YDiG?

BC's Magazine for Trenchless Construction

Cover Story:

Crossing the Fraser

Using HDD to remediate pipelines in BC's lower mainland

PLUS...

How to Comply with a Carbon Neutral Policy?

Trenchless Rehab of Large Diameter Watermains - Victoria BC

Reducing Costs, Risk of Collapse, and Inflow & Infiltration

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2011

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

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Y-Join NASTT BC?

The British Columbia Chapter of the North American Society for Trenchless Technology (NASTT)

NASTT BRITISH COLUMBIA CHAPTER: Leaders in Innovation

The BC Chapter of NASTT was established 2005, and exists to promote the use of trenchless technology in B.C. through education and standards. NASTT-BC has worked hard over the last 6 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! In wide use across North America, a revised version has now been completed and will be used by trenchless professionals to illustrate perhaps the most important benefit of trenchless - a reduced carbon footprint! **(See article on page 9)**. Other chapter achievements include:

- In the MMCD's new Platinum book, CIPP and Pipe Bursting are included, with remaining trenchless methods to follow.
- NASTT-BC has worked hard to provide training programs for government and consultants, as well as contractors, on the cost and carbon savings available.
- 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 is 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 that is dedicated to promoting the benefits of trenchless technology for public awareness 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 NASTT Chapter: Get Involved

NASTT has a network of nine regional chapters throughout North America. Regional chapters offer valuable educational and networking opportunities in your local area. Share your ideas, network with colleagues and find solutions to your everyday challenges. When you join NASTT, you automatically become a member of your regional chapter and a member of the International Society for Trenchless Technology (ISTT).

JOIN NASTT and NASTT-BC TODAY!

For further information visit www.nastt.org or call Gloria Grill at 604-436-6719 Gloria.Grill@metrovancouver.org

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Y-DiG?

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President's Message

KARL MUELLER

NASTT BC Chapter on the Move!

It has been an exciting year in British Columbia for trenchless technologies. This year's board of directors has revitalized NASTT-BC, and has been actively promoting the benefits of trenchless technologies across the province. This year's board is well represented with members of the contracting, supplier, consulting engineering and, most importantly, municipal government community, with the latter most representing 40% of the board.

The society increased its efforts in providing trenchless technology education, hosting three half-day learning seminars in Victoria, Vernon, and Vancouver. Although the seminars were sold out in Vancouver and Victoria, the Vernon event was poorly attended by municipal representatives, which indicates the need to get the message out in this region. At the time of writing, NASTT-BC is planning to host one more half-day learning seminar in conjunction with the June AGM, and two full-day technical seminars in June or July. Additional half-day learning seminars are planned for the Interior in our continuing effort to educate the municipal and engineering communities as to the advantages of trenchless technologies.

There is increasing demand in municipalities to use trenchless technologies. Metro Vancouver continues to use trenchless technologies to rehabilitate its large diameter sewers. The City of White Rock, District of Saanich, City of Richmond, City of Burnaby, City of North Vancouver, and City of Abbotsford all use trenchless technologies to rehabilitate existing and install new infrastructure. Trenchless technologies are definitely a part of the design and construction toolbox in the Lower Mainland and on Vancouver Island. Because municipal budgets are tight, I expect that trenchless technologies will be seen as advantageous by more municipalities, and I expect that their use will increase for both rehabilitation of existing infrastructure and new installations as well.

The Lower Mainland trenchless construction market has been relatively well served by local contractors and specialized trenchless contractors from elsewhere in Canada; however, typical long project lead times and construction durations indicate that the market could use additional trenchless contractors for construction services. I expect that trenchless technologies will become more prevalent in the Interior over the next few years once municipalities become more aware of their benefits and have completed their own successful trenchless projects. Local contractors would be well advised to take advantage of future work by adding trenchless technologies to their portfolio.

In the 2011/2012 year, the society will again be working closely with the national organization to bring training seminars and other learning opportunities to you. Be on the lookout for our updated website, which should be up and running soon. It looks like 2011/2012 will be a busy year for the industry and the society.

Karl Mueller, PEng
Design Engineer
Kerr Wood Leidal Associates Ltd.

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No-Dig on the Potomac

MIKE WILLMETS,
EXECUTIVE DIRECTOR, NASTT

Cherry blossom season in the Washington, D.C. area is a very special time of the year and I like to think that it was even more special this year with NASTT's 2011 No-Dig Show at the Gaylord National Hotel and Convention Center along the scenic Potomac River. For the over 1,800 people that attended, trenchless technology was in full bloom with new ideas, creative thinking, quality information and the solid value that our annual No-Dig Show is known for.

Fortunately, as the No-Dig Show continues to grow, so does the event sponsorship. Many thanks to our premium level sponsors and valued exhibitors for their very welcomed generosity. It is only through their support that NASTT is able to promote the trenchless industry to the extent we do.

To the credit of the 2011 Program Committee, lead by Jack Burnam of CH2MHill, we once again presented 140 peer-reviewed technical papers, with many of the session halls at standing room capacity. The quality of our technical program continues to impress, making the progress of selecting the awarding winning papers even more challenging. At this year's Kick-off Breakfast, the 2010 Outstanding Paper Award for New Construction was presented to Craig Prout of the Mears Group, and the Award for Rehabilitation went to City of Los Angeles Public Works staff Brad Jensen, Yasmin Hafeez, Yoon Cho and Ed Gobaton. Congratulations to these exceptional authors.

The 10th Annual NASTT Educational Fund Auction exceeded all expectations, smashing last year's contributions with a record $74,000 collected. These funds go directly to support the NASTT Good Practises Program and towards our Student Chapter activities. Remarkably, in ten years our Educational Fund Auction has raised an amazing $438,000. This speaks volumes about the character of the NASTT membership. Thank you and congratulations to the entire Auction Committee.

The NASTT Gala Awards Dinner was once again a sold-out event with fine dining and first-class entertainment. The Gala is NASTT's testimony to exemplary service and the showcase for rising stars. Jim Hoggatt of South Tahoe PUD received the Chairman's Award for Lifetime Achievement and Kathryn Wallin of Bennett Trenchless Engineers was the recipient of the Trent Ralston Award for Young Trenchless Achievement.

For the second time, NASTT was proud to grant five NASTT Student Chapter members with the Michael E. Argent Memorial Scholarship. In order to further their education, each student will receive $5,000 in direct financial assistance. The scholarship program benefits from the continued support of NASTT Board of Directors, who have championed investment in the next generation of trenchless experts.

It is no secret that it is volunteerism that drives NASTT and our No-Dig Show. Without the enormous commitment of our Regional Chapters and the collective membership, much of what our not-for-profit society represents would not be possible. Thank you for allowing your talents to be tapped and for your enthusiastic support. Hope to see you at the 2012 No-Dig Show in Nashville, Tennessee.

Best regards,

Mike Willmets
Executive Director,
NASTT

How do Municipalities Comply with a Carbon Neutral Policy?

David O'Sullivan,
PW Trenchless

In late 2007, 179 local governments in British Columbia agreed to be carbon neutral in 2012. This was initially agreed to at the UBCM of 2007. The number of local governments agreeing to carbon neutrality has continued to grow, until we now have all of the 179 agreeing to be carbon neutral, in name at least, which sounds good. However, it is the city administrators who have to deal with this promise.

Considering there were no rules when the municipal politicians agreed to this, it was a brave move to do. Now the rules have been drafted and can be seen at "The Workbook" Helping Local Government Understand How to Be Carbon Neutral in their Corporate Operations. These rules call for local governments to be neutral in their day to day operations only. This is a great start for the cities of BC and puts us far ahead of the rest of the world. If we embrace this positively and work carefully to bring in the changes to our society, we can be leaders towards Carbon Neutrality, just as we did with the environment and Greenpeace in the 1970's.

The trenchless industry in B.C. has been at the forefront of looking at ways at reducing carbon through the use of trenchless technology, and measuring that reduction. (Remember the old management concept "if it cannot be measured it does not exist") With that in mind, NASTT-BC developed a carbon calculator in 2007 and 2009, which has now been adopted for further development by NYSEARCH, the R&D side of 12 oil and gas companies in the eastern US, with participation and co-operation with the NASTT national.

But where do local governments start? It is a daunting task. In the case of a lot of cities who have just hired an environmental engineer, this engineer is tasked with the problem. The politicians have agreed with the BC Government, through the UBCM, to be carbon neutral by 2012, but implementing the details is the biggest challenge! This newly hired environmental engineer is faced with this task of turning the "ship" around and reducing the carbon emissions of their city.

Generally the first thing done is to measure the present emissions to establish a base line. Different cities have reached different stages of this requirement, but most are somewhere down that path now. The great difficulty is still, where is this whole "Carbon Reduction Thing" going?

PROBLEMS WITH CARBON REDUCTION

1 Local governments, as do any large bodies, face significant challenges in trying to overcome inertia and long-standing policies and procedures necessary for change. This is especially true when the change is this monumental.

2 Remember that most governments have difficulty in rewarding employees for good work, and are eager to pass blame when things go wrong.

3 We, the public, do not always want what is best for us but what is easiest, and we reward the politicians who give us the easy solution rather than the best solution, a mindset that further complicates this difficult problem of major change.

So how do we help these pioneers in Local Government make change happen?

The best way we can effect change is to have "buy in" from the people being changed. If the local government employees being asked to change see the reason for change they will embrace it, but if it is forced upon them they will actually fight the change. This resistance will make this first step to a carbon neutral economy very difficult.

As an example of the public wanting easy solutions, just take a look at the addiction all levels of government have to long term debt to satisfy the present taxpayers. We all want the easy life but we want others to pay for it. At present, we prefer to be able to pollute our atmosphere by emitting very high levels of carbon dioxide, rather than working harder to reduce them now, and let future generations deal with the costs and consequences.

SMALL SOCIETAL SOLUTIONS

The changes required to lower our carbon emissions are going to be made up of a lot of small changes in how we live. To do this we have to start asking ourselves the following questions:

1 Does it really matter if we drive to work in a vehicle with a 5 liter gas engine or a hybrid? City driving is slow as we move from light to light through traffic - who needs to go 100 KPH or has a 200KM commute? Hybrids easily satisfy the needs of most urban commuters.

2 Does it really matter to us where our electricity comes from? In fact, it comes from a socket in the wall, and most of us do not know or care how it gets there. In British Columbia we are lucky; we have the resources so our power does come from a clean, low carbon emission source - Hydro electric power via dams or run of river. We also have the potential to generate clean energy from tidal, geothermal, and wind energy sources to meet future growth demands or even export purposes.

3 Do we all need to live on 1/2 acre lots in suburbia which houses 3 to 5 people (average family size) and where driving to any services is the only way to get there? And how economical is it to serve these areas with public transit?

SMALL LOCAL GOVERNMENT SOLUTIONS

We in the Trenchless industry have a partial solution for Local Government to help them achieve Carbon Neutrality. Unfortunately, in the guidelines issued in "The Workbook" from the Province the whole issue of Carbon emitted from any construction is OUTSIDE the carbon neutrality requirements. However because cities do use various Trenchless Technologies in installing and repairing their utilities, the carbon they save through the use of trenchless can be eligible for carbon credits. These carbon credits can then be used internally within the city to offset against other carbon emissions. We are in the process of developing this "Protocol" to create these credits. Once it is established, the proven availability of carbon credits from the use of trenchless technology offers municipalities a quick jump-start towards their goal of carbon neutrality while we wait for more substantial steps to be implemented. Achieving carbon neutrality will require many changes in how we live and how we interact with our environment - some will be small, and some will require great change and strong commitment. But trenchless technology is something we can do now, today, and while it is nowhere near the solution to achieving carbon neutrality, it certainly does provide some immediate light towards the end of the tunnel. •

Reduce your carbon footprint by up to 90%

Each mile of open-cut sewer trench produces more than 1,300 truckloads of material which generates traffic disruption, road damage and emits carbon.

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PW Trenchless
Your No-Dig Specialists

Trenchless construction is a method for laying underground wire and piping- not only cheaper than traditional underground construction, it has a much lower carbon footprint.(90% less)

Trenchless procedures are more environmentally friendly because they can reduce dust, pollution and noise making installations through wetlands and other environmental sensitive areas far less disruptive. By minimizing the amount of excavation required to bury pipe and cable, trenchless construction reduces damage to land and road surface, including the costs to restore them, causes less disruption of traffic and other activities on and around the job sites and allows for installations in areas where excavation is impractical or impossible.

Although the end result is identical ie: the same pipes can be used, the methods of construction using trenchless procedures mean that the material from the ground surface down to the pipe zone is not disturbed. The biggest impact trenchless construction is having on the environment is the large reduction in carbon dioxide (CO_2) emissions...due to this lower use of energy, machines and material.

Various academic studies have shown (Arizona State University, and University of Waterloo) that the reduction associated with trenchless construction is achieved through less traffic disruption and a vast reduction of excavation and surface disruption while still achieving identical results.

The North American Society of Trenchless Technologies BC Chapter (NASTT-BC) first linked a reduced carbon footprint with trenchless technology and have since developed a carbon calculator for use by utility designers. This concept has now been taken up by NYSearch the R and D division of the oil and gas companies of the Eastern seaboard and the NASTT North American Society.

179 BC Municipalities have all agreed to be carbon neutral starting 2012 (in their day to day operations) because construction is outside of this agreement the use of trenchless technology earns carbon credits that can be used to offset the day to day operations of the city/municipality. PW Trenchless construction Inc. is working presently to develop the trenchless carbon protocol to allow these carbon credits to be generated.

Specializing in pipe bursting and slip lining, P.W. Trenchless Construction Inc. is one of the most experienced trenchless contractors in British Columbia. For more information, visit www.pwtrenchless.com

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QUESTIONS ABOUT TRENCHLESS?

We Have Answers.

NORTH AMERICAN SOCIETY *FOR* TRENCHLESS TECHNOLOGY

Get Connected to the Trenchless Industry

NASTT is your link to thousands of local, national and international trenchless professionals and industry leaders. Whether your business is engineering, public works and utilities, underground construction, or equipment manufacturing, NASTT is the definitive resource for the trenchless industry and the application of trenchless methods for the public benefit.

Education & Training

NASTT provides top-notch, quality education and training programs for trenchless professionals. Currently, NASTT offers six training courses covering Cured-in-Place-Pipe (CIPP), Horizontal Directional Drilling (HDD), pipe bursting, sewer lateral rehabilitation, an overview of trenchless technologies, and new installation methods such as auger boring, pipe jacking, pipe ramming, and the pilot tube method. Earn Continuing Education Units (CEUs) for your participation.

Join Today

From educational resources to training tools and more, NASTT members have access to a wealth of valuable information and networking opportunities.

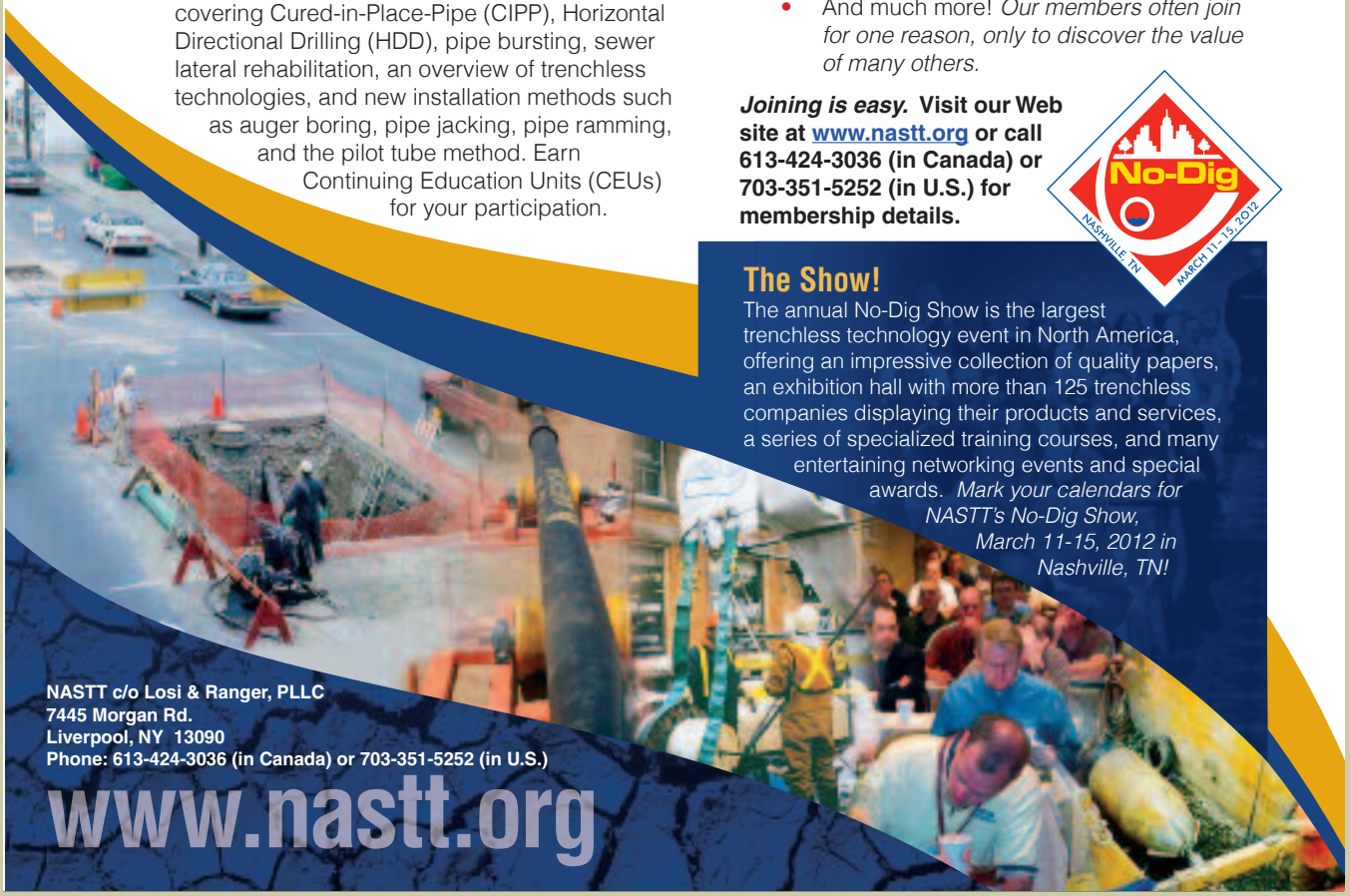
Membership benefits include:

- Members-only discounts
- Complimentary access to online reference tools and publications
- Subscriptions to industry trade magazines
- Leadership opportunities
- Involvement in your regional chapter
- And much more! *Our members often join for one reason, only to discover the value of many others.*

Joining is easy. **Visit our Web site at www.nastt.org or call 613-424-3036 (in Canada) or 703-351-5252 (in U.S.) for membership details.**

The Show!

The annual No-Dig Show is the largest trenchless technology event in North America, offering an impressive collection of quality papers, an exhibition hall with more than 125 trenchless companies displaying their products and services, a series of specialized training courses, and many entertaining networking events and special awards. *Mark your calendars for NASTT's No-Dig Show, March 11-15, 2012 in Nashville, TN!*



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Advanced Technology & Environmental Responsibility Can Work Together

Sekisui SPR Americas, LLC

Rehabilitation for storm water and gravity sewer pipelines is constantly evolving. New processes, methods and products are developed to meet the growing needs of the owners. In the trenchless market, the majority of rehabilitated pipelines are renewed with a mixture of cured in place liners, slip lining, pipe bursting, grouted in place liners, or spiral wound liners. Variables of each individual project can define the necessity for any one of the technologies, or combinations of a few.

Owners have had to choose a technology that meets all their needs, which could include structurability, flow capacity, environmental friendliness, bypass design, economical savings, installation times, or reduced carbon footprint. In the past, that could mean sacrificing some elements for others. Why should an owner have to relinquish one asset of a technology for another? They shouldn't.

Sekisui SPR Americas, LLC (SSPRA) is based out of Atlanta, GA, and covers all of the Americas, specializing in pipeline

30" CMP before SPR™ rehabilitation

30" CMP after SPR™ rehabilitation

rehabilitation for stormwater and gravity sewers. Sekisui offers the most technologically advanced, environment friendly trenchless solutions for small to large diameter pipe renewal, and has been providing environment friendly pipeline rehabilitation methods to the trenchless technology industry for 25 years worldwide. By using their experienced advisors and working with local Sekisui SPR Americas, LLC certified installation contractors; SSPRA can assist pipe owners and engineers with individual project requirements.

14' CMP rehabilitation by SPR™

The company offers both structural and non-structural solutions using spiral, machine wound, trenchless pipe renewal processes that meet several ASTM standards. These technologies can be utilized in a range of sizes (6"-144"+) for circular, non-circular, and odd shaped applications.

SSPRA'S THREE CORE TECHNOLOGIES

SPR™ is the most commonly specified product due to its wide range of applications, diameter range (18"-144"+) and the ability to negotiate directional changes. SPR™ is capable of

winding circular pipe, box culvert pipe, arched pipe, and other non-round applications. Typically, SPR™ can be installed in live flow conditions based on worker safety and other considerations. Other flow management techniques can be used to eliminate the need for bypassing.

The SPR™ profile was previously used for "man-entry" applications and larger diameter pipelines. Sekisui's research and development team produced a new machine, capable of static winding in small diameter, non man-entry applications. The static machine is currently capable of winding circular pipelines 18" and larger. SPR™s is also capable of winding odd shapes with a separate winding machine, because the SPR™ profile is formed on a winding frame with a set size and shape for the host pipe. Sekisui has wound teardrops, box culverts, and arch shaped pipelines.

SPR PE™ profile

SPR PE™ is a spiral wound HDPE product that is heat fused to form a structural pipeline rehabilitation product. By utilizing SPR PE™, circular pipelines ranging from 36"-120" in diameter can be structurally rehabilitated due to its high stiffness characteristics.

SPR EX™ is another technology that is offered by SSPRA. SPR EX™ is a tight fit spiral wound PVC structural liner for circular pipe rehabilitation. Application size ranges from 6"-30" in diameter. SPR EX™ is unique in it does not require grout in the annular space between the host pipe and the SPR EX™ profile.

METHOD

Each process is started the same way: the host pipeline is jetted, cleaned of debris, and then inspected. Each machine can be lowered in to a standard size manhole, or access point, and assembled in the pipeline.

For the man entry SPR™ process, the profile is fed from a spool on the surface to the machine. The hydraulic machines will lock the monolithic PVC profile into place, and simultaneously advance down the host pipe. Once the PVC profile is in place, a temporary bracing system will be erected if necessary. Grout is then injected into the annular space between the host pipeline and the new liner.

The SPR™ static winding machine, SPR EX™ machine and the SPR PE™ machine will all be set up the same way, beginning with cleaning of the pipeline, and inspection. Instead of the machines advancing down the host pipeline, they will sit static in the invert of the manhole or access point. The profile will be fed to the machine, the profile joint locking mechanism will be activated, and the profile will be fed into the host pipe. The annular space will then be grouted between the host pipe and the new liners. SPR EX™ does not require grouting at this stage because it fits tightly against the host pipeline.

SPR EX™ (expanded against host pipe)

All of Sekisui's technologies typically increase flow capacity because of their Manning's coefficients. Manning's coefficient measures flow capacity in open channels based off the roughness of the pipe material. Sekisui's three core profiles Manning's coefficient are lower then typical aging pipelines, therefore increasing the smoothness of the pipe, and maintain, if not increase, the flow capacity even though the cross section is being reduced.

The processes are cost-competitive with other technologies, and all of the Company's technologies can be installed in limited flow conditions, with only limited or no bypass.

For further information on how Sekisui's technological advances can save you time and money, work in the most challenging and unique situations, as well as maintain an environmentally friendly profile, please call 866-62-SSPRA(77772) or visit our website at www.sekisui-spr.com

Trenchless Rehab of Large Diameter Steel Watermains- Victoria BC

Jeff Somerville, P.Eng

The City of Victoria's large-diameter steel transmission watermains installed in the 1920s and '30s have begun to show signs of failure. A major break would leave large portions of the City without domestic water and fire protection. The steel watermain rehabilitation project includes trenchless lining over 8 kilometres of watermain throughout the City, completed in two phases. Using trenchless technologies and a triple bottom line approach, GENIVAR set out to improve the system's functionality, reduce seismic vulnerability and minimize potential service interruptions. The project is one of the largest trenchless rehabilitation projects of its kind in North America.

NO NEGATIVE IMPACT TO LEVEL OF SERVICE DURING CONSTRUCTION

Careful planning and the use of a water distribution system model allowed for significant operational upgrades that make the system more reliable and functional. The team converted a redundant 3.3 kilometre long, 500mm steel watermain to a high-pressure transmission main and used it to interconnect two distribution zones. This novel approach saved the cost of installing a new parallel transmission main through residential neighbourhoods and busy roads. Approximately 250 meters of additional small diameter domestic watermain was required to service homes previously fed from the 500mm steel watermain. The work improved water supply to the low-pressure network through two new pressure-reducing stations. New valves installed at critical locations increased operation and maintenance flexibility, and significantly reduced risks in the distribution system.

To maintain domestic water service to businesses and residents while the large diameter mains were shutdown for construction, various watermain isolation methods were employed, including operation of existing valves, live watermain linestops, hot-tapped valve insertions, and new cut-in valves. Linestops are a method to temporary insert a collapsible plug into a watermain, thereby stopping flow. Similarly, hot-tapped valves were installed on branch watermains up to 200 mm in diameter to control flow at critical locations without interrupting water service. Prior to any watermain work, the Contractor installed temporary water services to any properties that would be impacted by the rehabilitation work.

EXTENDING THE LIFE OF WATERMAINS WITH INCREASED SEISMIC AND FIRE PROTECTION

A semi-structural, tight-fitting, high-density polyethylene (HDPE) liner is inserted inside the host watermain. This reduces the risk of failure, improves pipe hydraulics, and saved approximately 30% in construction costs compared to

Pipe fusion and folding site on the roadside

traditional methods. The rehabilitation work will extend the life of the watermains by an estimated 75 years.

To line the steel watermains, HDPE pipe segments are fused together, then folded into a pretzel shape, reducing the effective diameter. Plastic banding is used to temporarily maintain the pretzel shape during the lining process. A winch is used to pull the liner into the steel watermain at entry pits located at strategic points along the watermain route. Consideration is given to existing bends, valves, landscaping, driveways, and traffic when selecting pit locations. Typically, a 100 to 150 meter long section of liner is installed between pits, greatly reducing the area of excavation and restoration.

Once the steel main is lined, specialized fittings are installed that grip both the liner and host pipes and provide a flanged connection. About 20 psi of water pressure is then applied to the liner, breaking the temporary plastic bands and reverting the liner to a round section. Because the liner relies on the host pipe for some strength, a thicker walled HDPE pipe is needed to withstand operational pressures in pit locations where a section of steel watermain was removed. After flushing, pressure testing, and disinfection, branch watermains and services are reconnected to the lined main.

The City of Victoria lies in an active earthquake zone, making the steel mains highly vulnerable to breaks during seismic events due to their age and condition. The HDPE material is heat-fused into one continuous segment, which provides the best available seismic resistance by eliminating joints, a typical source of leaks and breaks. HDPE watermains have been benchmarked against other common pipe materials in real-world seismic events, such as the 1995 Kobe, Japan earthquake.

Liner insertion at entry pit

A detailed review of the existing watermain appurtenances showed inadequate fire hydrant coverage and an insufficient number of air valves. Aging hydrants were replaced, with new hydrants installed at locations determined in coordination with the City and Fire Department. Large combination air valves were used to release air from the watermains and to provide protection against the liner collapsing in a vacuum event, such as a break or scheduled drain-down. Due to limited cover over the watermain, lockable aboveground chambers were designed to house the air valves.

QUALITY CONTROL A PRIORITY

With a specialized product and installation procedures, GENIVAR recognized the need for strong quality control and quality assurance during construction. The HDPE is heat-fused from 15 m segments into one continuous pipe prior to installation. Details of each fusion such as time, temperature, and pressure were digitally recorded and reviewed on a regular basis to ensure proper joining. All material was visually inspected for defects prior to installation. The host steel main and liner were reviewed before and after installation using dedicated CCTV video equipment to help identify potential problems and evaluate the finished product quality.

MINIMIZED DISRUPTION TO TRAFFIC, LOCAL BUSINESS AND PROPERTY ACCESS

Traffic disruption was minimized through careful traffic analyses of the City's arterial roads prior to construction. This minimized the time construction crews spent on major roads by selecting strategic staging areas. As a result, minimal vehicle travel lane restrictions were needed and traffic flow was maintained. Construction activities were limited in commercial areas to allow access to businesses and keep noise levels to a minimum. A public information process including newsletters, public open houses and door-to-door notification kept residents informed throughout the project.

Typical pit size for liner insertion; remainder of the block untouched by construction activities

As trenchless liner installation only requires small, strategically located access pit excavations, residential property access was rarely compromised. Conventional construction methods would have required significant trench excavations of roads, seriously affecting their integrity. Small, localized excavations reduced potential traffic delays, leading to significant savings. The minimal excavation also reduced the risk of damaging other utilities such as gas mains and electrical cables.

AN ESTIMATED 90% REDUCTION IN CO2 EMISSIONS

The City's drive to improve environmental sustainability requires solutions that reduce green house gas emissions on infrastructure projects. Conventional construction generates significant quantities through open-cut activities such as backhoes, equipment idling, and dump trucks en route to dump sites and transporting imported backfill materials. The use of trenchless methods to rehabilitate the City's large diameter steel watermains saved an estimated 90% (2,300 tonnes) of CO2 emissions versus traditional open-cut excavation methods. Calculations were taken from the NASTT-BC Carbon

Branch watermain connection to the lined steel main

Final tie-in at pit using a liner grip fitting, butterfly valve, and electrofusion coupler

Calculator, based on studies by the University of Waterloo.

The City of Victoria is a leader in low-impact infrastructure rehabilitation, with a strong focus on economic, social, and environmental aspects of construction. Incorporating sustainable design principles helped secure two-thirds funding for Phase 2 of the watermain rehabilitation from the Federal and Provincial Governments through the Building Canada Fund. Phase 2 is scheduled to be completed on March 31, 2011 by Insituform Technologies with Brunnell Construction as the excavation subcontractor.

Jeff Somerville, P.Eng is a Project Engineer in GENIVAR's Victoria office. He is a certified MMCD Contract Administrator and has over 7 years experience in various municipal infrastructure projects, including new construction, rehabilitation, and trenchless utility installation.

Environmental Success at Kelowna:

British Columbia's Sensitive Mission Creek Crossing

Kamloops Augering and Boring (KAB) successfully tackled the significant challenge of completing a crossing at the environmentally sensitive Mission Creek in Kelowna, British Columbia. The creek runs through a highly congested urban area and is a significant contributor to the local drinking and agricultural water supply. The area is so sensitive that it is protected by the Water Act and Drinking Water Protection Act - special precautionary measures were necessary to assume the protection of the watershed, wildlife and scenic nature of the area. The FortisBC project was initially designed as a 140m horizontal directional drill, but after careful consideration, the crossing was completed using a guided bore and pneumatic hammering method that eliminates the use of drilling mud and pressurized drilling.

The project was part of the Fortis BC Benvoulin Substation Distribution Project and called for the installation of 4 x 750mcm 25k V cables with a trenchless contractor to supply and install 2 x 18" (457.2mm) casings of 140m of smooth wall steel pipe. After Kamloops Augering and Boring reviewed the proposed HDD profile and visited the site it was determined that the proposed HDD did not provide sufficient depth of cover to insure the overburden pressure would be greater than the annular pressure of the drilling mud in the borehole. The HDD had the potential of causing harmful alteration, disruption, and destruction (HADD) of fish habitat by drilling fluids entering a water body, commonly known as a "frac-out". A frac would be a contravention of the Federal Fisheries Act and would be very costly to clean up if it should occur.

Mission Creek alignment

Kamloops Augering and Boring proposed an alternate to the original design utilizing a guided bore and pneumatic hammering method in place of HDD. Guided boring in conjunction with pneumatic pipe ramming eliminates reaming an oversized hole that is typical in HDD. The annular space created is no greater than the wall thickness of the pipe. Upon installation of the open ended casing it is cleaned out using an auger boring machine to make the casing ready for the product pipe. It also eliminates the use of pressurized drilling fluid used by HDD operations to carry cuttings out of the borehole and assist in lubrication during final pullback.

A guided boring machine installs pilot rods along a straight bore path. An adaptor is fixed to the pilot rods and an open ended casing is pipe rammed into position following the pilot rods. KAB could ensure that the casing would be installed on precise line and grade below the water table and line and grade could be verified prior to the casing being installed.

The proposed tie in location invert was proposed to be 1m deeper than original HDD design and 2m deeper at the exit location. The entire length of the crossing would be below the existing water table and would be the same depth under the center of the creek as the initial HDD design. Dewatering would be carried out locally at the entry and exit pit locations. Dewatering would not be required along the entire

Entry location

Exit location

length of the crossing.

The project commenced in February 2010. Following the site access construction the dewatering was installed using a well point system with the program dewatering 24 hours per day of a 30m x 15m area around 3 sides of the entry pit and 15m x 10m around the exit pit.

The pilot tube installation was complete in two shifts. The first shift obstructions were encountered at the 126 meter mark and with a second try the pilot emerged on design line and grade for a total length of 144m (472 ft). This was a substantial undertaking since the longest crossing completed by KAB with a guided boring machine was in fall 2009 at a distance of 129m (425 feet).

Hammering commenced with a 24" (Taurus) TT hammer advancing the 500mm casing at 12 ft per hour. Progress slowed and it was assumed that the length of the crossing was the culprit. Hammering came to a near standstill and it was suspected that obstructions were to blame. KAB potholed the line using a hydrovac and located the head wrapped in tree roots and metal banding. The 500mm casing was starting to show signs of fatigue and it was assumed the material would not hold up to the hammering for the entire 144m. After recalculating the projects requirements, Fortis determined that one 914mm casing would be sufficient for the utilities. The 914mm (36") casing was pounded over top of the 20" casing using a KAB owned TT 32" (Apollo) hammer for the remainder of the crossing. The 500mm (20") casing was removed and the casing was cleaned and prepared for the 4 x 750mcm 25k V cables.

While HDD continues to be an effective method to complete river crossings, the Mission Creek project is a successful example of recognizing how new technology can benefit a project by providing other trenchless options. The guided bore and pneumatic hammering method used by FortisBC and Kamloops Augering and Boring at Mission Creek allowed for the successful completion of this sensitive crossing with no environmental impact or lost time incidents. •

Sewer Rehabilitation with Trenchless Technology

Reducing Costs, Risk of Collapse, and Inflow & Infiltration

Mike Homenuke, P.Eng.,
Kerr Wood Leidal

Sewer rehabilitation and replacement is a great way to utilize trenchless technology, as it avoids many of the costly and annoying features of open cut construction such as excavation, hauling, road closures and so on. KWL has been involved with trenchless sewer rehabilitation projects for over 10 years, and over time, we've observed significant cost savings compared with open cut. This allows our cities to stretch their infrastructure dollars further to head off sewer deterioration before it becomes a costly problem, and introduces opportunities to reduce inflow and infiltration (I&I).

SAVING MONEY AND DISRUPTIONS WITH TRENCHLESS TECHNOLOGY

It is no secret that trenchless pipe renewal methods are less expensive than open cut in many situations. This gap is widening as trenchless increasingly becomes a 'default' solution for municipalities. We've observed an increase in the number of qualified suppliers providing trenchless construction services and improvements to the quality of trenchless products and installations in recent years. As trenchless products continue to improve, the real (inflation-adjusted) cost of trenchless work should become cheaper relative to open cut construction. Conversely, we expect the cost of open cut construction to increase over time due to rising fuel and labour costs, as it is highly sensitive to both factors to a greater degree than trenchless. Our data shows 200 mm dia. CIPP lining has averaged about $170/m in real $2011 between 1999 and 2010, while open cut 200 mm dia. sewer replacement starts at between $200/m and $300 /m and increases with depth.

Increasing difficulties in working conditions, such as pipe depth, traffic, and surface cover generally favour trenchless technology. A recent example of this was during the City of Victoria's James Bay I&I Reduction Pilot Project, in which a 300 m section of 200 mm dia. clay pipe was pipe burst up to 300 mm dia. on Dallas Road. The old sewers were situated underneath a row of 80-year old boulevard trees, and their replacement using open cut would have required cutting a new alignment in the roadway through bedrock and a known archaeological area, or having to remove the trees. This was an extreme case as all of the soil removed for entry, exit and lateral pits was sifted by archaeological monitors. The open cut alternatives would have resulted in significantly more disturbances to the community and higher costs than pipe bursting. The bursting setup is shown in Figure 1.

There are also the 'tangible intangible' costs of construction including disturbances to local businesses and residents, traffic delays, greenhouse gas (GHG) emissions, dust and noise. It is nearly impossible to account for all of these, but in all cases trenchless technology has lower impacts than open cut construction. A focus on GHGs was featured in the James Bay I&I

Figure 1 : Pipe Bursting Setup on Dallas Road for James Bay I&I Reduction Pilot Project

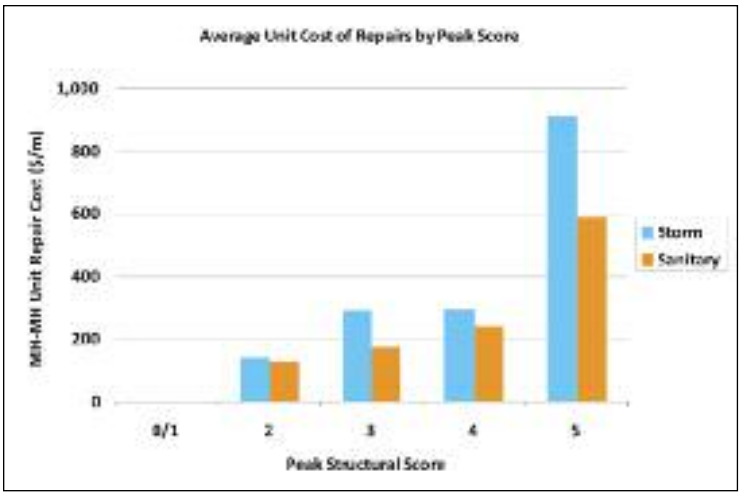

Figure 2: Unit Cost of Repairs by Condition Score

Reduction Project, where an evaluation of GHGs avoided by using trenchless technology was a requirement of a federal Innovations Fund Grant. We found GHGs were reduced by over 90% in comparing CIPP to open cut and by almost 50% for pipe bursting. Lower GHG emissions resulted from less fuel being consumed with trenchless. In a world of volatile oil prices this means trenchless technology is insulated from the effect of fuel pricing on construction costs. As shown in Victoria, it can also mean more money in the form of grants for resource-challenged cities to repair vital infrastructure.

CCTV HELPS TARGET DEFECTIVE PIPE AREAS

We've shown that trenchless technology can save money, so now how can we make the most effective use of it in rehabilitation programs? CCTV inspection is the first line of defence against sewer collapses and conducting inspections at the proper frequency is vital to identifying and tracking potential high-risk structural defects before they become collapses and insurance claims or spill reports.

Over time we've collected data that shows if repairs are caught at an early stage, they can be repaired at a much lower average cost per manhole-to-manhole segment than having to make emergency repairs and replacements because of collapsed pipes. Figure 2 shows the cost of trenchless repairs versus pipe structural condition. One of the reasons why Grade 5 pipes cost more to rehabilitate is because they are often too far deteriorated to use most trenchless methods. Figures 3 to 5 show defects that could be fixed with trenchless.

The key to making this work is by targeting repairs only to the defective sections of pipe. Using GIS to analyze the locations of structural defects in one city revealed that less than 5% of actual pipe network by length was structurally defective, and

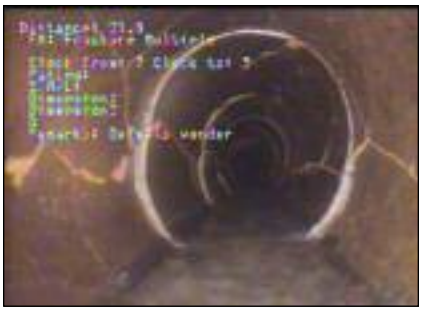

Figure 3: This fractured clay pipe should be burst due to the extent of deformation

Figure 4: Even though the pipe is broken, it can be lined as the shape is still circular

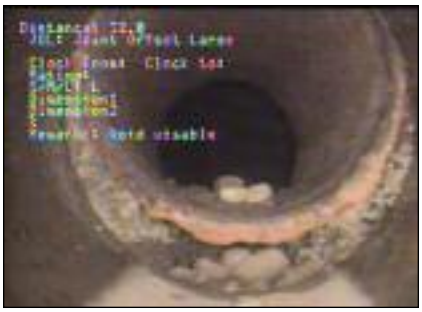

Figure 5: This joint is offset too much for a trenchless repair, but an excavated point repair will allow the pipe to be lined later on

of that, only 20% required immediate attention (1% of network length). We often recommend a rapid deployment point repair program that starts by targeting the most severe defects, and gradually works toward less-severe defects. In most cases this approach requires both excavated and trenchless repairs, as near-collapse or deformed pipes usually can't be fixed with a liner point repair. Holes, fractures, breaks, and minor displacements, however are often easily repaired with a CIPP point repair in combination with grouting to fill any voids. Manhole-to-manhole repairs quickly consume rehabilitation budgets, and would be used where there are multiple defective sections or a significant portion of pipe requiring repair. After the severe defects are dealt with, future programs can use manhole-to-manhole lining or other techniques to renew the pipes on a less-urgent basis. This approach has been employed in other places to reduce the average pipe structural grade by 30% in less than five years.

TRENCHLESS BEST AT INFLOW AND INFILTRATION (I & I) REDUCTION

Perhaps one of the best ways to utilize trenchless technology in sewer rehabilitation is I& I reduction. Metro Vancouver recently adopted a new Integrated Liquid Waste and Resource Management Plan that mandates creation of I& I Management Plans for member municipalities. The Capital Regional District is looking at similar measures. This means renewed focus on I& I in the upcoming years, and an excellent opportunity to increase the use of trenchless technology.

There are a number of ways in which trenchless approaches lend themselves to I& I reduction:

1. If leaking joints and services are the problem, but structural condition is good, grouting can sometimes be a cost-effective way to reduce I& I.
2. Pipe bursting and CIPP lining leave no joints to leak and form a sealed unit if service and manhole interfaces are grouted. These are good options if structural repairs are needed.
3. If abandoned lateral connections can be identified ahead of time, they should not be reinstated. We recommend using a lateral camera in combination with dye testing to locate abandoned connections. Abandoned laterals can also be removed individually by using liner point repairs and grouting to seal the void.
4. Service lateral renewal can be done with bursting, lining or directional drilling. Avoiding damage to landscaping can more than offset the cost of trenchless work on private property. If cleanouts are available at the building and property line, a true no-dig approach is possible.
5. Infiltration can easily enter manholes through the chimney

Figure 6: Before and after manhole coating and lining

or barrel. Liners can be installed to prevent this water entering a manhole. Grouting the soil around the manhole may also be effective if properly executed. Figure 6 shows a before and after manhole lining and coating.

We've employed all of these methods with varying degrees of success, but what we found in James Bay and other projects is taking a 'basin-wide' approach to I& I reduction works best. This includes gathering all of the necessary field data including flow monitoring (before and after), CCTV (mains and laterals), and smoke and dye testing. This way the engineer can select the most appropriate rehabilitation approach(es) based on accurate and complete information. There is also a correlation between the amount invested in rehabilitation and results. If one deploys a wide-spread program targeting a specific type of leak (e.g. joint grouting), one can expect less impact on I& I than concentrating resources in a single basin and using a technique that deals with multiple sources of I& I (e.g. properly designed full-pipe lining).

We believe trenchless technology is the default approach when it comes to sewer rehabilitation, and only resort to excavation when we absolutely have to. As more municipalities adopt this way of thinking, it is expected trenchless will have a greater market share and only get better and cheaper with time. •

Leave No Trace:

The History of Lateral Pipe Bursting

John Rafferty
Director of Marketing and
Technical Support, TRIC Tools, Inc.

Although lateral bursting has been used for a number of years in BC for trenchless infrastructure rehabilitation, the following information is provided for those still unfamiliar with this technology. Before lateral pipe bursting was introduced, trenchless pipe replacement methods catered almost exclusively to municipal or government projects: horizontal directional drilling for new utilities, guided pneumatic impact moles for bursting large sewer and storm mains, hydraulic rod-pusher/pullers for replacing other sewer and utility lines. All of these earlier methods and machines shared a common scope of work. Each was defined by projects that were large and public. By contrast, the first lateral pullers entered an arena whose jobs were small and private.

In this new private market, there were significant challenges to overcome. One major obstacle was pipe approval. Fused high-density polyethylene (HDPE) had been used for years by the gas industry, and was common in the existing pipebursting establishment. However, for the fledgling lateral bursting industry, HDPE was not a preference; it was a demand. Yet this pipe material was not listed in building codes regulating sewer replacement on private property, and therefore was not allowed.

Other challenges were mechanical. Laterals commonly include physical turns—1/8 or 1/16 bends in the line—to accommodate the flow path from building exit point to municipal connection. Sewers can exit a building from various points, which are often in restricted space or covered by surface improvements. City or county connections can be at the property line, in a side or rear easement, or in the public right-of-way, depending on the local regulations that define owner responsibility. None of the previously available bursting technologies were designed to deal with multiple bends and relatively small pipe (most laterals are 4" in diameter). Cured-in-place (CIP) liners were not as permanent a solution, and compared to bursting were neither practical nor cost-effective for most laterals, especially those in serious disrepair.

In California, TRIC Tools Inc. introduced the first lateral bursting systems to meet these unique logistical conditions. Their solution paired flexible replacement pipe (HDPE) with flexible steel cable to negotiate the inevitable bends in the existing pipeline.

The original configuration of the TRIC lateral system is still widely in use today

TRIC gained approval of HDPE for home sewers, city-by-city, in the San Francisco Bay Area where the company initiated commercial lateral bursting in the late 1990s. Since then, both pipe and process have been added to national and international codebooks.

TRIC co-founder Ward Carter (hard hat) and client make adjustments to a 50-ton puller prototype

The first TRIC pipebursting systems were devised using modified post-tensioning rams mounted on a pulley base against a resistance plate, directing the cable and pulling force vertically rather than horizontally. This allowed for a very small footprint, which was invaluable for sewers that were either shallow, obstructed, or in tight places (conditions that describe many home sewer laterals). These hydraulic rams were small, light, and high-pressure rated, making them portable enough to carry and position by hand, yet powerful enough to burst most home sewers easily.

Trenchless lateral replacement has since been widely accepted, and has become a specialized utility market segment. TRIC continues to expand its patented technology into other utility markets around the world, applying a philosophy of simple and effective solutions to various project scenarios in the underground construction industry.

For further information on applications for TRIC pipe bursting systems in your next trenchless project, please call 888-883-8742 or visit their website at www.trictools.com

Crossing the Fraser

Using HDD to remediate twin utility pipelines in the midst of an active, commercial area in BC's lower mainland.

Lon Briscoe
President,
Direct Horizontal Drilling

Justin Hedemann,
Business Development,
Direct Horizontal Drilling

Twyla Laakso
ABC TLCommunications

On the north shore of the Fraser River in Richmond B.C., equipment was set up across parking lots and local roadways, amidst warehouses, delivery trucks and staff vehicles. Stiff financial penalties would be incurred if commercial operations were disrupted.

After a 1,375 kilometer trek beginning high in the Rocky Mountains, the Fraser River ultimately winds it way into southwestern British Columbia and the Greater Vancouver Regional District. As a whole, this District is comprised of some 21 municipalities and is home to more than half of the provincial population.

Here the Fraser splits into north and south arms. The north arm serves as the southern boundary of metropolitan Vancouver and the south arm divides the city of Richmond from the municipality of Delta.

In 2009, an application was made to the British Columbia Utilities Commission to upgrade two natural gas transmission pipelines crossing the south arm of the Fraser River. Both crossings were deemed integral to providing natural gas service to Richmond, Vancouver, North Vancouver, West Vancouver and parts of Burnaby.

Work began in the early 90's to assess the reliability of the crossings, built in 1958 and 1974. A 2008 study reported that the pipelines were subject to damage from river erosion and dike settlement and were becoming increasingly vulnerable to failure in a significant seismic event.

This area of the country is particularly prone to seismic activity and failure of these pipelines would have significant consequences. Nearly 200,000 area residents would be affected and commercial businesses, many considered to be essential services in a catastrophic event, would be left without energy resources. Degrading of existing infrastructure and the unacceptable repercussions of pipeline failure called for the timely replacement of the NPS 20 and NPS 24 transmission lines.

Of the five potential methods offered for remediation, horizontal directional drilling emerged as the preferred method. In addition to offering the least amount of environmental impact, HDD presented clear cost efficiencies resulting in significant economic savings over alternate methods.

Following a competitive bid process, DIRECT Horizontal Drilling – a Western Canadian company – was chosen to complete the project and work began in early June of 2010.

By the time DIRECT came on scene, a number of decisions had been made and several courses of action had already been executed. Project engineers had determined that the intersect method would be the most expedient and economically efficient method for this HDD project.

Intersect technology has proven to be an extremely effective approach since its introduction in the early 2000's. It has been universally accepted by the industry and, over the last few years in particular, has been utilized and refined to the point where it is now regarded as common practice.

16 cranes were required to guide 1.4 kilometers of NPS 24 product line during installation.

DIRECT was an early adopter of the intersect method and their personnel actively participated in early field trials and have been at the forefront of the technology's growth in Canada. Today, they are responsible for nearly 90% of all Canadian intersects.

UNIQUE CHALLENGES

Even a single crossing in an unpopulated locale is a demanding task requiring planning, patience and the ability to think critically and act quickly in light of unpredictable and volatile circumstances. Crossing the Fraser River with parallel lines in an area developed with commercial operations, as well as drilling next to existing live gas lines fuelling a large part of metro Vancouver, meant this project presented several challenges at the outset.

Operating in a densely populated district meant working under intense public scrutiny. On the north shore of the Fraser River in Richmond, the drill sites were in close proximity to the warehouse and operations centres of at least two international courier companies.

Even in the face of necessary utility upgrades, multinational, multi-million dollar companies must keep operating. Project operators faced stiff financial penalties if drilling operations impeded day-to-day commercial activity. As a consequence, activities that interfered with these operations were, by necessity, restricted to weekends.

GETTING UNDERWAY

Prior to drilling, DIRECT brought in a 30" diameter TT Technology air hammer to install the heavy wall casing that was required to encapsulate the unconsolidated formation. Up to 60 meters of 48" diameter casing was installed in four locations: at entry and exit points for the 24" pipe and at entry and exit points for the 20" pipe, located just 10 meters away. Casing was subsequently cleaned out with the use of an auger bore machine.

Two HDD rigs were mobilized out of DIRECT's Edmonton yard using heavy-duty, specialized rig moving equipment. Rig 9, a 1,100,000 lb. rig capable of pumping and processing up to 4.5 cubic meters/minute of drilling fluid, was moved to its location in Delta on the south shore of the Fraser River. On the north shore in Richmond, DIRECT's Rig 4, a 160,000 lb. rig capable of pumping and processing 2 cubic meters/minute of drilling fluid, was rigged up. Drilling for the

Rigging up Rig 4 in Richmond. More than 1.5 kilometers of inspected drill pipe sit ready for the pilot hole.

DIRECT's 1.1 million lb. Rig 9 operating on the south side of the Fraser on Delta's Tilbury Island.

24" product line was underway.

It was soon discovered that the south shore soil formation was much softer than originally thought. This intersect was first planned to meet underneath the Fraser at approximately mid-point. But with softer formations the smaller, more nimble Rig 4 was able to drill much faster than anticipated. The rig was able to drill to 900 meters of the total 1400 meter drill length, so the intersect was re-scheduled to follow a faster timetable. Using a surface coil proved to be an effective way to intersect the two 12.25" pilot holes, and a closer proximity to the large rig allowed for increased directional control while conducting delicate maneuvers underground.

The pilot hole was reamed to a 36" diameter in a single pass, the cleaning pass was executed and the NPS 24 product line was pulled.

Specialized rig moving trucks were again brought in to facilitate the interlocation move, and the two rigs were moved to the NPS 20 drill path. With the knowledge gained from completing the NPS 24, DIRECT had determined that the best approach to reaming the NPS 20 was to ensure full circulation, maintain steady ream times and allow for cuttings removal. It was important to remain vigilant, however, as the sandy and unstable soil conditions were highly unpredictable.

The rigs began drilling simultaneously and, while satisfying the exacting standards imposed by the engineering company, the 12.25" pilot hole was completed with record-setting speed. It was ultimately completed in less than 3 twelve-hour shifts – a feat generally acknowledged as unprecedented.

The pilot hole was then reamed to a 30" diameter, the cleaning pass was executed and the line was pulled.

MAKING IT WORK

This was a project where all of DIRECT's assets were brought into play and served vital roles in project execution and completion.

TerraMAX reamers, a technology proprietary to DIRECT, allowed them to go directly from 12.25" pilot holes to 36" and 30" diameter reams in a single pass. These solid-state reamers created additional efficiencies by offering penetration rates up to three times faster than conventional methods.

Superior large capacity pumping and solids control cleaning systems facilitat-

The challenging sandy soil conditions prevalent in the area are evident in this picture of the north side of the Fraser River in Richmond.

The NPS 24 product line is hoisted into position prior to product pull

ed clean bore holes and allowed fast, clean pulls that avoided financial penalties by being restricted to weekends.

In crossing the Fraser River, DIRECT Horizontal Drilling – a Western Canadian company running 14 HDD rigs in Canada and the US – brought to bear the full weight of their extensive intersect experience, superior drilling equipment and innovative, proprietary technology. •

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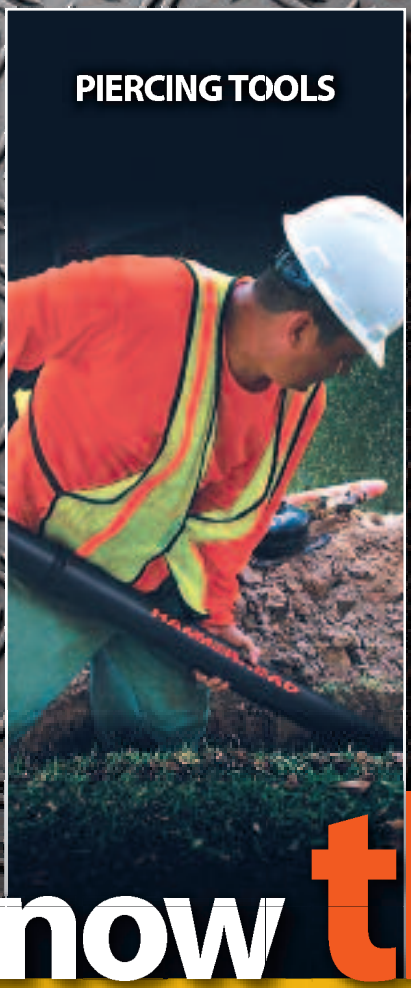
HAMMERHEAD
TRENCHLESS EQUIPMENT



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NASTT's 2012 No-Dig Show Call for Abstracts

Trenchless Takes Center Stage!

Submission Deadline: June 30, 2011

The North American Society for Trenchless Technology (NASTT) is now accepting abstracts for its 2012 No-Dig Show in Nashville, Tenn., located at the Gaylord Opryland Resort and Convention Center, March 11-15, 2012.

Prospective authors are invited to submit a 300-word abstract outlining the scope of their paper and the principal points of benefit to the trenchless industry. The abstracts must be submitted electronically via the No-Dig Show website at: www.nodigshow.com by June 30, 2011. The 2012 No-Dig Show Program Committee will review abstracts in mid-July and notify the primary authors of acceptance immediately afterward. To ensure meaningful technical content, all papers will be peer-reviewed. Final papers will be published in the conference proceedings.

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

Asset Management
- Pipeline Inspection and Locating
- Condition Assessment
- Subsurface Utility Engineering
- I&I and Leak Detection

Cutting-Edge Advances in Pipeline and Manhole Rehabilitation
- Cured-in-Place Pipe Lining
- Slip Lining
- Pipe Bursting
- Laterals Rehabilitation
- Grouting
- Lining Materials and Application Methods

New Installations
- New Concepts for Trenchless Equipment, Materials and Methods
- Horizontal Directional Drilling (HDD)
- Microtunneling
- New Applications for Boring Techniques (Auger Boring and Pipe Ramming)
- Pilot Tube Boring (Tunneling)

Trenchless Research and Development
- University and Industry Initiatives
- Education and Training

Environmental Incentives, Challenges and Sustainability
- Carbon Reduction
- Sustainable Construction Practices

Municipal Issues
- Selection Criteria for Contractors
- Development of Submittal Requirements
- Measuring Quality Assurance/Quality Control
- Project Budgeting and Prioritization
- Selection Criteria for Materials
- Funding for "Green" Technologies
- Lessons Learned

Industry Issues
- Social Costs and Impacts
- Industry Trends, Issues and Concerns

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No-Dig
NASHVILLE, TN
MARCH 11 - 15, 2012

NASTT

Vancouver's Jervis Forcemain No. 2 Sewer Upgrade Rock Tunnel

Jennifer Chu & Bruce Downing
Golder Associates
Redgenald Musana & Colin Meldrum
Metro Vancouver

The Jervis Forcemain #2 Project is a part of a major infrastructure upgrade initiative implemented by Metro Vancouver (formerly Greater Vancouver Regional District). The upgrade project consists of the installation of a new sewer main to replace an existing aging main that was built in the 1970s, which services the Downtown and West End areas of Vancouver, British Columbia. The upgrade will provide an increase in sewage capacity to accommodate the ever-growing population of Downtown Vancouver and provide an improvement in the system's reliability.

The entire route is approximately 2.2 km long and the construction of the new forcemain was divided into three phased contracts: Phase 1, the crossing under False Creek between Sunset Beach and Vanier Park, using horizontal directional drill methods; Phase 2, from Vanier Park to 4th Avenue in the Kitsilano area, using open cut excavation methods; and Phase 3, a section from 4th Avenue to 8th Avenue in the Kitsilano area, which included a 300 m long tunnel. Phase 1 and Phase 2 were completed by the summer of 2009, and the construction of Phase 3 commenced in April of 2010 and is due to be substantially complete by the end of April 2011. The construction of the tunnel portion of Phase 3 is the subject of this article.

SITE INVESTIGATION AND CONSTRUCTION TECHNIQUE

The construction technique used for Phase 3 of the project was governed by the dense urban setting and the depth of the sewer. From the portal, located between 4th and 5th Avenues, the ground surface rises steadily to the south, to a junction point with the existing Eighth Avenue Interceptor, which is located some 20m below ground surface. These criteria resulted in the design team opting for a tunnel solution.

A site investigation, which comprised a number of rotary boreholes drilled on or near the tunnel alignment, was completed by Golder Associates. Rock core samples were retrieved and a program of laboratory testing was conducted to establish rock properties (including rock strength and rock quality) along the tunnel alignment.

Through the implementation of the drilling investigation, it was determined that the tunnel was to be constructed entirely within sedimentary bedrock of the Kitsilano Member, belonging to the Huntingdon Formation. The bedrock predominantly consisted of sandstone and mudstone of extremely weak to weak strength, with some moderately strong to strong concretions of sandstone. Localized seams of coal were also encountered within the sedimentary bedrock, usually of thickness ranging from 0.03 m to 0.1 m. However, a thicker layer of coal and extremely weak mudstone of approximately 2 m thick was anticipated within the tunnel alignment. Single well response tests were also conducted during the site investigation, which determined that the hydraulic conductivity of the bedrock along the tunnel alignment was low. The results of the investigation were used to prepare a Geotechnical Baseline Report for the tunnel.

It was envisaged that there were two feasible options to

DOSCO MD1100 Roadheader

Entry shaft construction

excavate the tunnel, the use of a roadheader, or the use of a small tunnel boring machine. Drill and blast tunnelling was not considered on the basis of the potential for disturbance to nearby residents and the potential structural damage due to vibrations.

The Prime Contractor, Michels Canada Co., opted to excavate the tunnel with a roadheader to eliminate the need to construct a deep exit shaft on 8th Avenue in a busy urban setting, as the roadheader could be backed out through the completed tunnel.

The roadheader was a DOSCO MD1100 Roadheader supplied by NDCO Construction Services Inc, a Vancouver based company specializing in supplying new, used and refurbished roadheader machines. NDCO is the Exclusive North American Agent for DOSCO Overseas Engineering and works globally on some specific projects for DOSCO and globally for our used and refurbished equipment. Luke Mason, International Business Development Manager for NDCO, can

The start of Tunnel Excavation

Tunnel face – roadheader in action

be contacted at 604-535-7488 or luke.mason@ndcogroup.com

The tunnel dimensions were determined by the size of the roadheader rather than the requirement for installation of the product pipe. To accommodate the roadheader an arched section of excavated size 3m high by 3.6m wide was selected. Steel arched ribs with timber lagging were selected for temporary support of the tunnel during construction.

A 9.5m deep entry shaft was constructed in June 2010 using conventional dig and dump methods, which was temporarily supported with soldier piles and timber lagging. Tunnelling commenced in July 2010, and the sedimentary rock was excavated using a Dosco MD1100 Roadheader. The average cutting rate of the machine was measured to be approximately 30m^3/hour for extremely weak to weak sandstone. The tunnel excavation was completed in November 2010, two months later than anticipated, owing to a number of construction challenges.

CHALLENGES AND UNFORESEEN CONDITIONS

One of the first challenges encountered during construction was a mechanical breakdown of the roadheader. This resulted in a period of down time owing to the fact that replacement parts had to be imported from Europe.

Unforeseen ground conditions, which included a longer than anticipated section of rock with poor stability, as well as the occurrence of an interval of conglomerate bedrock, also affected tunnel advance rates over a portion of the tunnel.

The final challenge relating to the construction of the tunnel was completing the tie-in to the existing Eighth Avenue Interceptor while the sewer remained operational. At the time of the tie-in, flow velocity within the interceptor was measured relatively high, and the depth of sewage varied between 0.7 to 1.2 meters. The exact location and the wall thickness of the 50 year old un-reinforced sewer tunnel were uncertain owing to the limited as-built information that was available. To prevent damage to the existing sewer interceptor lining, when the tunnel was within close proximity, a series of horizontal test holes were drilled ahead of the tunnel face to locate the interceptor. The tie-in operations were implemented successfully by Michels Canada Co. over the course of three night shifts, while utilizing an isolation procedure that was designed by Michels Canada Co.

Existing Interceptor Exposed

Construction of Tie-in Structure

TUNNEL COMPLETION AND PIPE INSTALLATION

Following the completion of the tunnel, the road header was reversed to the entry shaft and demobilized. The product pipe, a glass fiber reinforced composite mortar (Hobas) pipe of 72 inch internal diameter, was installed in the tunnel to connect to the open cut portion of the project, near the tunnel entry shaft, to the Eight Avenue Interceptor.

The tunnel was completed with the grouting around the Hobas pipe within the tunnel, which was conducted by Pacific International Grout Co. using low density cellular grout. Given the large volumes of grout required and the need to avoid pipe flotation, the grouting was completed with seven lifts. A total of nearly 2,500 cubic meters of low density cellular grout was required to backfill the tunnel.

The new sewer main is scheduled to be put into service in the spring of 2011. Despite challenges associated with mechanical breakdown of machinery, unexpected ground conditions, and the need to tie-in to an existing interceptor of which the exact location was unknown, Phase 3 of the project is considered a success. The Contractor, the Owner and the Geotechnical Engineers worked together collaboratively to overcome these construction challenges. •

Product Pipe Installation

Fusible PVC™ Pipe Performs, Protects & Cuts Cost in a Variety of Applications

Louis-Philippe Dubé
Market Development Manager - IPEX Inc.

As municipalities throughout North America look to cut costs, improve long-term performance, and protect the environment, they are looking to a better alternative for both pressure and non-pressure underground piping systems — Fusible PVC.

MAKING A BETTER CHOICE

Primarily used in potable water lines, sewer systems, and fire protection systems, polyvinyl chloride (PVC) is today's most widely used pipe material as it continues to replace traditional outdated piping systems like ductile iron, steel, cast iron, and copper. Now in use for over 50 years, familiarity of PVC among owners, operators and contractors is well established.

PVC offers superior durability and stiffness compared to other plastic pipe, giving it the ability to withstand loading or movement caused by poorly compacted soils. As a non-conducting material, PVC is not subject to electromechanical and galvanic corrosion by salts, acids, and alkalis, which can attack metal pipe in underground applications. This makes coating or lining of PVC unnecessary.

Lighter weight than HDPE with a reduced wall thickness that results in a better strength-to-weight ratio, PVC typically provides a lower material and installation cost and yields better flow. With better corrosion and chemical resistance than HDPE, PVC is a more effective barrier against permeation of common environmental pollutants. Because PVC properties do not change over time, and it resists hydrocarbon permeation and oxidation, it offers a longer lifespan of 100 years or more.

Cast-iron outside diameter (CIOD) Fusible Brute PVC and Iron pipe size (IPS) Fusible Series PVC from IPEX combines the superior mechanical properties of PVC with an innovative patented butt fusion process. It enables fully restrained gasket-free joints with a tensile strength and corrosion resistance equal to that of the actual pipe itself, which has been proven via testing in accordance with ASTM F-1674 and D-638 methods. The higher tensile strength of the fused joints, allows for a greater pull force rating than HDPE and other restrained PVC systems. Greater pull forces offer safer installation in tough conditions and easier installation in long continuous trenchless and direct bury applications.

For municipalities, Fusible PVC enables easy connections to existing PVC water distribution and sewer systems via simple standard fittings, providing material consistency across entire systems. Standard fittings can also be used to tap, connect and change direction on Fusible PVC pipe systems, eliminating the use of costly transition or fused-on fittings. Because all the accessories are readily available, Fusible PVC pipe is easier maintain over the life of the system, offering further cost savings.

COMPLETING THE FUSION PROCESS

To create longer pipe lengths with Fusible PVC, a patented fusion process is used to connect sections and create gasket-free joints. This process incorporates a proprietary PVC formulation and a unique combination of heat, pressure and time, using slightly modified, standard industry fusion machines. The gasket-free joints and excellent abrasion and scratch-resistant properties ensure long-term reliability and reduced maintenance of systems.

The fusion process is typically completed above ground in a staging area, carried out by trained and licensed individuals to ensure consistent, reliable fusion that creates piping systems

By using a weather shelter during the fusion process, Fusible PVC can be installed under any weather conditions

of unparalleled strength. Fusion starts by precisely and securely aligning the pipe ends. A dual cutting head faces and squares both ends simultaneously and an electronically-controlled heating element heats the ends of the pipe, forming a bead of fusible material. Once the ends have been heated, the pipe ends are joined together and held under pressure until the newly-formed joint cools to the required conditions and the pipe is ready for installation. The lightweight, flexible lengths of pipe are then simply dragged on rollers from the staging area to the installation site.

Fusion time with Fusible PVC is comparable to other thermoplastic materials and can be performed under any weather conditions, as long as the pipe ends are maintained at a temperature above 4°C and both the pipe ends and fusion machinery are sheltered from the elements. When connecting to existing pipe that is too deep for above-ground fusion, the starting joint can be fused in the pit at the elevation of the existing pipe. Trench boxes may be needed as shoring to allow safe access into pits deeper than 1.37 meters.

SERVING A VARIETY OF APPLICATIONS

Fusible PVC is capable of being used in a variety of trenchless or conventional direct bury applications, and has been installed at numerous sites throughout the United States, Canada and Mexico for both pressure and non-pressure installations in the water and sewer industries.

- **Horizontal Directional Drilling (HDD) Applications**—When trenching or excavating is not practical, trenchless horizontal directional drilling (HDD) is used to install Fusible PVC in a shallow arc along a prescribed path with minimal impact on the surrounding area. HDD is often used to install pipe under natural obstacles like parks, lakes and rivers, which provides a greener more environmentally-friendly approach. In addition to preserving the natural environment, HDD applications can avoid tearing up asphalt and disturbing roadways, which can disrupt businesses and residents. HDD also reduces the risk of damaging other underground systems, which can require significant post-installation repair costs. In HDD applications, the smaller outside diameter of Fusible PVC pipe means that drilling equipment can make smaller bore holes, allowing for an easier, faster drilling process and reduced amount of drilling fluid required. In turn, using less drilling fluid reduces the amount of fluid waste that has to be disposed of, further making Fusible PVC a more environmentally-friendly choice. Fusible PVC also has a safe pulling allowance that is significantly greater than that of most other pipe systems, facilitating longer or more difficult HDD installations. With a lower overall material weight, Fusible PVC allows for smaller drilling equipment size and longer pull-in lengths for reduced cost.

- **Sliplining Applications**—As one of the oldest methods for repairing

Use Fusible PVC in an HDD application for a more environmentally-friendly approach in areas like parks, lakes and rivers

leaks or restoring the structural stability of existing pipelines, trenchless sliplining applications involve installing a Fusible PVC pipe into larger existing pipe. In sliplining applications, the existing pipe needs to first be surveyed. Often a camera is pulled through the entire pipeline to document its condition. The clearance between the existing pipe and the new Fusible PVC pipe depends on the overall condition and alignment of the existing pipe, but typically the clearance should not be less than 2 inches (50mm). The Fusible PVC pipe can be pushed or pulled into the existing pipe using common construction equipment. Once the new pipe is installed, the area between the two conduits is either grouted or filled with sand or other media to provide support for the new pipe. Fusible PVC is an excellent option for sliplining applications because it offers the largest internal diameter of any slipline material. However, if more flow is required than can be achieved with sliplining, other installation methods such as pipe bursting can be considered.

- **Pipe Bursting Applications**—A method of completely replacing existing pipelines, pipe bursting involves installing Fusible PVC that is attached to the back of an expander head, or burst head. As the expander head is introduced into the existing pipe, it breaks the existing pipe into small pieces and pushes them into the surrounding soil. Typically completed in 100 to 150m increments, pipe bursting results in the same or larger inner diameter as the existing pipe. This makes it an ideal solution for when equivalent or larger flow is required. Because Fusible PVC offers the largest internal diameter of any pipe bursting material, a smaller outer diameter can often be achieved. This also enables using a smaller expander head and less expensive bursting equipment. Fusible PVC's excellent scratch and abrasion resistance also makes it well suited for maintaining durability in pipe bursting applications.

Fusible PVC offers the largest internal diameter of any sliplining material available today

- **Casing Applications**— In some applications, it can make sense to encase Fusible PVC within a larger-diameter Fusible PVC. This system is not considered a double-encasement system required for harsh environments where the pipe needs to be protected from acidic soil or where chemicals in the waste system are not suitable for contact with the surrounding ground water. It does however create a system that is more corrosion proof and allows for the inner pipe to be removed, repaired and reinstalled if necessary, without disturbing the surrounding environment. For example, casing applications might be used for installing pipe under roadways to prevent collapsing. The outer pipe maintains the stability of the surrounding earth, while the inner pipe can be easily removed and reinstalled.

- **Direct Bury Applications**—When a trenchless application is not required, direct burial applications can be a practical, cost-effective method for installing Fusible PVC pipe. As a system that is fused above ground outside of the trench, Fusible PVC offers the option of using higher production excavation trenching equipment, saves time and improves scheduling by allowing the fusion to take place independent of trenching, and ensures a safer work environment because workers are not always required in the trench. Depending on the site conditions, the fully restrained, non-gasketed joints of Fusible PVC can also eliminate the need for mechanical restraints in the trench, and remediation of joints prior to backfilling is not required. Fusible PVC's superior durability also limits long-term deformation under soil load, and its material properties are resistant to hydrocarbon permeation from the surrounding soil.

ACHIEVING RELIABLE, PROVEN SYSTEMS

As the only solution for installing a continuous, non-corrosive fully-restrained pipe system, Fusible PVC is quickly gaining acceptance throughout North America for pressure and non-pressure installations in water mains, sanitary sewers, process and raw water systems, reclaimed systems and storm drains.

With record setting installations of continuous pull-in lengths of more than 1500 meters, higher flow rates, material consistency, lighter weight, reduced material and greater pull force rating than other systems, Fusible PVC is significantly cutting costs for municipalities. At the same time, its gasket-free joints, durability and excellent material properties are creating systems that stand the test of time, reducing total cost of ownership over the life of the system. The ability to install Fusible PVC in a variety of trenchless and direct-bury applications makes it an easy environmentally-friendly choice for today's pipe systems.

Over one million meters of Fusible PVC have been installed in more than 1,000 projects across North America... including one of the largest HDD installations of 1,950 meters. IPEX is the leading supplier of Fusible PVC in Canada with over 120 installed projects across the country. To ensure fusion quality of Fusible PVC, IPEX has established a network of Licensees, which involves strict adherence to established fusion parameters and a mandatory 2-day training course for fusion technicians. Through state-of-the-art manufacturing facilities and distribution centers, IPEX offers CIOD Fusible Brute PVC and IPS Fusible Series PVC in sizes ranging from 100mm (4") to 600mm (24") with larger sizes in development. Pipe sections come in 12.2m (40 foot) lengths made to AWWA C900, AWWA C905 and certified to CSA B137.3, NQ3660-950 and NSF-61.

Choosing Fusible PVC as the alternative for today's pipe systems ensures performance, protects the environment and saves money. •

District of West Vancouver Ambleside Sewer Rehabilitation - Innovative Solutions to Reducing Infiltration and Inflow

Steam curing of CIPP. Other end of sewer can be seen in the background.

KIERAN FIELD, E.I.T.
GURJIT SANGHA, P.ENG.
ANDY KWAN, P. ENG.

INTRODUCTION

The Federal/Provincial Infrastructure Stimulus Fund has assisted the District of West Vancouver to rehabilitate its Ambleside Sewers. The project has included the CIPP relining and Pipe Bursting of 3600 metres of sanitary sewers. There were many interesting challenges for this project, including its tight schedule. This required pre-flow monitoring, CCTV, assessment, rehabilitation of sewers, and post-flow monitoring within 9 months. The schedule has been kept on track, with the team's ingenuity including using multiple contracts for flow monitoring, CCTV, bursting, and relining.

BACKGROUND

In 1997 Opus DaytonKnight (formally Dayton & Knight) completed an inflow and infiltration study for the Ambleside Area. The area was divided into 10 sub-catchments. Six of the sub-catchment areas were video inspected, smoke tested and flow monitored. CCTV inspection included documenting sewer defects but excluded a defined scoring system to prioritize infiltration and structural repairs. The area was found to have high infiltration and inflow.

ASSESSMENT (CCTV)

Updated CCTV inspection, smoke testing and sewer evaluation was required for reassessment, and more importantly to provide a systematic approach for prioritization.

Due to the tight construction schedule it was contemplated to include CCTV work as part of the overall construction tender. We decided to not proceed with this due to uncertainties in construction limitations for the contractor and cost control for the overall project.

Instead we decided to expedite CCTV inspection. It was recognized that prompt CCTV inspection of the sewers would be the critical path for successful implementation of this project. CCTV inspection crews can typically video up to 1000 metres per day under ideal conditions which would suffice for the needs of any project under ordinary circumstances, but due to the time constraints on this project alternative tendering options were explored and assessed. Our project required CCTV inspection and report submittal of 26 km of sewers in one month.

The area of inspection was split into three sections and the contract was tendered with the understanding that the lowest bidder may not necessarily be awarded the entire contract. The tender emphasized the importance of schedule and a requirement to demonstrate the ability to complete the inspection within the required timeframe. The CCTV work was awarded to two contractors. Mar-Tech Underground Services Ltd. was awarded 17 km of CCTV inspection and smoke testing and ABC Pipe Cleaning Services Ltd. was awarded 9 km. As a result of this, the entire CCTV inspection and smoke testing of over 26 km of pipe took place in less than 2 months. This allowed for more time to be spent on assessing the poorest pipes and rehabilitating them. CCTV inspection was completed by August, 2010.

The CCTV sewer inspection videos and reports were assessed to confirm the method of rehabilitation with the District. From the 400 pipe lines that were inspected, 96 were chosen to be rehabilitated on the original contract with 22 pipe bursts, 43 spot repairs, and 31 relinings. The majority of rehabilitations were to be trenchless due to the significantly lower cost, as well as reduced asphalt cutting and patching and the reduction in inconvenience to the public during installation. DVDs of the sites were made for the District and for the use in the tender process.

FLOW MONITORING

In conjunction with CCTV inspection, options were reviewed for completion of a flow monitoring program that could be used to assess the achieved reduction in I&I. Given the limited pre-flow monitoring window, flow monitoring was assessed quickly. The District had decided to purchase the portable flow monitoring equipment because rental costs were calculated to be more expensive than the cost of purchasing. Flow monitors were installed in August of 2010.

DETAILED DESIGN

Detailed design for the sewer rehabilitation was undertaken for relining, pipe bursting, point repairs, service connections, cross connection repairs, manhole benching and grouting.

The design for CIPP pipe liners was based on the ASTM F1216-93 standard, and recommendations were made on the relevant design criteria for each section, including whether pipelines were partially or fully deteriorated, long term flexural modulus, ovality, external pressure (soil and groundwater), enhancement factors and Poisson's ratio. CIPP liners are typically a very economical form of complete structural sewer rehabilitation. CIPP liners were used where possible in this project but were limited in areas of ovality, joint offsets and capacity concerns.

The design for pipe bursting was based on the use of high density polyethylene pipe. Pipe bursting was used in areas that CIPP could not be utilized including joint offset and where capacity upgrades were warranted by diameter upsizing.

We decided to tender two separate contracts for pipe bursting and CIPP lining. This was in effort to expedite the construction schedule. We also felt that providing tenders for specific areas of bursting and CIPP would allow for increased competitive bidding from contractors that specialize in these respective areas.

The pipe bursting contract was awarded to PW Trenchless Construction Inc. and the relining contract was awarded to Mar-Tech Underground Services Ltd in November of 2010. The two contracts came in underbudget at a total cost of about $1.3 million which compared to our original estimate of $1.8 million.

CONSTRUCTION

Relining of most of the sewers involved the use of CIPP liners. Installation involved access to upstream and downstream manholes of a sewer. CIPP liners are resin impregnated liners that are installed and cured within the host pipe. The liner is inserted through the host pipe using a winch system and then pressurized to about 10 psi for one hour. Total installation time typically takes about 5 hours. Once installation has been completed a router and CCTV camera are inserted into the line and services connections are cut out. Service interfaces are then sealed using chemical grouting and a service interface grout packer.

Steam curing of CIPP for shorter section of pipe in owner's backyard

Tugging machine in trench with shoring cage

Pipe bursting included upsizing of sewers by one pipe diameter. All sewers that were burst were either 150 mm or 200 mm diameter and were increased to 200 mm and 250 mm diameter respectively. Pipe bursting involved the use of a pneumatic burst head where appropriate and a static head where not. Soils in the area were predominantly hardpan in nature. Installation for the pipe bursting sections typically took 4 hours per section.

Spot excavation and replacement was required in some locations where blockages or collapsed sections of sewer prevented trenchless methods. This typically included replacement of 3 metres of sewer with the use of PVC pipe and couplings.

BUDGET

In addition to the original 96 lines a further 32 lines were added to the contract given the budget surplus, the rate at which the two contractors were completing the project and the extension to the Federal/Provincial Infrastructure Grant.

CONCLUSION

Although some difficulties arose during construction (shallow pipe, concrete encased pipes, service connections requiring bypass pumping etc.), the overall rehabilitation process has been running smoothly. We have made changes on the go. In some cases where a sewer was originally to be relined and it was then discovered that a joint offset would impede on the liner, a change order would be issued to move it to the pipe bursting contract. Likewise, if a sewer was originally to be burst but the District did not want to cut freshly paved

PW Trenchless replacing a manhole on Marine Drive.

PW Trenchless were meticulous in their site restoration using the originals paving stones side by side.

asphalt around the existing manhole, it was changed to the relining contract.

The trenchless methods utilized have minimized impact of construction to the neighborhood. Many residents within the area were unaware of the construction that had taken place for this project. If this project utilized traditional open-cut construction residential impact would have been substantially increased as well as potential damage to older trees in the area.

As the project is still underway it has yet to be determined as to the extent of I&I reduction in the area. One thing is known however; due to the cost savings associated with trenchless technologies and the ability to go where open cut rehabilitation cannot, the District of West Vancouver was able to rehabilitate and rectify more structural defects in their sewer system with these methods then by excavation alone.

Mar-Tech's method of relining enables them to reline in more inconvenient areas

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Dinosaur Pipe as a Teaching Aid

Wayne Nowlan, Founder and Superintendent, Waterworks Technology School

When visitors drop into Wayne Nowlan's office at Waterworks Technology School, they are amused by the many parts and pieces and appurtenances that make up our municipal underground utilities. Then, they usually spot an old "wooden pipe", and of course conversations start there. Wayne enjoys telling the story of how this wooden pipe was installed in downtown Calgary in 1893, replaced in 1923 by cast iron watermains, and finally they were recently replaced with the help of one of his graduates with a modern piping system.

This pipe is a dinosaur of the municipal utilities industry, according to Wayne Nowlan, and he warns all who will listen: If all levels of companies and workers in the municipal piping industry don't continue to upgrade themselves with new ways of doing things, they too will become dinosaurs within the industry.

"Trenchless Technology is such a broad leap out from the dinosaur days of standard utility methodology," states Nowlan. "Yet, I still hear of companies that have not yet embraced Trenchless methods or are extremely timid to venture into these new methods. I find that to be unfortunate. Trenchless is so exciting and interesting in every way. Trenchless Technology is kind to the environment, cost efficient, provides a safer work environment and, best of all, Trenchless allows for piping installations, replacements and rehabilitation that often no other piping system could accomplish."

"I have been engaged for four decades in the municipal utilities industry from coast to coast to coast, and it is my opinion our cities and towns are in a fragile state with far outdated underground utilities. With federal, provincial and municipal budgets that are just not enough to get the job done, we need to make greater advancements into the acceptance of Trenchless methods to rehabilitate and replace our old piping systems. The efficiency of speed and less disruption of associated facilities always reflects well on budgets. To be part of the solution, we cannot continue to be part of the problem by using dinosaur methods."

Wayne Nowlan, a mechanical engineering technician with four decades in the municipal utilities industry, continues to be a proponent of the latest in new technologies. Mr. Nowlan is the Founder and Superintendent of Waterworks Technology School, where municipal utilities students are taught the rewards of embracing new ideas and methodologies.

For further information on the educational opportunities at the Waterworks Technology School, call 250-385-5407 or visit their website at www.waterworks-tech.com

Effectiveness of Hydrofracture Prediction for HDD Design

Kimberlie Staheli, Ph.D., P.E., Christopher G. Price & Laura Wetter
Staheli Trenchless Consultants, Inc.

The risk of hydrofracture is a consideration on most major horizontal directional drilling (HDD) projects. Within the last 10 years, there has been a concerted effort within the HDD community to quantify limiting down-hole fluid pressures which will cause hydraulic fracturing of the soils, possibly resulting in inadvertent drilling fluid returns at the ground surface. Many have evaluated and used the cavity expansion model (Luger and Hergarden, 1988) to determine the maximum down-hole fluid pressures and to determine appropriate drilling depths beneath critical project elements such as rivers or wetlands. Although the merits of the method have been argued, insufficient data have been collected on HDD projects comparing the actual down-hole fluid pressures at locations of inadvertent fluid returns to the model predictions. Here we compare theoretical calculations for maximum bore pressure and actual bore pressure observed on different HDD projects where hydrofracture occurred, characterizing the effectiveness of the method, and furthering the accuracy of hydrofracture prediction for future HDD designs.

CAVITY EXPANSION THEORY

Cavity expansion theory was first applied to HDD bores by Luger and Hergarden in 1988. The model was developed to establish the maximum allowable pressure that can be applied to a given soil without hydrofracture occurring. This maximum allowable pressure is expressed as the following:

The value for the radius of the plastic zone (Rpmax) is established by the user. When trying to establish the pressure at which hydrofracture will occur, the value for the radius of the plastic zone is typically set to the ground surface elevation. During design, a factor of safety is commonly applied to the radius of the plastic

$$p_{max} = u + [\sigma_0' \cdot (1 + \sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi] \cdot \left(\left(\frac{R_b}{R_{pmax}} \right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G} \right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c \cdot \cot\varphi$$

Where:

p_{max} = Maximum Allowable Mud Pressure $\left[\frac{lb}{ft^2}\right]$

R_b = Bore Radius $[ft]$

R_{pmax} = Radius of the Plastic Zone $[ft]$

Variables Dependent on the Soil:

φ = Soil Friction Angle $[°]$

c = cohesion $\left[\frac{lb}{ft^2}\right]$

G = Shear Modulus $\left[\frac{lb}{ft^2}\right]$

γ = Unit weight of soil above the groundwater $\left[\frac{lb}{ft^3}\right]$

γ' = Unit weight of soil below the groundwater $=\gamma - \gamma_w$ $\left[\frac{lb}{ft^3}\right]$

Variables Dependent on Bore Geometry:

h_s = Depth of the Bore below Ground Surface $[ft]$

h_w = Height of groundwater over the bore $[ft]$

u = Groundwater Pressure $= \left[\frac{lb}{ft^2}\right]$

σ' = Effective Stress $= \gamma \cdot (h_s - h_w) + \gamma'(h_w) \left[\frac{lb}{ft^2}\right]$

zone to ensure that the plastic zone does not reach the surface. Safety factor values of 1.5 are usual for sands while values of 2.0 are applied for clays (Delft, 1997; Bennett and Wallin, 2008).

DOWNHOLE PRESSURE MEASUREMENTS AND FIELD DATA

On two recent projects, Staheli Trenchless Consultants provided on site construction risk management services, monitoring the contractor's actions, drilling parameters, and performing time-in-motion studies to provide information to the Owner with respect to real-time evaluation of drilling progress and the nature of any challenges that arose during drilling operations. On these projects, down-hole pressure monitoring was performed by including a pressure transducer in the drill string, approximately 25 feet behind the drill bit. The pressure sensor was hardwired through the drill pipe, and provided information to the locator on the same computer used for the tracking system.

When drilling the pilot bore on these projects, inadvertent returns occurred at two locations with dramatically different conditions, i.e. soils, depths, groundwater level, etc. Each of these locations were captured on the down-hole pressure monitor, and significant increases in pressure could be seen at the inadvertent return locations.

Location 1

The first site for analysis was an HDD that was constructed in hard to very hard silt with sand. The depth of the bore at the location of the inadvertent return was 70 feet. The geotechnical report provided measured values for the unit weight of the soil, friction angle, and groundwater elevation. The values for cohesion, Poisson's ration, and the elastic modulus were estimated and are shown in Figure 1.

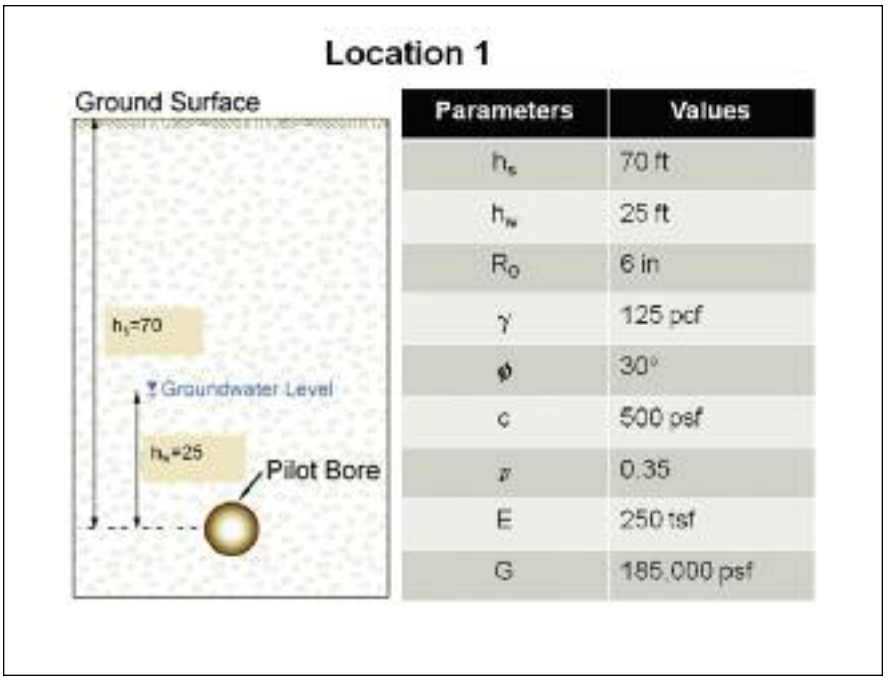


Figure 1: Location 1 – Geometry and Soil Parameters

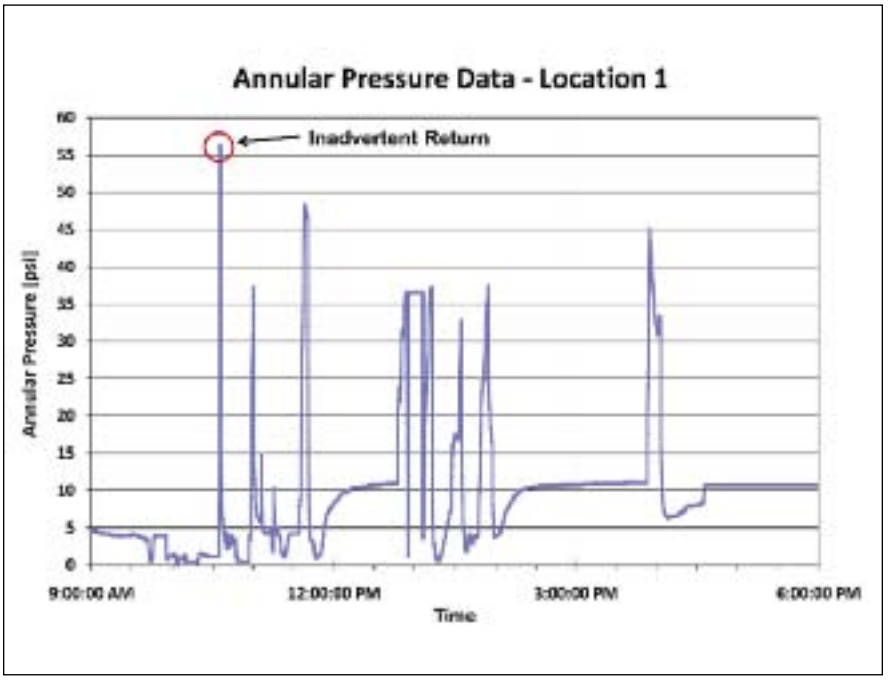


Figure 2: Location 1 – Annular Pressure Data during Inadvertent Return

Down-hole pressures were relatively low during pilot bore drilling, except during borehole collapse. During these times, the down-hole pressure sensor would record significant and immediate spikes in pressure that would only dissipate when the blockage along the bore path was cleared or when drilling stopped and the bore-hole pressure was allowed to dissipate. Figure 2 shows a graph of the down-hole pressure data at inadvertent return Location 1.

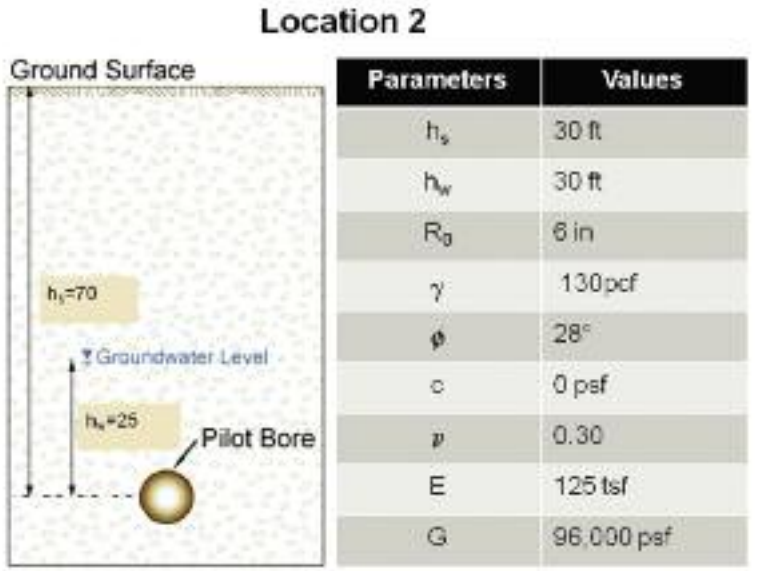
Location 2

The second site for analysis was an HDD that was constructed in alluvial deposits comprised primarily of medium dense sands with some silt and gravel. At the location of the inadvertent return the bore was approximately 30 feet deep and had groundwater at the ground surface. Figure 3 shows the bore geometry at the location of the inadvertent return as well as the soil parameters. Only the soil unit weight was provided in the soils report. The

other soil parameters in Figure 3 were estimated based on published values.

At Location 2, the pilot bore was nearing the exit location when the inadvertent return occurred. Like Location 1, it is believed that the borehole collapsed just prior to the inadvertent return. As circulation was lost, the annular pressure increased, and drilling fluids were then observed at the surface. Figure 4 shows the down-hole pressure readings throughout the duration of the inadvertent return.

After the initial inadvertent return occurred just prior to 12:00 pm, the drilling fluid escape path was allowed to "heal" and drilling continued once an open borehole was reestablished. However, an additional inadvertent return occurred after 3:00 pm at the same location when the bore once again collapsed.



Parameters	Values
h_s	30 ft
h_w	30 ft
R_0	6 in
γ	130 pcf
ϕ	28°
c	0 psf
ν	0.30
E	125 tsf
G	96,000 psf

Figure 3: Location 2 – Geometry and Soil Parameters

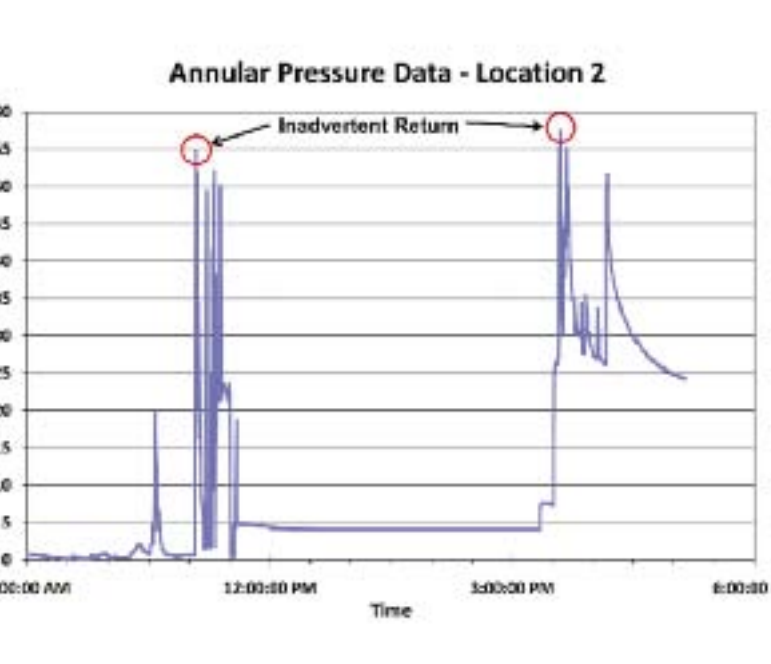


Figure 4: Location 2 – Annular Pressure Data during Inadvertent Return

COMPARISON OF DOWNHOLE PRESSURE MEASUREMENTS AND PREDICTED VALUES

For each of the inadvertent return locations, the measured down-hole pressure readings were compared to the predicted maximum pressure using the cavity expansion model with the radius of the plastic zone at the ground surface (Table 1).

We hypothesize that setting Rpmax at the ground surface yields a calculated maximum pressure that was much higher than the actual pressure that caused inadvertent returns. When considering its influence in the maximum pressure equation and the localized nature of the plastic zone from the bore, it is not realistic to assume that Rpmax would reach the ground surface before hydrofracture occurs. Additionally, Xia (2009) conducted a series of large and small scale experiments at Queen's University and was able to show that the Delft equation grossly over-predicted the maximum pressure when using Rpmax at the ground surface (Xia, 2009), in some cases by more than 150%.

Figure 5 shows the radius of the plastic zone corresponding to the pressure at which inadvertent returns occurred at Location 1. The material was hard silt and had a very small expansion of the cavity of only 1/4 ft prior to reaching the pressure in which inadvertent returns actually occurred.

Figure 6 shows the radius of the plastic zone corresponding to the pressure at which inad-

	Location 1	Location 2
Maximum Pressure using Cavity Expansion Model with Rpmax at the ground surface.	314 psi	133 psi
Measured Pressure Causing Inadvertent Returns	56 psi	55 psi

Table 1. Predicted and Measured Limiting Pressures Using the Cavity Expansion Model.

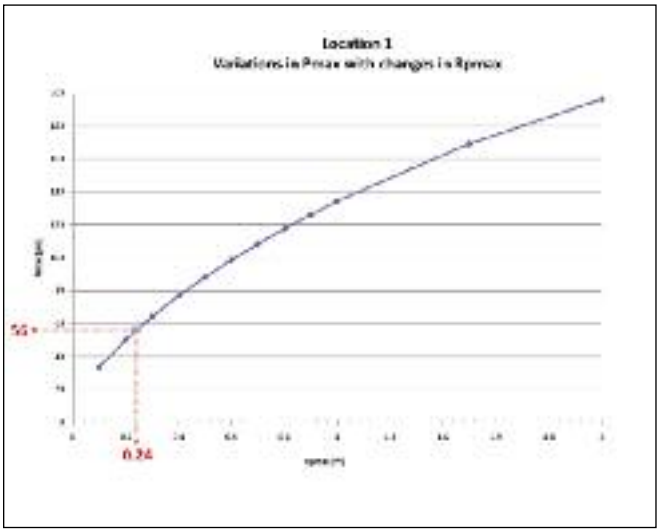


Figure 5: Location 1 – Frac-out Pressure and Plastic Zone Radius

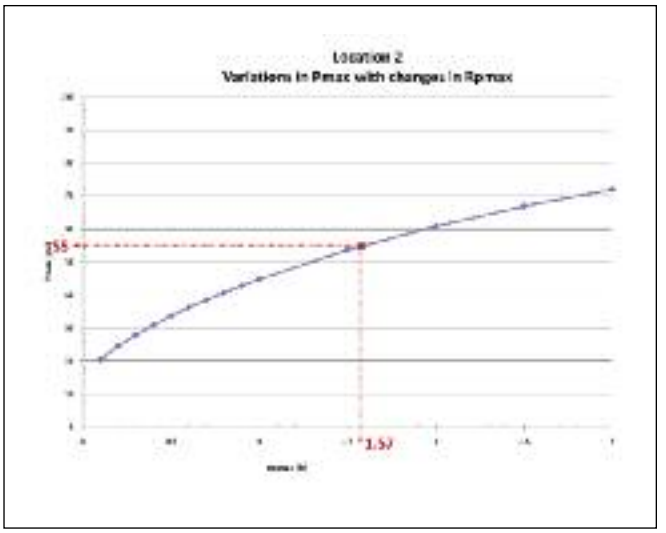


Figure 6: Location 2 – Frac-out Pressure and Plastic Zone Radius

vertent returns occurred at Location 2. The material for this bore was medium dense sand with some silt and gravel. According to the Delft equation, the radius of the plastic zone at the pressure where the inadvertent return occurred was approximately 1-1/2 ft.

CONCLUSIONS

We conclude that the use of the maximum pressure calculation using the cavity expansion model overestimates actual pressure at which inadvertent returns occur when using large values of Rpmax. The accuracy of the predicted maximum pressure could be improved by calculating Pmax when Rpmax is very small (on the order of 2-3 borehole diameters or less). Alternatively, a safety factor should be applied to the calculated maximum pressure value with Rpmax calculated at the ground surface. Engineering judgment must be used to limit the hydrofracture pressure for a conservative design. Although the cavity expansion model is a valid method of calculating maximum pressures, it is clear that all input variables must be thoroughly understood before accurate predictions may be made. To this end, it is important that more down-hole pressure data be collected and compared with cavity expansion predictions where inadvertent returns occur so that we may gain a better understanding of the plastic zone behavior.

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