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TRENCHLESS JOURNAL



THE OFFICIAL PUBLICATION OF THE NORTHWEST CHAPTER OF
THE NORTH AMERICAN SOCIETY FOR TRENCHLESS TECHNOLOGY

2016 NW TRENCHLESS
PROJECT OF THE YEAR WINNER:

Northern Courier Pipeline Project



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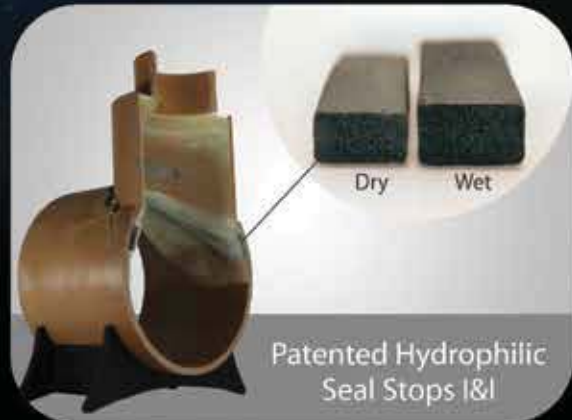
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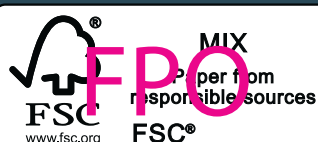
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Publication Mail Agreement #40065075

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2017 IS OFF TO A GREAT START!

2017 is off to a great start! With summer fast approaching there have been a number of great projects kicked off and running in our region. We are fresh off of a record-setting NASTT No-Dig Show in Washington, DC with great representation from our Chapter. Additionally, we added a few new Directors to our local Chapter Board. Ben Campbell returns to the Board as a Director after a short absence, and we are excited and welcome Ed Douziech from CCI to bring some new energy to our Chapter.

This year's conference will be held in Calgary on November 8 and 9 – more information to come so please look for it and check our Chapter website periodically. Please join us for a reception for all attendees on the evening of Wednesday, November 8, after the Short Course. This is a great opportunity, especially for new members, to come out and network with

**“WE ARE FRESH OFF OF A
RECORD-SETTING NASTT NO-DIG SHOW
IN WASHINGTON, DC WITH GREAT
REPRESENTATION FROM OUR CHAPTER.”**

your colleagues and get to know your NASTT-NW Board of Directors.

As we enter our summer break with respect to our Chapter technical lunches in both Edmonton and Calgary, I would like to reach out to our Chapter members and remind you all that we are always looking for great topics and new presenters to become active and participate in our Chapter! Be sure to look for advertisements and check our website, www.nastt-nw.com, and our Chapter LinkedIn page for additional information on the Trenchless Conference and technical lunches. And if you haven't attended a Chapter technical lunch yet, they feature

great, applicable industry topics and provide a great networking opportunity. If you have a specific topic or project that you would like to see us spotlight, please reach out and let me know.

We are always looking for volunteers, fresh ideas, and new perspectives! If you wish to participate as a volunteer or just provide suggestions on how to improve our Chapter, please do not hesitate to contact me directly at craigvandaele@michelscanada.com. ■■■

Craig Vandaele

Chair, NASTT – Northwest Chapter



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KEEPING OUR FINGER ON THE INDUSTRY'S PULSE

Hello Northwest Chapter Members! As the year gets underway, I'm excited for the future during my term as Chair of the Board of Directors. The year is off to a great start. NASTT's 2017 No-Dig Show and ISTT's 35th International No-Dig in Washington, D.C. were very successful on all accounts. The exhibit hall was a sell-out once again and we experienced excellent attendance. We were thrilled to host delegates from all over the globe!

NASTT exists because of the dedication and support of our volunteers and our 11 regional chapters. There are many Northwest Chapter Members that served on our No-Dig Show Program Committee and volunteered their time and industry knowledge to peer-review the 2017 abstracts. These committee members ensure that the technical presentations

"THE NORTHWEST CHAPTER IS ALSO HOME TO SOME OF OUR SESSION LEADERS."

are up to the standards we are known for: Erez Allouche, Ali Bayat, David Krywiak, Jim Murphy, and Craig Vandaele. The Northwest Chapter is also home to some of our Session Leaders. Session Leaders are Program Committee members who have the added responsibility of managing a session of the technical program and working with the authors and presenters to facilitate excellent presentations. I would like to extend a special thank you to the Northwest Chapter Members who also served as Session Leaders: Erez Allouche and Jim Murphy.

In addition to the annual No-Dig Show, NASTT provides many trenchless training

courses. We are focused on trenchless education and our highly experienced instructors are dedicated to trenchless education, providing their expertise strictly on a volunteer basis. They donate personal time to travel around North America to provide high-quality training on a host of trenchless technologies. I would like to thank Northwest Chapter Members Jason Lueke and Chris Macey for serving as instructors this year. Jason teaches our Horizontal Directional Drilling (HDD) Course, our Laterals Course, and our Pipe Bursting Course, and Chris teaches our Cured-in-Place-Pipe (CIPP) Course.

The North American Society for Trenchless Technology is a society for trenchless professionals. Our goal is to keep our finger on the pulse of our industry and provide beneficial initiatives. To do that, we need the involvement and feedback from our professional peers. If you are interested in more information, please visit our website at www.nastt.org/volunteer. There you can view our committees and learn more about these great ways to stay involved with the trenchless community and to have your voice heard. Please consider becoming a volunteer – we would love to have you get more involved.

NASTT has a very promising future because of our amazing volunteers. Thank you again for your continued support and dedication to NASTT and the trenchless technology industry. ■■■

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IN THIS ISSUE



Welcome to another Spring/Summer issue of the *Northwest Trenchless Journal*. This issue of the Chapter magazine highlights the 2016 Northwest Trenchless Project of the Year. It also provides readers with information about the upcoming 2017 Northwest Trenchless Conference being held in Calgary, Alberta on November 8 and 9. Be sure to check out our website at www.nastt-nw.com for more information and updates.

Also in this issue, we are pleased to present you with two featured regional papers focusing on trenchless project successes and challenges. Additionally, please see pages 39–44 for our annual Buyers' Guide.

The next issue of the *Northwest Trenchless Journal* is scheduled for distribution in October 2017 and will provide all the details you need regarding the Chapter's 2017 Annual Conference.

We are always interested in relevant, regional content to share with our members. To submit a project paper or other content and ideas for an upcoming issue of this Chapter magazine, please contact **Carlie Pittman** at pittmanc@ae.ca. Your submissions are welcome and content is due by September 1, 2017.

Be sure to find us online and join our LinkedIn group at www.linkedin.com/groups/NASTT-Northwest-Chapter-4430433. ■ ■

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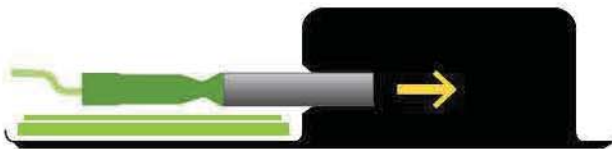
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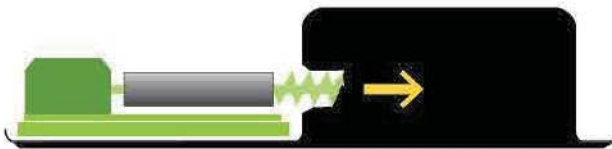
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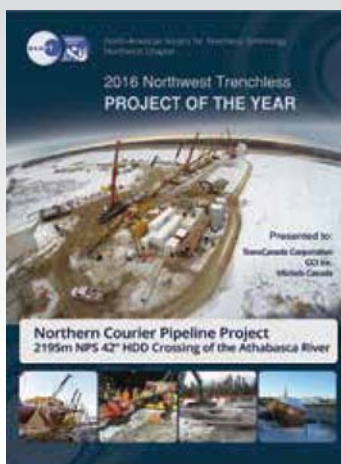
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2016 NW TRENCHLESS PROJECT OF THE YEAR



CONGRATULATIONS TO THE TRANSCANADA CORPORATION, CCI INC., AND MICHELS CANADA ON BEING AWARDED THE 2016 NORTHWEST TRENCHLESS PROJECT OF THE YEAR FOR THE NORTHERN COURIER PIPELINE PROJECT!



ABOUT THE PROJECT

TransCanada Corporation (TransCanada) proposed the design and construction of the Northern Courier Pipeline Project (NCP) to carry hot bitumen from the Fort Hills Terminal to the Suncor tank farm at the Voyageur East facility. The pipeline project included several large watercourse crossings, with the largest crossing identified being the Athabasca River, located north of Fort Mackay, Alberta. An NPS 42 x 1" wt. pipe was installed and is to be utilized as a casing for the internal 24" bitumen line.

The successful completion of this crossing considering the length and required finished borehole diameter, 2,195 m and 54", respectively, was a milestone for the HDD industry as this is the longest NPS 42 installation completed to date in North

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America. The HDD construction required thorough planning and implementation of an approved preliminary construction plan and the ability to adapt to changing conditions as they presented themselves in a very remote region of Alberta, Canada. Utilizing sound HDD experience and a combination of cutting-edge installation tooling and techniques, such as pilot-hole intersect gyro steering, pipe thrusters, equipment winterization, and deployment of properly sized equipment for achievement of the installation which occurred during the winter of 2015.

Michels Canada was contracted by TransCanada to perform construction of the HDD as well as the pipe makeup and pullback support of the Athabasca NPS 42 HDD. The Athabasca River crossing was part of an overall program that included six HDDs and one Direct Pipe all installing NPS 42 casing. Preconstruction plans were submitted as part of the requirement by the owner following the TransCanada HDD specifications – TES PROJ HDD Rev 1.

Mobilization to the prepared HDD work pads started in August 2016 from a staging yard that was provided by TransCanada at a nearby site outside of Fort McKay, Alberta.

Surface casing was part of the initial proposed design that had 20 m specified at both the entry and exit sides of the crossing. Soft near surface formation common to the area quickly gave way to

competent formation that only allowed for the 20 m installation as designed. The steel conductor casings were both installed using a pneumatic hammer, or were excavated at the required entry/exit angles to facilitate the given designed geometry.

Entry and exit sides were set up simultaneously with full spreads dedicated on each side in preparation for staging the 1,200,000 lb. HDDs as well as a full complement of mud cleaning and recycling equipment capable of pumping and cleaning 4m³ per minute as would be expected during operations.

“THIS IS THE LONGEST NPS 42 INSTALLATION COMPLETED TO DATE IN NORTH AMERICA.”

The pilot hole was initially drilled to 12 ¼ inches with 4-radius curves to manage the entry angle of 12 degrees and exit angle of 11 degrees, which were critical in the overall project design. Due to specified grouting

requirements, the installation needed to maintain precise gradients at critical points along the projected profile in order to adhere to the engineered grouting plan for installation of the grout in lifts for proper curing. Performing the pilot hole intersect was a major challenge in itself as it had to take place along a 0.75° slope designed for the tangent. A combination of guidance systems including gyroscope and Para-tracker systems were used during the pilot hole drilling due to the length, depth of 70 m (230 feet), and annular pressure monitoring requirements in the sensitive area.

TACKLING THE CHALLENGES

Subsurface conditions proved formidable and inconsistent. Crews drilled and navigated through variable formations consisting of oil sands, sands and silts, hard limestone, sandstone and siltstone, while attempting to maintain control of mud properties efficient in holding the hole and carrying out drilled cuttings. Northstar Fluid Solutions provided the Engineer Designed Fluid Program that was approved by the owner before drilling and had managed it closely with regular checks to react to the changing formation. Cleaning the hole along a drill path of this length proved challenging with the flow of drill fluid cuttings going to both entry and exit sides unexpectedly. With both entry and exit having full and complementary mud cleaning and recycling equipment, the program was successful and finished with what both owner and contractor agreed was a cleaned hole.

Due to being in a remote and secluded location, having a large variety of downhole tooling available was important to facilitate as little downtime as possible. After review of the available geotechnical data Michels had source or redesigned the required tooling early to insure continuous optimal production. Sizes and types of tooling ranged from 12 ¼" pilot bits to 54" reamers/fly-cutters all capable of soft displaceable formation up to hard rock. Due to the length, diameter, and elevation change of the borehole, added flow capacity was needed to remove cuttings and maintain a clean hole. Bitumen zones proved most challenging as equipment wear was substantial requiring continual monitoring and maintenance.

The finished hole was reamed to a final diameter of 54" in multiple stages to accommodate installation of the 42" x 1.00" wt. steel casing.

The image is a promotional graphic for CCI PIPE 360°. It features a blue background with white and yellow text. The company name "CCI PIPE" is prominently displayed in large, bold, white letters, with "360°" in a yellow circle to the right. Above the name, the word "Engineering" is written in white, and below it, "Construction" and "Forestry" are written in white. To the right of "Forestry", the word "Wellpads" is written in white, and below that, "Environmental" is written in white. At the bottom, the contact information "Cochrane: 403-932-0560 | Edmonton: 780-784-1990" is written in white, followed by the website "www.ccisolutions.ca". In the bottom left corner, there is a logo for "BEST MANAGED COMPANIES" with a green leaf icon. At the very bottom, the text "Innovative and award-winning HDD services since 2004" is written in white.

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Michels and the owner had agreed to implement a water recycling system unique to large-diameter HDDs, which had success in the earlier stages of the program but challenges through the later, larger ream stages due to the large volumes required for processing. The high concentrations of bitumen made the recycling and drying process challenging. The overall implementation of this type of program has recognizable benefits, however further refinements for large diameter HDD will need to be studied and addressed.

Drill fluid and cuttings disposal was managed by the owner with Michels utilizing local sumps on site to maintain production. This process was by Michels' estimation a success due to minimizing traffic and maintaining production on site.

Michels Canada mobilized, assembled, and managed the massive pipe string. The NPS 42 pullback was designed to extend 2,195 m back from the exit location. Due to available workspace before a ravine and waterbody, a 2,000-meter radius horizontal curve was required to avoid a protected area. The section was prepared in one continuous string to minimize the stops during pullback. The pipe string was strategically placed on rollers to conform to points on a curve for the access road. The curve encompassed almost 70% of the laydown length as pull rollers were strategically placed along the curve under the string for the pullback.

The exit angle required a detailed and comprehensive pullback plan to be prepared with precise pick points as pipe-handling crews had to carefully hoist the pipe section 14.3 meters into the air to form the over-bend radius.

The assembled 42-inch pipe string weighed upwards of 1,000,000 lbs.

"THE ATHABASCA HDD INSTALLATION WAS COMPLETED WITHOUT LOST-TIME INJURIES."

To handle the pipe during pullback safely and efficiently, Michels used 10 cranes, five side booms, and three excavators.

As an added contingency, Michels' 750-ton Herrenknecht Pipe Thruster™ was set up at the exit location to engage if pull loads during HDD pullback exceeded a set limit, ensuring the stress on the downhole tooling was minimized during pullback operations. Due to this addition of a surface-staged Pipe Thruster, a modified plan was developed at the last minute between Michels and the engineering firm to accommodate the additional equipment that added height to the pipe section design during the pullback phase. The maximum pullback force that the rig faced was 650,000 lbs., while the thruster supplied a maximum of 300,000 lbs. of thrust and was initiated primarily during the radius portion of the pull along the profile to get the pipe moving.

During pipe pullback operations, the buoyancy plan was key to a smooth pullback; special attention was paid to the calculated buoyancy program that had staged frac tanks and used 15 water trucks to continuously supply the massive section during critical pulling operations to minimize the required force.

Safety as always is of paramount importance as with all TransCanada projects. The Athabasca HDD installation was completed without lost-time injuries.

Crews worked two shifts 24 hours per day, six days a week for the duration of the project. They encountered all the typical Canadian weather for fall and into the winter months ranging from 30 degrees Celsius to -25 degree Celsius, which required boilers to be added to the contingency of entry and exit side equipment. Michels' schedule started in August and ended mid-November of 2015.

AN EXCEPTIONAL ACCOMPLISHMENT

Michels constructed the crossing without any inadvertent fluid releases along the environmentally sensitive and highly visible alignment. Constant monitoring of the drill path as well as the river channel was carried out by Michels as well as TransCanada inspection. ■■■

Athabasca River HDD – in addition to being one of the longest large-diameter crossings successfully completed in North America, this crossing included several innovative components such as thruster assist, EDFP in bitumen and on grade intersect, which has established the Athabasca River HDD as an exceptional accomplishment for the industry. We would like to recognize the entire team for combining their efforts and utilizing their experience and expertise. All components from engineering to HDD and pipeline support did a solid job of installing the Athabasca crossing without any lost time incidents or environmental issues.



The North American Society for Trenchless Technology – Northwest Chapter is proud to present the

2017 Northwest Trenchless Conference

This year's conference will be held in Calgary, Alberta on November 8 and 9.

Registration for the 2017 Northwest Trenchless Conference will open in July. For more information, please visit the Northwest Trenchless Conference page on our website. www.nastt-nw.com



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NASTT instructors are experts in their field and volunteer their time to educate the trenchless industry. Thank you to our 2016 instructors and panelists for helping to advance NASTT's mission to educate, publish, research and train!

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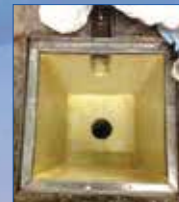
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BACK TO CONTENTS

Largest Diameter Microtunnel in Calgary – 37 Street Storm Trunk Relocation



Charles Pullan, P.Eng., City of Calgary, Calgary, Alberta
Gabriel Jean, P.Eng., Associated Engineering, Calgary, Alberta
Brian Fahy, Ward and Burke Microtunnelling Ltd.

ABSTRACT

As part of the SW Ring Road project, Alberta Transportation requested that The City of Calgary (The City) construct a new 5,250 ft. long, 96-inch diameter storm trunk within the 37 Street SW right of way, south of Glenmore Trail to the Elbow River. Because of scheduling concerns and approvals requirements, the project was divided into Contract 1, which includes 4,593 ft. of pipe installation, and Contract 2. Associated Engineering (AE) determined that the northernmost 1,312 ft. of the installation for Contract 1, which ranges in depth from 29.5 ft. to 45.9 ft., should be completed through trenchless installation to maintain vehicle traffic. As the City does not maintain a list of contractors pre-qualified to complete such work, AE developed and evaluated a tunneling contractor pre-qualification to limit the pool of bidders to those with the relevant experience. The trenchless methods allowed included microtunneling and tunneling. Other options were provided to the contractor, and were managed with performance specifications suitable to the conditions and the installation requirements. Teaming with Whissell Contracting Ltd. (Whissell), Ward & Burke Microtunnelling Ltd. (W&B) began microtunneling construction in mid-August 2015. Microtunneling 65.6 ft. away from houses and close to a major road required noise, vibration, and road settlement monitoring. This paper highlights the design and construction challenges related to the microtunnel. At an ID of 100-inch, this marked the largest diameter microtunnel in Calgary. The microtunneled portion was successfully completed in December of 2015.

BACKGROUND

The Province of Alberta manages the ring road around The City. The northeast, northwest, and southeast portions of the ring road, known as Stoney Trail, are currently in operation. The West and



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Largest Diameter Microtunnel in Calgary

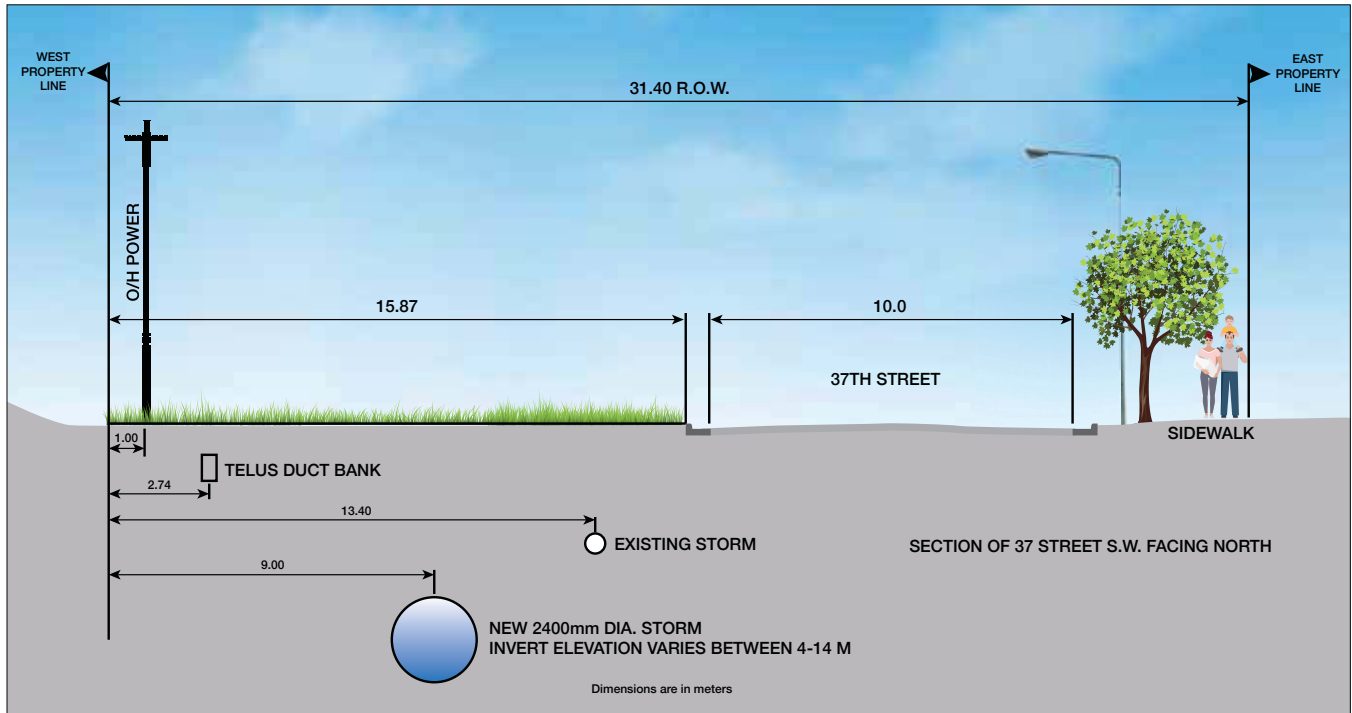


Figure 1. 37 Street SW Right-of-Way

Southwest segments are yet to be constructed. According to Alberta Transportation (AT), the Southwest Ring Road Project is slated to begin in 2016, and involves construction from Highway 8 (near the Elbow Springs Golf Club) to Macleod Trail SE including reconstruction of Glenmore Trail from Sarcee Trail to east of 37 Street.

As part of the South West Ring Road project, AT requested that The City construct a new 1,600 m (5,250 ft.) long, 1,800 mm (72-inch) diameter and 2,400 mm (96-inch) diameter storm trunk within the 37 Street SW right of way, south of Lakeview Drive SW to the Elbow River, to replace the existing storm trunk that crosses the Tsuut'ina Nation lands.

The existing storm trunk collects stormwater runoff from the Tsuut'ina First Nation lands and Glenmore Trail SW, as well as the communities of Glamorgan, Glenbrook, Lincoln Park, and Rutland Park within the City of Calgary.

Following the construction of the relocated 37 Street storm trunk and the diversion of stormwater from the existing storm trunk into the new storm trunk, the City would no longer use the existing storm trunk.

To accommodate the schedule requirements set by AT, the project was split into two contracts: Contract 1 including the northern portion of the installation from Lakeview Drive to 66 Avenue and Contract 2 from 66 Avenue, through North Glenmore Park to the Elbow River.

The City retained the services of AE to design Phase 1 and 2 of the storm trunk relocation, which will need to convey a peak flow of 17.6 m³/s (621.5 ft³/s) during the 1:100-year return period storm event. The requirement for construction completion for Contract 1 was set at June 2016, while Contract 2 is not expected to be completed until end of 2017. This paper highlights some of the design and construction challenges related to Contract 1, in particular the trenchless aspect.

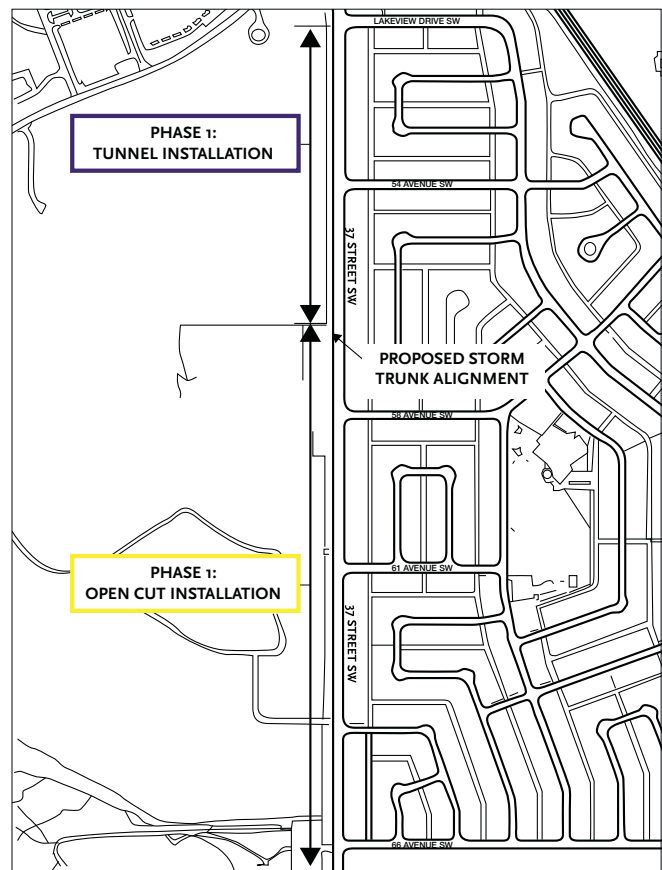


Figure 2. Extent of Tunnel and Open Cut Installation

Largest Diameter Microtunnel in Calgary



DESIGN

The Province investigated the possible future realignments of both the storm and sanitary trunks that pass through the Tsuut'ina First Nation lands. Only a single alignment was considered for the realigned storm trunk. The alignment followed the 37 Street SW right-of-way and continued directly south, through north Glenmore Park, to a new outfall at the Elbow River.

AE looked at different options for the horizontal alignment within the 37 Street SW right-of-way. 37 Street SW is an arterial roadway with a right-of-way width of 31.4 m (103 ft.). The pavement width of the roadway is 10 m (32.8 ft.). For the majority of 37 Street SW, there are two lanes of traffic and a parking lane on the east side of the street.

The design of the relocated storm trunk must respect the Tsuut'ina First Nation land boundary, and be located completely on City lands. The alignment must also accommodate the existing utilities and future utilities along the 37 Street right-of-way, and minimize disruption to traffic. In addition, the relocated storm trunk at Lakeview Drive is required to be approximately 14 m (45.9 ft.) deep from ground to pipe invert. Installing a pipe at such a depth within the 37 Street right-of-way using open cut methods presents many challenges.

Based on the constraints above, the horizontal alignment for the relocated storm trunk was set at 9 m (29.5 ft.) east of the western limit of the 37 Street SW right-of-way. Preliminary geotechnical analysis by Thurber Engineering (Thurber)

indicated that bedrock is approximately 3 m (10 ft.) below grade from Lakeview Drive to a point roughly 300 m (984 ft.) south, at which point the bedrock begins to drop steeply to over 35 m (115 ft.) in depth at 66 Avenue. To maintain one-way traffic in 37 Street, it was determined that a trench depth of up to 8.3 m (27.2 ft.) to invert is possible for open cut installation in overburden soils and 9.3 m (30.5 ft.) in overburden/bedrock. A trenchless installation for depths greater than 8.3 m (27.2 ft.) in overburden soils is therefore required. Figure 1 shows a cross section of the 37 Street SW right-of-way.

AE determined that the northernmost 400 m (1,312 ft.) of Phase 1 of the storm trunk should be completed by tunneling. In this location, with the tunneling conditions expected to be primarily bedrock, the use of an open-faced machine was permitted. The remaining 1,000 m (3,280 ft.) of Contract 1 would be installed by open cut method.

AE completed tender documents that enabled the contractor to have flexibility on the southernmost limit of tunneling installation by including a transition zone between the open cut excavation limits and the tunneling limits. Other options provided to the contractor included the use of microtunneling, tunneling, pipe material (concrete or fiberglass reinforced polymer), and the direction of tunneling. These options were managed with performance specifications suitable to the conditions and the installation requirements. Figure 2 shows the horizontal alignment of the storm trunk and the extent of tunneling.



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A geotechnical baseline report (GBR) was also prepared in collaboration with Thurber. The GBR is to be used as the primary interpretation of the subsurface conditions anticipated along the proposed trunk route in the areas described as tunnel construction and transition zone.

PRE-QUALIFICATION AND TENDER PROCESS

For construction projects, the City typically issues a tender to a list of pre-qualified contractors. As the City does not have a pre-qualified list of tunneling contractors, it was necessary to evaluate potential tunneling contractors ahead of the tender. Simultaneous to detailed design, AE performed a tunneling and microtunneling contractor pre-qualification process to limit the pool of bidders to those with the appropriate experience with this type of installation in both length and diameter.

The City posted a Request for Pre-Qualification (RFPQ) for tunnel work in April 2015. The RFPQ essentially provided general parameters related to the project and invited tunneling contractors to submit their qualifications in order to be eligible for the job, pending a thorough evaluation. The RFPQ was open to tunneling contractors around the world. Tunneling installation of this type requires contractors with specific expertise.

In the RFPQ, contractors were asked to provide relevant tunnel boring machine (TBM) or microtunnel boring machine (MTBM) project experience as defined in the RFPQ. Additionally, the RFPQ required experience be demonstrated in projects with large diameter (1,800–3,000 mm [72-inch to 120-inch] ID) circular pipe with a depth between 8 m (26.2 ft.) and 35 m (114.8 ft.). The tunneling method should have provided full active face support and tunnel support throughout the excavation. Although full active face support was not required for Contract 1, it would be a requirement for tunneling in Contract 2. The RFPQ encompasses both contracts.

At the close of the RFPQ, the City received 12 submissions. Following an evaluation by the City and AE, seven of the 12 contractors were deemed to be qualified. Those seven contractors were included in the list of pre-qualified tunneling contractors that the City's pre-qualified underground general contractors could select as sub-contractors at the project tender. Whissell Contracting Ltd. (Whissell) was the lowest bidder for Contract 1 and selected Ward and Burke Microtunneling Ltd. (Ward & Burke) as their tunneling sub-contractor.

CONSTRUCTION

Construction of the storm trunk began in August 2015 with open-cut installation at the south end of the trunk. Ward & Burke began the tunneling construction for Contract 1 in mid-August 2015. Their method consisted of installing a 2,500 mm (100-inch) inside diameter concrete pipe by microtunneling, using a Herrenknecht AVN D2500A Microtunnel Tunnel Boring Machine (MTBM). The pipe was manufactured by Munro (now Decast) and delivered from Ontario on flatbed trucks.

The installation also featured a 12 m (39.4 ft.) outside diameter, 14 m (45.9 ft.) deep launching shaft at the north end, and a smaller retrieval portal at the south end of the tunnel segment. The launch shaft was constructed using a watertight sinking caisson installed in 2.5 m (8.2 ft.) high sections. The construction of the shaft took approximately two months. The retrieval portal consisted of open



excavation protected by a trench box and a non-reinforced concrete wall at the face of the tunnel breakthrough.

37 Street SW is one of the main access routes for the residents of the community of Lakeview and users of North Glenmore Park and the Weaselhead Natural Area, so it was important to maintain some traffic access on 37 Street SW. The southbound lane of 37 Street SW was closed to traffic for the duration of the project to allow space for access, laydown, and shaft construction. Two-way traffic was set up for the north half of the site. In the south half, southbound traffic was detoured through the Lakeview community.

The amount of work space between 37 Street SW and the City limit was limited, so the contractor arranged an agreement with the Tsuut'ina Nation to use their lands adjacent to the shaft for an additional laydown area.

The contractor proposed to tunnel through 25 m (82 ft.) of the transition zone, and install pipe by open-cut for the remainder. A section of the transition zone was determined to contain pit run, so the contractor chose to excavate and mine the pitrun, replacing it with clay.

The MTBM was delivered on October 17. Microtunneling began six days later on October 23. Tunneling progressed without any

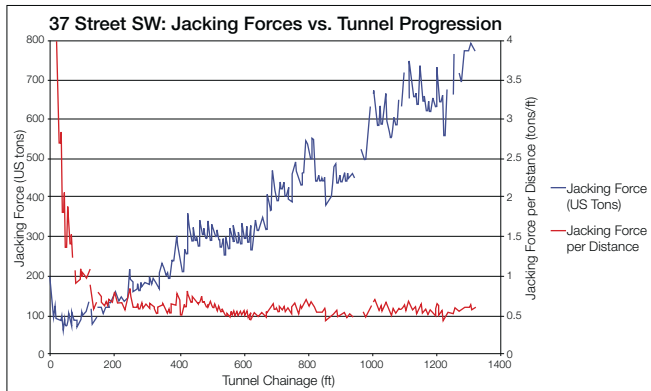


Figure 3. Microtunnel Jacking Forces During Installation

major delays. Crews worked 24 hours to expedite construction. Two intermediate jacking stations (IJS) were installed in the pipe train to reduce the forces on the jacking pipe. The IJS were introduced after 91 m (298.5 ft.) and 270 m (885.8 ft.) of pipe installation. Figure 3 shows the microtunneling jacking forces recorded during the installation.

Thurber was on site regularly and monitored vibration, as well as surface settlement. Thurber noted that the caisson construction caused more vibration than the microtunneling. They also took soil samples during microtunneling. The maximum unconfined compressive strength (UCS) for the samples taken was 40.27 Mpa (5,840 psi), well below the baseline of 90 Mpa (13,053 psi) set in the GBR.

Because of the proximity of the work area to the residences east of 37 Street, it was also necessary to monitor construction noise. As mentioned earlier, microtunneling was a 24-hour operation. FDI Acoustics Inc. set up a noise monitoring system during microtunneling, which provided almost instantaneous noise readings. AE/City used weekly blog updates to keep residents apprised of construction progress.

Once tunneling was completed, a manhole was constructed at the transition from open-cut to trenchless installed pipe. The annular space of the tunnel was grouted, and a roof was installed on the launch shaft, leaving it accessible for the upstream tie-in to be constructed by others.

CONCLUSION

The relocation of the existing storm trunk that crosses the Tsuut'ina Nation lands is required by Alberta Transportation as part of the Southwest Ring Road Project. The first phase of the relocation includes the installation of 1,600 m (5,250 ft.) of 2,400 mm (96-inch) diameter and 1,800 mm (72-inch) diameter concrete pipe by open cut and microtunneling.

The installation for the first phase was successfully completed in December of 2015. Pipe installation was completed on schedule as provided by Whissell, and six months ahead of the contract completion date.

Three main lessons can be learned from this project:

- Stainless steel band for microtunnel pipe – The jacking pipe used had an epoxy coated steel band at the bell end. The coating on the band can get damaged during installation. Over the long term, the band can corrode, and facilitate infiltration.



Repair of the band coating is difficult to achieve while the pipe is installed. One way to address this would be to specify a stainless steel band for the jacking pipe.

- GBR is helpful – The GBR helped clarify what the contract expectations of the City were regarding the subsurface conditions, despite what was found in the transition zone.
- Size of construction area – It would have been difficult, but not impossible, for the contractor to fit all the microtunneling equipment in the original construction area provided. For future projects similar to this one, a larger area for laydown should be considered. ■ ■ ■

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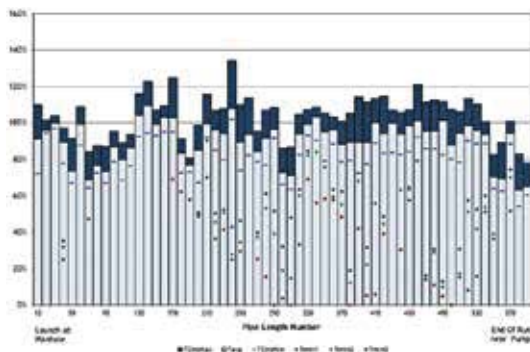
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Challenges and Successes on the City of Edmonton's SESS SA1a Tunnel



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K.C. Er, Shanghai Construction Group Canada, Edmonton, Alberta
Jason Lueke, Ph.D., P.Eng., Associated Engineering, Edmonton, Alberta
Chris Lamont, E.I.T., Associated Engineering, Edmonton, Alberta

ABSTRACT

The South Edmonton Sanitary Sewer (SESS) trunk system consists of a series of staged tunnels and pipe segments that will ultimately convey sanitary sewer flow from new development on the south side of Edmonton to the Alberta Capital Region Wastewater Commission treatment plant. In 2014, the City of Edmonton tendered SESS segment SA1a consisting of approximately 1,300 m of 2,200 mm diameter gravity sewer crossing Anthony Henday Drive, within the Transportation Utility Corridor, from Parsons Road to 91st Street. Through a competitive tendering process, the project was awarded to Shanghai Construction Group (Canada) Corporation (SCGCC), a subsidiary of one of the world's largest contractors, headquartered in Shanghai, China. Being SCGCC's first project in North America, there

were numerous organizational, logistical, and planning challenges with bringing SCGCC's operation to Canada to deliver this project. SCGCC teamed with Associated Engineering, who provided general engineering services during construction to assist in project delivery, permitting and approvals, environmental coordination, survey, and pipe certification. The tunnel construction was successfully completed in the spring of 2016. This paper provides an overview of the techniques utilized in the construction of the SESS SA1a trunk, the custom-manufactured microtunneling machine used on the project, certification of concrete pipe from China, innovative solutions to deal with difficult ground conditions, and lessons and experiences gained during the delivery of SCGCC's first tunneling project undertaken in Canada.

"The SA1a trunk will initially provide storage during peak hours and then be discharged at low-flow periods. Once the surrounding areas are fully developed the trunk will act as a normal conveyance system."

INTRODUCTION

Created in 1999, the City of Edmonton's (City's) Sanitary Sewer Servicing Strategy is a 75-year plan to provide sanitary servicing to undeveloped areas of Edmonton, and to facilitate redevelopment of mature neighborhoods, through the construction of large diameter sanitary transmission trunks. These projects are funded through the Sanitary Servicing Strategy Fund (SSSF), which is comprised of contributions from the private development industry and the City. This funding strategy was developed to meet the challenges of providing sanitary servicing through long-term planning and, as of 2014, has been used to construct approximately 36 km of sanitary tunnel. One component of the Sanitary Sewer Servicing Strategy is the South Edmonton Sanitary Sewer (SESS) system. SESS was developed to ultimately convey sanitary flows from areas in south Edmonton to the Alberta Capital Region Wastewater Treatment Plant. These trunk systems are being constructed in stages that, in the interim, will store wet weather flows to enable continued use of the existing sewer system.

The SA1a Sanitary Trunk is one stage of the SESS trunk system. It will convey sanitary flows from various development areas in south Edmonton to the wastewater treatment facilities located on the eastern side of the capital region. After reviewing various alignment alternatives, the final alignment was chosen to follow Parsons Road north to immediately south of the Transportation Utility Corridor. The line then enters the Transportation Utility Corridor, crosses beneath six energy pipelines, and then turns to north-east paralleling the energy pipelines beneath Anthony Henday Drive. The line then connects to an existing trunk currently running along 91 Street. The SA1a trunk will initially provide storage during peak hours and then be discharged at low-flow periods. Once the surrounding areas are fully developed, the trunk will act as a normal conveyance system.

A portion of the SA1a project was delivered as an evaluated tender, and was awarded to Shanghai Construction Group Canada Corporation (SCGCC) in the spring of 2014. This paper will discuss the project from tender through construction and highlight the various methods used, challenges encountered, and innovations utilized to construct the sanitary tunnel. Associated Engineering (AE) was retained as the contractor's engineer to provide various construction and general engineering services to SCGCC. Thurber Engineering (Thurber) was retained to provide support services to AE, and to aid in the development, installation, implementation, and analysis of the settlement monitoring plan.

PROJECT OVERVIEW

Construction of the SA1a trunk was broken out into two portions: one to be constructed using in-house City construction forces and the other to be externally contracted. The portion of SA1a tendered consisted of construction of an approximately 1.3 km-long section of sewer from the internally constructed section to the existing SA1b trunk downstream. Of this, 1,212 meters was to be

a 2,100 mm inside diameter (ID) tunnel crossing beneath Anthony Henday Drive and an existing pipeline corridor. The remaining 70 m consisted of twin 1,500 mm ID pipes traversing beneath a high-pressure gas line. This section also included construction of six access manholes located north of an existing pipeline corridor crossing (MH100), before and after the high-pressure gas line crossing (MH101 and MH102), before and after the Anthony Henday Drive Crossing (MH103 and MH104), and before the connection to the downstream system.



Figure 1. SA1a Site Overview

Originally, the external portion was tendered primarily with over 70% to be constructed with either open cut or trenchless methods, and approximately 30% required to be installed by trenchless methods. The sections specified to be constructed using trenchless methods were located beneath the Anthony Henday Drive right of way, a pipeline corridor, as well as a high-pressure gas line. SCGCC decided to bid on the option for a complete microtunneling installation based on high water tables within the clay ground conditions. Within their tender, SCGCC proposed using a 2,200 mm diameter concrete pipe from China.

PRECONSTRUCTION ACTIVITIES

With the challenges presented by the tunnel alignment and construction by a contractor with a base located overseas, a significant amount of time and effort was placed on planning and associated activities prior to the start of construction. Some of the key considerations in this stage are described below.

Procurement of Microtunnel Boring Machine

Based on the geotechnical report, SCGCC determined that microtunneling with a Slurry Pressure Balancing Shield best suited the project requirements and began designing and manufacturing

the MTBM in Shanghai, China. The MTBM was delivered on site on August 11, 2014. The MTBM is specially designed for jacking the 2,200 mm ID concrete pipe, and has an outside diameter (OD) of 2,640 mm. The MTBM is 4 m in length and weighs 32 tonnes. There is a rock crusher and five water jets built into the head of the MTBM. These jets can be operated individually or in tandem. The cuttings are discharged as a slurry. The face pressure and volume of the slurry discharge is closely balanced to keep ground settlement to a minimum.



Figure 2. Custom Manufactured MTBM

The MTBM is operated and remotely controlled by an operator through a series of Programmable Logic Controllers (PLC). Through a CC-Link data cable, the PLC transfers all real time MTBM performance data and tunneling parameters to a central control room where the information is used by the operator and stored in the computer. All PLCs are synchronized to allow the operator full control of the MTBM operations. The MTBM is also equipped with an advanced alarm system that is colour coded to warn the operator of potential deviations from the operating parameters. The MTBM and its ancillary equipment were manufactured to meet Canadian Standards Association (CSA) electrical codes.

The MTBM is complemented with four main hydraulic jacks, each capable of generating 400 tonnes of thrust. Intermediate jacking stations (IJS) were also manufactured for use with the jacking pipe in the event they were required to augment the jacking force. Each IJS is equipped with twenty-six, 35 tonne hydraulic thrust cylinders. The IJSs were custom manufactured to complement the MTBM and the 2,200 mm pipes. The OD of the jacking station is the same as the OD of the concrete jacking pipes.

The MTBM was manufactured to allow +/- 2 degrees on directional control, with a maximum rotating torque of 414.9 kNm at 2.2 rotations per minute wheel speed.

Jacking Pipe Certification

In order to safeguard the pipe from failure under Anthony Henday Drive, and to ensure the pipe could withstand the thrust needed to jack 645 m of pipe, SCGCC specified in their tender submission that a 2,200 mm ID concrete pipe would be manufactured and delivered from China. This 2,200 mm ID concrete pipe has been used successfully for more than a decade in China. Engineers from AE and the City of Edmonton independently travelled to the manufacturing facilities in Shanghai, China to assess the facilities' conformance to Canadian concrete pipe standards, specifically CSA A257. The facilities visited include concrete, steel, and aggregate suppliers and manufacturers, as well as the pipe manufacturing facility. All facilities are members of the Shanghai Construction Corporation. Tests were completed and their results reviewed to assessed conformance of the various components of the pipe to the applicable CSA standards. The tests witnessed included:

1. Concrete pipe fabrication materials;
2. Concrete mix design and concrete batching facilities;
3. Reinforcing steel, materials, and cage fabrication;
4. Quality control processes and data;
5. Concrete pipe fabrication process;
6. Hydrostatic testing of concrete pipe; and
7. Three edge bearing testing of concrete pipe.

Fabricated pipes were visually inspected with respect to the dimensions and permissible variations, as well as the quality of work and finish as per the CSA A257 specifications. Assessors concluded that the precast concrete pipe produced at the inspected facility meets the requirements as set forth in the City of Edmonton contract documents for the SESS SA1a Project. The City of Edmonton subsequently performed random quality checks from core samples drilled from the pipes that were delivered to the SA1a project site.

The pipes used in the SA1a project are manufactured in 2.0 m sections with an OD of 2,640 mm, an ID of 2,200 mm, and a wall thickness of 220 mm. Each pipe weighs 8 tonnes. Several jacking pipes were manufactured with four grouting ports where bentonite

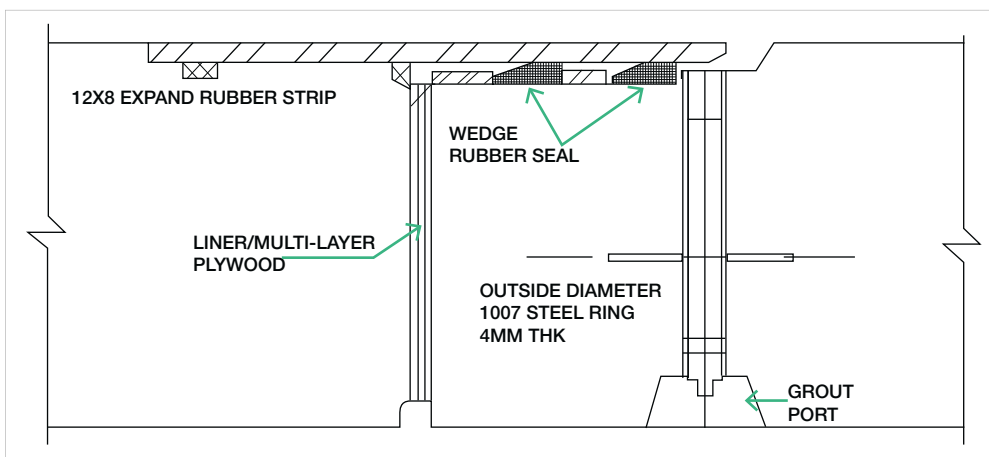


Figure 3. Concrete Pipe Joint Configuration (left) and Intermediate Jacking Station on Site



could be pumped to lubricate the pipe and fill the annular space. SCGCC has perfected a pipe joint that is leak proof not only on a straight alignment, but along curved tunnel alignments as well. The bell end of the pipe has a 10 mm steel band that is coated for corrosion protection and the spigot end of the pipe has two wedge shaped rubber gaskets.

Pipe and Equipment Delivery

All the pipe and tunneling equipment were shipped from Shanghai to Vancouver and after being cleared by Canadian Customs, were shipped by rail and land transport to the job site in Edmonton. Two hundred and twenty containers were used to ship 660 pieces of pipe to Edmonton. Each container held three pieces of pipe with each pipe secured to prevent movement during shipping. A tarp was used to cover the top of the container to prevent seawater from landing on the pipes while crossing the Pacific Ocean. The first shipment of pipes was delivered to the project site in mid-July 2014, and the balance of the pipes was delivered on a weekly basis. The MTBM and its ancillary equipment were stored in containers for shipping across the ocean. The MTBM was the only piece of equipment that was transported by land to Edmonton once it cleared Canadian Customs. The rest of the equipment containers were subsequently shipped by rail from Vancouver to Edmonton and then transported by truck to the job site. The MTBM and all its ancillary equipment arrived on site in mid-August 2014.



Figure 4. Pipe Delivery and Removal from Shipping Container

Construction Crew

Since the MTBM for this project was specifically manufactured in China, it was important to have personnel familiar and capable of operating and maintaining the MTBM throughout the project duration. Three key trade personnel were sent to work on the MTBM during its entire manufacturing process. Since all the MTBM controls are identified in Chinese, an eight-person team from China was created to operate and maintain the MTBM. The rest of the heavy equipment was purchased and rented locally. Additional laborers were hired from the local community.

Tunneling Segment Staging

While planning the tunneling staging for the project, SCGCC proposed the elimination of manhole MH104, which was located immediately north of Anthony Henday Drive. In removing the

manhole, and with a small deflection at manhole MH103, SCGCC developed a 645 m long drive. The remaining segments between manholes included drives of 90 m, 160 m, and 310 m. Construction of the 645 m drive required the use of three intermediate jacking stations located at strategic points within the pipe string. These were used to keep jacking forces within a comfortable range of the allowable jacking force of the pipe.

CONSTRUCTION OVERVIEW AND CHALLENGES

During construction, several challenges were encountered that required adjustments to be made to both construction processes and equipment.

Access Road

Suitable site access required improvements and an extension to the existing access road, which included ramping over six shallow buried pipelines with rig mats and nearly 2 m of clay fill as required by the pipeline representatives. Existing pipeline depths varied from 1-3 m, requiring adequate protection from the potential loading of up to 40 tonnes of equipment being mobilized at once. The road structure was built with clay, geo-grid, gravel, and crushed concrete. All existing topsoil was stripped and stockpiled prior to the road structure being built. Once the access road was built, the site was developed with the required equipment, storage, and materials. More than 600 m of road was necessary to access the required site location.

Slurry Recycling and Water Storage Ponds



Figure 5. Slurry Settlement Ponds Prior and During Construction

The allowable workspace allocated for the project provided SCGCC with an opportunity to develop an HDPE lined slurry settlement pond system comprised of four excavated pits connected by weirs. As the slurry flowed from one pond to another, the heavier material settles, allowing the cleaner slurry to be reused. The settlement ponds were progressively excavated and the excavated material stored onsite. Permission was provided through the provincial Ministerial Consent regulations to allow SCGCC the use of a pie-shaped area to dry and dispose of the material excavated as a result of tunneling operations. Additionally, raw water storage ponds were also excavated adjacent to the settlement ponds, and lined to ensure sufficient volumes were available during the construction process. Development of the site was conducted with consideration

“Tunneling advanced reasonably well until an unknown obstacle was encountered part way through the AHD crossing. The torque on the MTBM cutter head almost doubled and the MTBM was vibrating violently.”



Figure 6. Configuration of Settlement Monitoring Points Across Anthony Henday Drive

for winter construction. Preparations for winter construction included the installation of buried, insulated, and heat traced slurry feed and return lines to ensure they were not damaged by freezing temperatures. The water supply line from a nearby hydrant was also insulated and heat traced.

Settlement Monitoring Plan

For crossing Anthony Henday Drive, the Province of Alberta provided guidelines that required the impact to the riding surface to be equal or less than 2 mm/m as per the International Roughness Index (IRI). This plan was developed in conjunction with Thurber Engineering, who has extensive experience with settlement monitoring during tunnel construction. The plan included the installation of 21 individual subsurface monitoring points, installed to a depth of 2 m, that were monitored before and after construction of that section. Additional long-term monitoring included data collection six times over 12 months following completion of the crossing. Monitoring points were placed on the centerline of the proposed sanitary trunk, with some additional points offset perpendicular to the alignment to create a surface cross section. These data will allow the generation of graphical information that will document the potential impact of the installation. The points were separated into four sites traversing the medians between the three asphalt surfaces. No asphalt surface monitoring points were allowed to eliminate any impact to traffic. Deep benchmark monuments were installed to a depth of 6 m and used during each survey to ensure the data collected were relative to the same datum. IRI scans are conducted on a yearly basis by the Operator / Caretaker of the Anthony Henday P3 project, who said that no concerns were noted from the yearly reports.

Construction Sequence

Tunneling began on the 310 m section between manholes MH102 and MH103 in order to calibrate the equipment and to optimize its operation within the existing ground conditions. The experience and operational knowledge gained in the first section were key to ensuring minimal settlement on the 645 m crossing of the Anthony Henday and the remaining TUC. The 645 m section, between MH103 and MH106 was completed next with the hand tunnels underneath the high-pressure gas line being started during that time. Once the MTBM reached MH106, it was relocated to MH100 where it tunneled to MH101. The MTBM was relaunched from MH100 and was removed from a temporary shaft at the south end of the project.

Main Working Shaft (MH103)

Due to the location within the alignment MH103 was chosen to be the main working shaft for the project. This shaft was constructed to have a 9 m inner diameter, with 400 mm thick reinforced concrete walls. The two portholes were cast to a diameter of 2,850 mm, which also doubled as the reaction walls for the opposite drives. The south opening was used to tunnel 312 m towards MH102. The MTBM was then retrieved from MH102 and lowered into this working shaft and then tunneled 645 m in the opposite direction toward MH106.

Tunneling

Tunneling from the main working shaft towards MH102 was the first leg chosen to be tunneled. This leg was 312 m. It provided an opportunity to evaluate and adjust the MTBM performance and miscellaneous equipment calibrations. The MTBM performed as expected until gravels and cobbles were encountered within the water bearing clay till. The MTBM is able to discharge gravel and crushed cobbles through the slurry line. However, the combination of gravel and cobbles mixed within the tacky clays frequently plugged the slurry discharge line. Modifications to the slurry discharge had to be implemented on site. A device was inserted at the beginning of the slurry discharge line to limit gravel less than 100 mm from going through the discharge line. The slurry line was also reconfigured so that the slurry was filtered and gravel and crushed cobbles were removed just ahead of the discharge pump. The 312 m tunnel was completed on grade and only 4 mm off its

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"The boulder was pushed approximately 350 m before permission was given to excavate and remove what remained of the boulder and its various fractured components."

horizontal alignment. In preparation for tunneling the longest stretch of tunnel in this project underneath Anthony Henday Drive (AHD), the MTBM was cleaned, inspected, maintained, and repaired, and the 100 mm slurry discharge line was replaced with a larger 150 mm line.

Tunneling advanced reasonably well until an unknown obstacle was encountered part way through the AHD crossing. The torque on the MTBM cutter head almost doubled and the MTBM was vibrating violently. The AHD is within the provincial jurisdiction and surface excavation is strictly prohibited within the ADH right-of-way. To meet the stringent surface settlement criteria, SCGCC had no way of accessing the face of the MTBM to determine size and type of obstruction. A decision was made to continue with tunneling and pushing the obstacle ahead of the MTBM slowly until it cleared the ADH right-of-way. At this point, a pit was excavated and shored, and a one-cubic-meter granite boulder was extracted. It took almost a month to repair the damage sustained by the MTBM. Tunneling for the balance of the project went well until the pipeline alley where six pipelines were buried. Extreme care and strict adherence to safety procedures had to be followed while tunneling 50 m across the pipeline alley – every pipeline had to be exposed by hydrovac, and a representative of the pipeline had to be on site to verify and give the permission to proceed once there was adequate separation for the MTBM to safely tunnel across the utility line. This was a time-consuming process that could not be avoided.

Hand Tunneling

Small sections of hand tunneling were required as a result of the crossing of the high-pressure gas mains. Due to the reduced clearance identified during the design stage, the 2,200 mm trunk was transitioned down to a twin 1,500 mm to achieve the required separation. Each installation was originally 45 m in length but was extended to 48 m, due to the locating of a previously unknown fiber optic line that required the shifting of the shafts 3 m along the alignment. Hand tunneling through the soft clays proved to be simple in terms of the removal of spoils and logistics but complications were encountered due to the materials used during construction.

LESSONS LEARNED

Throughout the construction of the SA1a Sanitary Trunk, SCGCC was able to work with the City and its team to resolve issues encountered along the way.

Ground Conditions

Shortly after tunneling commenced, gravels and cobbles were noticed. While a small amount of this material was expected, the frequency of the material appeared to increase, which caused clogged slurry lines and damage to pumps. This required the crews to temporarily stop tunneling to remove the plugged lines and reconnect the system. As tunneling continued, larger material was encountered, which resulted in the addition of a material screen to remove larger granular material prior to entering the slurry return line and settlement system. In addition to the screen, the slurry

return line port was large enough to fit equipment to fracture boulders and was used for that purpose when possible. After the first section was completed, some cutting teeth were replaced and the MTBM was prepared for the Anthony Henday Drive crossing. Roughly 80 meters into the crossing the MTBM encountered a large boulder. After pushing it approximately 50 m, consideration was given to excavate and remove the obstacle from in front of the machine. The permitting required for the installation beneath the major free such that no excavation was allowed within the right-of-way under any condition. Access through the slurry return line port was not possible due to the location of the boulder. As a result, the decision was made to push the boulder until it broke up and entered the rock crusher or until the MTBM reached an area where excavation was allowed. The boulder was pushed approximately 350 m before permission was given to excavate and remove what remained of the boulder and its various fractured components.



Figure 7. Large Boulder Pushed by MTBM

Utility Conflicts

Various utility conflicts encountered required changes during the course of construction. These included:

- **High-Pressure Gas Line** – crossing of the 508 high-pressure gas main became more critical when the existing elevation was found to be much lower than expected.
- **Unidentified/Unknown Fiber Optic** – during the construction of Manhole 101, an existing but previously unknown fiber optic line was located, which required the shifting of the shaft.
- **Primary Power Lines** – the existence of three power lines required daylighting but the three were found to be stacked vertically instead of at the same elevation horizontally.
- **Storm Siphon Repair** – crossing of an existing storm siphon required the repair of the separated joints and grouting of the surround ground. Siphon crossing was installed with less than 120 mm separation.

Lessons Learned

Entering a new market provides challenges; these challenges can include procuring equipment, finding experienced manpower, and gaining a trusted circle of support. Being SCGCC's first project in North America, overall it was a successful project that includes a few lessons learned:

“Entering a new market provides challenges; these challenges can include procuring equipment, finding experienced manpower, and gaining a trusted circle of support.”

- It will be beneficial to seek input and clarification of the geology from local experts to have a better understanding of the ground conditions likely to be encountered prior to tendering.
- Pre-planning and careful scheduling are key to avoiding unnecessary delays in applying for working permits for foreigners, clearing the Immigration and Canadian Customs for material and equipment deliveries, since the key personnel, pipe, and MTBM came from overseas.
- Adjust all aspects of the construction to ensure compliance with all the applicable rules and regulations.
- The experience in dealing with gravel and cobbles within the clay till.
- How to cope and work in a cold winter environment. ■ ■ ■

ACKNOWLEDGEMENTS

The authors would like to acknowledge Stantec as the owner's engineer and designers of the SA1a project; SMA Consulting as the owner's construction inspector; and AMEC Environmental and Infrastructure as the owner's geotechnical consultant for this project. All were integral to the successful implementation of this project.

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