As the technology in the HDD industry continues to expand, the lengths and complexity of the bores become longer. Though Scholl has no problem with that, he says there is concern when these record lengths are completed and heralded but with little discussion of the numerous complications, delays and disputes that resulted.

"Just because there has been some success with crossings of this magnitude, does that mean other similar crossings should be attempted? What is the risk of failure? Should a crossing be attempted if there is a 1-in-5 chance of failure on the first attempt? What is the client’s tolerance for risk? Does the project schedule allow for the significant delays that may result if the crossing is attempted? These are the challenging questions we face," Scholl says. The risk events or operational problems themselves are not all together very different from those encountered during shorter crossings, but the length of the bores magnifies those risks.

Scholl offers this example: With an 8,000-ft pilot hole, even a simple wire line short when 6,000 ft out from the rig, can involve the better part of a week to trip out, repair the wire line, and trip back to the hole face. When compounded on a very long crossing, even small problems like this can significantly increase the duration of a crossing. In the end, the originally estimated duration of a crossing may end up increasing by 100 percent or more. A good design engineer will make the client aware of risks like this during the planning phase. This is also where an engineer who specializes in HDD can prove to be an advantage to a client. J.D. Hair & Associates, prefers to have an engineer onsite during construction to handle any design issues that may arise.

"A good example would be discovering previously unknown utilities or other obstructions right after the contractor mobilizes to the site. This is particularly true in urban areas," Scholl says. "The field engineer can put together a workable design on the spot or review any changes that are requested by the HDD contractor, thereby avoiding costly standby time."

A second example Scholl offers is daily monitoring of the position and curvature of the pilot hole. The field engineer can review and analyze the contractor’s downhole survey data after each shift and verify that the pilot hole is within specification. If a radius of curvature violation is discovered, it can be brought to the contractor’s attention the next day, minimizing the amount of re-drilling that may be necessary.

Thanks to increased knowledge, improved geotechnical data and better design software, rare are the days where a contractor receives an unde-drillable design. Scholl offers one final suggestion. Often overlooked in the design, but crucial to a successful project, is providing the HDD contractor with reasonable pilot hole tolerances. This gives the contractor flexibility to adjust the bore on the fly. Unnecessarily holding the contractor to strict line and grade requirements or strict radius requirements can increase construction duration, cost and public impact.

Mike Kezdi is an assistant editor for Trenchless Technology.
Buoysed by the phenomenal success of the 2015 HDD Academy, Arizona State University’s Del E. Webb School of Construction and Benjamin Media Inc. (BMI) are once again working together to plan the 2016 Horizontal Directional Drilling Academy (HDD Academy).

Horizontal directional drilling (HDD) is rapidly emerging as the primary choice for owners when confronted with river, road and railway crossings or situations requiring minimal disruption to surface activities. The technique provides a less-disruptive method and, oftentimes, a lower-cost opportunity for utility pipeline installations.

The goal of the HDD Academy is to establish an annual learning platform for owners, regulators, contractors and engineers focusing on the options and opportunities for future utility pipeline projects.

The 2016 HDD Academy will take place Feb. 11-12, at the Tempe Mission Palms Hotel, located across from the conference hotel, the Marriott Residence Inn Tempe Downtown. Arizona State University will award 1.8 Continuing Education Units (CEUs) upon successful completion of the course. Registration is limited in order to provide quality networking with HDD industry leaders and maintain a low student-instructor ratio.

Last year’s inaugural event sold out and brought together more than 100 HDD experts and contractors to Tempe, all of whom were interested in gaining knowledge about HDD and networking with HDD professionals.

“The success of the 2015 HDD Academy is a testament to the growing strength of the HDD market and thirst for very specific industry education,” says BMI president Robert Krzys. “Drillers want good information from experts in the field. They don’t want a sales pitch. The HDD Academy is exactly what they are looking for.”

HDD Academy program instructors are all industry leaders who will cover numerous topics including HDD contracts and specifications; estimating; designing projects for specific pipe materials; drilling fluids; locating; damage prevention; and case studies covering HDD installations for several pipe materials, Direct Pipe installations and installations for specific utilities.

To date, supporting associations include the Distribution Contractors Association (DCA), Pipeline Contractors Association of Canada (PLCA), Pipeline Contractors Association (IPLOCA) and Association of Equipment Manufacturers (AEM). Event sponsors to date include Herrenknecht Tunneling Systems, Underground Solutions Inc., Vermeer and Derrick.

Benjamin Media Inc is a multi-faceted business-to-business media company in markets ranging from construction to water infrastructure. It is dedicated to meeting the expectations of its readers, advertisers, vendors and all stakeholders in the markets it serves. BMI has found success identifying and promoting emerging markets through quality publications and in-

The Del E. Webb School of Construction (DEWSC) is housed within the Ira A. Fulton Schools of Engineering at Arizona State University and is one of the top Construction programs in the country. Established in 1957, the DEWSC is home to Construction Management and Construction Engineering degree programs. Currently, there are 17 full-time faculty members and over 400 undergraduate and graduate students in the School. This past July, the DEWSC moved into a new $55 Million, 130,000 sq. ft. state-of-the art facility in Tempe, Ariz.

For more information, visit hddacademy.com. For sponsorship opportunities, contact Brittany Maurer at bmaurer@benjaminmedia.com.

The 2015 HDD Academy sold out and brought together more than 100 HDD experts and contractors, all of whom were interested in gaining knowledge about HDD and networking with other HDD professionals.

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Horizontal directional drilling (HDD) technology has advanced dramatically in the past two decades. Projects once considered impossible are completed routinely, and acceptance of HDD by design engineers and project owners has reached levels where HDD often is the preferred method of construction, even in conditions where excavation is an option.

Horizontal directional drilling may have become commonplace, but some projects stand out from the hundreds being done each year — those that generate special note includes those that are long, deep bores to pull back large-diameter product. Long water crossings are among the most interesting, attention-getting and talked about projects that are done in the industry.
Michels Pipeline Construction recently completed a 2,350-ft-long bore under the Milk River in Montana to install 12-in. diameter steel gas line to replace an older segment of pipe. The bore path was 35 ft beneath the river bottom and parallel to an existing pipeline.

“There was ample room to set up the drill rig to launch the pilot bore, weld the pipe and plenty of work space at the exit end, also,” said Rob Healy, Michels senior project manager. “Width of the river at the crossing was 80 ft. The length of the bore was determined by distance needed to achieve the required depth to go under the river and come up to the exit point. Minimum radius of the bore path was 1,200 ft.”

**Project Challenges**

Healy described subsurface conditions as “difficult,” composed of sandstone and clay stone.

“We used a 6-3/4-in. tri-cone bit for the pilot hole and used walkover tracking equipment,” said Healy. “We did not need a boat for tracking — we were able to locate by wading into the river.”

The first pass was made with a 16-in. tri-cone reamer and the second pass was made with a 20-inch hole opener. Pullback was complete in one day.

A Ditch Witch JT100 All Terrain (AT) model drill rig was used, powered by a 268-hp diesel engine. In addition to 100,000 lbs of pullback, the machine develops 12,000 ft-lbs of rotary torque.

Ditch Witch AT equipment uses a mechanical, dual-pipe drilling system with an inner rod to drive a rock bit and an outer pipe to steer the downhole housing and to provide rotary torque for the hole opener during backreaming. The
system delivers maximum available power to the downhole tool for drilling through solid rock, fractured rock, and mixed soil conditions. Because the drilling system is mechanical, AT equipment requires no more drilling fluid than conventional equipment.

“The primary challenge to this crossing was the tough soil conditions,” concluded Healy. “From set up to demobilization, the project was completed in 26 days.”

Michels Pipeline Construction is a diversified pipeline construction contractor with the experience, expertise, personnel, and equipment to perform every phase of pipeline construction. It is a division of the Michels Corp. which provides construction, engineering and procurement services for the energy, transportation, telecommunications and utility construction industries. Michels is based in Brownsville, Wis. Michels offers a wide range of HDD services with an industry leading fleet of equipment and experienced personnel.

Ditch Witch, a Charles Machine Works Co., invented the underground utility construction industry, and today it designs, manufactures and markets a complete line of directional drills, drill pipe, HDD tooling, vacuum excavators, trenchers, chain, teeth and sprockets, mini-skid steers and vibratory plows. Handcrafted in the United States, its products are supported by the Ditch Witch dealer network with more than 175 locations worldwide.

Established in 1902, Charles Machine Works, an employee-owned company, founded in Perry, Oklahoma, is the only manufacturer and global distributor that solely exists to make underground utility construction profitable. Its family of brands includes Ditch Witch, Subsite Electronics, DW/TXS, Hammer-Head, Radius HDD, American Augers, Trenchor and MTI Equipment.

This article was provided by Ditch Witch.
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Environmental initiatives from car manufacturers typically focus on developing vehicles that run on renewable fuels. But Toyota is going beyond that by turning to green electricity to help power a massive Kentucky plant that makes cars, including hybrid models.

The project by Toyota Motor Mfg., Kentucky Inc., will convert landfill gas, which is normally burned off as waste, to electricity and transfer it to its assembly plant in the town of Georgetown.

To get the electricity from the landfill to the plant nearly seven miles (11.3 km) away, Toyota turned to G&W Construction to install transmission lines. The utility contractor had to drill and trench through hard Kentucky limestone to get the job done, but owner Darrell Alderman says it was well worth the effort in order to be part of a project with a major company that will help the community and the environment.

“That makes it that much more exciting to work on it,” he says. “It’s great to be working on a green project where you know that this energy is not just burnt off and wasted but is going to be used to create electricity.”

Gas Becomes Electricity

As solid waste decomposes, a gas that is roughly half methane and half carbon dioxide is produced. The gas often is flared off at landfills.

Landfill gas can lead to smog, harms the atmosphere and contributes to climate change. In many cases, however, it does not have to be flared and can instead be captured and converted to energy.

As of March, there were 645 operational landfill-gas energy projects in the United States, according to the U.S. Environmental Protection Agency, adding that another 440 landfills were candidates and would produce enough electricity to power nearly 512,000 homes. The agency calls using landfill gas for energy a “win/win opportunity” that destroys methane, generates renewable energy, reduces air pollution and creates jobs.

The Central Kentucky Landfill in Georgetown, which is just outside Lexington, is one of the latest operations to accept that win-win premise. Toyota teamed up with landfill owner Waste Services of the Bluegrass on the landfill gas-to-energy project.

The Georgetown facility is Toyota’s largest vehicle manufacturing plant in North America. It is 7.5 million sq ft (696,773 sq m), sits on 1,300 acres (526.1 ha) and employs more than 7,500 people. Last year, it produced its 10 millionth vehicle since opening in 1988.

Toyota reports that the landfill gas system will generate 1 megawatt of electricity an hour, which is about what it takes to power 800 homes. In actual use, the electricity will power the production of 10,000 vehicles a year. Also, greenhouse gas emissions from the landfill will be cut by as much as 90 percent, the company says.
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As a corporate citizen of central Kentucky, we are committed to smarter and better ways of doing business to enhance our community and environment,” says Todd Skaggs, CEO of Waste Services of the Bluegrass, in a news release. “We look forward to being a partner in Toyota’s sustainability efforts.”

Once finished, a network of wells at the landfill will collect and prepare the gas, which will be used to fuel generators to produce electricity, according to the news release. Underground transmission lines will then carry the electricity to the Toyota plant to the south.

Heavy Artillery Installs Conduit

G&W Construction was tasked with installing those lines over 35,000 ft (10,668 m). The company, located about an hour’s drive east of Georgetown in the town of Morehead, started work in December and finished the following spring.

The specs from Toyota called for the use of horizontal directional drilling on about 23,000 feet (7,010.4 m) of the installation, most of it in residential neighborhoods. The rest was installed by a track trencher in a rural setting.

The crews were pulling three 2.87-in. (7.3-cm) conduits with the electric transmission line in them. The HDD work called for bores with a diameter of 7.5 in. (19.1 cm) ranging from 1,000 to 1,500 ft (304.8 to 457.2 m) in length, and a minimum cover of 48 in. (121.9 cm). With the track trencher, they were cutting 48 in. (121.9 cm) deep and 14 in. (35.6 cm) wide.

Georgetown is in north-central Kentucky, which is notorious for its limestone. The rock is hard and takes more time to cut through, and it can be rough on equipment. Alderman says there was a relatively thin layer of clay on top and then the crews had to work through limestone of around 12,000 psi (827.4 bar).

“It was pretty much a no-brainer that we were going to have to have some pretty heavy artillery to get this in,” Alderman says.

G&W Construction used two Vermeer D100x140 Navigator horizontal directional drills and a Vermeer T655 Commander 3 tractor with a trencher attachment. Two HDD crews operated simultaneously and leapfrogged each other as they completed bores. They were able to bore 2,000 to 3,000 ft (609.6 to 914.4 m) per day during the winter.

Because of the limestone, they used a 5.75-in. (14.6-cm) diameter hammer drilling system for the pilot bores and did not need to backream. The hammer system can fracture rock and made a large enough hole that backreaming was not required.

“The limestone is layered, and in layered rock the steering is a little more of a challenge,” Alderman says. “So we just drilled it and hooked to the conduit and pulled it back, which really saved time.”

For its drilling fluid needs, the company used a Vermeer MX240 drilling fluid system and a Vermeer by McLaughlin vacuum excavator.

On the open-cut portion of the job, the trenching crew installed an average of about 500 ft (152.4 m) of conduit a day. They used a chevron formation for the trencher teeth to cut through the limestone. It’s a more versatile pattern in solid or chunky layers and one G&W Construction previously had success with in similar conditions, according to Alderman.

Meeting Industry Challenges

Alderman says the project was an example of how important equipment is in today’s underground industry. G&W Construction has been in business for half a century, since Alderman’s father started the company to construct commercial buildings. These days, it specializes in underground utility installation, and Alderman says increased competition is shaping the industry. That makes bidding on jobs a bigger challenge than ever, and Alderman says a successful company must have the right equipment to work as efficiently and as productively as possible.

The Toyota job had tough ground conditions with the limestone and a tight deadline, and G&W Construction worked for a major company on a cutting-edge project that will turn landfill gas into energy.

“We were proud to be selected by Toyota to do this job,” Alderman says. “Then the production we were getting made it that much sweeter. It was just a real neat challenge.”

Gregg Hennigan is a features writer for Two Rivers Marketing, Des Moines, Iowa.
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Faced with boring through wetlands and under a creek to address much needed improvements to its sanitary sewer system, the City of Elmhurst, Ill., turned to new large diameter restrained-joint PVC pipe and horizontal directional drilling (HDD) to get the job done.

After area homes were plagued with sanitary sewer backups following a severe storm in 2010, the Chicago suburb launched the $10 million Southwest Elmhurst Wet Weather Control Facility project. This was not the first time the City had faced storm-related backflow problems, and the new project aimed to alleviate sewer backups in as many as 2,300 homes in the southwest corner of the City, the area hit hardest by sewer backups.

The initiative included the installation of a deeper, 24-in. gravity sewer line that can accommodate higher flow rates delivered to an upgraded lift station, which includes larger pumps, enhanced controls and an expanded wet well. From the station, sewage is currently pumped by way of a 10-in. dry-weather force main to the existing gravity interceptor. A new 18-in. wet-weather force main is also being constructed that zigzags beneath the City toward a new, 2 million-gal storage tank at the city’s Water Reclamation Facility.

The main goal of the City and its engineers was to divert excess sewage generated by extreme weather from entering and overwhelming the Water Reclamation Facility and causing sewer backups in area homes. They knew they needed the larger diameter pipe, but also had to contend with the challenges of working in a residential area and boring in difficult ground conditions.

Catherine Morley, P.E., senior project manager with RJN Group of Wheaton, Ill., explained that in order to address the problematic sanitary overflows, the City needed to approach its sewer system in a new way.

“Essentially, we redefined the pump station by making it both a dry weather and wet weather station,” she said. “We will still pump the sewage to the interceptor during small rain events via the dry-weather force main, but when that interceptor is overloaded during extreme conditions the addition of the 18-in. force main and the above-ground storage facility will enable the station to pump higher flows without overloading the Water Reclamation Facility and downstream sewers.”

Morley says it took a good deal of planning to figure out how to essentially divert large volumes of excess flow from the City’s residential area to the treatment plant and storage facility. “To get there was tricky because we would be working in residential areas and having to cross a creek to reach the treatment plant, we had limited routes with which we could work,” she said.

The City needed 5,000 ft of 18-in. force main; however, a good portion of this line would have to run beneath flood plain, under levees and cross under a creek and wetlands. For these more sensitive areas, RJN specified nearly 2,000 ft of 18-in. Certa-Lok C905 restrained-joint specialty PVC pipe from North American Pipe Corp. (NAPCO) to be installed via horizontal directional drilling.

“We were required to bore through wetlands because the open-cut method is not feasible in these areas. Part of the project also required the pipe to go under Salt Creek, and the county required we bore that part of the project, as well,” explained Garry Sementa, project manager with Archon Construction Co. Inc., of Addison, Ill.

Morley said they chose Certa-Lok PVC pipe for its ability to hold up in the unstable ground of the wetlands. Its easy-to-assemble restrained joints would also prove useful because the crew had limited space in which to assemble the pipe when working near the creek. Fortunately NAPCO had recently begun manufacturing the time-tested Certa-Lok pipe in an 18-in. size, which was a perfect solution for this project.

Certa-Lok C905 RJ is the industry’s original non-metallic, mechanically re--
strained-joint piping system designed for use in force main sewer systems, water and other applications. It utilizes precision-machined grooves on the pipe and in the coupling which, when aligned, allow a spline to be inserted, locking the pipes together. A flexible elastomeric seal, or O-ring, in the coupling provides a hydraulic seal. This is the first time Elmhurst’s superintendent of water and wastewater distribution Christopher Dufort has worked with Certa-Lok.

“It’s been a learning experience for me. Seeing how it works. I was pretty amazed at how well it operates and how much force you can use to pull those pipes together with their spline. I’m impressed so far. We did three bores with it and it worked out great,” he said.

The drills that ran the Certa-Lok force main beneath the berms, the creek and the wetland were undertaken in typical fashion. At each of those sites, Archon Construction set up the boring machines, drilled the hole, treated it with bentonite drilling fluid, reamed it, then pulled the pipe through. Vacuum trucks were nearby to extract sludge and slurry. The creek, however, was a little different.

This phase of the project totaled more than 1,000 ft. The crew initially installed 165 ft of 30-in. steel casing beneath the creek for protection, which is a county requirement. To bore the pipe, the crew dug pits on either side of the creek, with the access pit about 800 ft away on the east side, outside of the flood berm. The crew bored the initial hole, then during pullback it installed the casing spacers onto the last 170 ft of the Certa-Lok. This work was done while the crew was 15 ft deep in the entry pit with only 40 ft available to prepare the final sections of pipe for insertion into the casing. During this final phase, the crew pushed the Certa-Lok joints close to their maximum tolerance, reaching 67,500 lbs pull pressure at times.

“The limited amount of space we had to work on the west side of the creek to get the pipe back to elevation was interesting,” Sementa said. “Certa-Lok’s ability to bend was a huge benefit in this case, and everything held together.”

Morley agreed. “It is a great pipe. This is the fourth project in which we’ve used Certa-Lok. In this project, especially where we needed shorter lengths, it was ideal. The standard length is 40 ft but for some of the installs the manufacturer provided 20-ft pipe sections. We had limited space in which to work so we needed a pipe that we wouldn’t need to be fused together,” she said.

This phase of the Southwest Elmhurst Wet Weather Control Facility project was expected to be completed in June. The City expects the entire project to be up and running in 2016, when the team completes the pump station and storage tank.

Chris Aldred is with North American Pipe Corp.
Boring down nearly 11 m (36 ft) enabled a new potable water pipeline to be installed in 14 days without disrupting above ground construction or soils by trenching, which could cause unwanted settlement of the new ring of multi-lane roadway.

To serve the City of Edmonton, Alberta, Canada, an existing potable water service line had to be connected under the North East Anthony Henday Drive (NEAHD) ring road. When completed in late 2016, the $1.8 billion ($818.8 million U.S.) highway project will connect the northwest and southeast parts of Anthony Henday Drive from Manning Drive to Whitemud Drive East. Work includes the construction of 27 km (16.7 miles) of six- and eight-lane divided roadway, nine interchanges, two road flyovers, eight rail crossing (flyovers) and two bridges across the North Saskatchewan River, for a total of 46 bridge structures. Using the Public-Private Partnership (P3) process, it is anticipated that the road will be finished three years earlier than through conventional methods.

The 549-m (1,800-ft) pipeline needed to be monolithic and joint free to reduce the risk of any issues such as leaks, joint separation or other problems that can be found with traditional products and materials. Operating pressure is 200 psi.

The decision was made to use horizontal directional drilling (HDD) for the pipeline using 450-mm (18-in.) diameter DR 11 PE4710 high density polyethylene (HDPE) pipe from WL Plastics, of Fort Worth, Texas. The drill was through clay and gravel substrates, which posed a challenge but was successfully completed. Each end of the drill involved reconnecting the HDPE to existing ductile iron and PVC bell and spigot water mains. Because of the soil conditions, overall length and depth of the installation, it was decided that there would be inspections and monitoring milestones throughout the course of the project.

This was a deep bore that hit a few voids along the way. The soil is mostly clay but the HDD crew would hit pockets of sand that would cause the head to drop. The reamer head weighed about 1,600 lb and would drop when it got to that wet, silky material and was hard to hold it on the path. Different kinds of drilling mud were used to solve the problem.

The crew made several passes until the final 450-mm (18-in.) HDPE pipe was pulled. The first was 6.5 in. followed by 18 in. and ending with 28 in. on the last bore.

Four milestone inspections were established for the construction process in order to raise confidence in line construction to help ensure a problem free system. They were categorized as:

1. Inspection of the pipe during and after the delivery and unloading at the work site.
2. Monitoring and recording of all fusion conditions, fusion processes (including pipe staging area) and assembled storage.
3. Monitoring of the pipe pulling process once pilot holes where completed via HDD.
4. Monitoring of the pressure testing and disinfection process.
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Safety aspects and milestones expectations were reviewed, communicated and responsibilities assigned prior to starting any process for handling, assembly, installation and testing. This provided clarity for individual responsibilities, timing, accountabilities and what to do if unusual circumstances occurred. WL Plastics was asked to assist in monitoring all these milestones. When the aspects of design, manufacturing, handling and installation are conducted in accordance to specified industry design and procedures, the life cycle of HDPE installations, according to WL Plastics, will meet or exceed expected service lives, which reduces costs for generations to come.

The 18-in. diameter (450-mm) IPS DR 11 PE4710 line required product approval in accordance with the local utility’s construction standards. The pipe was produced at the WL Plastics Calgary, Alberta plant in accordance with ASTM F714, AWWA C906 and Factory Mutual requirements. The WL Plastics pressure-rated PE4710 pipe is manufactured from engineered polyethylene compounds (WL106B) that provide a balance of short-term and long-term properties for pressure-pipe applications. The PE4710 pipe resists pressure surges, handling and installation, soil subsidence, frost heave and seismic displacement.

The 549-m (1,800-ft) PE4710 pipeline had no lateral connections but needed to be connected to both existing steel and bell and spigot PVC at either ends.

For the PE4710 pipe sections, there were 56 fusions, which where all data logged, monitored and inspected for consistency. Each fusion included proper cleaning of the pipe, properly aligning pipe in fusion machine, closely checking the pipe after facing, cleaning and measuring both sides of heater plate, monitoring heat soak and heat bead formation, visually inspecting every heated fusion interface once the heater plate was removed, bead formation once interfacial pressure was applied and cooling times with consideration for warm ambient conditions.

Once the pipe was properly cooled and removed from the fusion machine the length of pipe was pushed out and placed on rollers to protect against scouring or gouging and also to reduce friction forces when pulling the pipe through the bored hole. After the entire line was fused together and inspected one last time, the drill was pulled back.

Once installed, a minimum period of 24 hours was provided to allow for any “pull back” or “shrinkage” of the pipe prior to reconnecting to existing ends. The higher performance of this PE4710 pipe provides a very durable system due to its improved properties,” said Camille Rubeiz, P.E., director of engineering for the Plastics Pipe Institute Inc.’s Municipal Division. PPI is the major trade association representing all segments of the plastic pipe industry.

“It is designed for water and wastewater applications meeting AWWA C906 and ASTM F714 standards and because it is strong and durable, it is the material of choice for trenchless applications such as HDD, sliplining and also for pipe bursting.” Once stabilization of the pipe length was finished, the pipe was connected to the existing ends and filled with water. The final stage of the installation was the pressure testing of the newly installed HDPE section. Hydrostatic pressure testing was conducted once the line was filled with water and all air was removed from the system. It was pressure tested to ensure no leakage or pipe separation had occurred during installation. Once stabilized the pressure was held for an hour to ensure no leaking occurred. None occurred over the entire 1,800 ft or in any of the 36 fused joints, and the line was approved for operation.

“The benefits of this installation is that HDPE piping is considered leak free and corrosion resistant,” explained Richard Kolasa of WL Plastics and a certified engineering technologist, plastics and polymer engineering. “For the NEAHD millions of infrastructure dollars were spent on the ‘ring road’ highway, therefore digging open trenches and ripping up the road was impossible. Plus the project required a pipeline with high integrity that would last for many years.”

“The other benefit was the installation itself. Cost reductions were realized because the open trench would have been close to 20 m (65 ft) in depth and wide. Using HDD there was hardly any evidence that the new pipeline was installed. In addition to the labor, back-hoes, trucks and use of trench boxes, excavating a deep trench caused concern of settling soils under the roadway. The last real benefit for PE4710 pipe is the resistance to surge events and freezing resistance. We are extremely confident that the new PE4710 water transmission line section under the North East Anthony Henday Drive will provide reliable flows and a maintenance-free system for many years to come.”

Steve Cooper has been reporting on the water and pipe industries for several decades.

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With millions of kilometers of buried utilities beneath Canada’s surface and records inaccurate or incomplete, it is surprising that there is not more property damage and personal injury occurring every time somebody puts a shovel in the ground. Even backyard landscaping can cause millions of dollars in damage when utility lines get hit, service is interrupted and expensive repairs have to be undertaken.

One can only imagine the ten-fold risk and additional expense when it comes to large scale infrastructure projects taking place across Canada. In a 2011/2012 report by Statistics Canada it was revealed that 40 percent of all damages to underground infrastructure occur due to a failure to notify, a frightening 84 percent of damages cause a service interruption, and 75 percent of all damages are due to outside force through usage of a backhoe or mechanical excavation.

In recent years, many initiatives have focused on mandating safer installation, exposure, maintenance

While the One Call System is a good starting point to identify a utility’s location, properly exposing the infrastructure is the only sure way to know where it truly lies, and how the pipe or wire has been run.

```plaintext
Horizontal Directional Drilling Guide

SAFE EXPOSURE:
Uncovering the Benefits of Hydro Excavation

By Tisyn Milne

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Redesigned From The Ground Up

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and repair of buried utilities. While the One Call System is a good starting point to identify a utility’s location, properly exposing the infrastructure is the only sure way to know where it truly lies, and how the pipe or wire has been run. This is where hydro excavation comes in as an essential tool of visually locating utilities to mitigate the risk of striking underground infrastructure.

With current government regulation prohibiting the use of mechanical means to dig within 45 cm of buried cables or pipes, hydro excavation is an ideal method to expose underground infrastructure, drill pile holes, trench slots, install signs and poles and conduct landscaping and potholing.

A Vital Industry
What is standard practice in Canada today, began more than 50 years ago in the Alberta oil and gas fields where hydro excavation machines were used to ‘daylight’ buried gas pipes and other utility lines. Cold weather, and even permafrost, would only allow year-round excavation by using heated water, which made Hydro Excavators all the more popular.

When customers began modifying vacuum trucks and sewer cleaners for hydro excavation use in the 1970s and 1980s, and even mounted vacuum components on all-terrain vehicles to get into remote locations the demand was recognized and the manufacturing of dedicated truck-and-trailer-mounted hydro excavation units began in the 1990s due to the growing demand.

The millennium hit, and hydro excavation was already widely accepted and used by utility contractors across Canada for locating and non-destructive digging. It was around that time, that Illinois-based Vactor Mfg. introduced its first dedicated HXX Hydro Excavator as a purpose-built unit and became a leading manufacturer for this ever-growing market.

Horizontal Directional Drilling Guide

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Today, hydro excavation is considered to be a best practice by municipalities, contractors and public utility organizations alike. As the HydroVac Alliance of Ontario (HVAO) together with the Ontario Regional Common Ground Alliance (ORCGA) indicate in a recent report, the size of Ontario’s hydrovac market has grown significantly since the first custom-built hydro excavators appeared. The associations estimate that there are between 450 and 500 units in operation across Ontario responsible for a total annual revenue of $180 million to $200 million.

Extremely versatile, hydro excavators can be seen virtually on every street corner where they drill holes for fence posts, poles and signs or conduct daylighting of underground gas pipes. And once you see a hydro excavator in action, you will never forget the efficiency and power this unit demonstrates while completing a job. A recent study by the City of London says it best: “…The hydrovac unit effectively replaced the hand digging requirement being completed in 1/3 of the time and with 1/2 of the crew. The cost of using a shovel and backhoe compared to a hydrovac unit on the identical job is 4.1 times greater.”

Born To Run

As hydro excavation becomes more and more popular, the importance of zero downtime applies to most hydrovac companies to ensure they can keep up with the day-to-day demand for their services. Industry veterans such as the Toronto-based PGC Services Inc. (PGC), a member of the Powell Group of Companies, trust a full service shop of the likes of Joe Johnson Equipment for new purchases, rental units, used equipment and to regularly service and maintain their hydro excavating equipment.

Regular inspections do not only benefit operators and customers, increase safety and are better for the environment, but they also lead to higher resale and trade-in values based on the service history.

In search of a safe, cost-effective and non-disturbing option to expose underground infrastructure when performing an excavation project, the past 30 years have seen a major shift to move from backhoe digging to hydro excavating. Associations such as the Canadian Common Ground Alliance (CCGA), the Centre for Advancement of Trenchless Technologies (CATT) and the members of the HVAO have become important advocates in promoting safe digging procedures, and with the increasing use of hydro excavation, Canada leads the pack as a nation that knows how to safely deal with its underground infrastructure.

Tisy Milne is a product sales manager at Joe Johnson Equipment.
TRENCHLESS TECHNOLOGY SPECIAL SUPPLEMENT 49

PARAMETRIC STUDY OF PULLBACK FORCES ON PIPELINES INSTALLED BY HORIZONTAL DIRECTIONAL DRILLING

By Ashkan Faghih, Anup Ghimire and Dave Dupuis

This paper reviews the design parameters for the pullback force calculation during Horizontal Directional Drilling (HDD) method. A comparison was made between actual measured pullback forces and theoretically calculated values for more than 50 HDD projects. The study showed that the measured pullback forces were higher than the theoretically calculated forces for small HDD installations, while the results were reversed in the case of medium and particularly large HDD projects. Among many factors affecting pullback force, the design values for soil coefficient of friction, fluidic drag coefficient, drilling mud density and roller coefficient of friction are often assumed the same in the calculation for all different HDD projects.

A parametric study was carried out to show the significance of these design input variables in the pullback force estimation. Comparison of the results with the actual recorded pullback forces suggested modifying the design values based on the specific design case in order to enhance the accuracy of theoretical calculations. Design of Experiment (DOE) methodology was also used to further study the significance of design parameters on pullback force. The study showed that the order of significance of the design parameters varied for different case studies and the impact of one factor on pullback force is relatively independent of the level of the other factors.

INTRODUCTION

The HDD methodology has three essential stages: pilot bore, pre-ream and pullback. During the pullback stage, the pipe being installed is subjected to a complex combination of various forces. Accurate estimation of pullback force is necessary during the design stage of HDD projects to select the appropriate product pipe and rig size. The product pipe should be designed to have adequate strength to avoid damages during installation while the HDD rig should be capable of successfully pulling the pipeline.

Pullback force estimation can be relatively complicated due to the numerous factors affecting the pullback. Pipe properties, borehole geometry, existence of a buoyancy control, soil properties, drilling fluid properties, pipe handling on surface and rate of pullback are some of the many factors that are significant in pullback force estimation. Most of the required information for force analysis is site specific, vary from one job to the other and some is unknown or hard to determine. Therefore, implementing simplifications and assumptions into calculations for engineering design purposes are an inevitable fact. The key to a good design of HDD crossings is to select the right parameters for each specific project using rational assumptions, despite the many uncertainties associated with each project.

Pullback force calculation method based on the Pipeline Research Council International (PRCI) (J.D. Hair & Associates, 2008) has been widely accepted in the industry as it incorporates well-known static and dynamic concepts and applies them for use in HDD design. The total pull force required for pipe installation is calculated by summing forces resisting the pipe movement in straight and curved segments of the borehole. PRCI has proposed equations for different sections of drill path as the pipe is pulled through each of them.

Design of HDD projects is important particularly for the larger scale projects where any delay in project execution could create an economic nightmare and an efficient design could result in considerable savings while delivering the project on time. This paper presents the results of a comparison between the predicted and actual measured pullback forces for more than 50 projects. To further investigate the significance of design input variables, a parametric study was completed. Design of Experiment (DOE) was also used to study the dependency of the calculated pullback force on the design variables.

THEORETICAL VS. MEASURED PULLBACK FORCES

Fifty-four HDD projects located throughout Alberta and Northern British Columbia were selected to compare estimated theoretical pullback forces vs. actual measured forces. These projects were designed, inspected and monitored during their construction by CCI Inc. between 2012 to 2014. The projects involved installation of single steel pipe ranging in diameter from 114 mm (NPS 4) to 1,067 mm (NPS 42). The subsurface geological materials encountered during the projects comprised clay, silt, sand, gravel overburden soils and clay shale, sandstone, siltstone and coal bedrock. The HDD rigs ranged in size from 80,000 lbs (push/pull) to 110,000 lbs for small HDD installations, 140,000 lbs to 220,000 lbs for medium HDD installations, and 330,000 to 1,100,000 lbs for large HDD installations.

Actual rig load during pullback operations was recorded in the field for each project. In a majority of the cases, the maximum rig force was recorded near the pullback completion. Assuming that the forces required to pull the drill pipes and the reamer assembly are negligible at the end of the installation, the actual rig force can be compared with the theoretical force required to pull the product pipe. In general, it is a conservative approach to compare the maximum theoretical pullback force calculated based on PRCI with the actual maximum rig load. However, due to the lack of reliable data to quantify the amount of force required to pull the reamer assembly, there are currently no de-
sign methods available to estimate the actual HDD rig pull force. HDD engineers estimate the total rig load by adding safety factors to their pullback force calculations.

The theoretical and measured pullback forces for all 54 projects were summarized in Figure 1, which illustrates pullback forces based on the HDD rig size used on each project. The projects were categorized into three groups: small HDD, medium HDD and large HDD installations. The average variation observed between theoretical and actual forces was different for each group. For small HDD installations, actual forces were 35 percent underestimated by the theoretical calculations while theoretical forces were higher than actual loads by 26 percent and 54 percent for medium and large HDD installations, respectively.

It should be noted that the execution of the HDD construction is a major factor affecting the pullback force. Generally speaking, better quality of workmanship, better equipment, and better execution of the job are implemented for large HDD installations to account for the higher risks and costs associated with each project. Proper conditioning of the borehole, multiple reaming passes and slow pull rate in large HDD operations eliminate excessive mechanical work required for pulling the pipeline. On the other hand, poor borehole cleaning in small HDD projects leads to additional forces required to displace soil cuttings during pullback. The over conservatism in PRCI equations is another factor that con-
tributes to overestimation of pullback forces in longer and larger diameter HDD crossings.

Accuracy of pullback force estimation can be improved by modifying the design input values and safety factors. The type of project, subsurface conditions and quality of project execution can all be taken into account during the design stages of HDD operations. Careful selection of design input values are necessary in order to properly estimate the actual pullback process. The next section presents a parametric sensitivity analysis to investigate the changes of design input values on pullback force and compares the estimated forces with actual measurements.

PARAMETRIC STUDY

The HDD pullback force calculation depends on various parameters. Some of these parameters depend on site specific conditions such as borehole geometry, subsurface conditions and pipe properties, and their input values vary according to the case requirements. However, certain parameters such as soil coefficient of friction, drilling mud density, fluidic drag coefficient, and roller coefficient of friction are usually assumed the same for all the cases. In this parametric study, significance of these parameters on pullback force calculation is investigated. The sensitivity analysis was conducted for two case studies; representing small and large HDD installations. Table 1 presents the parameters of the case studies.

Typical values and ranges for the selected design parameters are discussed below:

i) Soil Coefficient of Friction, \( \mu_{\text{soil}} \) - This parameter depends on the soil conditions along the bore path, which the pipeline is pulled through. PRCI suggested a value of 0.3 for HDD installations where the pipe is pulled through a hole filled with drilling fluid. For this study, a range of values from 0.2 to 0.4 is defined for this parameter.

ii) Drilling Mud Density, \( W_{\text{mud}} \) - Typically, the range for drilling mud density in HDD application varies from approximately 9 ppg (1078 kg/m³) to 11 ppg (1518 kg/m³), considering clean bentonite content to higher solid content. A conservative value of 14 ppg (1678 kg/m³) is used in this study as the upper limit.

iii) Fluidic Drag Coefficient, \( \mu_{\text{mud}} \) - The fluidic drag coefficient depends on the drilling fluid rheology, flow rate, annular geometry, and rate of pull. The PRCI recommends the value of 0.025 psi for the fluidic drag factor. A range of 0.0025 psi to 0.0475 psi was selected for this study. Further details on the fluidic drag coefficient can be found in Faghih et al. (2015).

iv) Roller Coefficient of Friction, \( \mu_{\text{roller}} \) - The PRCI calcula-
tion does not typically consider the friction between the pipeline and the roller on the surface. Hence, a range of 0.0 to 0.2 was selected for this parameter.

Pullback force was calculated as each parameter deviated from its mean value. The mean values of the parameters are $\mu_{\text{soil}}=0.3$, $W_{\text{mud}}=1400 \text{ kg/m}^3$, $\mu_{\text{mud}}=0.025$ psi and $\mu_{\text{roller}}=0.1$. These values are commonly used by engineers to design HDD projects.

Figures 2 and 3 show the results of the sensitivity analysis for small HDD and large HDD installations, respectively. Ranges of actual rig loads recorded near the pullback completion are also shown on the graphs.

The pullback estimation based on the average values of the parameters suggested maximum pullback forces of 17,000 lbs for case 1 and 246,000 lbs for case 2. These graphs show the ranges of design input values that bring the pullback force estimation in the actual load zone. For the case of small HDD as shown in Figure 2, higher values of the defined range for mud density, soil coefficient of friction and fluidic drag coefficient would result in realistic pullback force estimation. For large HDD as shown in Figure 3, lower range of $\mu_{\text{mud}}$ and $\mu_{\text{soil}}$ would lead to better accuracy in pullback force estimation. In both cases, changes in $\mu_{\text{mud}}$ resulted in higher amount of variation in pullback force. This is due the wide range of possible input values for this parameter. Roller coefficient of friction had the least impact on pullback force for both case studies.

**DESIGN OF EXPERIMENT**

DOE is a systematic approach to the investigation of a system or process, where the planned changes are made to the input parameters to identify their effects upon the response or the output. The parameters of interest are first identified, and then the experiment or analysis is carried out at certain ranges of the value, known as ‘high’ and ‘low’ representing the maximum and minimum magnitudes of the parameters. DOE results can be used to understand the effect of each parameter and their interaction (if any) with other parameters upon the output.

‘One change at a time’ testing always carries the risk that the experimenter may find one input variable to have a significant effect on the response (output) while failing to discover that changing another variable may alter the effect of the first (i.e. interaction between parameters). This is because the temptation is to stop the test when this first significant effect has been found. However, DOE plans for all possible dependencies in the first place, and then prescribes exactly what data are needed to assess them, whether input variables change the response on their own, when combined, or not at all.

For the case study described in this paper, the identified parameters were...
set at two different levels (low and high) and then the pullback force was calculated. $2^k$ combinations were considered that represents the 'full factorial' design where $2$ represents the level of ranges, which is 'low' and 'high', and $k$ represents the number of parameters chosen which is 4 in this study. So, a total of 16 runs of pullback force calculations were measured at different combinations of defined parameters at different levels. The parameters and their ranges are presented in Table 2.

Table 3 shows different combinations used in the analysis where "-" refers to the low range of the parameter while "+" represents the high range. The effects of terms A, B, C and D on the response are called main (single) effect and different combinations of the main factors such as AB, AC, ..., ABCD are called interactions of factors.

Design-Expert software (Design-Expert, 2015) was used to carry out the parametric study. Different geom-
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Entries, pipe sizes, and drill lengths were tested in the analysis for small, medium and large HDDs to represent all possible design scenarios. The pullback force was calculated for different combinations of these parameters (as shown in Table 3) for each case. Then, the results were analyzed using the factorial analysis and Analysis of Variance (ANOVA). Table 4 summarizes the significance of the parameters for different HDD cases.

The analysis showed that the main effects of factors A, B and C were more significant than the interaction of the parameters as shown in Table 4. It simply means that the impact of the parameters on pullback force is relatively independent of the level of the other factors. Fluidic drag coefficient (parameter C) had the highest impact on pullback force for small and medium HDD while drilling mud density (parameter B) had the highest contribution for large HDD. Therefore, the order of significance
of design parameters varied for different case studies.

Table 4 also shows that there is a small interaction between factors A and B. In the analysis for the medium HDD installation, the pullback force was increased by 78 percent when the soil coefficient of friction changed from 0.2 to 0.4 while drilling mud density was set at high value. By setting the mud density at low value, 55 percent increase in pullback force was resulted by changing the values of soil coefficient of friction from low to high. The same agreement was obtained for small and large HDD installations.

It is also can be seen from Table 4 that the effect of roller coefficient of friction (parameter D) was negligible on pullback force. Table 4 also shows that the percentage for contribution of curvature is very low indicating that the relationship between the pullback force and the parameters are linear.

### Table 2. Ranges of the parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>DOE Notation</th>
<th>Low (-)</th>
<th>High (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Coefficient of Friction - $\mu_{soi}$</td>
<td>A</td>
<td>0.2</td>
<td>0.4</td>
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<tr>
<td>Drilling Mud Density (ppg) - $W_{mud}$</td>
<td>B</td>
<td>9</td>
<td>14</td>
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<tr>
<td>Fluid Drag Coefficient (psi) - $\mu_{mud}$</td>
<td>C</td>
<td>0.0025</td>
<td>0.0475</td>
</tr>
<tr>
<td>Roller Coefficient of Friction - $\mu_{roller}$</td>
<td>D</td>
<td>0.0</td>
<td>0.2</td>
</tr>
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</table>

**CONCLUSIONS**

Accurate pullback force estimation is complicated due to the existence of many factors, which some are site specific and some are unknown or hard to determine. Therefore, implementing simplifications and assumptions into calculations are necessary for engineering design purposes. As a result, design practice recommended by PRCI is widely used in the industry. However, there is a wide range of acceptable design inputs that can be used in the pullback force calcula-
In practice, the design values of parameters such as $\mu_{\text{soil}}, \mu_{\text{mud}}, W_{\text{mud}},$ and $\mu_{\text{roller}}$ are often kept the same regardless of the project types. Comparisons between measured and predicted pullback forces proved that larger pipe installation in longer crossings may require less pullback force in practice compared to the one calculated theoretically. Reverse statement is valid for the case of small pipes and shorter crossings. Other factors such as proper borehole cleaning, quality of work execution, and pullback rate are among the many parameters that can change the amount of pullback force during pipeline installation.

A parametric study showed how pullback force changes as values of design inputs vary. For the case of small HDD installations, higher range of values for $\mu_{\text{soil}}, \mu_{\text{mud}},$ and $W_{\text{mud}}$ led to closest estimation of actual loads. The study for large HDD installations suggested using the low values of $\mu_{\text{mud}}$ and $\mu_{\text{soil}}$ for design purposes. Further analysis by DOE proved that main (single) effect of factors is major in pullback force while impact of one factor on pullback force is relatively independent of the level of the other factors.

<table>
<thead>
<tr>
<th>Combinations</th>
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Table 3. Matrix of the parameters
Table 4. Summary of effects of main factors and interaction of factors

<table>
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<tr>
<th>Coded Parameters</th>
<th>% of Contribution to Pullback force</th>
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<tr>
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<td>Small HDD</td>
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<td>B</td>
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<td>D</td>
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<td>AB</td>
<td>2.33</td>
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<td>Curvature</td>
<td>0.032</td>
</tr>
</tbody>
</table>

Ashkan Faghih, and Anup Ghimire are with CCI Inc. Edmonton, Alberta, Canada and Dave Dupuis is with CCI Inc., Calgary, Alberta, Canada.

REFERENCES


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CCI Rentals

With decades of experience, CCI Rentals newest release, the Pipe 360 Cradle, has combined safety with versatility. CCI Rentals new Pipe 360 Cradle is a fully self-contained pipe lifting device that demonstrates innovation in day-to-day pipeline operations. The Pipe 360 Cradle is perfectly suited for all types of pipe handling scenarios. It works with pipe sizes from 20 to 48 in. It is also great for tackling large HDD pullback operations. The Pipe 360 Cradles are specially designed and optimized for handling line pipe. These cradles can be used with concrete, steel, plastic, and cast iron pipe across the full range of coatings such as tape, fusion bonded epoxy, concrete, and various insulations.

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Century’s exclusive product lines offer tools suitable for a diverse range of drilling rigs and formations to be encountered. In line with Century’s reputable Hole Openers are Century’s Fly Cutters. Ideal for soft sand and clay formations, as well as harder gravel and cobble formations, Century’s Fly Cutters are engineered for maximum performance and reliability. Built for both the large and small rig class, Century’s Fly Cutters are available in Standard Duty (SD) and Heavy Duty (HD) Series for rigs more than 200,000 lbs., and Light Duty (LD) Series for rigs 50,000 to 200,000 lbs. Every Fly Cutter utilizes a hardened shaft welded to spokes for superior strength. Replaceable Carbide Jets are strategically placed both forward and aft to clear cuttings. A hard-
faced ring with welded replaceable carbide teeth incorporates full concentric radial tooth coverage for high penetration rates. Century’s Fly Cutters are available in custom one-of-a-kind designs or industry leading off-the-shelf solutions.

CETCO

Maintaining borehole integrity demands a drilling fluid you can count on for all drilling conditions: It demands HYDRAUL-EZ from CETCO. HYDRAUL-EZ is a specially formulated bentonite drilling fluid that offers superior suspension properties and borehole stability for all soil conditions. To see the light at the end of the borehole, choose HYDRAUL-EZ – the product of choice among experienced drillers. Our complete line of professional drilling products will keep your operations running at peak efficiency and will enhance the cost-effectiveness of your drilling operations. The experienced team of field engineers and research scientists at CETCO offer drillers on-site mud schools, advanced technical support, and continuous product development. Excellent service and support is a priority at CETCO. Check out our complete line of professional drilling products and other useful tools such as our HDD Calculator on our website at cetco.com/dca.

Copperhead Industries

No matter how difficult or how long the HDD project, Copperhead Industries now has the widest breadth of tracer wire manufactured with drillers in mind. SoloShot EHS is six times the strength of comparable sizes of solid copper wire. SoloShot EHS incorporates an HDPE coating thickness of 45 mil to protect the wire. SoloShot Xtreme is the toughest, most durable tracer wire designed for the most critical HDD bores. With a break load of 4,700 lbs, it is greater than all other tracer wires. SoloShot Xtreme has a 50-mil HDPE coating thickness for additional protection. All SoloShot HDD tracer wires manufactured by Copperhead Industries have a patented process for HDD and are manufactured with the proven copper clad steel technology. Both SoloShot EHS and SoloShot Xtreme can be incorporated with the Copperhead complete tracer wire system, including test stations, connectors and grounding anodes. Visit copperheadwire.com.

Ditch Witch

To improve jobsite efficiency and reduce jobsite expense, the new Ditch Witch MR90 mud-recycling system promises versatility on the job. The single, self-contained unit can mix and recycle mud, handle spoils, and is the only unit that can be transported full of fluid. Powered by a 25-hp Kubota Tier 4 engine, this compact unit is designed for small to medium-size drills (pullback ratings from 20,000 to 60,000 lbs) with up to 90-gpm cleaning capacity. The MR90 uses hydraulic leveling on shaker assembly and trailer jackstand, delivering fast setup – as few as 10 minutes. Learn more here: ditchwitch.com/trenchless/fluid-management/mr90-mud-recycler.

Drillhead Inc.

Starting at only $375, the Rok-Klaw from Drillhead Inc. is an economical, yet very rugged tool for drilling through medium-hard soil, soft rock and cobbles conditions. The teeth can be quickly replaced without removing the bit from the housing. Sizes range from 3 to 6 ½ in., they are available in all Vermeer and Ditch Witch bolt patterns. Its proprietary design uses standard size “trencher” teeth available from most HDD supply stores. Contact Drillhead Inc. at 580-222-4851 or visit drillhead.net.

E&M Supply

We have the 5 ¼ in. FH DOUBLE SHOULDER—the single most popular drill stem for most rigs between 300,000 – 750,000 lbs. E&M SUPPLY GROUP has a large supply of this pipe available for sale at our Breaux Bridge, La. facility. This pipe is hard to come by. The majority of premium 5 ¼-in. that comes into the market is standard FH, not double shoulder. HDD operators prefer double shoulder because it offers more torsional strength than standard FH, and because it is more resistant to over-torque. If your rig has at least 50,000 ft-lbs of rotary, then 5 ¼-in. double shoulder is the way to go. Please call us at 337-332-0239 or email brandon@emspecialty.com for more info on this drill pipe. E&M SUPPLY GROUP has been the industry leader in premium used drill pipe for nearly three decades. We carry all sizes HDD drill pipe, along with experienced product support and service after the sale.

Ezebreak

Ezebreak’s Micro-Blaster rock and concrete breaking systems allow users to tackle small to medium demolition projects in almost any location including inside buildings and confined spaces. The active component used by the Micro-Blaster System is a proprietary cartridge design containing a small quantity of propellant which when initiated provides sufficient gas pressure to crack hard materials. Our systems require only a 5/16-in. (8-mm) diameter drilled holes, 10 to 16 t deep, for quick and effective demolition. The dangers of collateral damage from shock waves or fly-rock are essentially eliminated and no Federal Blasting Licenses are required for legal use. Used by miners, HDD contractors, rescue personnel, prospectors, excavators, cave explorers, and farmers to quickly solve difficult demolition problems.
**Horizontal Directional Drilling Guide**

**HammerHead Trenchless Equipment**
HammerHead Trenchless Equipment has introduced the HammerHead ROUGHNECK R600, the largest of its pneumatic percussion drilling systems for use in HDD applications. Designed for drilling solid rock with bit diameters of 7.25 to 8 in., the R600 gives HDD contractors the ability to complete larger diameter bores in fewer passes as well as access to a wider range of single-pass boring applications. The larger bits driven by an R600 also increase the range of single-pass applications the driller has access to such as in communications and or other service installations. The R600 completes the range of existing HammerHead ROUGHNECK rock drills available to HDD customers. It joins the R400 designed for 5.25-in. straight and offset bits and the ROUGHNECK R500 for straight and offset bits to 6.25 in. in diameter. All three ROUGHNECK hammers turn any horizontal directional drill in the construction industry into a high-production rock drilling machine. Capable of penetration rates of 150 ft or more an hour, the rock hammers feature heavy-duty, high-flow housing; patent-pending pullback kit; control station/oiler; and drill conversion kit.

**Hunting Trenchless**
With a design that sets them apart from conventional mud motors, the new Hunting M-Series Mud Motors incorporates SWB (Survey While Boring) Technology that directly improves your ability to control the bit’s direction by locating the sonde housing just three feet behind the bit. This provides the operator more accurate tracking information than any other mud motor in the industry. And with Hunting, our mud motors come with a unique sealed oil bath bearing design eliminating the problem of mud flushing through the bearing housing just three feet behind the bit. The tool is modular in design. With the combination of Hole Opener and Jet Pump an exactly round, clean borehole is created in one single step and expensive bentonite can be saved.

**Herrenknecht**
Herrenknecht has collaborated with recognized HDD specialists to develop innovative downhole tools. With these, crossings can be carried out more quickly and economically. With the new Full Face Hole Opener, pilot holes can be enlarged in a single step. The tool is modular in design. Thanks to replaceable disc cutters it can be used in various ground conditions and quickly and economically refurbished or modified. They also recently developed Down Hole Jet Pump ideally complements it. The pump is installed directly behind the Full Face Hole Opener, cleans the borehole and removes the cuttings directly inside the drill string. As a result, the simplest drilling fluid can be used even with larger cuttings. Its only function remains the support and sealing of the borehole. With the combination of Hole Opener and Jet Pump an exactly round, clean borehole is created in one single step and expensive bentonite can be saved.

**Jet-Lube**
ECO-SAFE Drilling Compound provides excellent protection against seizing and galling and can be used for pipe joints or thread connections. ECO-SAFE is an entirely metal-free compound containing carbon-based fibers and additives and other extreme pressure and anti-wear additives. These are blended into JET-LUBE’s complex base grease. This new base grease offers the additional advantage of superior adhesion to wet steel surfaces and resistance to water wash-off.

**KEMTRON Technologies**
KEMTRON Technologies has become a leading manufacturer of effective mud recycling systems in North America. Designed for today’s HDD drilling contractor with 80,000 to 150,000 lb pullback rigs in the trenchless, water-well or geothermal industry, capable of processing up to 600 gpm of drilling fluid. Featuring an industry-first touch screen control panel with Wi-Fi capabilities, the Tango 600HD2 allows the operator to run the system from a smart phone, tablet or laptop. In addition, the Tango 600HD2 features the new Hyper-G six-panel linear motion shaker and single-point leveling jack, Firestone single-piece vibration isolation system, independent centrifugal pump pockets for direct maintenance access and eight 4-in. desilter hydrocyclone manifold. Trailer-mounted systems feature a heavy-duty dual-axle configuration with hydraulic leveling jacks for efficient unit placement at instance, when drilling through fractured formations. Having this information available in real-time can make the difference between keeping the bore on target and having to abandon the hole. For more information, email sales@inrock.com or visit inrock.com.
rig site. The Tango 600HD2 tank has been significantly increased from 3,000 gals to an impressive 4,000-gal capacity with new fold out/walk up ladder and increased working deck space.

**McLaughlin Mfg.**

The Vermeer VX 50-500 vacuum excavator by McLaughlin features Tier 4 Final engine technology and a new engine enclosure to help reduce engine noise levels and vibration. Operator-friendly enhancements include a large access door to the engine enclosure to provide improved accessibility. The unit’s three-stage cyclonic filtration system allows for wet and dry vacuum excavation while prolonging filter life and keeping maintenance costs low. An improved external hydraulic door opens at an 85-degree angle, allowing for easier and more rapid dumping and cleaning of the spoils tank. A patented mechanical cam-over locking system provides a 360-degree positive door seal, even under reverse pressure, without additional clamping requirements. The VX 50-500 vacuum excavator also features a low profile design, allowing access to areas previously limited by height restrictions. For more information visit mclaughlinunderground.com or email McLaughlin at mmole@mightymole.com.

**M-I SWACO**

M-I SWACO, a Schlumberger company, offers Drilplex HDD inorganic viscosifier, specially engineered for water-base bentonite drilling fluids to accommodate both max, as well as compact HDD rigs. The viscosifier improves solids suspension, enables a higher rate of penetration, optimizes cuttings transport, and creates borehole stability, thereby lowering drilling costs. Drilplex HDD viscosifier allows the formulation of fluids with shear-thinning properties, resulting in a drilling fluid with both dynamic and static carrying capabilities that does not shear degrade at a high shear rate. When mud is not circulating, it instantly reverts to a gelled state, resulting in a high viscosity and static carrying capabilities that does not shear degrade at a high shear rate.

**Premier Drill Pipe Ltd.**

Premier Drill Pipe LTD manufactures and distributes the most complete line of horizontal drilling (HDD) tubulars in the world. We set the standard for forged-end inertia-welded rods and have yet to have a single inertia weld failure. Premier is so confident in our inertia-weld that we offer an unconditional guarantee on the weld irrespective of operating conditions. Premier provides virtually all sizes of Vermeer, Jet Trac and Case compatible rods, as well as rods for other rigs. We also design and manufacture specialty strings for any number of unique projects. HDD projects can be unpredictable and the need for drill rods may be immediate, that is why Premier maintains a qualified network of distributors and stock points in Houston, Los Angeles, Atlanta and Minneapolis. Our experienced staff and advanced manufacturing technology is the basis for our superior product quality.

**Melfred Borzall**

A small, mud-filled pit is the last place you want to be fighting to change out a drill head after a pilot bore. With Melfred Borzall’s new (patent pending) Eagle Eye FastBack you don’t have to. With just a hex wrench you can pull out ever having to take the drill head off. Rear facing carbides and MudBoost fluid ports make sure your pullback is fast and successful. This economical, compact reamer is perfect for jobs with limited space. To learn more, call 800-833-1252 or visit melfredborzall.com.

**Prime Horizontal**

The Prime Horizontal MudVis System is an automated system that measures and logs the Viscosity and Specific Gravity of your drilling fluids. Designed specifically for the HDD industry, MudVis continually samples your stock or mixing tank bentonite at regular intervals. The Viscosity and Specific Gravity values are stored internally and are displayed on a sunlight viewable LCD screen for easy viewing at a glance. With the unit’s enhanced wireless capabilities it is possible to monitor live fluid readings. For more information, visit miswaco.com.
data from around the drill site using a wireless display, laptop or standard mobile device. It also allows for wireless downloading of stored data. MudVis enables you to react quickly to changing fluid characteristics, reducing your operational risk. It saves time for your onsite personnel improving their efficiency and allows detailed post project analyses using the recorded data. MudVis requires minimal setup and maintenance as it is self-calibrating and self-spooling.

**Radius Tools**

Contractors continue to count on Radius Tools as their “Go to” source for all HDD tooling. In an effort to support their customers, Radius continues to expand its “HDD Custom Sub Service.” Contractors can still log on to radiushdd.com and design virtually any connection they require and how fast they need it. Now Radius has expanded its capacity in order to offer even faster service. For critical situations where rigs are down or jobs are on hold, Radius offers Custom subs — made and shipped the same day. Radius keeps a massive inventory of common cross-over and connection subs, but even if you need an odd connection rest assured, Radius can deliver. Call today for more information and a catalog on its complete line of HDD tools.

**Railhead Underground Products LLC**

We’ve made a good thing even better. The success of the 8-, 12- and 16-in. EXTReam has led us to the 6- and 10-in. EXTReam reamers. Now available in five sizes from 6- to 16 in. in diameter. Connections for virtually every drill. The newly designed 6-, 8- and 10-in. EXTReam Reamers are built with an API pin and box with a removable pulling eye at the back of the reamer. This allows the user to quickly hook up many configurations. For more information, 817-594-6663 or visit railhead.com.

**RIGID**

The RIGID SeekTech SR-24 Line Locator streamlines the creation of accurate maps of underground utilities in order to protect critical assets. Using integrated Bluetooth communications, it transmits locating data to a third-party survey grade GPS or a mobile device. Data logging capabilities allow recording GPS and locating data to an onboard micro SD card. In addition to OmniSeek passive locating capabilities, the SR-24 can be programmed to detect any active frequency from 10 Hz-35 kHz. The free RIDGIDTrax app, for use on iPhone, iPad or Android, provides basic utility mapping. With the SR-24, the app will display GPS position and depth of the target utility on a real-time map. A user can identify the type of utility (water, gas electric, etc.) and display multiple utilities on the same map. A completed map can be saved and viewed inside the app or exported to a universal file format for use with popular GIS programs such as Google Earth.

**Sharewell HDD**

Precise Drilling Components and Sharewell HDD are pleased to announce the newest innovation in reaming technology for the small and mid-sized rig market. Utilizing “Pro-Cut” cutter modeling software and the highest standard of American carbide, PDC has developed this unique self-centralizing reamer capable of outperforming the competition in a variety of formations. The HydraMax’s simple yet rugged body design allows for both push and pull reaming operations and easy refurbishing for increased cost savings. Benefits: bi-directional cutting capability; reduced torque self-centralizing design; better penetration rates in all formations; capable of handling rock and cobble; easily repairable to new standard; and available in sizes from 10 to 24 in.

**StraightLine HDD**

The Crusher is the latest in a series of customer-generated reamer designs from StraightLine HDD. In this case, conventional thinking in rock formations dictate a hole opener for back-reaming. But a growing number of today’s HDD contracts call for small-diameter bores, which eliminate hole openers as a viable option. The Crusher fills the gap. A one-piece body and shaft design, the Crusher can be configured with short-bodied radius carbide buttons for hard rock up to 25,000 psi or chisel-top carbide buttons for softer formations. Carbide buttons are located on independent cutting paths to insure maximum contact. Replaceable fluid ports deliver fluids exactly where needed to insure smooth and efficient cutting action. A tapered solid-body, which transitions into full diameter in the back of the tool, promotes stabilization in the hole and superior cuttings control. Available in diameters from 4 to 10 in., the Crusher thrives in harsh conditions, such as hardpan, cobble and solid rock.

**The Toro Co.**

When productivity counts, the new Toro DD4045 horizontal directional drill delivers. Combining 40,000 lbs of best-in-class thrust and pullback, along with 4,500 ft-lbs of rotational torque and drilling fluid pump infinitely variable up to 70 gpm, the DD4045 has what it takes to perform a variety of different bores. Operators will appreciate the flexibility to use either single or dual joystick
controls while drilling, the large multi-function LCD display, and the clear visibility of the tool joint that comes from having open-top vice wrenches. The DD4045 comes equipped with 52 pieces of 10-ft. one-piece-forged pipe for durability in a variety of conditions, and an easily removable pipe rack for bores longer than 520 ft. This unit boasts a powerful 160-hp Cummins QSB4.5 diesel engine, and an optional enclosed operator cabin. Please contact Global Machinery (GlobalMachinery.com) for more information or to schedule your next demo.

### Torquato Drilling Accessories Inc.
Torquato Drilling Accessories Inc. of Old Forge, Pa., designs and manufactures a wide range of high speed Silver Bullet PDC Bits and Reamers for horizontal directional drilling. Silver Bullet PDC Bits drill 5-1/2- and 6-1/2-in. pilot holes considerably faster than roller cone bits in consolidated rock such as sandstone, limestone and shale. Our HDD PDC Reamers are available in sizes up to 26 in. in diameter for smooth and efficient reaming. Contact us today for more information at (800) 500-2487.

### Underground Tools Inc.
Other than our swivels, the only thing spinning will be your head when you realize how strong and affordable UTI’s HDD Pullback Swivels are. Several unique design features incorporated in our swivels combine to make them the strongest on the market. Four bearings and a larger shaft constructed from tool steel provide added strength you won’t find with competitors swivels. Full diameter shouldered pins, recessed into the smooth and durable outer casing creates a tremendously strong connection and also allows for snag free pullbacks. These swivels also have side-mounted, recessed grease fittings which protect the fittings and also make for easy access when performing swivel maintenance. UTI offers a complete lineup of premium quality clevis x clevis swivels ranging from 8,500- to 120,000-lb working loads. Higher rated swivels with API box x clevis connections are also available. For more information call UTI 866-488-3478.

### TuffRod
TuffRod offers the most comprehensive lineup of one-piece forged drill pipe in the United States. Forged drill pipe is available for virtually every Vermeer and Ditch Witch drill on the market, as well as several other manufacturers’ drills. TuffRod drill pipe is made from only the finest quality materials. Every joint of pipe produced is subject to rigorous quality assurance procedures, which begin at the point of material selection and continue through final inspection. Processes such as upsetting, machining, heat treating are inspected and recorded by certified operators. These measures ensure that customers receive only the best quality drill pipe. TuffRod also offers both new and premium used range 2 drill pipe for maxi drills. We also provide engineering services and can design custom pipe or connections for any application. For more information call TuffRod at 844-586-9354 or visit tuffrod.com.

### Vermeer Mfg.
The new D20x22 S3 Navigator HDD is a small footprint machine yet one that is able to increase productivity when working in urban or tight jobsites. A 74-hp, Deutz engine powers the machine and is capable of 12 percent greater power compared to its predecessor, the D16x20 Series II. The D20x22 S3 features 19,550 lbs. of thrust/pullback with 2,250 ft-lb of torque. The D20x22 S3 has a faster carriage speed, which can lead to an increase in the amount of product installed per minute. The 167 ft per minute now exceeds competitive models in the same class. The D20x22 S3 features the common control system currently used on larger Vermeer drills. The system features a digital display and improved onboard diagnostics, which allow operators to customize the available drill information. The noise level output from the drill has been reduced to enhance operator comfort.
Horizontal Directional Drilling Guide

Trenchless Technology Supplement

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- Environmental Considerations of Drilling Fluids
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• Properties of Restrained Joint Ductile Iron Pipe
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• Drill Fluid Selection
• Testing of Drilling Fluid Properties
• Environmental Considerations of Drilling Fluids
• Recycling of Drilling Fluids
• Direct Pipe HDD Installations
• Tooling Efficiency
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AD INDEX

Trenchless Technology Supplement

<table>
<thead>
<tr>
<th>ADVERTISER</th>
<th>PAGE #</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Augers</td>
<td>11</td>
</tr>
<tr>
<td>Armadillo LLC</td>
<td>50</td>
</tr>
<tr>
<td>Benjamin Media Resource Center</td>
<td>57,66</td>
</tr>
<tr>
<td>Bit Brokers International</td>
<td>64</td>
</tr>
<tr>
<td>BlueArc HDD LLC</td>
<td>37</td>
</tr>
<tr>
<td>Carson Corporation</td>
<td>34</td>
</tr>
<tr>
<td>Derrick Equipment Co</td>
<td>3</td>
</tr>
<tr>
<td>Ditch Witch</td>
<td>13</td>
</tr>
<tr>
<td>E &amp; M Specialty Co. Inc</td>
<td>56</td>
</tr>
<tr>
<td>Ellingson Companies</td>
<td>31</td>
</tr>
<tr>
<td>HDD Broker Inc</td>
<td>2</td>
</tr>
<tr>
<td>Horizontal Directional Drilling Academy</td>
<td>65</td>
</tr>
<tr>
<td>Horizontal Technology Inc</td>
<td>41</td>
</tr>
<tr>
<td>Hunting Trenchless</td>
<td>15</td>
</tr>
<tr>
<td>KEMTRON Technologies Inc</td>
<td>46</td>
</tr>
<tr>
<td>Laney Directional Drilling</td>
<td>54</td>
</tr>
<tr>
<td>Lee Supply Company Inc</td>
<td>33</td>
</tr>
<tr>
<td>McElroy Manufacturing Co</td>
<td>64</td>
</tr>
<tr>
<td>Mears Group Inc</td>
<td>53</td>
</tr>
<tr>
<td>Melfred Borzall</td>
<td>35</td>
</tr>
<tr>
<td>MTI</td>
<td>43</td>
</tr>
<tr>
<td>NASTT’s 2016 No-Dig Show</td>
<td>67</td>
</tr>
<tr>
<td>Oz Directional Drilling</td>
<td>50</td>
</tr>
<tr>
<td>PowerStream Technology</td>
<td>64</td>
</tr>
<tr>
<td>Prime Drilling GmbH</td>
<td>57</td>
</tr>
<tr>
<td>Radius HDD Tools</td>
<td>7</td>
</tr>
<tr>
<td>Railhead Underground Products LLC</td>
<td>39</td>
</tr>
<tr>
<td>Southeast Directional Drilling</td>
<td>32</td>
</tr>
<tr>
<td>Superior Drilpipe</td>
<td>34</td>
</tr>
<tr>
<td>Torquato Drilling Accessories</td>
<td>64</td>
</tr>
<tr>
<td>Trechnless Technology Road Show BC</td>
<td>45</td>
</tr>
<tr>
<td>Trinity Pumpworks LLC</td>
<td>17</td>
</tr>
<tr>
<td>Tuff Rod LLC</td>
<td>48</td>
</tr>
<tr>
<td>Tulsa Rig Iron</td>
<td>51</td>
</tr>
<tr>
<td>Underground Tools Inc</td>
<td>52</td>
</tr>
<tr>
<td>Universal HDD</td>
<td>47,64</td>
</tr>
<tr>
<td>Vac-Tron Equipment LLC</td>
<td>Back Cover</td>
</tr>
<tr>
<td>Vacuworx</td>
<td>55</td>
</tr>
<tr>
<td>Vermeer</td>
<td>5</td>
</tr>
<tr>
<td>Wyo-Ben</td>
<td>54</td>
</tr>
</tbody>
</table>

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