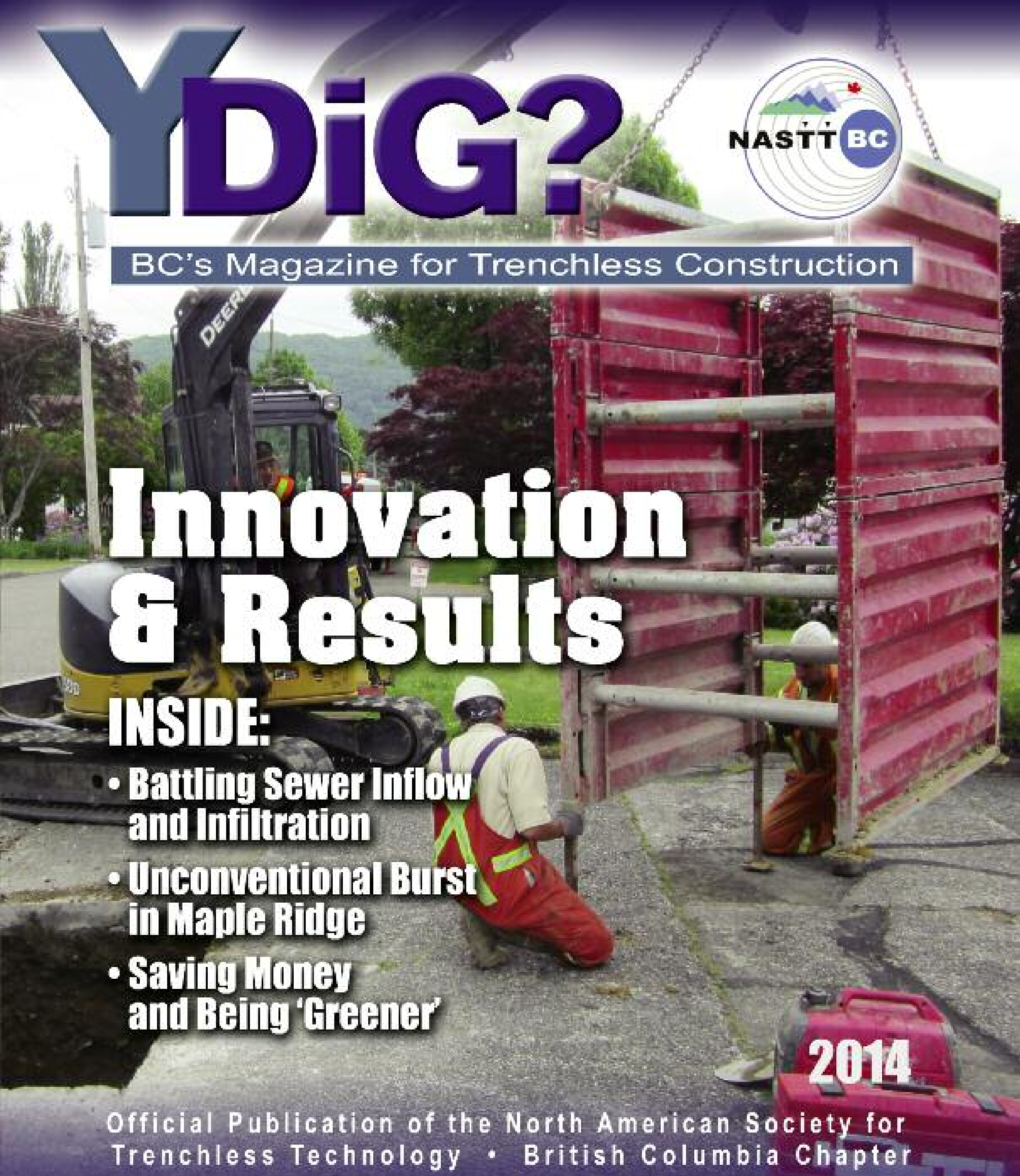

YDiG?

BC's Magazine for Trenchless Construction

Innovation & Results

INSIDE:

- Battling Sewer Inflow and Infiltration
- Unconventional Burst in Maple Ridge
- Saving Money and Being 'Greener'

2014

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

www.nastt-bc.org

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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

Formed in 1997 as part of the original NASTT Northwest Chapter, the BC Chapter was established separately in 2005. It exists to promote the use of trenchless technology in B.C. through education and standards. NASTT-BC has worked hard over the last 8 years to have trenchless standards adopted throughout the Province. In 2008, work began by the Chapter to develop a tool for accurately determining the reduced carbon footprint that various trenchless technologies offer - the Carbon Calculator! Use this program to estimate the tons of carbon emissions that were eliminated by the trenchless construction method that you have chosen for your project. Watch for the posting of the latest version of this useful tool to enhance sustainability in British Columbia.

- In the MMCD's new Platinum book, CIPP and Pipe Bursting are included, with remaining trenchless methods to follow.
- NASTT-BC held 3 seminars last year around the province to bring local trenchless knowledge to each region. In 2013, there will be 3 more seminars on new topics in Kelowna, Burnaby and Victoria.
- 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. As the North American component of the ISTT (International Society for Trenchless Technology), NASTT is dedicated to promoting the benefits of trenchless technology through education, training and research. NASTT is the definitive resource for trenchless professionals like you, who are concerned with underground systems and the applications of trenchless technology.

Trenchless Technology

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

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

Membership

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

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

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

Your Regional Chapter - NASTT-BC

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

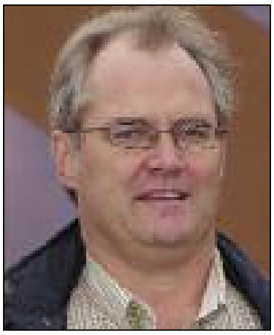
For more recent information on Trenchless Construction in British Columbia and BC Chapter activities, go to **www.nastt-bc.org**.

JOIN NASTT and NASTT-BC TODAY!

To become a member of NASTT-BC, contact Monica Perry at mwperry@telus.net

President's Message

David O'Sullivan



Potential Cost Savings with Trenchless Work

Trenchless construction by its very nature is much less intrusive than traditional open-cut. However, did you know it can also be much cheaper?

It is difficult to evaluate the cost advantages in a side-by-side comparison. The best way of doing so is by having the project bid both ways and having the market decide. After a number of projects are bid side-by-side, a pattern will emerge.

We must understand that trenchless will not always be the cheaper option. Sometimes the project lends itself to an open-cut option and sometimes the market dictates that the open-cut contractors for business reasons are willing to be very much cheaper.

See Table 1 for the results of different projects completed in the lower mainland of B.C. that we were involved with, where the projects were bid as both trenchless and open-cut.

These were bid head-to-head and demonstrate substantial savings when trenchless was allowed to go head-to-head with open-cut. That is not to say that trenchless is suitable for all open-cut projects, but where utilities have to be replaced on existing roads we need to look at trenchless as the solution before traditional open-cut and not the other way around. This list of projects included pipe bursting and HDD only; it did not include any CIPP, which is generally cheaper again.

This is a very important message, and the potential cost savings need to be recognized from the start. However, because the tendering market can change, our thoughts may be to offer the contracts both as trenchless and open-cut and let the contractors decide.

PROJECT	OPEN CUT	TRENCHLESS OPTION
2013 Surrey Sewer Repair and Maintenance program	$1,470,000	$960,000
2013 Delta Scott road sewer replacement	$2,200,000	$1,520,000
2008 to present, Surrey water to farming areas	$5,000,000	$3,800,000
2010 Coquitlam South west forcemain	$630,000	$412,000
2008 Burnaby 1st Avenue Force Main	$278,000	$175,000

Table 1. Cost-comparisons between open cut and trenchless for recent local projects.

NASTT Exists Because of You

Michael Willmets
NASTT Executive Director

Hello, my fellow Canadians!

How about those Olympic Gold Medal Hockey Teams?! There is much to be proud of, and not just with all the Olympians that came from British Columbia, but with NASTT-BC too.

It was such a pleasure and an honour for me to visit the B.C. Chapter recently and attend the CIPP Good Practices training course held in Surrey in February. More than 60 trenchless professionals attended this training event taught by our volunteer industry expert instructors Ian Doherty and Chris Macey. It was great to network with so many trenchless enthusiasts and hear about many exciting local projects. B.C. really is a trenchless hotbed.

The success of this training session was due to the hard work and organization of B.C. Chapter Director (now Chair) David O'Sullivan, who dedicated many hours to arrange this event. Past Chapter Chair Preston Creelman also needs to be recognized for his contribution not only for this event but many other initiatives over the past years. Let's not forget Monica Perry either, who David and Preston say deserves the real credit. Thank you, Monica, David and Preston!

The B.C. Chapter has been an important part of NASTT since 2005, and the hard work and accomplishments of your Chapter are greatly appreciated. NASTT depends on the strength of our regional chapters and its volunteer members to be the premier resource for knowledge and education in the trenchless industry.

In other news, this April NASTT's 2014 No-Dig Show is being held in Orlando, Florida, with over 150 exhibitors on hand to display their innovative contributions to the trenchless industry. Over 160 non-commercial technical papers were to be presented over three days covering all aspects of trenchless technology topics. One great success of this year's show is the return of the NASTT Municipal and Public Utility Scholarship Program for the second year in a row. Over 100 scholarship recipients from all over North America received full conference registrations and hotel accommodations at the host hotel, the Gaylord Palms Hotel & Convention Center. We are proud to say that several of this year's recipients represent municipalities in British Columbia.

NASTT thrives and survives on the commitment and dedication of the regional chapters and volunteer membership. Simply put, we exist because of your enthusiasm and your support. NASTT has many great things on the horizon in the months to come, and I wholeheartedly look forward to working with the B.C. Chapter in the future.

NASTT Events

April 13-17, 2014

NASTT's 2014 No-Dig Show

Gaylord Palms Hotel & Convention Center
Orlando, Florida
Information: www.nodigshow.com

April 16-17 2014

NASTT's Horizontal Directional Drilling (HDD) Good Practices Course

Gaylord Palms Hotel, Orlando, Florida
Information: www.nastt.org

April 16-17, 2014

NASTT's Pipe Bursting Good Practices Course

Gaylord Palms Hotel, Orlando, Florida
Information: www.nastt.org

April 16-17, 2014

NASTT's Sewer Laterals Good Practices Course

Gaylord Palms Hotel, Orlando, Florida
Information: www.nastt.org

April 16-17, 2014

NASTT's Cured-In-Place Pipe (CIPP) Good Practices Course

Gaylord Palms Hotel, Orlando, Florida
Information: www.nastt.org

Wednesday, May 14, 2014

Subsurface Utility Engineering: Knowing Before You Dig

Coast Kamloops Hotel & Conference Centre
1250 Rogers Way, Kamloops, B.C.
Information: Monica Perry, mwperry@telus.net

April 16-17, 2014

NASTT's New Installation Methods Good Practices Course

Gaylord Palms Hotel, Orlando, Florida
Information: www.nastt.org

March 15-19, 2015

NASTT's 2015 No-Dig Show

Denver Convention Center, Denver, Colorado
Information: www.nodigshow.com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Agassiz Townsite Sanitary Sewer Rehabilitation

Kieran Field, EIT
Opus DaytonKnight Consultants Ltd.

Mick Thiessen
District of Kent

Bob Kennedy
Mar-Tech Underground Services Ltd.

The groundwater level in the Agassiz Townsite in the District of Kent is subject to high fluctuations between summer and winter. It is influenced by the water level of the Fraser River, which rises and falls dramatically with each year's snow melt. The groundwater in turn regularly rises above the town's sanitary sewer system each year, most notably during the months of June and July. This results in high levels of infiltration, which cause additional operational costs for the District.

Wastewater from the Agassiz Townsite is ultimately received and treated at the Agassiz Wastewater Treatment Plant (WWTP). The District recognized that the high levels of inflow and infiltration (I&I) in the townsite sewerage system increased energy use and operational requirements, and adversely affected system capacity. The sanitary system consists of five lift stations and approximately 14 kilometres of gravity sewer ranging in diameter from 150 to 375 millimetres, largely constructed from vitrified clay pipe installed in the 1960s.

Mar-Tech installs liner before curing.

An inversion sample is taken for testing.

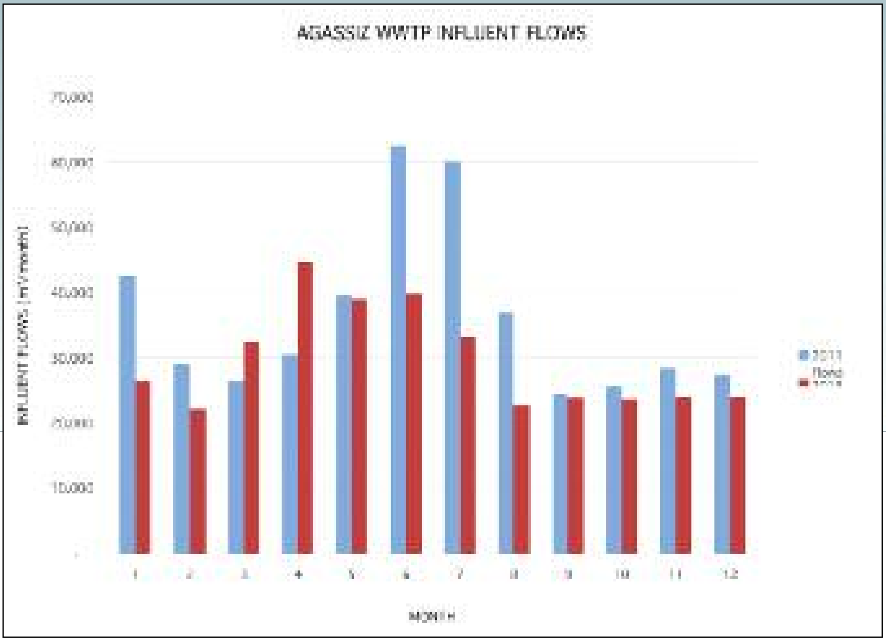
The District's primary objective was to establish a maintenance and rehabilitation program in order to reduce I&I, stretch system capacity and delay high-capital-expenditure works. The program will also improve sustainability in the region through a reduction in the frequency and volume of potential emergency spills. The District received funding approval through the Federal Gas Tax Regionally Significant Project Grant Program administered by the Fraser Valley Regional District, and had a construction budget of approximately $300,000 for investigation, repairs and upgrades in the Agassiz Townsite.

Opus DaytonKnight Consultants (Opus DK) and their subs, Mar-Tech Underground Services (Mar-Tech), were retained by the District to undertake a detailed sanitary sewer system upgrade study for the Agassiz Townsite area. This included an investigation into the condition of the sewer system in order to determine a priority repair and replacement program to be undertaken in 2013.

Mar-Tech started their condition assessment (including cleaning) in August 2012 and completed it the next month. In total they cleaned and inspected 12,676 metres of pipe and reported on 220 manholes. Mar-Tech submitted the inspection reports to Opus DK. These reports and videos were reviewed by Opus DK, and rehabilitation recommendations were made and prioritized with an emphasis on fixing any sewers where infiltration was present at the time of inspection. Cost estimates were provided and sewers were chosen for rehabilitation based on priority and budget. The rehabilitation contract was tendered in March of 2013.

In early spring of 2013, Opus DK put out another contract called "The District of Kent, Agassiz Townsite Sanitary Sewer Upgrades." This contract included main-line relining, installation of segmental point repairs, manhole grouting and digging, and replacement of extremely damaged pipe. Mar-Tech was the successful bidder on this contract. Mar-Tech does not do any excavation work, so they subcontracted PW Trenchless for that portion of the contract.

Nearly all of the work (97 percent) was completed by June of 2013, with minor works scheduled for later in the year to avoid working during the high-groundwater period. The project was completed at a total cost of $254,910.



RESULTS

Recorder data from 2011 and 2013 is used to compare pre- and post-rehab flows. Numbers from 2012 were not used as the flows resulting from the flushing of sewers during the inspection phase would not have provided an accurate datum for the post-rehabilitation flows to be compared with. Recorded Fraser River levels for 2011 and 2013 indicate that the snow melt, or freshet, for both years is comparable, with 2013's levels being slightly lower and slightly earlier in the year.

Accompanying this article is a graph showing 2011 and 2013 influent flows at the Agassiz WWTP. The 2013 June, July and August flows are significantly lower than the corresponding 2011 flows. March and April 2013 flows are higher than the 2011 flows as these were the months where the majority of the rehabilitation work was completed.

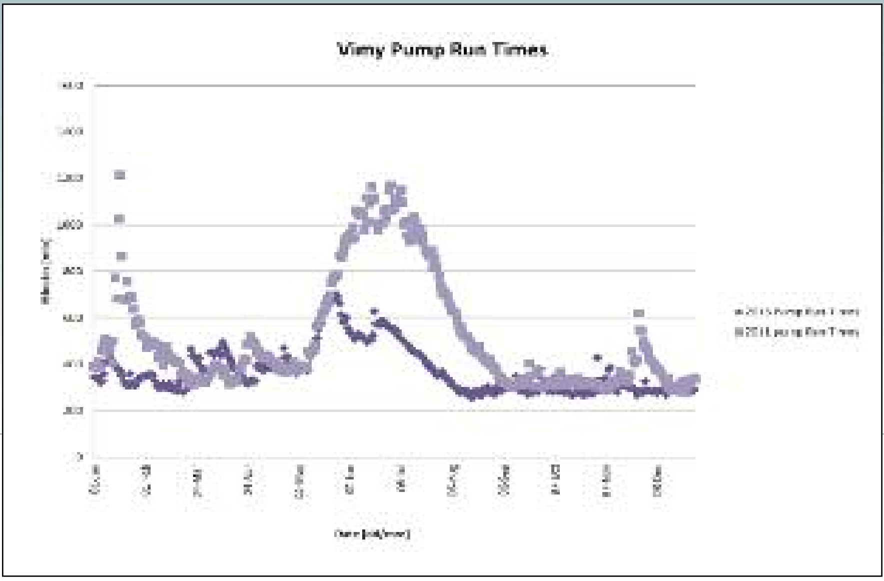
Overall, there was a total reduction of 18 percent in influent flows throughout the year (77,519 cubic metres), including a 40 percent reduction in June and July alone (49,542 m^3).

No costs associated with the treatment of sewerage in Agassiz Townsite were available to us. But the cost saving associated with reducing I&I is not limited to the WWTP. As mentioned previously, the Agassiz Townsite is serviced by five lift stations: Vimy, McCaffery, Maplewood, Cheam and Aberdeen. These stations have seen a significant reduction in operating times since the rehabilitation work. The largest lift station, Vimy, has 3 x 20 horsepower pumps. A comparison of the 2011 and 2013 pump runtimes is given in the graph below:

A significant decrease in pump run times from June to August can be observed. The difference in yearly operating times for each pump station is shown in the table below.

There was no noticeable change in the Aberdeen station's pump run times as there was little to no infiltration in the Aberdeen catchment area.

When summarized, the 27 percent reduction in pump run times equates to a 25 percent reduction in electrical costs



Pump Stations	Pump Run Time (hr)		Difference in Run Times (hr)	% Decrease
	2011	2013		
Aberdeen	200	240	-40	-20%
Cheam	1880	1199	681	36%
Maplewood	668	604	64	10%
McCaffery	986	732	253	26%
Vimy	3156	2265	891	28%
TOTAL	**6889**	**5041**	**1849**	**27%**

alone. Additional savings associated with increased pump life and decreased maintenance have not been quantified.

With a relatively small investment in sewer inspection and rehabilitation, the District of Kent has stretched the capacity of its lift stations and WWTP, avoiding expensive upgrades to their facilities and hence extending the life of their assets.

- ***Kieran Field**, EIT is a Project Engineer with Opus DaytonKnight Consultants Ltd. and a Director for the North American Society for Trenchless Technology – B.C. Chapter.*

- ***Mick Thiessen** is the Director of Engineering Services with the District of Kent, providing direction for all civil engineering aspects within the District.*

- ***Bob Kennedy** is a Director of Mar-Tech Underground Services Ltd.*

An Unconventional Burst in Maple Ridge

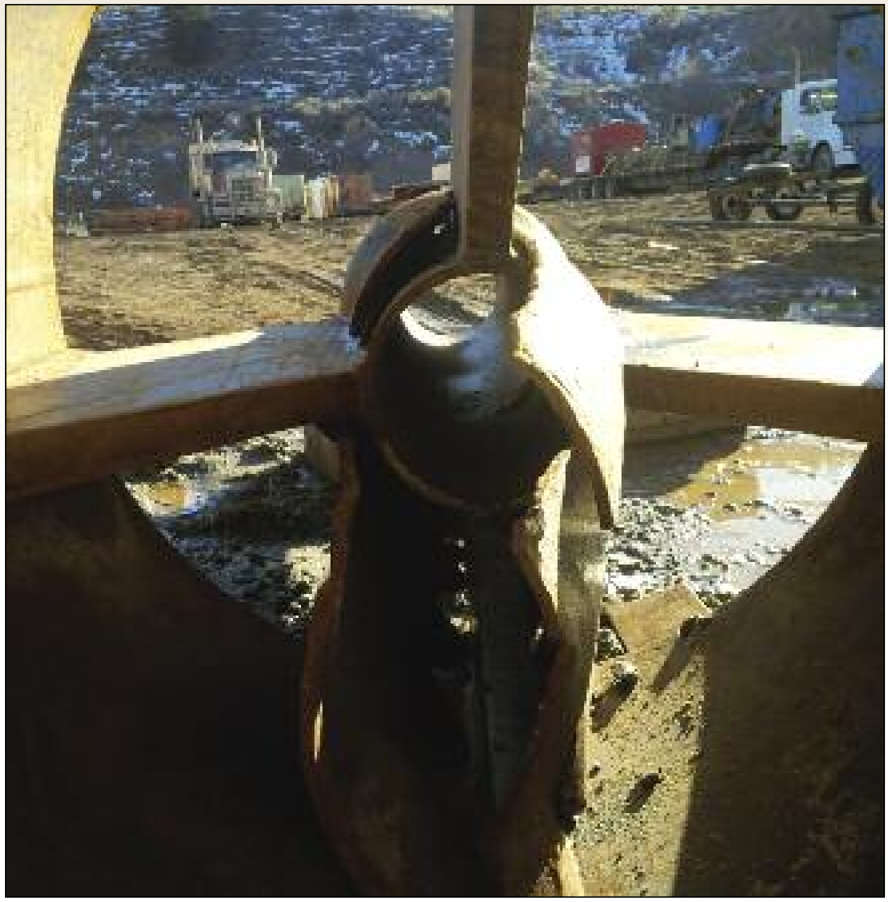
Harry Dickinson, AScT.
Kamloops Augering and Boring Ltd.

The Corporation of the District of Maple Ridge issued a tender in December of 2012 for work that consisted of upgrading existing waterworks and sanitary sewer at 236 Street and the CPR spur line. The work generally consisted of bypassing the sanitary sewer flow from east of River Road and from 236 Street to west of River Road, environmental construction management, traffic management, launch/receiving pits construction, pipe jacking/pipe ramming of steel casings, watermain and sanitary sewer installations and site restoration. Pedre Contractors Ltd. was the successful bidder and awarded the two trenchless crossings to Kamloops Augering & Boring

(KAB) Ltd.

The initial construction schedule was for the spring of 2012, but due to delays it was postponed until the spring of 2013. The watermain casing was a very typical rail crossing; however, the sanitary crossing proved to be a special crossing. The new 475-millimetre PVC DR35 pipe was to be installed in the exact same location as the existing 250-mm PVC sanitary pipe. The invert of the new product pipe was very critical due to the existing infrastructure. The design only indicated that 53.17 metres of 711.2-mm OD SCH30 ASTM A253-3 to be installed by pipe ramming.

We immediately requested a change of 711.2-mm (28-inch) pipe to 762-mm (30-inch) pipe, due to availability. We initially contemplated just pipe ramming the 30-inch casing over the existing 250-mm (10-inch) PVC and then pushing the casing/PVC-engulfed pipe through to the exit side – basically, doing a re-ram and leaving an empty 30-inch casing for the new sanitary line. However, it was noted that the PVC pipe transitioned to ductile iron pipe. The connection for this transition was unknown and created a new risk for our installation. The potential for not being able to engulf the transition and maintaining the desired grade became too great for pipe ramming only.



A project in Maple Ridge required a specially designed burst head.

KAB then decided to do an unconventional burst. We decided that we would force the casing through the existing PVC. To do this we designed an eccentric burst head to be welded to the lead pipe of the 30-inch casing. Since the invert elevations were critical, we had to fabricate the burst head so that the new 475-mm PVC would match the existing 250-mm. To control the alignment and grade, we proposed to use nominal eight-inch SCH40 pipe. This pipe would be pushed through the existing PVC/ductile sanitary line. Custom fins were cut out of 1.5 inches mild steel plate and arranged at the 12, 3, 6 and 9 o'clock positions. The height of each fin created an axis that would not be centrally located. This arrangement would hopefully solve the problem of achieving the design invert elevations of the proposed new sanitary.

Pedre had to excavate the jacking pit along the existing alignment. To do so, they had to set up a bypass system. Shutting down the

Good teamwork made the Maple Ridge project much easier than it could have been.

sanitary line was not an option. Once the bypass was in place, the excavation was completed without incident. The existing sanitary pipe was cut out and the pipe to be burst had to be flushed. An exit pit was excavated for removal of the eight-inch pipe during the installation of the 30-inch casing.

An additional concern at the exit side was the proximity of a hydropower pole. The pole was directly above the casing alignment. The depth of the pole was confirmed. There would be 20 centimetres of clearance from the top of the casing to the bottom of the pole. The hazard of inadvertently compromising the pole due to casing installation procedures had to be addressed. The local businesses required power during the day, so the final push for the casing installation was planned to be done on a night shift.

Once the entry/exit pits were completed, a visual confirmation of the pipe was performed. The pipe was not straight and had a horizontal deviation; it was deemed that the eight-inch pipe should easily push through the existing PVC. The concern was what would the 30-inch casing do through this section. The primary concern was that the eccentric head being welded to the eight-inch pipe could possibly roll. This would

KAB designed an eccentric burst head for the Maple Ridge project.

greatly affect the desired elevations.

The installation of the 30-inch casing was done by conventional auger boring. The casing with the customized burst head was hydraulically advanced by the auger bore machine. Each section of casing was marked with top dead centre to confirm burst head alignment. The pipe was also secured with extra welding to mitigate any rotation. The PVC portion was removed easily. The ductile iron eventually became anchored to the burst head and was pushed out to the exit side. The casing installation was completed on night shift and there were no issues with the existing hydro pole. BC Hydro used a pole truck to secure the pole during the night shift operations. The casing was installed within five millimetres of design.

The teamwork between Pedre & KAB made this difficult crossing easy, and the coordination and cooperation of all the stakeholders was greatly appreciated.

Listening and Looking Under Pressure

Piero Salvo, P. Eng., M. Eng.
President, GAME Trenchless Consultants

Trenchless Consultants were contracted by Royal Building Products to provide condition assessment and leak detection of a watermain in Whistler.

Most pressurized pipeline inspection allows you to listen as the tool advances into the pipe. The new JD7 LDS1000™ process used by GAME Trenchless Consultants* allows for a visual and acoustic inspection of watermains in live systems, while users still have domestic water and fire protection supply. The acoustic capability of the camera head works on the premise that under a pressurized environment, a leak (big or small) will create a sound. The sensitivity of the microphone can pick up the sound and the sound increases as the microphone nears the source and decreases as it moves

The LDS1000 system, which includes a camera and microphone, was used to inspect a watermain in Whistler.

away. Once the location is determined audibly, the video will show what is happening at that location (is there a joint, a valve, a tee, etc.). If the leak is large enough, swirling water in that area may be seen.

The LDS1000's combination of camera/microphone and location devices provides live video and audio to inspection personnel. The specialized launch mechanisms provide continuous pressure seal while simultaneously allowing disinfection of the cable entering and leaving the watermain. Residents on the water system will not be affected in any way during the inspection and do not even know that an inspection is taking place.

In July 2013 GENIVAR was contracted by Royal Building Products to provide a visual condition assessment and leak detection of a 350-mm (14-inch) watermain having a length of approximately 520 meters (1,700 feet) in the Resort Municipality of Whistler (RMOW). The LDS1000 technology was chosen because the inspection could be performed while the watermain was still live and because the LDS1000 device required only a small tap of 50 mm (two inches) on the main line for access. The tap was installed in an adjacent section of the watermain, not directly under a secondary roadway. Following the inspection, the RMOW still required a final leakage test prior to accepting the original installation.

The Whistler watermain condition assessment was conducted in July 2013.

Due to system layout, isolating this section of line was not an easy task, given that there were no isolation valves at either extremity of the watermain to be inspected. For this particular project, all the pipes between the existing isolation valves were installed in three sections by three different contractors. Several unsuccessful attempts at verifying the line were undertaken by the contractor in 2011 and early 2012. The Investigator+TM, normally used for pipes up to 300 mm, was attempted in early 2013. Despite the high operating pressure of the watermain (175 psi) and multiple attempts, only one inspection of approximately 70 metres (230 feet) was completed with the Investigator+. Given the diameter of the pipe, its orientation with multiple changes in direction, and the fact that we were in February, the decision to use the LDS1000 in the summer of 2013 was taken.

In July 2013, the crew returned to do the inspection and the required 50-mm tap was installed on the existing watermain that connected to the 350-mm PVC pipe. This connection point was placed in a gravel parking area, upstream of the watermain to be inspected. This installation provided for a traffic-free environment, as well as allowing for the inspection vehicle to set up as close to the connection point as possible.

The project coordination was discussed and executed by all parties. The LDS1000 launch mechanism was installed onto the 50-mm ball valve connection point. In order to successfully inspect the pipe with the LDS1000 technology, a minimum

Water service continued as inspection of the main was conducted.

flow of approximately 0.3m/s is required to make the tool advance in the watermain. RMOW was able to create a flow of approximately 0.6m/s. During the entire operation, the cable being fed into the watermain was constantly chlorinated.

Given the flows provided, the LDS1000 tool with a parachute attached to the sensor head was "dragged" the entire distance to be inspected. During the insertion, the LDS1000 continuously provides a visual and acoustic inspection. Once the sensor head was at the desired distance, the flow was no longer required and the official visual and acoustic inspection, at a controlled pullback speed, was completed.

During the entire visual and acoustic inspection, no leaks or sound signatures were heard or detected. In layman's terms, you could hear a pin drop, or in our case you could hear the microphone picking up "scratching" noises as the sensor head was being pulled back along the wall of the pipe. During the entire video inspection, no visual or acoustic anomalies were detected. Once the inspection was complete, the entire video was reviewed again in the office as part of the QA/QC done before preparing a written report. A copy of the report was provided to the RMOW. Following this inspection, final acceptance of the installation of the 350-mm PVC watermain was granted for inclusion of this section into the overall water distribution system for the RMOW.

In one day, the LDS1000 system permitted video and audio inspection of this watermain with no disruption of water service to local residents to the neighbourhood. Costly excavation, traffic control/single lane access, draining and refilling twice of the section of line and expensive restoration for isolation valves/pits, was avoided. A report was provided to the designers and owners with a report that confirmed that the watermain was performing as designed.

**GAME Trenchless Consultants purchased the Canadian rights to the JD7 LDS1000 and Investigator+ process from GENIVAR Inc. in October 2013.*

Quantifying Pipe Corrosion:
Applications of Pipe-Penetrating Radar for Advanced Pipe Condition Assessment

Csaba Ékes, PhD, PGeo.
SewerVUE Technology Corp.

Robin Krause, P.E.
Clark Regional Wastewater District

Robert Lee, P.E.
Brown and Caldwell

Obtaining quantitative pipe deterioration information is of increasing interest to engineers and pipe owners. Traditional CCTV inspections, while useful, have a number of limitations. CCTV is imprecise and subjective. It does not provide information on actual corrosion rates, the presence of voids outside the pipe wall, or the structural condition of the pipe. Laser profiling provides inner diameter and ovality but is still limited to what is visible within the pipe.

Pipe penetrating radar (PPR), the in-pipe application of ground penetrating radar (GPR), is one of the most promising quantitative pipe condition assessment technologies to emerge in recent years. A high-frequency PPR survey was carried out to inspect sections of the Salmon Creek and St. Johns Trunk lines on behalf of Clark Regional Wastewater District (CRWD) in Vancouver, Washington, in September 2013. The St. Johns Trunk is 36 inches in diameter; the total inspected length is 1,562 feet. The Salmon Creek Trunk is 21 inches in diameter for 2,174 feet and then 24 inches for 351 feet. Both pipes are concrete sanitary sewer pipes.

The objective of the PPR survey was to determine the condition of the RC pipes by mapping their wall thickness and rebar cover, and detecting voids and/or other anomalies within or outside the pipe wall.

PIPE PENETRATING RADAR

The SewerVUE Surveyor is the first commercially available multi-sensor inspection robot that uses visual and quantitative technologies (CCTV, LiDAR, PPR) to inspect underground pipes. This fourth-generation PPR pipe inspection system is mounted on a

The SewerVUE Surveyor is a multi-sensor robot that utilizes CCTV, LiDAR and PPR.

rubber-tracked robot and equipped with two high-frequency PPR antennae. Radar data collection is obtained via two independent channels in both in and out directions, providing a continuous reading on pipe wall thickness, rebar cover and voids outside the pipe. CCTV data is recorded simultaneously and used for correlation with PPR data.

The robot is equipped with three cameras (front, antenna and back) and has the capability to take quantitative measurements of inside pipe walls. This LiDAR technology employs a rotating laser to collect inside pipe geometric data which is then used to determine pipe wall variances from a manufactured pipe specification. LiDAR data is correlated with an onboard inertial navigation system that can accurately map the x, y, and z coordinates of the pipe without the need for external references. LiDAR and x, y, and z data collection, however, were not part of the scope for this project.

METHODOLOGY

PPR is the in-pipe application of ground-penetrating radar (GPR) technology. It can be used to detect pipe wall fractures, changes in material, reinforcement location and placement, and pipe wall thickness.

Resolution is primarily determined by wavelength but also affected by such factors as polarisation, dielectric contrast, signal attenuation, background noise, target geometry and target surface texture, all of which influence the reflected wave. Since the primary factor determining signal penetration is the conductivity of the soil, it is important to point out that PPR works where traditional "above ground" GPR does not.

The CRWD project's PPR survey was completed using 1.6- and 2.3-GHz-frequency antennae. Two-dimensional line data were collected on the crown of the pipe. The PPR lines were located along the 10, 11, 1, and 2 o'clock positions inside the pipe.

Data processing was completed using Burnaby-headquartered SewerVUE's proprietary radar processing software, Pipe Penetrating Radar Data Interpretation Application (PP-RADIAN). By processing the data, more information is extracted as the weak and closely spaced events are enhanced and better resolved by applying different correction, gain and filter functions.

RESULTS & CONCLUSIONS

The 2.6-GHz PPR data are of excellent quality. Signal penetration allowed analysis to a depth of 12 to 14 inches from the inside pipe wall surface. The objective of PPR data display is to present the processed data that closely approximates an image of the pipe and its bedding material with anomalies that are associated with the objects of interest in their proper spatial positions. The most commonly used data displays are the two-dimensional cross sections or the two-dimensional depth slice.

A more user-friendly data presentation that is readily understood and faster to review by lay audience was developed for this project. The PPR inspection results are summarized on graphs presenting distance (feet) versus pipe wall thickness and rebar cover (inches). These summary graphs are based on data extracted from the processed and interpreted individual PPR depth sections.

Pipe wall thickness is represented by a continuous black line. Change in rebar cover is represented by bar graphs showing rebar cover variations (min-max) for every three-foot interval. Red dots mark average rebar cover for the same three-foot interval.

CCTV inspections showed all 1,549 surveyed linear feet of the St. Johns Trunk to have concrete surface spalling and buildup above the water level. The CCTV results also showed two locations with visible infiltration at joints located in the downstream end.

The PPR data show variations in pipe wall thickness, as well as location, depth and spacing of rebar. The results show that pipe wall thickness is around 5 to 5.25 inches in the first 1,085 feet, 4.5 to 5 inches between 1,085 and 1,460 feet, and 3.75 to 4.5 inches between 1,460 and 1,545 feet at the upstream manhole MH 28-377, where corrosion appears most severe.

Rebar cover varies between 1 and 4 inches. Rebar signal is weak between 1,475 and 1,505 feet and very weak or appears to be absent between 1,505 and 1,545 feet. A minor void was detected at 27.5 feet.

Overall, the majority of the 36-inch trunkline is structurally in fair to poor condition. Inspection of the upstream-most pipe segment revealed evidence of severe corrosion.

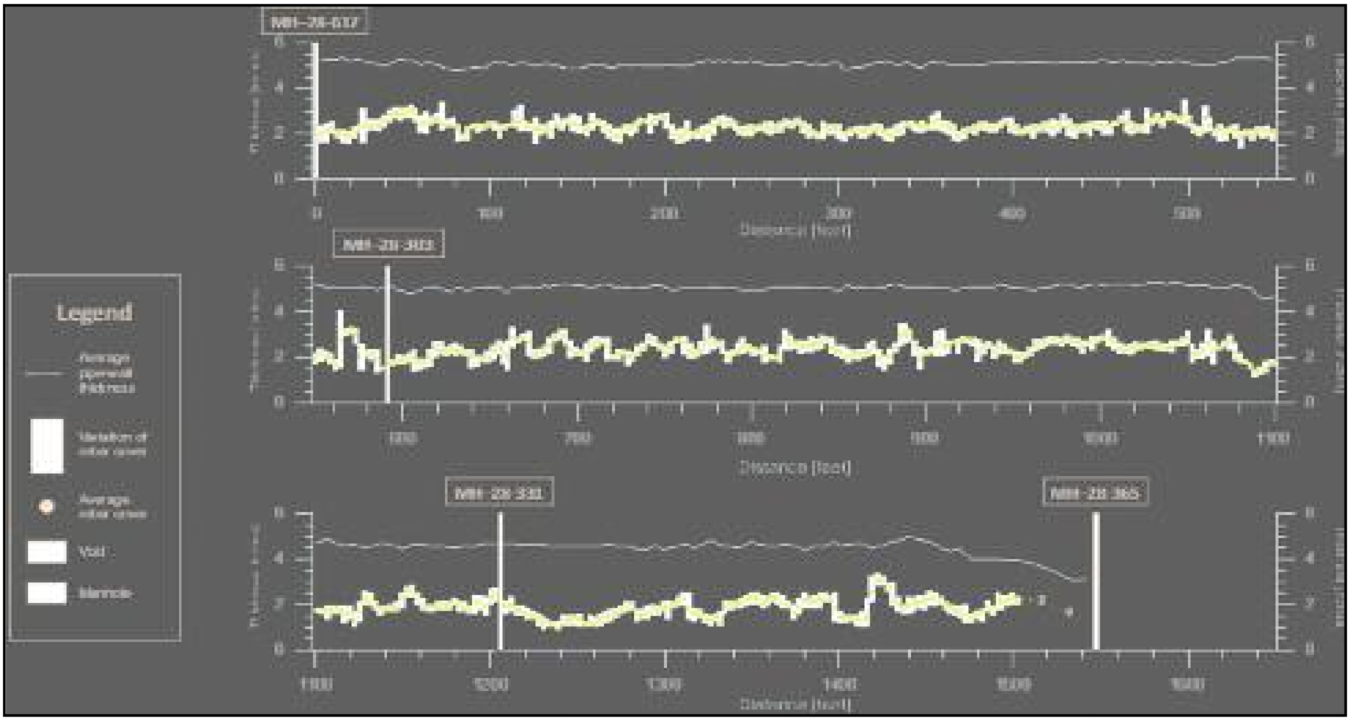
Nearly all of the Salmon Creek line showed concrete surface spalling and buildup above the water level. The CCTV and PPR results showed evidence of infiltration at four locations.

PPR data indicate pipe wall thickness is 3.25 inches with little variation. What is striking is the apparent lack of rebar. Except in the first 225 feet, and briefly at two other locations, there appears to be no rebar reflection on the PPR profiles. Signal quality is otherwise very good. This leads us to conclude that there is no rebar in most of the pipe. Where rebar is present, it appears to be uniform with adequate cover and little variation in depth. PPR scanning did not detect any voids in the fill material around the pipe.

Structurally, the majority of the 21-inch-diameter portion revealed evidence of concrete corrosion. The interior cement layer had either corroded or eroded, resulting in projecting aggregate.

The 24-inch segment that crosses underneath the Interstate 205 overpass revealed a uniform wall, a fairly smooth interior cement layer, and hardness commensurate with normal concrete. PPR also indicated that reinforcement is present in the pipe with ade-

The SewerVUE Surveyor robot is deployed at St. Johns manhole 28-377.



Summarized PPR results for St. Johns Trunk

quate concrete cover. Overall, the 21-inch-diameter portion of the Salmon Creek line is in poor structural condition and the 24-inch-diameter portion is in fair to good structural condition.

SUMMARY

Over 4000 feet of PPR data were collected with the SewerVUE Surveyor inspection robot for the St. Johns Trunk and Salmon Creek Avenue lines. The St. Johns Trunk data indicate corrosion and pipe wall loss, and rebar signal appears to be weak or missing for about 70 feet.

The Salmon Creek line's 21-inch-diameter concrete pipe appears to have no significant pipe wall loss. As well, no significant pipe wall loss was found in the 351 feet of 24-inch pipe that was inspected; rebar, however, seems to be missing from approximately 336 feet of this pipe. Where rebar is present in the 24-inch pipe, it appears to be uniform with adequate cover and little variation in depth.

The use of PPR combined with man-entry coring and visual CCTV data provided the necessary information for the District to understand the condition of these critical trunk lines.

For the St. Johns Trunk, the lack of rebar signal and the concrete material scraped off during the PPR inspections indicate poor structural condition. This condition can be addressed trenchlessly before further deterioration renders a trenchless solution infeasible.

For the Salmon Creek Interceptor, knowing that the 21-inch portion does not contain reinforcement is important information. Follow-up man-entry inspections and localized visual observation of defects revealed that the pipe is in poor to fair condition; rehabilitation, while not immediately urgent, should be planned for in the near future.

Slipline of Pipe Arch Under BC Rail Properties

Kirk McLeod, AScT
Paragon Engineering Ltd.

PW Trenchless was contracted by BC Rail to rehabilitate an existing 28-metre-long steel plate arch culvert at 9 Mile Creek in Delta, B.C. Replacing this culvert under an active BC Rail track, with trains running several times daily, would prove to be a nearly impossible task if not for trenchless methods.

Inspection indicated that the existing culvert was showing its age and its galvanized coating was deteriorating. The steel plate had eroded to a thickness of two millimetres in certain locations, and oxidization was visible along the springline of the culvert.

The solution was to slipline a 3,100-by-1,980-millimetre Bolt-A-Plate Pipe Arch Structure into the existing 3,500 mm x 2,300 mm, 27-metre-long CSP arch culvert and grout the annulus with a controlled density fill.

Advantages

There are several advantages to using the slipline method for this situation. The most important one is that it allows train schedules to continue without delay. Any slight delay in the transportation of freight could result in costs into the millions. Based on this factor alone, there was no other viable option.

Excavation and removal of this culvert was not an option. At over three metres of fill to the top of the culvert, the volume of excavation would have required more equipment hours as well as trucking costs associated with off-site disposal.

Through the use of the Atlantic Industries Bolt-a-Plate structure system, the working area required at the inlet was limited to the width of three plates. One by one, the plates can be bolted and sliplined. As the work area for this project proved to be tight due to the coffer dams required, other methods of slipining may not have been ideal for this situation. The dewatering procedures that would have been required would have also been significant and costly. The excavation area was limited to the entry pit at the inlet; hence the requirement to prevent erosion and sediment control was considerably diminished with the sliplining method chosen.

The materials required for the sliplining included 28 linear metres of 3,100 mm x 1,980 mm steel plate arch culvert and approximately 60 cubic metres of controlled density fill, whereas the quantities required for a full removal and replacement were 28 linear metres of a steel plate culvert, approximately 500 cubic meters of backfill, and reinstatement of the surface structure, in this case railway tracks. (In other cases it may be asphalt ,concrete, etc.)

Schedule

The start date of this project was critical. Starting within a window of favorable weather in the summer months was ideal as the water levels and flow within the creek needed to be as minimal as possible to ensure

A Bolt-A-Plate structure system was used to slipline a culvert under a BC Rail track.

the coffered dams would function safely and keep the site dry. Trenchless construction significantly reduced the schedule compared to open-cut construction. A reduced schedule not only reduces the workforce and equipment hours but also reduces risk of a significant rainfall event; hence less risk to the site.

Design

A 3100 mm x 1980 mm Atlantic Industries Ltd. 15PA10-9 Bolt-A-Plate structure pipe arch was proposed as a stand-alone structural liner for the installation. This product satisfied the 75-year design-life requirement. The pipe arch at a thickness of 4.0 mm was designed to withstand the loading of the existing cover of approximately three metres as well as the loading caused by the train traffic.

The transfer of loading was ensured by grouting the annulus between the existing and new pipe. The liner installation and grouting of the annular space would eliminate any existing carrier pipe deflection due to further deterioration. In addition, grouting of the annulus would fill any voids in the proximity of the existing culvert preventing any future potential sinkhole issues.

Construction

The challenges with the rehabilitation of this culvert came in part from the limited access due to the high water levels, and in part maintaining the flows through the two adjacent parallel culverts. The ideal time of

A dry working environment was required for the culvert rehabilitation project.

year for this type of work would be limited to the dry months of summer. In order to perform the work, a dry working environment would need to be maintained. PW Trenchless installed a steel plate weir system to provide a dry coffered dam area on the inlet and outlet ends of the existing culvert. The inlet and outlet access points were excavated of all organics and sediment and then lined with drain rock for ease of culvert liner constructability.

The existing system consists of three parallel 3500 mm x 2300 mm steel arch culverts and during construction the two east culverts would also have to handle all flows during rehabilitation of the third.

Approximately 300 mm of sediment existing along the invert of the culvert was removed, followed by pressure washing of the existing culvert and then the installation of two steel rails welded to the bottom of the culvert for its entire length to allow for the new arch to 'slipline' into the culvert. The initial three plate widths of the new arch were installed in an upper working area, then lowered to the inlet access work area. The bolt-a-plate structure was installed plate by plate and pushed in one section at a time.

An existing pipe can lose its shape over the years through deflection, misalignment and settlement, so prior to the assembly of the new arch, measurements of the existing culvert were taken to confirm the feasibility of the installation. (Deflection and misalignment of the existing culvert can provide 'pinch points' which the new culvert may encounter as an obstacle). Sliding a new arch structure through the existing structure and maintaining alignment on the guiderails required careful and precise installation. Should the new arch structure lose its position on the rails, repositioning of the entire culvert would have been required. In this case the new culvert was pushed into place, which requires a slightly more precise method for maintaining the alignment of the culvert. Pulling of the new culvert into position was not an option due to the limited work area on the outlet side of the culvert.

Prior to the installation of the controlled density fill, the annulus interface of the inlet and outlet were reinforced with a concrete bulkhead to contain the controlled density fill. Temporary bracing was installed along the interior length of the culvert, preventing pressure of the controlled density fill from deforming the new arch. Upon completion of the sliplining installation, installation of the bulkheads and temporary interior bracing, the controlled density fill (grout) is installed into the annulus via pumps and grouting ports.

The surrounding area was reinstated with erosion-control materials, the weir plates were pulled and the new culvert was in full operation.

Construction of this project took 2.5 weeks. Even considering that open-cut removal and replacement was not an option for this situation, this example can demonstrate that there are economical options in the replacement and rehabilitation of CSP and Steel Core arches for many similar situations.

CSP pipe and steel core arches have been fundamental in drainage infrastructure across the province of British Columbia for many years. As B.C.'s highways and railways are under continuous maintenance, economical rehabilitation of existing infrastructure through trenchless construction methods should be a forefront option.

Trenchless Construction: Save Money AND Make The World A Greener Place?

Kenneth Leung, EIT
Paragon Engineering Ltd.

Most of the world's major concerns today are environmental ones, and the global drive to "go green" has never been stronger. Rating systems for construction of green buildings such as Leadership in Energy and Environmental Design (LEED) and going "carbon neutral" are put in place to help owners and operators be environmentally responsible and use resources efficiently. As a result, the niche market of trenchless technologies is becoming one of the most rapidly growing sections of the civil engineering and construction industry.

Yes, niche market. Despite environmental concerns being in the forefront, open-cut is still the preferred method of construction. In contrast, utilizing trenchless technologies is often an afterthought as project managers look for other ways to control schedule and cost, both key aspects to successful projects. But readers of Y-Dig won't make this mistake, as they are aware of the schedule and cost benefits of using trenchless technologies.

It's simple: Time is money. The longer a project takes, the more the affected parties suffer from the opportunity cost. In construction, the affected parties are the contractors, owners and, more often than not, the taxpayers. The time it takes to excavate, transport spoil materials, and then restore the area to pre-construction state is a significant portion of the traditional construction schedule and cost.

But the project managers and owners aren't the only ones who suffer. Businesses, residents and traffic in the area are all disrupted during construction, causing a chain effect that inconveniences more people than one would imagine.

This is where trenchless technologies really shine. Take replacing approximately 400 metres length of sanitary sewer pipe at three metres deep as an example. Using open-cut methods, approximately 1,400 to 1,600 cubic metres of earth would have to be excavated. That's enough material to fill an entire ice hockey rink at one metre depth. In the case of pipe bursting, the only excavation required is for entry and exit pits for the length of pipe and service lateral reinstatement pits where applicable, a far cry from the amount of material you would have to remove and transport for open-cut construction.

On the topic of transportation of materials, did you know it would take approximately 180 truck-trailer loads to transport the material in the above example? In this age when the world is trying to reduce its carbon footprint and fuel prices are at historical highs, trenchless construction offers the best solution by reducing the amount of materials that will have to be transported. By reducing the amount of excavation, you are also minimizing the possibility of erosion in the construction area, which in turn lessens the chance of sediment and/or other contaminants leaving the construction area.

But how does all this translate to cost for the owners? In side-by-side comparison of bid results for a recent sewer repair and maintenance program in Surrey, B.C., the option to go with trenchless construction resulted in savings of over 30 percent of what it could have cost for open-cut, a difference of approximately $500,000. And these savings don't even include the social-cost benefits due to reduced impacts to surrounding businesses, residents and traffic.

For those not familiar with trenchless technologies, familiarize yourself with them and see how they can benefit you in the success of your projects. It's never more evident than now that instead of asking ourselves why we should consider trenchless construction, we should be asking "Why not?"

Carbon and Trenchless in B.C.

David O'Sullivan
PW Trenchless Construction Inc.

The NASTT-BC chapter has been promoting the link between all of the trenchless technologies and lower carbon emissions for seven years now. Here is a little history of where this came from, and it should help make you proud of where the trenchless industry of B.C. is on this important topic.

It all started at the Union of B.C. Municipalities trade show in September 2007, when three members of NASTT-BC were at lunch discussing the recently introduced legislation from the Gordon Campbell government on climate change (passed in November 2007). After a bottle or two of merlot, the light went on and we could see clearly the link between trenchless construction and a low carbon footprint. We thought, What a great way to promote trenchless. As it was lunch and we had to go back to the trade show, we stopped imbibing in the nectar of the gods and were able to retain the great idea.

Because trenchless construction involves no – or at least much less – excavation, the amount of energy consumed to install a given pipe is vastly reduced. It is this reduction that allows trenchless construction to claim to have lower carbon emissions.

When one thinks about the process of installing a utility, the amount of ground removed to allow that utility to be positioned where it needs to be is enormous compared to the size of the utility. A 200-millimetre pipe has a cross-section of 0.031 square metres while a 2.4-metre-deep trench with a width of 1.5 m has a cross-section of 3.6 sq. m. This means we work on a cross-sectional area 116 times the area of the actual pipe. If we could install this pipe by a trenchless method, that removal and replacement of material would not happen.

NASTT-BC took this concept forward and had a crude carbon calculator developed to calculate these carbon savings. The tool was to allow designers to make an informed decision with regard to carbon emissions, just as is done all the time when thinking about financial costs.

NASTT-BC then commissioned SFU to develop a more robust calculator, which they did in 2010. However, at that time NASTT (not the B.C. chapter but the North America-wide organization), who had also been working on this issue, launched their calculator. We, the little chapter on the West Coast, backed off. In short order Germany, the U.K., New Zealand and Australia as well as others all followed with their own calculators.

However ,as the flow of merlot did not stop on the Canadian West coast, neither did the ideas.

In 2010 the Province of B.C. announced that the day-to-day operations of the government were carbon-neutral and that all but one of the cities of B.C. would be carbon-neutral in 2012.

We thought of how we can capture the carbon savings already realized by the cities that have trenchless programs and get them a carbon credit/offset*. We commissioned a consultant to develop a carbon protocol to define how this would be completed. We then approached a member of the UBC staff in Environmental Science and Metro Vancouver, and we are now months away from having the world's first system to allow a local government to gain a carbon offset for the trenchless work that it does.

In fact, Metro Vancouver has now taken this project and is "stick handling "it through the provincial government on behalf of the cities of B.C. NASTT-BC is acting as the funder of this project with donations from private industry.

**These will always be offsets, as we do not feel cities will ever be in a position to sell these carbon reductions on an open market (carbon credits) but they can offset them against their other emissions.*

2014 NASTT-BC Board of Directors

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