT-BC Chair

Going Green in B.C.

I have had the pleasure of taking the helm of NASTT-BC this year, and it has been a great year for trenchless. I have just returned from NASTT's 2019 No-Dig show in Chicago, and the technology, papers and presentations there were fantastic. This reminds me that in early May we at NASTT-BC along with CATT will be hosting the Trenchless Technology Road Show here in our home province at the Sheraton Vancouver Airport Hotel. I think back to the last TTRS held here and I smile. The sessions, vendors and just the people that attended were first rate. This was truly a welcoming and informative few days I had, being in a smaller, more intimate location. The smaller venue had the advantage of networking with peers and colleagues alike and had a more local feel to it, a feeling of home.

B.C. has been a leader in the push for "going green" in the fast-moving world and the evolving political climate we live in. This ties in with our theme this year for the Road Show, which should be our general statement for the use of trenchless technologies in B.C.: Going Green.

In past years, through the advocacy of the current membership and leadership team, great strides have been made in attaining the recognition that using trenchless technologies is the green choice. Reducing traditional practices and replacing them with trenchless innovations saves time and money and reduces our carbon footprint. This was first established through the introduction of the trenchless Carbon Calculator by NASTT-BC, and as you will read elsewhere in this edition of Y-DIG?, now the B.C. government will allow the use of trenchless to be a recipient of Green carbon capture credits. The issuing of Green credits will greatly affect our businesses and should raise the bar and anticipated use of trenchless methods in B.C. We have a great opportunity to spread the word and usher in this new era of accountable construction practices through the responsible use of trenchless technologies.

"B.C. has been a leader in the push for 'going green' in the fast-moving world and the evolving political climate we live in."

All of the efforts put forth by NASTT-BC are only as strong as our membership, and an active trenchless community can only be maintained by participation and advocacy. This is a call to all members of the community to participate in NASTT-BC events and promote trenchless in their own workplaces. This year of Going Green can be our call to advocate and educate our respective workplaces, and assist in establishing the new normal by using trenchless technologies and reaping the mutual benefit of carbon capture credits to the project owner and increased awareness of trenchless technology.

No-Dig Success

Craig Vandaelle
NASTT
Chair

Hello, British Columbia Chapter Members! As the year develops we're looking forward to the continued growth of the trenchless industry and our Society. We've just wrapped up another impressive conference as NASTT's 2019 No-Dig Show in Chicago was highly successful on all accounts. The exhibit hall featured over 200 exhibitors, which is the most we've hosted yet. We also welcomed more than 2,200 attendees from all over the world, who came to experience the world-class technical sessions and networking events that our No-Dig Show is known for.

NASTT exists because of the dedication and support of our volunteers and our 11 regional chapters. Our No-Dig Show Program Committee members volunteer their time and industry knowledge to peer-review the abstracts which then become presentations and technical papers. These committee members ensure that the technical presentations are up to NASTT standards. This year we had 160 presentations over the course of three days on all aspects of trenchless technology. We also featured three industry forums hosted by trenchless experts in their fields and encouraged input from the audience members. These topics included Direct Pipe, Advanced Pressure Pipeline Condition Assessment and Innovative Products.

Plans are now underway for the 2020 conference in Denver, Colorado. If you would like to join the Program Committee to help us develop the technical sessions and special events for next year's No-Dig Show, meet us in Denver this summer! Please contact us at info@nastt.org for more information.

We are also very excited about the No-Dig North event supported by our three Canadian NASTT chapters. This inaugural show will take place at the Telus Convention Centre in Calgary from October 28th to the 30th. Please visit the No-Dig North website (www.nodignorth.ca) for additional information. I look forward to seeing you in Calgary.

The North American Society for Trenchless Technology is an organization for trenchless professionals. Our goal is to provide innovative and beneficial initiatives to our members. To do that, we need the involvement and feedback of our professional peers. For more information about volunteering in NASTT, please visit our website at nastt.org/volunteer. There you can view our committees and learn more about these great ways to stay active with the trenchless community and have your voice heard.

Our continued growth relies on the grassroots involvement of our regional chapter advocates. Thank you again for your support and dedication to NASTT and the trenchless technology industry.

Y-Join NASTT BC?

THE BRITISH COLUMBIA CHAPTER OF THE NORTH AMERICAN SOCIETY FOR TRENCHLESS TECHNOLOGY (NASTT)

NASTT BRITISH COLUMBIA CHAPTER: Leaders in Innovation

Formed in 1997 as part of the original NASTT Northwest Chapter, the BC Chapter was established separately in 2005. It exists to promote the use of trenchless technology in B.C. through education and standards. NASTT-BC has worked hard over the years to have trenchless standards adopted throughout the Province. In 2008, work began by the Chapter to develop a tool for accurately determining the reduced carbon footprint that various trenchless technologies offer - the Carbon Calculator! Use this program to estimate the tons of carbon emissions that were eliminated by the trenchless construction method that you have chosen for your project. Watch for the posting of the latest version of this useful tool to enhance sustainability in British Columbia.

- In the MMCD's Platinum book, CIPP and Pipe Bursting are included, with remaining trenchless methods to follow.
- NASTT-BC has held numerous trenchless technology courses and seminars, and hosted Trenchless Technology Road Shows in 2015 and 2017. It will host the Road Show again in May 2019.
- NASTT-BC has worked to be a leader in promoting the use of trenchless as a low cost /low carbon method of construction.
- Since 2005, the chapter has published their annual magazine Y-DIG?
- The chapter and Y-DIG? Magazine are a great way for consultants to promote their successes, for cities to learn about the projects, methods, lessons and experiences of other cities, and for all 3 partners (owners, consultants and contractors) to share information.

WHAT IS NASTT?

Founded in 1990, NASTT is a not-for-profit educational and technical society. As the North American component of the ISTT (International Society for Trenchless Technology), NASTT is dedicated to promoting the benefits of trenchless technology through education, training and research. NASTT is the definitive resource for trenchless professionals like you, who are concerned with underground systems and the applications of trenchless technology.

Trenchless Technology

By using trenchless technology methods, you are reducing the impact of underground construction on your community. The benefits of trenchless technology are priceless:

- Minimizes surface disruption & trenching
- Reduces public inconvenience
- Cost-effective methods
- Less traffic congestion
- Widely utilized & accepted
- And this all adds up to - REDUCING CARBON FOOTPRINT BY UP TO 90%!

Membership

If you're interested or concerned in underground systems and the application of trenchless technology, then NASTT membership is right for you.

NASTT connects you to the people and businesses involved in the trenchless industry.

NASTT is your link to thousands of trenchless professionals and leaders working in regional, national and international levels. Membership is open to individuals, agencies and companies involved with providing gas, water, sewage, communications and electrical services.

Your Regional Chapter - NASTT-BC

A major contribution the NASTT-BC Chapter has made to the global trenchless effort is the promotion of trenchless technology as a low carbon option.

For more recent information on Trenchless Construction in British Columbia and BC Chapter activities, go to **www.nastt-bc.org**.

JOIN NASTT and NASTT-BC TODAY!

To become a member of NASTT-BC, contact Charlotte Wong at charlottenapwong@gmail.com

Events & Training Opportunities

May 7-9
Trenchless Technology Road Show
Sheraton Vancouver Airport Hotel
Richmond, B.C.
Information: www.trenchlessroadshow.ca

May 26
BCWWA Annual Conference & Trade Show
Victoria Conference Centre
Victoria, B.C.
Information: www.bcwwa.org

June 6
NASTT's Gas Distribution Good Practices Course
Bryant University
Smithfield, Rhode Island
Information: www.nastt.org

September 26
World Trenchless Day
Information: www.worldtrenchlessday.org

October 23-24
RM-NASTT Trenchless Elevated 2019
Denver, Colorado
Information: www.nastt.org

October 28-30
No-Dig North 2019
Telus Convention Centre
Calgary, Alberta
Information: www.nodignorth.ca

April 5-9, 2020
NASTT's 2020 No-Dig Show
Colorado Convention Center
Denver, Colorado
Information: www.nodigshow.com

Chapter News

NASTT-BC Award Presented

Camosun College Civil Engineering Technology students Joel Clarkson and Jean-François Gagne (centre) were presented with the NASTT-BC Trenchless Technology academic award by Zoe Broom, P.Eng., the college's chair of Civil Engineering Technology, and Dave Neveu, AScT, representing NASTT-BC.

NASTT-BC annually recognizes one or more students in Camosun College's Civil Engineering Technology program who write an excellent report about trenchless technology as part of their second-year Asset Management course. Clarkson and Gagne's report included case studies of sliplining projects, including a CSO (combined sewer overflow) diversion in Port Angeles, Washington, and rehabilitating the 155-year-old brick storm drain system in the Ross Bay Cemetery in Victoria, B.C.

2020 NASTT's

NO-DIG SHOW

April 5-9 | Denver, Colorado

Colorado Convention Center

CALL FOR ABSTRACTS

Submission Deadline: June 30, 2019

Questions? Please contact:
Michelle Hill | NASTT Program Director
E: mhill@nastt.org | P: 888-993-9935

Photo: Scott Dressler-Martin

The North American Society for Trenchless Technology (NASTT) is now accepting abstracts for its 2020 No-Dig Show in Denver, Colorado at the Colorado Convention Center on April 5-9, 2020. Prospective authors are invited to submit a 250-word abstract outlining the scope of their paper and the principal points of benefit to the trenchless industry. The abstracts must be submitted electronically at NASTT's website by **June 30, 2019:** **nastt.org/no-dig-show**.

Abstracts from the following subject areas are of interest to the No-Dig Show Program Committee:

Potable Water and Pressure Systems

- Pipeline Inspection, Locating, and Condition Assessment
- Pipe Rehabilitation
- Pipe Bursting
- Emerging Technologies
- Case Studies

Wastewater, Storm water, and Non-pressure Systems

- Advanced Pipeline Condition Assessment
- I&I and Leak Detection
- Pipeline and Laterals Rehabilitation
- Pipeline Inspection, Locating, and Condition Assessment
- Cured-in-Place Pipe Lining
- Sliplining
- Pipe Bursting
- Spray Applied Linings
- Grouting
- Manhole Rehabilitation
- Case Studies

Energy Pipeline Systems

- Pipeline Inspection, Locating, and Condition Assessment
- Aging System Rehabilitation
- New Trenchless Installation
- Standards and Regulations

Trenchless Research and Development

- University and Industry Initiatives
- Education and Training

Industry Issues

- Subsurface Utility Engineering
- Submittal Requirements and Quality Assurance/Quality Control
- Project Budgeting and Prioritization
- Funding for "Green" Technologies
- Selection Criteria for Contractors
- Social Costs and Impacts
- Carbon Footprint Reduction
- Sustainable Construction Practices
- Industry Trends, Issues and Concerns
- Differing Site Condition Claims

New Installations – Tunneling, Boring and Pipe Ramming

- New Concepts or Trenchless Equipment, Materials and Methods
- New Applications for Boring Techniques (Auger Boring and Pipe Ramming)
- Pilot Tube Boring (Tunneling)
- Case Studies

Horizontal Directional Drilling (HDD)

- New Concepts and Applications for Horizontal Directional Drilling Equipment, Materials and Methods
- Case Studies

Microtunneling

- New Concepts and Applications for Microtunneling Equipment, Materials and Methods
- Case Studies

The No-Dig Show is owned by the North American Society for Trenchless Technology (NASTT), a not-for-profit educational and technical society established in 1990 to promote trenchless technology for the public benefit. For more information about NASTT, visit our website at nastt.org.

For more information visit

NODIGSHOW.COM

Carbon Calculator Update: Trenchless Technologies Recognized

David O'Sullivan
PW Trenchless Construction Inc.

This is a quote from the Province of British Columbia in January 2019: "The Green Communities Committee (GCC) is pleased to announce the availability of a sixth GCC approved Option 1 project to assist local governments in meeting their climate action goals – the Trenchless Technology Project."

Back in 2007, three of the older promoters of trenchless technologies in B.C. – Michael Alldritt, Preston Creelman and David O'Sullivan – decided to pursue an idea that the Province was encouraging. The B.C. government joined with the California government in promoting the concept of a low-carbon society. We three met at a break at the UBCM yearly meeting in Vancouver and decided to develop an approved system to account for the carbon savings from the use of the various trenchless methods. Little did we know that it would take 12 years before we finally could look at the statement above.

With the support of the National Research Council's IRAP, we commissioned a UBC student to develop a simple tool and work with Professor Mark Knight of the University of Waterloo in developing this first tool. We promoted it at the No-Dig conferences in 2011 and 2012, and at the BCWWA conferences in 2013 and 2016, as well as to other organizations in B.C. and elsewhere in Canada. We naively thought this would be an easy process, as to us it was so obvious; however, to the B.C. government it was not.

In the early part of this decade we teamed up with Mahbod Rouhany, who was working in UBC at the time, as he had worked on another calculator for Hot In Place Asphalt. He was willing to work with us to move our calculator to a higher level. This was the third different calculator we had developed. Mahbod then suggested that we work with Metro Vancouver and ask their Air Quality people to help us in moving this through the system.

When we look back now, we see that we presented to the Regional Engineers Advisory Committee in July 2013 on behalf of Metro. The staff of Metro Vancouver worked with Mahbod and finally got the approval needed in December 2018 when we got notice that we finally had an Option 1 approval.

The City of New Westminster did seek an approval of an Option 2 inclusion in June of 2017, and this helped to prove the viability of the process to the Province. However, it took them a further 18 months to finalize the approval of an Option 1 system for trenchless methods.

The tool is set up for horizontal direction drilling (HDD), sliplining and pipe bursting, and cured-in-place pipe (CIPP) lining, point repair and grouting. This allows you to demonstrate the emissions for your trenchless method versus an open cut, and in British Columbia so far the difference between the two can be used as a carbon credit. The tool is set up so that it is adaptable to other provinces and stat-

ed with a little adjusting. We hope that this will lead to major advances in the future in how we replace our aging utility infrastructure.

Below is the GCC release as published in January allowing B.C. municipalities to become the first in the world to claim carbon offsets for their trenchless programs.

New CARIP Option 1 Project Profile: Trenchless Technology Project

"Local Governments from across BC have demonstrated strong leadership in signing on to the BC Climate Action Charter and committing to work toward reducing GHG emissions and taking actions to make their communities more complete, compact and energy efficient.

"Since 2007, the joint Provincial – UBCM Green Communities Committee (GCC) has worked with local governments to assist them in achieving these goals, including developing a common approach for carbon neutrality.

"In 2011, the GCC established the Carbon Neutral Framework for BC local governments that included 4 steps (measure, reduce, offset/balance and report) and two types of projects - Option 1 and Option 2 projects - that local governments can undertake to reduce GHG emissions within their communities as a way of balancing their corporate GHG emissions. Option 1 projects are pre-defined projects approved by the GCC. Option 1 projects are pre-defined projects approved by the GCC. Option 2 projects are projects proposed and undertaken by the local government and validated and verified by third parties. The GCC has previously developed and approved five Option 1 GHG reduction projects – supported by five related project profiles.

"This GCC communiqué announces the sixth GCC-approved Option 1 project: the Trenchless Technology Project. The attached Trenchless Technology Project profile provides guidance on estimating the emission reductions associated with using trenchless technologies, rather than conventional open-cut trenching, for capital projects to upgrade, repair, replace or construct water or wastewater utility pipes. An accompanying GCC Carbon Calculator enables local governments that undertake eligible capital projects that use trenchless technology to replace utility pipes (general maintenance projects are not eligible) to estimate the amount of emission reductions realized.

"The Trenchless Technology Project profile and the GCC Carbon Calculator can be found on the BC Climate Action Toolkit Carbon Neutral page: www.toolkit.bc.ca/cnlg (Under the HOW tab)."

Metro Vancouver Water Main Rehabilitation

Greg Deacon
PW Trenchless Construction Inc.

Danica Vulama, P.Eng.
Metro Vancouver

PW Trenchless Construction Inc. worked closely with Metro Vancouver Regional District (Metro Vancouver), the City of Burnaby, and MJP & Associates to successfully complete the final phase of the Douglas Road Main No. 2 Delta Avenue Section Project in 2018.

The scope of this final phase was to rehabilitate a 380-metre-long section of aging steel transmission water main constructed in the 1940s. The project is located in Burnaby along Albert Street between Beta Avenue and Delta Avenue. Rehabilitation was completed by sliplining a new 30-inch (762-mm) HDPE DR9 pipe into the existing 36-inch (914-mm) riveted steel water main.

This project is unique because it is the first time that Metro Vancouver has used HDPE sliplining to rehabilitate one of its water mains. In situ rehabilitation is typically not possible on Metro Vancouver's water infrastructure due to system configuration, large pipe diameters and high operational pressures.

The key benefits of using trenchless technology to rehabilitate this water main were to avoid impact to the existing utilities, reduce construction disruption to the local community and maintain the existing water main alignment. Several trenchless technologies were considered for this project, but sliplining was selected because it provides a full-service life, does not depend on the structural integrity of the host water main, and provided the ability to downsize the water main to better accommodate the hydraulic capacity required after the reconfiguration of the overall system.

Metro Vancouver procured this contract through a Request for Proposal (RFP) rather than through a traditional tender. This provided PW Trenchless with more flexibility to adapt to site conditions and modify construction methodology as required. Per the contract, PW Trenchless was responsible to complete a successful hydraulic pressure test by the end of March so that the site could be handed over to Metro Vancouver crews to complete disinfection and tie-ins prior to the high water use period (April–October). Metro Vancouver awarded this project to PW Trenchless at the end of January 2018 after Metro Vancouver isolated this section of water main.

PW Trenchless ordered the pipe for the project and submitted permit applications as soon as the contract was awarded. At the beginning of March 2018, we mobilized on site and the 30-inch HDPE DR9 pipe was delivered to the site. The truck payload capacity was limited to hauling nine pipes each having a length of 50 feet and weighing over 6,000 pounds. The pipe wall thickness was 3.33 inches and was selected by MJP to handle the high hydraulic and transient pressures in Metro Vancouver's water system.

The as-built drawings for the existing water main showed a vertical bend at the mid-point of the project. Figure 2 illustrates the site profile and sliplining set-up. With such a tight slipline (30-inch outside diameter HDPE pipe inside riveted steel pipe with a 36-inch inside diameter) and such a stiff pipe (30-inch DR9 with 3-inch-thick pipe walls), we were concerned that the pipe would not be flexible enough to bend through the existing vertical bend on the riveted steel pipe. We excavated the exit pit at Delta Avenue to video inspect the existing water main and identify the type and location of vertical bend.

Figure 1: Existing Riveted Steel Pipe

Unfortunately, the video was not conclusive on the type or location of the bend.

To further investigate, we decided to excavate the mid-point pit at the location of where the bend was shown on the as-built drawings. The mid-point pit was excavated on March 5, and we were pleased to find that there was no bend, and that the vertical deflection appeared to be achieved through multiple gradual mitred cuts. Knowing the deflection was gradual, this gave us confidence that the HDPE pipe would be flexible

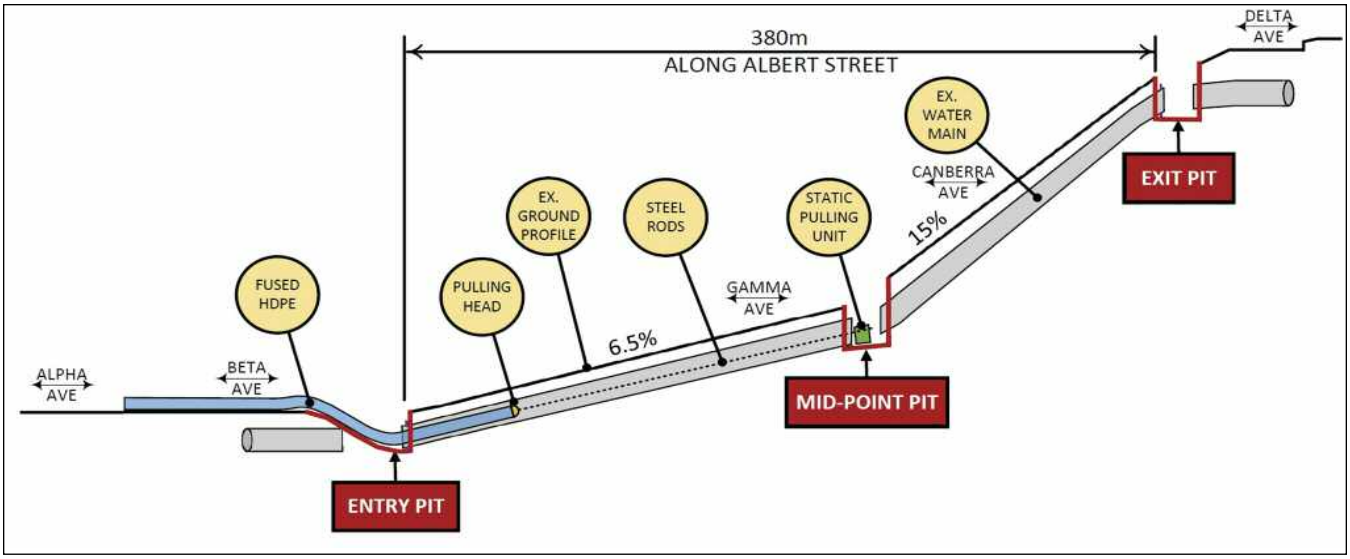

Figure 2: Sliplining Installation Schematic

enough to bend through the vertical deflection and that we would be able to pull the full 380m length of HDPE pipe from the exit pit to the entry pit in one go. In addition, this avoided the need for what would have been a very difficult HDPE joint which was planned for at the mid-point of the project.

We then excavated the entry pit at the lower end of the project located at Beta Avenue. This excavation was started on the 6th of March. The entry pit for the 30-inch DR9 HDPE pipe needed to be ramped and considerably longer than the other two excavations. The length was approximately 20 metres and took approximately four days to complete. The existing steel pipe was cut and removed at all three pit locations.

At the entry pit and exit pit, we welded restraining lugs to the existing riveted steel pipe. The lugs are designed to restrain the new steel tie-in section to the existing riveted pipe as a secondary measure to prevent stresses on the HDPE-to-steel pipe flange connection from expansion and contraction

Figure 3: HDPE pipe is fused together

Figure 4: 800G Static Pulling Unit

of the HDPE pipe. These lugs were welded to the existing steel pipe before the HDPE pipe was installed to avoid any potential damage the welding heat could cause on the HDPE pipe.

During all this excavation work, fusing of the 30-inch HDPE pipe was being completed near the entry pit. PW Trenchless personnel fused 125 m of pipe together over four days using the McElroy TracStar 900. Each joint fuse for this size and thickness of pipe took approximately two hours from setup to the completion. The HDPE pipe was positioned in place in the fusing machine and the ends of the HDPE pipe were re-faced to ensure they were flush. Once positioned, the fusion machine heated the HDPE ends and pushed the two pipe ends together to form the joint. The pipe remained in the machine until the joint cooled (approximately 40 minutes). Each joint was visually inspected and data (heat and fusion pressure) was reviewed by MJP. None of the project's 29 joints failed inspection.

We then set up our 800G Static Pulling Unit at the mid-point pit (Figure 4). PW Trenchless typically uses this piece of equipment for pipe bursting work, but because of the weight and length of this slipline we felt this was a better choice over our 10-ton or 20-ton winches. The 800G has a pulling power of 80 tonnes, and the 380-m length of HDPE was estimated to weigh 70 tons. Once in place, the 800G was able to feed steel rods through the existing pipe from the mid-point pit to the entry pit.

We fused a pulling head to the start of the 30-inch HDPE pipe at the entry pit (Figure 5). The pulling head was attached to the steel rods that the 800G Static Pulling Unit pulled. The 125-m section of fused HDPE pipe was installed in one day on March 14. Once the initial 125m was installed, we continued to fuse pipe to the end of the sliplined pipe at the entry pit and pulled the HDPE pipe after each joint fuse was completed. Once the HDPE approached the mid-point pit, we moved the 800G to the exit pit and again fed the rods down through the riveted steel water main to attach to the HDPE pulling head that was now at the mid-point pit. We completed the installation of the full 380 m of pipe in four days.

Once the pipe was in place, we installed the 30-inch HDPE flange adaptors (with

Figure 5: Pulling Head

Figure 6: Sliplining at Entry Pit

backing plates) (Figure 7) to the HDPE pipe using electrofusion couplings at each end (at the entry pit and exit pit). The pressure test was completed to 275 PSI as required. Before injecting grout into the annular space between the HDPE pipe and existing riveted steel water main, we did an initial pressure test at 200 PSI on March 22nd. This test passed, and so we proceeded with grout injection.

The grout used was a foamed cellular grout with a 28-day strength of 0.8 MPa. Due to the grade of the pipe and the pressure required to fully fill the annular space, we filled the sliplined HDPE pipe with water during grout injection to provide internal resistance to the pressure around the pipe from the grout injection process. In addition, to protect the HDPE pipe, water was circulated through the HDPE pipe to cool the pipe to combat any heat that the grout would produce during curing. The grout was injected in two lifts and was completed over two days. A large concrete bulkhead (Figure 8) was also required at the entry pit and midpoint pit to handle the pressures produced by the grouting injection process.

Once the grout was installed, we completed our final hydraulic pressure test on March 29th. The pipe was successfully brought to and maintained at 275PSI for two hours. The disinfection and tie-ins were then completed by the Metro Vancouver crew. The

Figure 7: HDPE Flange Adaptor with steel backing plate (red) for tie-ins

Figure 8: Concrete Bulkhead for injecting grout into annular void

tie-ins were completed by bolting a pre-fabricated steel spool to the backing plate installed on the HDPE ends.

From start to finish this job went as planned, which for any underground construction is rare. Open communication, good planning and a great crew successfully delivered this job. PW Trenchless, Metro Vancouver, the City of Burnaby and MJP & Associates collaborated to make this project a success. Metro Vancouver is pleased with the final product and looking forward to implementing this technology again on future water main rehabilitation projects where possible.

Figure 9: HDPE Flange Adaptor bolted to steel spool (white)

Start Right
Surveying in the Trenchless Environment

Steaphan MacAulay
Global Raymac Surveys Inc.

Have you ever dug a hole with a spade or shovel only to break the surface and uncover something that you were not expecting? Was there a surprise that altered your plans or delayed your progress? That is what happens when you don't utilize the proper planning tools on the front end of your design.

Much like the above personal or home-based scenario, the same issues occur daily on the commercial side of the industry. That said, there are several variables that can assist in alleviating these issues yet are generally overlooked.

To end right, you must start right. As such, how are you supposed to design in the trenchless world without a good model of current site conditions? To achieve a functional, accurate and reliable model, a geomatics professional must be engaged. With the expertise of a surveyor, reputable data is collected, modeled and provided to the design team. Proper procedures in the field allow this model to be retraced at any point in time, ensuring reliable repeatability.

Moreover, with the addition of subsurface utility engineering (SUE), the model will be a true representation of all above- and below-ground features, allowing the designer to execute with confidence. Design-wise, with true geodetic elevations from a surveyor, the chance of clash is mitigated when construction commences.

In many cases today, pressure to cut costs squeeze the subcontractors to the lowest point they can work. No surprise to anyone reading this, the struggle becomes real when the shovels hit the dirt. The schedule will spiral out of control due to poor design as nobody wanted to pay for a survey on the front end of the project. The costs escalate quickly and become tough to manage. The delays for redesign compound rapidly, and the frustration on site skyrockets as everyone looks to blame everyone else.

Inevitably, all problems could have been eliminated with a strong survey and reliable SUE.

As a case in point, a few months ago

Cold, snowy weather accompanied the start of this trenchless work in B.C.

A topographic survey coupled with SUE can mitigate delays and cost overruns in a project.

there was a line-locating company performing some designation along the frontage road. There is a new communication line slated to be installed underneath the road and sidewalk. The approximate locations of all the buried facilities were visible with various paint markings and pin flags. At that point, the line-locating company would have sent the information collected via sketch and photographs to the design team. Keep in mind, however, that this was not surveyed; there were only sketches and plans drawn by hand.

After the design was completed and the contract went out for bid, months later, the tender was awarded to a company to perform the installation via horizontal directional drilling (HDD). When the rig showed up and positioned itself at the entry point, the drilling commenced. On day one, everything appeared to be going as planned. The surface monitoring reflected the constant depth every 10 metres of 1.6 m.

On the second day of drilling, when I was walking on the sidewalk during a lunch break, the surface monitoring marks started to show some deviation as the depth was becoming shallower. The last mark on the sidewalk showed a depth of 1.1 m and all production stopped. Clearly, the steering was not going well, and the drill bit would be surfacing in the middle of the road if the HDD continued.

Following the shutdown of day 2 for the construction team, Mother Nature decided to blanket the region with ambient temperatures of -30° Celsius. For the next two weeks, not a wheel was turned on the project. When the weather finally broke to a civilized outdoor working temperature, some heavy equipment appeared, and the road was narrowed to one lane only. The asphalt was saw-cut, and the excavation began to determine what went wrong underground. Naturally, with frozen ground, there was a hydraulic hammer on backhoe to break the substructure of the road apart along with the frozen earth. The pictures included here reflect the current state of the site at the time of writing this article.

Without being privy to all the pertinent details of the project and the planned construction execution plan, comments cannot be validated; however, what is obvious is that this project did not go as planned!

To mitigate all the delays and immense cost overrun, and drilling home the whole point of this article, all that was needed to understand the site was a topographic survey coupled with SUE. Plan, check and execute! Speaking confidently, the cost for the front-end survey and SUE, clearly omitted, would have been a "rounding error" in the overall cost of the project in its current condition, and there are still weeks of work remaining to complete the overall project.

The project being immediately in front of a geomatics company's office along with two floors of design engineers is the "icing on the cake."

Not Just Utility Mapping
Done Right, SUE is Change-Order and Risk Mitigation

Ophir Wainer
T2 Utility Engineers Inc.

Subsurface Utility Engineering (SUE) — the term has come a long way since first introduced in Canada back around 2002. The adoption of this practice has set a high but attainable bar for collecting and depicting information about existing utilities. This was the goal — achieve a common standard that could be followed regardless of state and provincial boundaries. The initial steps were taken by the American Society of Civil Engineers (ASCE) and Construction Institute (CI) via creation of CI/ASCE 38-02 as the basis for where we are today. Further steps were made with the publication of the CSA S250-11 Standard in Canada in 2011.

Every jurisdiction may have its own formatting CAD layers… but the depicted information should be uniform throughout North America. By having quality levels from CI/ASCE 38-02, each utility is placed with its associated quality level from D to A. By having this common system, engineers throughout North America can plan and execute a project based upon the highest quality of information and mitigate the risk derived from using the ad hoc methods of the past.

SUE stands for subsurface utility **engineering**. As it sounds and as defined in CI/ASCE 38-02, SUE is a discipline of engineering dealing with managing certain risks associated with utility mapping at appropriate quality levels, utility coordination, utility relocation design and coordination, utility condition assessment, communication of utility data to concerned parties, utility relocation cost estimates, implementation of utility accommodation policies and utility design. SUE is not to be confused with just a locate function that many firms and jurisdictions have mistakenly devolved the practice to be. It should also not be forgotten that SUE is more than just the mapping at appropriate quality levels – there is more to a utility engineer!

A truly diverse SUE firm should hold all the disciplines involved in the process: proper record collection, designating, locating, utility coordination, relocation design and more. SUE can act as the complete package in conjunction with the Transportation Association of Canada (TAC) guidelines for the coordination and relocation of utilities, taking a project through inception, planning, preliminary design, detailed design, early works, final design and construction. Although rooted in engineering, the SUE firm needs all types of professionals including engineers with both conventional open-cut and trenchless experience, technologists, CAD operators, project managers, and SUE field technicians, as well as support staff.

A great example of a project involving multiple aspects of SUE is the TTC Union Station Expansion project in Toronto, Ontario, completed by T2 Utility Engineers – a firm based in Whitby, Ontario. This project is very relevant for B.C. as the province has focused on major transit initiatives including West Broadway LRT and perhaps the Surrey Sky Train.

The project is situated on Front Street in downtown Toronto. It involves expansion of the existing station to accommodate an extra platform and overall expanded capacities. Figure 1 shows the project under construction, with several of the utilities being supported to facilitate the massive excavation needed to construct the new station.

Due to the complexity of the utility-related issues in the project, a Subsurface Utility Exploration Engineering (SUE) mapping investigation was completed in accordance with ASCE 38-02. The investigation included a full review of available records information from private and public utilities present in the area. A field investigation was then completed consisting of the designation of utility locations using a variety of methods including cable locate equipment, GPR, sondes and CCTV cameras. Sewer inverts and chamber sizes were investigated and reported. Vacuum excavation was also used to collect QL-A data at critical locations. As a final product, a stamped and signed SUE report was provided for the project.

T2ue was also involved from the beginning of the project in all

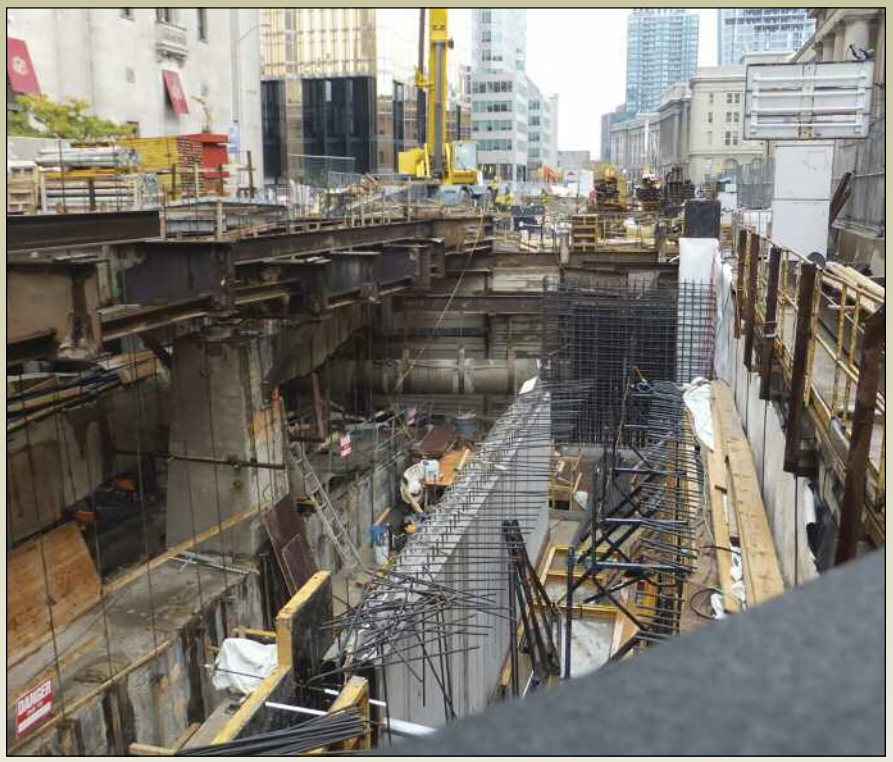

Figure 1 – Excavation at TTC Union Station

aspects of utility coordination. The role was to manage risks associated with the numerous utilities that would be present within the project area. Numerous meetings were held with utility companies to determine the optimal method for managing their utility. Some were relocated out of the project area, others were relocated within the project areas, and still others were supported in place during construction; additionally, some utilities were relocated through trenchless methods.

For those that needed to be supported during construction, T2ue engineers designed support systems that would meet both the utilities' standards and the project team requirements. There were several special circumstances that needed to be addressed, including 115KV buried electrical lines (see Figure 2), Toronto Hydro electrical manholes, trunk sewer mains, and

Figure 2 – Support of telecom structure (left) and 115KV oil-filled lines (right)

Figure 3 – Support of a large-diameter gas main and telecom conduits

large-diameter gas mains (see Figure 3).

Those utilities that could not be supported in place needed to be relocated to facilitate construction. T2ue engineers worked with the various utilities and design disciplines to design the relocations. Key relocations included telecommunication structures, large-diameter water mains, and distribution gas mains.

Support from the T2ue SUE team continues as the project nears completion. SUE took a prominent role when the project commenced in 2008 and continues to play a key role in the construction phase of the project. It is expected that the whole project will be completed on time in 2019, thanks in great part to SUE!

The TTC Union Station project is a great example of how SUE is used to its fullest extent. Although SUE is sometimes just thought of as a process for utility mapping, in reality it is and can be much, much more than that. Utility mapping may be the foundation, but utility coordination, utility condition assessment, and utility design are all key aspects. As the discipline of SUE gains familiarity, we can expect to see growth in the overall appreciation of what it includes.

Figure 4 – Temporary reduction of a 600mm water main to facilitate construction

Subsurface Utility Engineering

A Damage Prevention Tool for Trenchless Technology

EDITOR'S NOTE: Below is a paper (somewhat abridged) presented at the 1995 North American Society for Trenchless Technology Conference in Toronto. What has changed in investigating utilities?

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ABSTRACT

The limited excavation volume of trenchless technologies(TT) is one reason for its attractiveness to project owners. Less volume usually equates with less probability of damage to existing utilities and to the environment. However, damage possibilities still exist. Currently, TT operators use a variety of techniques to reduce these risks. Some of these techniques, such as notification of one-call centres and known utility owners, are mandated by statute in many areas of the United States. Steerable cutting head systems can maneuver around and between utilities, if the exact location of these utilities are known. Surface geophysical ELF and VLF equipment have "depth determination" capabilities, according to their various manufacturers, and are used by TT operators to identify both the horizontal and vertical indications of utilities for these steering purposes. TT operators are trained to recognize "excavation resistance" and to back out their cutting head and try a different route when such resistance is encountered.

All of these methods leave a lot to be desired as damage prevention tools. Not all utility owners belong to one-call centres, nor can they mark their facilities in the field with assurance. Depth determination devices from the surface can be, and usually are, misleading due to calibration problems, antenna misalignments, and electromagnetic fields that are combined from more than one subsurface conductor. Some utilities are such poor conductors of current that electromagnetic methods don't work at all. Localized corrosion cells causing future problems can result from just the smallest of incidental contacts with a cutting edge, even if no immediate damage results.

Subsurface utility engineering is a new technology that greatly reduces all of the above problems.

INTRODUCTION

Underground infrastructure is increasing rapidly throughout the world in proportion to population and technology growth. Subsurface utilities make up a small percentage of the volume of this underground infrastructure. However, this small volume of occupied space represents a disproportionate amount of risk during excavation. These risks come in many forms. Structural integrity of the utility system can be compromised when an excavation device comes into contact with it. The "Great Chicago Flood" which cost taxpayers about $1.4 billion is such an example. If broken, product-carrying pipelines can cause leakage into the environment, creating possibilities for explosion, toxic releases, and environmental clean-up costs. The pipeline explosion in 1994 in Edison, New Jersey, is testimony to the adverse effects that can be placed on the public. A 1991 FAA report identified 114 disruptions in a one-year period as having "significant operational impact, including air traffic delays, increased air traffic workload, and safety concerns." And of course, we have the stark reality of deaths on a regular basis as a direct result

of utility construction damage. These are extreme examples that make international news because of their effects. However, excavation damages occur daily and are on the rise, according to data presented at a 1994 U.S. National Transportation Safety Board workshop. In one respect, the use of trenchless technologies (TT) decreases the risk of compromising the integrity of underground utilities by reducing the volume of excavation. However, the use of TT also increases the potential for damage because existing utilities are not exposed for visual verification of their presence, location, size, material type, or condition.

TRADITIONAL DAMAGE PREVENTION STRATEGIES

Trenchless technology operators use a variety of techniques to decrease the potential for damage to underground utilities. These techniques include site research, equipment enhancements, and operator training and certification programs. Site research may include a request of utility owner records, along with a thorough visual examination of the involved area. The visual examination may identify above-ground features that indicate the presence of underground utilities for which there are no owner records, features such as repair patches, gas leakage "pinpointing" holes, and trenchlines. Utility appurtenances, such as fire hydrants, valves, and access holes, may also protrude above ground. Sometimes these features can give a reasonable estimate of a utilities' horizontal position. Many times, however, utilities may not trend straight between two structures, or the structures themselves may be misinterpreted as to function. Measuring the depth of utilities in valve boxes or manholes can give an accurate depth only at that exact spot, since utilities' elevation installation may not be constant. Utility owners' records that may indicate depth below grade can be misleading due to grade changes over the years. Even so-called as-builts lack the detail and veracity needed for design and construction purposes in a utility-congested environment. Overall, utility owners' records can be misleading or difficult to interpret because:

- They were not accurate in the first place--design drawings are often not "as-built," or installations were "field run" and no record was ever made of actual locations;
- On old sites, there have usually been several utility owners, A-E's and contractors installing facilities and burying objects for decades in the area. The records seldom get put in a single file and are often lost -- there is almost never a composite;
- References are frequently lost -- the records show something 28' from a building that is no longer there, or from the edge of a two-lane road that is now four-lane, or part of a parking lot; or
- Lines, pipes and tanks are abandoned, but do not get taken off the drawings.

Notifications to one-call centres and known utility owners are another damage prevention strategy employed by the excavation industry. In many parts of the country, this notification is mandated by law, and there is a growing constituency that wants to see national notification mandates. A one-call centre operates basically as a message screening and forwarding centre. Information regarding who, what, where, when, and why excavation is planned is forwarded to utility owners that participate in the one-call centre. Not all utility owners do participate in such an operation, so the excavator may get a false sense of security that all owners have been notified via the one-call number. Again, there is a growing movement to require all owners to participate, but strong lobbies by the state DOTs, railroads, and municipalities will probably exempt them from participation. Owners that are currently no longer in business are also ignored. Owners of private structures, such as underground storage tanks, are not included. So, it becomes obvious that not all utility owners will be notified of excavation by a one-call centre, regardless of pending legislation. A thorough visual inspection may identify some of these absentee owners, but it will not come close to identifying them all.

Utility owners have strategies in place to mark their facilities' approximate horizontal location on the ground surface just prior to construction. They either use their own forces to do this, or they contract for this service. Sometimes multiple owners will contract with one provider of this service to reduce the inefficiencies of travel and site review in a practice commonly called "joint locating." More recently, the one-call centres themselves may provide this field service. Invariably, however, not all utility owners, past and present, will agree to participate in such a "joint locating" service. Without a single responsible party to make sure all utility information is correctly identified, many errors can and do result. For instance, the gas company may mark the water line as a gas line. The water company, in most likelihood, will not mark the gas line or in many cases even notify the gas company that there may be a mistake in the field. Abandoned utilities may be assumed to be the active ones. There are a lot of permutations of errors available here.

Abandoned utilities are often ignored. Many times this creates danger when an abandoned utility is marked and/or uncovered and assumed to be the active one. Further excavation in the area is assumed "safe" and the active line is hit. A very short time is available (48-72 hours) to receive notification and act on it in the field. This time pressure often results in errors. Certainly there is little time to initiate proper quality control procedures. Data is lost the minute construction (other than TT methods) obliterates the marks. Contractors which mark facilities are mostly hired on the basis of low bids, with little attention to education, training,

available equipment, and past performance. Often "gypsies" who "buy" jobs will close shop when damages occur. Mix-ups or miscommunications in ticket locations often occur. So, while implementation of a one-call centre program certainly reduce the damages to utilities by indicating where some utilities may lie in the horizontal plane, it is not the panacea, and probably never will be, that the utility and one-call industry would like it to be.

Enhancements over the years in TT equipment provide a significant role in reducing underground utility damage. Steerable cutting heads can go around existing utilities, if their location is known. TT methods now allow deeper and more parabolic shaped routes through the underground space. Excavations can be planned to go deeper than where any utility is expected to be. Video inspection techniques help visualize the underground environment.

Operator training plays a big role in damage prevention. The ability of an operator to identify features indicating underground utilities is crucial. So too is the ability of the operator to know where his equipment is in relationship to himself. An operator's experience may allow him to "feel" anomalies in the resistance to his excavation, and make assumptions regarding its cause, which may be utility structures or trenches. However, regardless of his training in this regard, any impact with an underground utility, even if damage is not immediately evident, may result in future corrosion cells at the stress point. Manufacturers of some radiofrequency electromagnetic utility detection equipment provide a "depth" function, which gives a reading from the ground surface to the utility. More and more, TT operators are trying to rely on this information, planning their excavation to miss existing utilities. This is a very dangerous practice for several reasons. Utilities and other subsurface structures are composed of differing materials, sizes, and methods of enjoinment. They are emplaced at varying depths. Their surrounding environments can change drastically from point to point. Surface features such as water and buildings vary from site to site. Utility corridors are often highly congested with many different types of utilities. The resultant electromagnetic field can be vastly different from one generated by a single conductor in a homogeneous environment. These methods also measure to the centre of the underground conductor. If the diameter of the structure is unknown, the clearances required for safe excavation cannot be determined. Many important utilities are encased in non-conductive ducts or other structures. Without knowing the shape and size of the structure, electromagnetic depth measurements can only give misleading information. Additionally, frequent calibration of these delicate electronics are necessary. These factors combine to defeat the accurate depth determination by surface geophysical means in a target-rich environment. In other words, without known accurate records referenced to permanent survey control, the location and configuration of underground utilities are impossible to determine with any certainty from the use of surface instrumentation.

SUBSURFACE UTILITY ENGINEERING

An emerging interdisciplinary technology addresses the problems of poor records, misleading visual information, inaccurate depth determinations, short planning time frames, absentee utility owners, abandoned utilities, etc. Subsurface utility engineering (SUE) is a proven process. Many federal agencies recognize through extensive case studies that SUE is an important component of any damage prevention program.

To understand SUE, it is first necessary to define the quality levels of utility information that are available to the design engineer, constructor, project owner, and TT technician as follows:

- Quality Level "D" – Existing Records: Results from review of available records. Gives overall "feel" for congestion of utilities, but is highly limited in terms of comprehensiveness and accuracy.
- Quality Level "C" – Surface Visible Feature Survey: QL "D" information for existing records is augmented using surface visible feature survey and digitizing data into CADD. The danger here is that much of the data is "digitized fiction."
- Quality Level "B" – Designating: Two-dimensional horizontal mapping. This information is obtained through surface geophysical methods. It is highly useful for design basis information for conceptual design, and for proceeding prudently to QL "A". It should not be used for design basis vertical information, or where exacting horizontal tolerances are expected.
- Quality Level "A" – Locating: Three-dimensional horizontal and vertical mapping. This information is obtained

through vacuum excavation of test holes at points of conflict. This is the highest level of accuracy of subsurface utility engineering data. It provides horizontal and vertical design basis information for engineering, construction, maintenance, remediation, condition assessment, and related efforts.

(Source: Stutzman, H.G. and Anspach, J.H., Research Needs in Automated Excavation and Material Handling in the Field, National Science Foundation, April 1993.)

Subsurface utility engineering departs from traditional engineering practice in the Designating (QL "B") component. This component consists of applying surface geophysical methods to the project area, interpreting the results in the field, marking these designations on the ground surface, and surveying the designations to permanent project control. The final work product undergoes a rigorous professional review both in the field and in the office. Existing utility owner information is correlated to the work product and discrepancies are either resolved or forwarded to the client for further recommendations. Deliverables are "sealed" by an appropriately registered professional.

Unlike utility owners (or their contractors) marking their facilities at time of construction, the SUE practitioner has available many surface geophysical methods and equipment (see Table 1). This eliminates many of the problems referred to earlier regarding differing materials, combined electromagnetic fields, etc.

If a project had an unlimited budget, perhaps all available methods would be used by the SUE practitioner. However, this is a luxury rarely allowed or prudent. Through a combination of existing utility information, visual site investigations, experience, and project owner parameters, the SUE practitioner selects appropriate methods.

Occasionally, utilities exist in the subsurface environment for which no reasonable combination of surface geophysical methods will provide interpretable results. Additionally, the amount of extra cost to identify some utilities through these methods can be counterproductive to the project budget. Therefore, typical cost-effective scopes of work for most projects limit techniques to ELF, VLF, LF, magnetics, and elastic wave propagation through water lines, with additional surface geophysical techniques recommended only on a case specific basis.

Radiofrequency Electromagnetics - ELF, VLF, LF ranges	Inexpensive and highly useful for metallic utilities, or utilities that can be accessed and a conductor or transmitter inserted into them.
Magnetics - Flux gate	Inexpensive and highly useful for utilities or their appurtenances that exhibit a strong magnetic field at the ground surface.
Elastic wave introduction into a non-compressible fluid.	Inexpensive and moderately useful for water lines with sufficient access points (typically fire hydrants) and low ambient noise.
Terrain Conductivity	Moderately inexpensive and useful in non-utility congested areas, or areas of high ambient conductivity. Most useful for tank and drum detection.
Impulse radar (Ground Penetrating Radar)	Moderately expensive and highly interpretative. Useless in areas of high conductivity such as marine clays, or for small utility targets.
Seismic Reflection and Refraction	Expensive and highly interpretative. Usefulness under field conditions extremely limited due to signal/noise ratio problems.
Thermal Imagery	Moderately expensive and interpretative. Sometimes useful for poorly insulated steam systems or other high heat-flux systems.
Radioisotope tracing	Moderately inexpensive to highly expensive. Useful for utilities already impregnated with radioactive isotopes.
Microgravitational	Expensive. Limited to identifying utilities of great mass differential from their surrounding environment.

Table 1. Available surface geophysical methods for subsurface utility characterization

This Quality Level "B" data is usually sufficient to indicate the approximate horizontal position of existing utilities. Decisions can be made on where to place TT construction to avoid conflicts with existing utilities. Slight adjustments in design "footprints" can produce significant cost savings by eliminating wide-scale utility relocations or potential vertical conflicts. However, conflicts will still occur in the complex underground setting.

As design proceeds to more advanced stages of refinement, the engineer and TT technician need data about precise width, location and horizontal extent of the utility system, elevation, configuration of non-encased multiple ducts, utility size, utility condition and material type, surrounding environmental conditions, etc. Such data cannot be obtained by simply applying the technologies outlined in Table 1 (QL "B"). Therefore, as a further refinement to the previous designating process, a physical exposure of the utility system at the appropriate location must be made. This is necessary to resolve ambiguities and to obtain more precise data on utilities. This process is termed Locating and represents Quality Level "A" data.

Traditional excavation methods using backhoes or other heavy equipment, and even hand shovels or "post-hole" diggers present the real possibility of damage to the utility being exposed. Utility systems such as fiber optic cables, terra-cotta or tile ducts, and small gauge command and control cables can be easily cut. Corroded metallic systems, spalled concrete pipe, and asbestos cement pipes can be quite fragile. Even steel systems in good condition can be unknowingly compromised when their protective coatings and wrap-

pings are nicked or gouged, creating localized corrosion cells.

Air/vacuum excavation systems eliminate the above problems. Additionally, the work area/surface cut is quite small, often measuring no more than eight inches square as compared to a typical three feet by five feet backhoe pit. Dump truck support vehicles for both dirt hauling and backfill material are unnecessary, reducing the imposition on existing traffic flow. The small excavation that exposes the utility system at the precise spot where data is necessary does not require sheeting or shoring. Dewatering of high water tables is easily accomplished when necessary. Backfill and proper compaction of the excavation and paving repair is a simple and inexpensive task. Traffic control and worker safety is better in this small confined work area. This small excavation can be left open for visual inspection of line & grade and clearances with existing utilities for certain TT methods. A small beveled-edge plate can allow traffic to flow unimpeded while allowing the test hole to be dug well in advance of the TT excavation, thereby reducing delays. The air/vacuum system is a better way to dig a hole, but the real value comes in the data collected from the exposed utility.

By knowing precisely where a utility is positioned in three dimensions at the beginning of the final design process, the designer can make prudent decisions. Small adjustments in design elevations or horizontal locations of new structures might eliminate a utility adjustment. Cut and fill areas might be altered to accommodate the existing utilities while still accomplishing the design mission. Sometimes utility relocations are necessary. By knowing the size, material, and location of the existing utility, the designer can produce realistic cost estimates for moving the utility out of the way of construction when necessary. By using the previous Designating data, empty corridors for the utility relocations can be quickly identified.

The physical location of the utility is not the only useful data supplied to the designer during the Locating stage. Soil conditions, groundwater elevations, possible soil contamination, paving thicknesses and type, condition of the utility, and the depth to rock under the utility trench are all factors that may affect design and construction technique decisions.

The data as discussed above is collected by field engineers, surveyed to permanent survey control, and formatted for easy reference for both the designer and the constructor. As in the Designating process, rigorous quality control processes are employed. The data is "sealed" by an appropriately registered professional and insured against errors and/or omissions.

While the utility is exposed, an assessment of its condition can be made. Nondestructive testing techniques to meet the needs of the project owner, project designer, and utility owner are discussed before excavation. Typical techniques used are ultrasonic pipe wall thickness measurements, pipe-to-soil potential measurements, current flow measurements, acoustic emission measurements, temperature gradient measurements, and visual examination by camera insertion. This information is useful for the utility owner, who may decide to replace a system before broadscale failure. The contractor also benefits from a record of the utility condition before construction begins, as he can make the proper excavation and utility protection choices.

The optimum project would have Quality Levels "B" and "A" utility information procured well before the TT operation is planned or procured. This would allow the design engineer to pick the best available route horizontally to avoid as many conflicts as possible. It would also allow prudent decisions on types of excavation (e.g., direct trench vs. direction bore) based upon ground and utility conditions documented during the QL "A" process. When this information is available to excavators before bidding, considerable savings can be realized. However, not all projects will proceed with good utility information in the design phase. Efficiency may be decreased and costs may be increased if this is the case, but safety demands that some reasonable effort should be made to characterize the utilities, even if costs are borne by the TT excavator. QL "A" information can be obtained just prior to TT excavation without other Quality Levels available. At a minimum, every utility that will be crossed or that will be in close horizontal proximity to a TT excavation should be exposed.

CONCLUSION

Trenchless technologies are a valuable construction technique. However, any time excavation occurs without visual confirmation of a utilities' location or the soil conditions surrounding those utilities, the possibilities for damage exist. Subsurface utility engineering is a proven technology that significantly decreases the risks of damage to existing utilities by characterizing them through the combination of surface geophysics and non-destructive excavation. The trenchless technology industry needs to take a serious look at existing practices and recommend appropriate techniques to its project owners, engineers, and excavation technicians.

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