2019 | NORTHWEST

SPRING/SUMMER

TRENCHLESS JOURNAL

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

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IN THIS ISSUE:

DEPARTMENTS:

ON THE COVER: Railway tracks leading to skyscrapers in Calgary, Alberta, Canada. © Golasza | Dreamstime.com

2019: WE ARE ON THE NATIONAL STAGE!

Our 2018 Conference was such a sounding success, we decided to take the Northwest Conference even farther in 2019. The Northwest Chapter has partnered with the other two Canadian Chapters, NASTT-BC and NASTT-GLSLA, to present No-Dig North 2019. No-Dig North is a brand-new National Trenchless Conference that will provide a great opportunity for Owners, Consultants, Industry Experts, Suppliers, and Contractors to reach a larger Canadian audience to showcase the great things that are happening in the trenchless industry. The conference planning is well underway with the Technical Program and Short Course offerings already released.

No-Dig North 2019 is being held at the TELUS Conference Center in Calgary, Alberta between October 28 and 30. It will include a pre-conference reception, pre-conference short-courses, keynote speaker, a two-day three-track technical program, exhibitor hall, and the presentation of three Regional and one National Project of the Year Awards. For more information, please visit the Conference's webpage – ***www.nodignorth.ca***.

Like a few of us, I just blew back from the Windy City where I was lucky to be one of the 2,200 in attendance at the NASTT 2019 No-Dig Show. It was another awesome record-breaking show; I enjoyed chatting with many of our members and taking in the outstanding presentations from our Chapter. As in past years the Chapter held a Board meeting at No-Dig, in which we introduced our newly elected Directors to our local Chapter Board. We are excited to welcome Sam Wilson from CCI Inc. We also say goodbye to outgoing Board member Ed Douziech, who is departing us after completing his term. Ed's contributions to the Chapter while serving on the Board are greatly appreciated.

In March we closed out another great Technical Lunch Program in both Edmonton and Calgary, where we spotlighted some of our great local projects and new products. We will be commencing the planning of the 2019–2020 Program over the summer and I would like to extend an invitation to our Chapter members to submit topics for this program. If you have a specific topic or project that you would like to see us spotlight, please reach out and let me know.

And new this year, the NASTT-NW Chapter will be holding a mixer in September at the University of Alberta, which will be open to members, non-members, and students. Look for further information via email over the summer months.

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 *gtippett@nastt-nw.com*.

Be sure to check our website, *www.nastt-nw.com*, and our Chapter LinkedIn page for additional information on what is happening within our Chapter.

Greg Tippett
Chair, NASTT – Northwest Chapter

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WE ARE AT THE HELM

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

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

Plans are now underway for the 2020 conference in Denver, Colorado. If you would like to join the Program Committee to help us develop the technical sessions and special events for next year's Show, meet us in Denver this summer! Please contact us at *info@nastt.org* for more information.

I'm also excited for the upcoming No-Dig North conference! The Canadian Chapters are hosting the first annual No-Dig North in Calgary in October. The show will consist of two days of technical paper presentations and industry exhibits in the trenchless technology field. Pre-event Good Practices Courses will also be held. The Northwest Chapter is at the helm in planning this inaugural conference and I'm confident this is going to be the trenchless event to attend in Canada in 2019! I'd like to thank Greg Tippetts for his leadership in the planning of No-Dig North. The event will be held at the Telus Convention Centre in Calgary. Visit *www.nodignorth.ca* for all the details.

The North American Society for Trenchless Technology is a society for trenchless professionals. Our goal is to provide innovative and beneficial initiatives to our members. 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 active with the trenchless community and to have your voice heard.

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

Craig Vandaelle
NASTT Chair


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IN THIS ISSUE

Welcome to another Spring/Summer issue of the *Northwest Trenchless Journal*. This issue of the Chapter magazine provides information about the 2018 Project of the Year Winner: the Rainbow Road Sanitary Trunk Microtunnel. For full details, see pages 13–18 in this magazine.

In addition, we are pleased to present the 2019 NASTT-NW Buyers' Guide and registration details for the upcoming No-Dig North event being held in Calgary in the fall. Be sure to check out our website at *www.nastt-nw.com* for more information and updates.

Our Chapter magazine is published twice a year. The next issue of the *Northwest Trenchless Journal* is scheduled for distribution in October 2019 and will highlight full details about the No-Dig North event.

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 August 21, 2019.

Remember, you can also find us online and join our LinkedIn group at *www.linkedin.com/groups/NASTT-Northwest-Chapter-4430433*.

"We are pleased to present the 2019 NASTT-NW Buyers' Guide and registration details for the upcoming No-Dig North event being held in Calgary in the fall."

Call for Submissions

If you would like to submit your project paper or other content and photos for an upcoming issue of this Northwest Chapter magazine, please contact Carlie Pittman, Magazine Committee Chair, at *pittmanc@ae.ca*.

Editorial submissions for the *Northwest Trenchless Journal* are welcome and due for our next publication by late August 2019.

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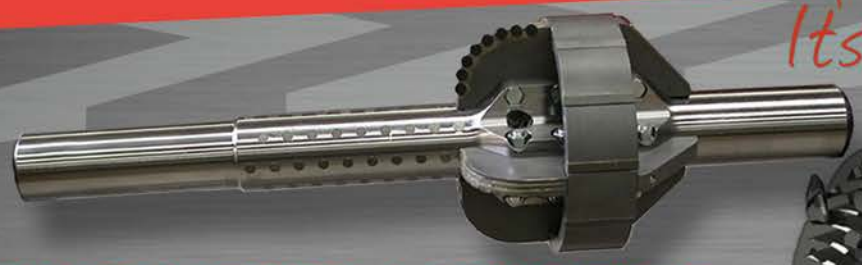

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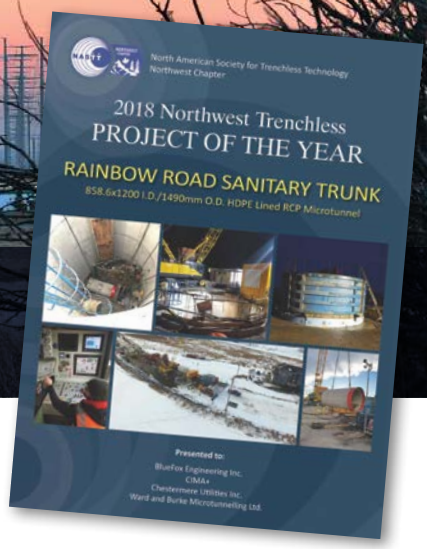
2018 Northwest Trenchless Project of the Year

Congratulations to the Chestermere Utilities Inc., BlueFox Engineering Ltd., CIMA+, and Ward and Burke Microtunnelling Ltd. on being awarded the 2018 Northwest Trenchless Project of the Year for the Rainbow Road Sanitary Trunk!



Rainbow Road Sanitary Trunk Microtunnel

Bertus Vos, MBA, P.Eng – BlueFox Engineering
Steven Dawe, P.Eng – CIMA+

Project Overview

Chestermere Utilities provides safe and efficient utility services to the City of Chestermere, AB. It is dedicated to continuous improvement and developing innovative solutions to provide the highest value to its customers. Chestermere is one of the Canada's fastest growing communities and requires additional sanitary sewer servicing capacity to support future development. CIMA+ was retained as the prime civil consultant, with BlueFox Engineering as the trenchless consultant. Two multi-curve microtunnels were installed to provide the required solution.

Phase 1 of the Rainbow Road Sanitary Trunk entailed the installation of approximately 900 m of sanitary sewer from Rainbow Falls Gate, to the newly constructed Lift Station on the southeast side of Rainbow Road.

As the project developed, it became clear that due to existing infrastructure including a 400/500 mm diameter water pipeline running parallel to the proposed alignment, Canadian National Railway, Alberta Environment Irrigation Canal, and newly installed road surface and sidewalks, that a conventional open-cut solution would not only be very difficult and disruptive but also very costly to the project owner.

Alternatives analysis by CIMA+ included the discussion of trenchless options, which led to the retaining of BlueFox Engineering as a trenchless engineering consultant. Together, BlueFox and CIMA+ investigated trenchless solutions including: Horizontal Directional Drilling an inverted siphon, Pipe Jacking, Auger Boring, and Closed Face Slurry Microtunneling.

To meet the vertical clearance requirements from the Canal and to be able to service all developable area within the City's boundary to the west of Chestermere, the Rainbow Road Sanitary Trunk needed to be up to 14 m deep in Phase 1. Due to the depth, a preference for an on-grade installation method and following geotechnical investigations – microtunneling was selected as the optimal solution.

The selected microtunnel methodology allowed for the installation of an on-grade sanitary sewer at much greater depths (up to 14 m) than what would be easily achievable by conventional means, considering the nearby obstacles and existing utilities. We were able to navigate without impact, below, alongside, and underneath all of the existing infrastructure such as: overhead powerlines along the alignment, existing roadways, the City's water supply main, canal, and a CN railway. Once the project workspace was set up, the noise and construction traffic had minimal impact to nearby residents, as the tunnel progressed continuously for 24 hours per day, 7 days per week.

"The 100:1 savings in excavated material realized by microtunneling translates to a vast reduction in the amount of fossil fuels consumed to install the Rainbow Road Sanitary Trunk at its design depth."

Environmental Benefits

Surface disturbance was minimized by using specialized microtunnel equipment to install underground infrastructure. The new sanitary sewer pipeline infrastructure was installed under O/H power lines, a canal, roadway, railway, agricultural lands, and a wetland without any surface disruption along the trajectory.

Because the MTBM only excavates the area required to install the pipeline, excavation equipment and spoils removal volume is reduced when compared to conventional methods that require significant large vehicle movement. As an example, for each linear meter of tunnel approximately 2 m^3 of excavation was required. Compare this to an open excavation that is 14 m deep which requires approximately 200 m^3 of excavation per linear meter of pipe. The 100:1 savings in excavated material realized by microtunneling translates to a vast reduction in the amount of fossil fuels consumed to install the Rainbow Road Sanitary Trunk at its design depth.

Design Considerations

The Rainbow Road Sanitary Trunk was required to maintain an alignment within the 20 m wide road right of way. Given the required depth of approximately 14 m, a trench with side slopes of 1:1 would mean a 28 m wide excavation at the surface, not including working space and benching to enable safe excavation. This combined with the fact the City's main water supply pipeline was located within the potential open-cut trench zone meant that standard construction methods would be very costly, if not impossible.

After deciding on microtunneling as the basis to overcome the majority of the obstacles on this project, the design proceeded with a central, bi-directional microtunnel launch shaft constructed as a concrete caisson with two reception shafts on either end. This particular microtunnel is more complex than traditional microtunnels, as it needed to be designed on-grade,

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and included two horizontal curves for the south drive, which totaled 390 m in length. The north drive amounted to 490 m length and had one horizontal curve. The curves were required in order for the tunnel trajectory to follow the existing road-utility right-of-way without affecting adjacent developments or residents.

The drive length of the north microtunnel required the use of two intermediate-jacking-stations (IJS), and the south tunnel required one IJS to provide the required thrust force. Local geotechnical investigations encountered sandy gravel and silty clay, underlain by the mudstone part of the Paleocene Paskapoo Formation. A mixed-face microtunnel boring machine (MTBM) face was specified for execution in order to process both overburden deposits and bedrock geology.

Alignment

South Tunnel

The South Tunnel was designed with a total length of 390 m at a constant vertical slope of 0.12%. The design depth of the gravity sewer pipe varied from 13 m deep at the north to 6 m deep at the south. The alignment starts at the central launch shaft and includes two horizontal curves as it continues south. The two horizontal curves were designed with a 430 m and 500 m radii to ensure that the alignment of the sanitary trunk remained within the 20 m wide road right of way. This section of the tunnel terminates at a reception shaft that was constructed over top of the downstream connection, a 1050 PVC pipe, that was stubbed out from an existing lift station.

The decision to design a microtunnel for this section of the alignment was due to four primary reasons:

1. Existing water main – On the west side of the 20 m wide road right of way exists a 500 mm water main that is the primary water supply pipe for the City of Chestermere. An open-cut excavation if at 13 m depth would interfere with the integrity of the water main, requiring it to be temporarily relocated prior to the start of construction for this project.
2. Existing overhead power – On the east side of the 20 m wide road right of way are existing 25kV overhead power lines. Discussions with the local utility indicated that temporarily relocating these lines would be expensive and time consuming.
3. Environmentally sensitive areas – On both sides of the 20 m wide road right of way exist wetlands that would be difficult to work around using an open-cut installation method.
4. Safe trench – Common safe trench practice requires 1:1 trench back sloping to be considered safe. This means that a 10 m deep installation by open trench would require the full width of the 20 m wide road right of way. This doesn't include working space or room for a spill pile.

North Tunnel

The North Tunnel was designed with a total length of 490 m at a constant vertical slope of 0.12%. The design depth of the gravity sewer pipe varied from 14 m and 10 m deep. The alignment starts at the central launch shaft and includes one horizontal curve as it continues north. The horizontal curve was designed with a 500 m radius curve to ensure that the alignment of the sanitary trunk remained within the 20 m wide road right of way and to avoid the bridge crossing the canal. This section of the tunnel terminates at a reception shaft that was constructed with approximately 1.0 m separation from an active roadway.

The decision to design a microtunnel for this section of the alignment was due to five primary reasons:

1. Existing water main – On the west side of the 20 m wide road right of way exists a 500 mm water main that is the primary water supply pipe for the City of Chestermere. An open-cut excavation if at 13 m depth would interfere with the integrity

of the water main, requiring it to be temporarily relocated prior to the start of construction for this project.
2. Existing overhead power – On the east side of the 20 m wide road right of way are existing 25kV overhead power lines. Discussions with the local utility indicated that temporarily relocating these lines would be expensive and time consuming.
3. Canal crossing – The owner of the canal required the Rainbow Road Sanitary Trunk to be 5 m below the bottom of the canal.
4. Railway crossing – The railway required a crossing that would be self-supporting that was sufficiently deep to prevent settlement of the rail in the future.
5. Safe trench – Common safe trench practice requires 1:1 trench back sloping to be considered safe. This means that a 10 m deep installation by open trench would require the full width of the 20 m wide road of way. This doesn't include working space or room for a spill pile.

Caisson Microtunnel Shafts

The Rainbow Road Sanitary Trunk project includes three shafts designed for caisson construction method. Using this method, a steel cutting shoe is formed at existing ground elevation and the first pour of concrete is formed on top of it. The shaft is excavated from inside until the entire structure sinks into the ground under its own weight. Each concrete pour is approximately 2.5 m in height and the wall thickness is approximately 700 mm. Once the caisson is sufficiently sunk, the second pour is added and excavation continues. A waterproofing barrier is placed between each pour to ensure that the shaft is water-tight upon completion. This sequence is repeated until the caisson shaft is sunk to the design elevation. The north reception shaft and the launch shaft were designed and constructed to be 6.0 m inside diameter while the south shaft was designed and constructed to be 5.0 m inside diameter.

Microtunnel Pipe

The microtunnel pipe was specified as a wet-cast reinforced concrete pipe. Wet-cast was specified due to its smooth outer finish that significantly affects the total jacking forces required to install the pipe by microtunnel. Each pipe segment is approximately 3 m long and weighs around 4,200 kg. The inside diameter of the pipe is 1,200 mm and the outside diameter is 1,490 mm. The pipe was specified with an HDPE liner that was cast into the concrete at the time of manufacturing. Once the tunnel was completed, each joint had to be sealed with a cap strip. This resulted in a sanitary sewer pipe that had the benefits of being essentially jointless with the corrosion resistance and flow characteristics of a typical HDPE or PVC pipe.

Microtunnel Boring Machine

Microtunneling is a process of remote-controlled, continuously supported pipe jacking method whereby soil excavation takes place by way of infusing the soil with slurry at the face of the microtunnel boring machine (MTBM) which is excavated by picks at the machine head and high pressure jets that cut soils in the excavation chamber. The cuttings are forced into the slurry inlet holes and pumped to the fluid separation plant and back

to the machine head through a closed-loop system. Due to the local geology encountered, a mixed-face MTBM was specified, which is able to excavate soils as well as bedrock formations. The mixed-face MTBM is equipped with a cutterhead consisting of picks and jets for soils, along with roller cones and cutting disks for bedrock. Along with excavated soils, granular deposits or bedrock fragments are also forced through a crushing cone before entering into the closed-loop slurry circuit.

The complete microtunnel operation is comprised of the MTBM, control container, guidance system, remote hydraulic power pack, jacking frame, and slurry separation plant. The three-piece articulating MTBM and 3 m pipe segments allow for both horizontal and vertical curvature which was required on this project to maintain the alignment. The borehole overcut was specified at 1,541 mm, allowing for 50 mm overcut from the outside diameter of the pipeline being installed. The overcut area is filled with a bentonite slurry that acts as a lubricant as the pipe advances. The bentonite slurry also acts to cool the machine face while excavating and helps to stabilize the formation. The slurry supported excavation and pressurized face requires no dewatering activities during excavation.

Hydraulic jacks within the launch shaft push the MTBM and pipe segments through the ground at the same time as excavation takes place at the machine face in a single pass. The machine size specified was able to exert up 5,000 kN of thrust force. Due to the required drive lengths of the project, one intermediate jacking station was installed on the south drive, and two intermediate jacking stations were installed on the north drive. Following tunnel completion, the intermediate jacking stations are collapsed, removed, and the space is closed.

The MTBM is guided by a motorized total station and laser target unit which is able to determine the horizontal and vertical position, pitch, and roll of MTBM at any point. Surface-placed prisms at the top of the launch shaft and prisms placed throughout the installed pipe segments are able to bounce the laser beam from the total station to the target for progression and calibration. This system was selected for its advantages in longer and curved microtunneling projects, as the ability to determine and continually update and display the MTBM position, independent of drift or refraction, was required for the more complex curvature associated with this project.

The guidance system employs a self referencing algorithm that uses measured system points to create a whole, uninterrupted representation of the actual pipe string position. The motorized laser total station is mounted in a fixed position in the pipe. The system measurements are carried out during the machine's ongoing advance, meaning there is no interruption to the production.

"The guidance system employs a self referencing algorithm that uses measured system points to create a whole, uninterrupted representation of the actual pipe string position."

Geotechnical Investigations

The project area is located at the boundary of the Southern Alberta Uplands and the Western Alberta Plains. The terrain is characterized by level to very gentle undulating, locally hummocky, plains. Slopes are typically in the 3 degree range or less. Elevations along the trenchless route are in the order of 1,105 meters above sea level.

Bedrock of the Paleocene Paskapoo formation underlies the Chestermere area. The primary lithological units consist of nonmarine sandstone, siltstone, and mudstone. Glacial till, a heterogenous mixture of clay including cobbles forming draped moraine, is considered to be the predominant surficial material in the area.

A local field investigation program was completed in September 2017 consisting of three test holes located in close proximity to the shaft sites for microtunnel launch and reception. The drilling and sampling work was undertaken by a truck-mounted M10 drilling rig. The boreholes were advanced by means of continuous flight, solid stem auger drilling.

The stratigraphic profile along the microtunnel alignment remained fairly consistent, comprised of a relatively thin mantle of glacial silty clay till, underlain by weak mudstone bedrock. Surficial gravel deposits were also noted toward the south end of southern alignment. Moisture contents within the clay till ranged from 12 to 18%, with liquid limits 31 to 34, and plastic limits between 13 and 15, corresponding to material of medium plasticity. SPT blow counts ranged from 7 to 28 blows/0.3 m, indicative of stiff to very stiff consistency. A 2.3 m thick layer of sandy gravel was encountered and described as wet, fine to coarse grained, and poorly graded. The moisture content was noted at 16.5% and SPT blow count value of 16 blows/0.3 m, indicative of material of compact relative density. Mudstone bedrock was penetrated at all three test holes, described as damp to moist, highly weathered, extremely weak to weak.

Social/Economic Benefits

The consideration to implement microtunneling for this project was initiated by the technical hurdles that had to be overcome, and was supported by social and economic benefits, such as:

- Minimal disturbance to surroundings – The footprint for the microtunnel construction zone was much smaller compared to a conventional solution and completed within the existing right of way (5,000 m^2 vs. 70,000 m^2).
- Noise and dust – The microtunnel launch site was located approximately 250 m for the developed part of Chestermere (there was a single residence within 25 m of the launch site). The type of equipment required and the distance from the developed part of the City meant there was practically no impact to existing residents due to noise, even considering the 24-7 nature of the tunneling operations. Microtunneling creates a very low amount of airborne dust compared to traditional open trench construction, meaning that existing properties were not affected by dust from this project.
- Decreased time – By confining the project to the 20 m wide road, time-consuming approvals and land agreements for working space were avoided. The project was completed in April by microtunnel whereby a traditional open-cut installation could not have even started until April due to winter conditions.
- Less money – Because this project was completed in less time – including preparation and restoration – with decreased disturbance, this project was more economical than the open-cut alternative at 14 m depth when you consider the costs of shoring or relocating the existing water supply main and overhead power lines.

"The project was completed in April by microtunnel whereby a traditional open-cut installation could not have even started until April due to winter conditions."

Meeting the Client's Needs

The objective of this project was to expand the City's sanitary sewer servicing capacity along its western boundary in an efficient, cost-effective manner with minimal impact to the environment and residents. The Rainbow Road Sanitary Trunk Microtunnel project delivered a solution that met the client's needs by:

- Capacity – Delivering the required servicing volume to unlock development along the western boundary of the City of Chestermere.
- Maintenance – Providing an on-grade solution that minimizes future operational costs (for example, flushing of an inverted siphon). This Rainbow Road Sanitary Trunk also does not require any future additional lift stations within the proposed servicing area, again reducing future operational costs.
- Schedule – The project's budget and timeline requirements were met.

NO-DIG NORTH

2019

The North American Society for Trenchless Technology Canadian Chapters will be hosting the first annual No-Dig North in Calgary, Alberta on October 28 to 30, 2019.

The show will consist of two days of technical paper presentations and industry exhibits in the trenchless technology field. Pre-event Good Practices Courses will also be available on Monday, October 28, 2019.

The event will be held at the Telus Convention Centre in Calgary, AB. We are currently accepting applications for the 2019 Project of the Year. Learn more at *www.nodignorth.ca/program*.

About No-Dig North

The North American Society for Trenchless Technology Canadian Chapters are pleased to present the 2019 No-Dig North, the first Canadian National event for NASTT.

Featuring a two-day conference will include a keynote presentation, two-day, two-track technical session, and a trade exhibition all designed to highlight innovation in trenchless technology.

October 28, 2019 – Short Course and Conference Reception

October 29–30, 2019 – Conference & Tradeshow

The TELUS Convention Centre will play host to the No-Dig North for 2019. The Conference Centre and downtown Calgary offer conference delegates much in the way of activities and social options.

For more information please visit the Conference's webpage at *www.nodignorth.ca.*

Please join us in October 2019 and see for yourself all that Trenchless has to offer!

2019 NASTT-NW Chapter Buyers' Guide

When making purchasing decisions about products and services in the trenchless technology industry throughout Manitoba, Saskatchewan, Alberta, and beyond, please support the companies whose advertising makes the NW Trenchless Journal possible. You will find them quickly with our convenient, easy-to-use Buyers' Guide.

On the following pages, you will find information that will help you meet your purchasing requirements throughout the year ahead. The initial section of this Guide lists categories of products and services along with the various companies that can provide them to you. The following section provides an alphabetical listing of those companies, as well as the contact information you will need to reach them.

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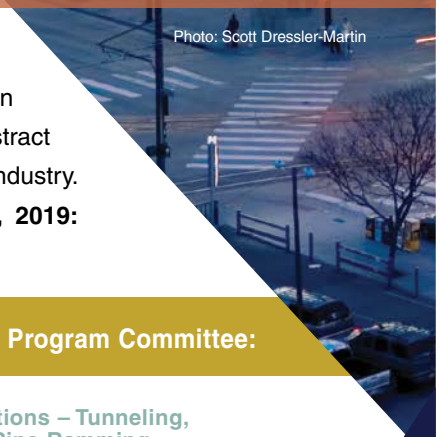

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The North American Society for Trenchless Technology (NASTT) is now accepting abstracts for its 2020 No-Dig Show in Denver, Colorado at the Colorado Convention Center on April 5-9, 2020. Prospective authors are invited to submit a 250-word abstract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

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

Potable Water and Pressure Systems

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

Wastewater, Storm water, and Non-pressure Systems

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

Energy Pipeline Systems

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

Trenchless Research and Development

- University and Industry Initiatives
- Education and Training

Industry Issues

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

New Installations – Tunneling, Boring and Pipe Ramming

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

Horizontal Directional Drilling (HDD)

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

Microtunneling

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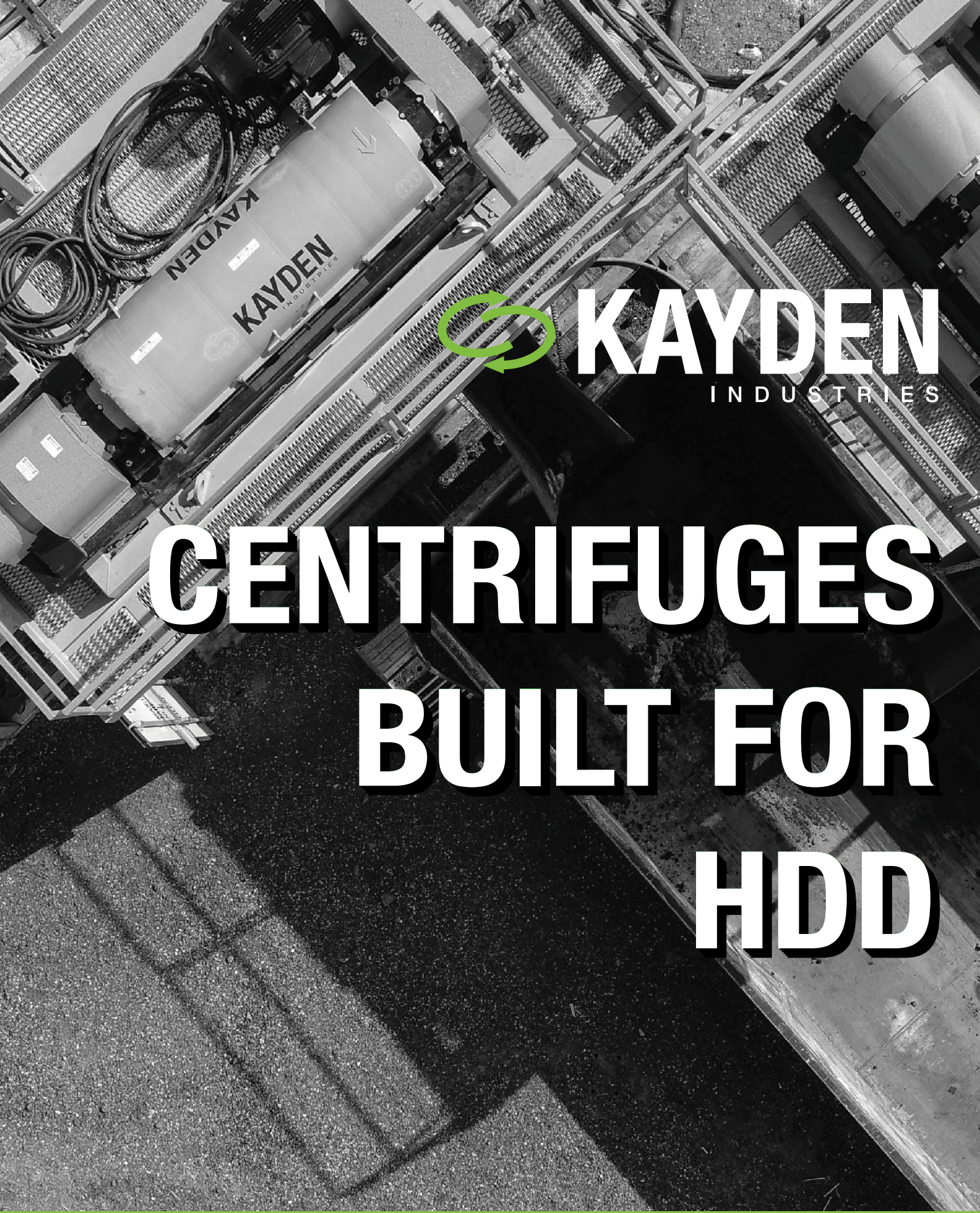

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