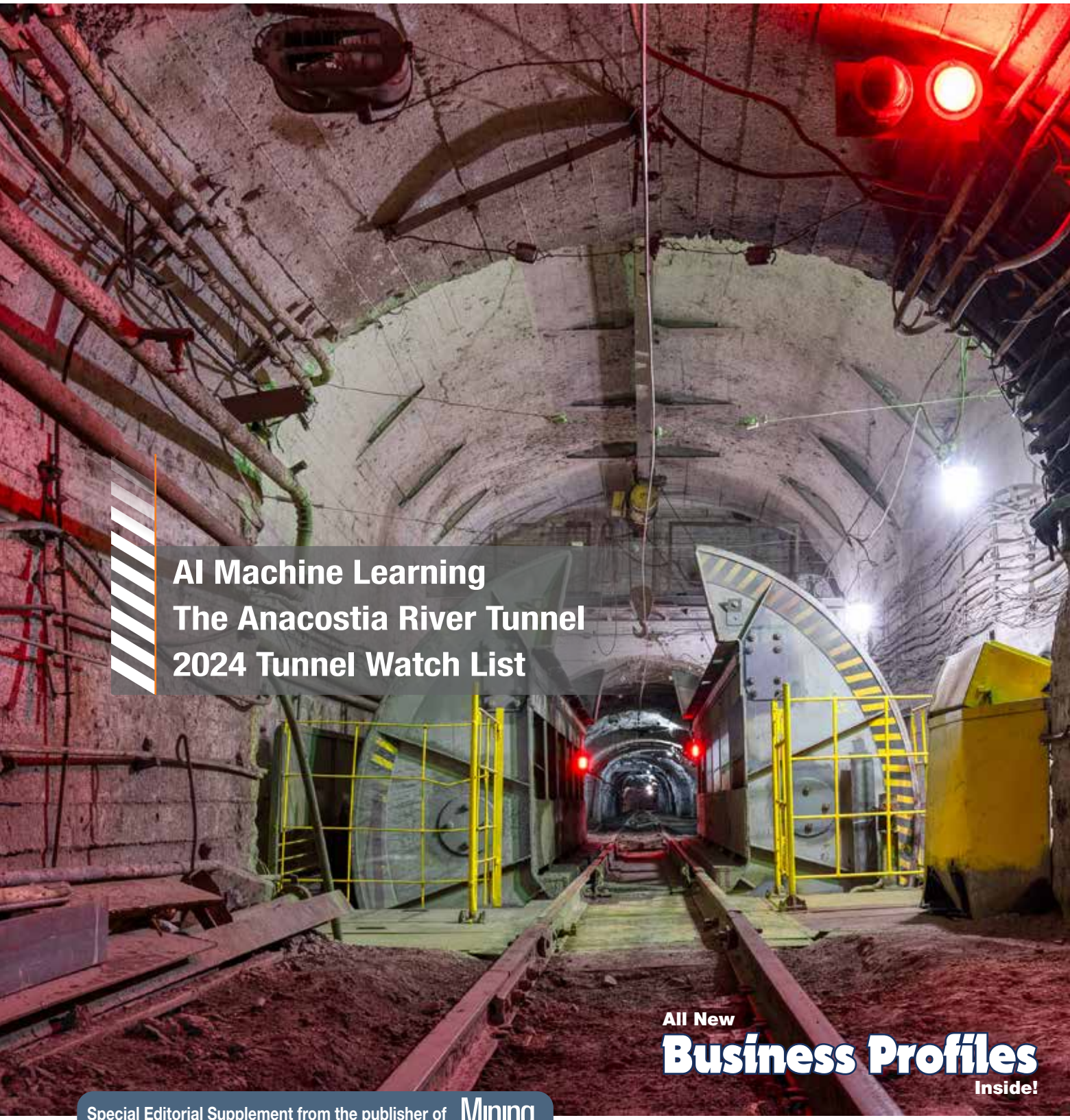
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Tunneling & Underground Construction

OFFICIAL PUBLICATION OF UCA

Volume 18 NO. 4 // December 2024



AI Machine Learning
The Anacostia River Tunnel
2024 Tunnel Watch List

All New
Business Profiles
Inside!

Special Editorial Supplement from the publisher of Mining engineering

HAMPTON ROADS BRIDGE TUNNEL, USA

U-TURN WITH HERRENKNECHT

Challenging crossing between two artificial islands under the seabed with low overburden. Herrenknecht supplied the world's largest Variable Density TBM (Ø 14 m) with accessible cutting wheel. After the first breakthrough in April 2024, the TBM shield, with a weight of 2,300 tonnes, was successfully turned using a nitrogen cushion solution supplied by Herrenknecht. Putting the TBM in position to excavate the second 2,440 m long road tunnel.

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Owner:
› Virginia Department of Transportation (VDOT)
Contractor:
› Hampton Roads Connector Partners (Joint Venture of Dragados USA, Vinci Construction Grands Projets, Flatiron Constructors, Dodin Campenon Bernard)

PIONEERING UNDERGROUND TOGETHER

HERRENKNECHT
Tunnelling Systems

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December Contents

Departments

2 Chair's column

4 Underground construction news

27 UCA news

30 Tunnel demand forecast

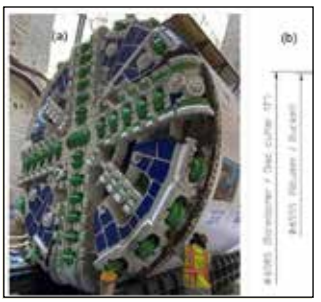
Cover Story



In This Issue

The management of cutterhead torque on tunnel boring machines is important for reducing power consumption, reducing tool wear and keeping the operating torque below the installed capacity. On page 14, an article by Mike Mooney and co-authors present the use of AI machine learning and mechanics-based modeling in the characterization of slurry shield cutterhead torque. Cover design by Ted Robertson.

Feature Articles



14
Slurry shield cutterhead torque characterization using AI machine learning and mechanics-based modeling

Mike Mooney, Vitaly Proshchenko, Hongjie Yu, Rakshith Shetty, Claudio Cimiotti, Matt Kendall and Nick Karlin



21
The Anacostia River Tunnel System in Washington, DC; Construction and performance of one of the world's largest CSO reduction infrastructures

John Beesley, Jeffery Peterson, John Cassidy and Martino Scialpi



27
UCA updates tunnel watch list to elevate the visibility of important tunnel projects

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Mining engineering

UCA Executive Committee nominations are now open

The UCA is once again seeking nominees for the Division's leadership positions and needs your help to ensure a stable and successful leadership succession. Nominations are sought for five positions, including UCA Division Executive Committee Vice Chair and four UCA Executive Committee members.

There are so many programs and resources that the UCA is developing to serve our membership and the tunnel industry. The Cutting Edge Conference 2024 hit record numbers this year and we received many positive comments from the attendees and speakers. The industry remains strong while we remain focused on the challenges of meeting the demand, of growing and retaining our skilled workforce and finding ways to continue to progress innovation. If you are interested in helping in a leadership role or would like to volunteer for these programs and new programs, you are encouraged to reach out to us (see page 10).

Serving on the executive committee and as Chair of UCA is so rewarding. I enjoy meeting folks from across the industry and leveraging my past experience to give back to the tunneling community. We have a diverse executive committee, bringing together different perspectives and experiences, which is what I enjoy. This also ensures that the products we produce and experiences we offer span across the diverse industry we have. We have amazing folks who serve as volunteers and on the executive committee and staff and it is great to work with them all.

The UCA Division Executive Committee Vice Chair term is from 2026-2028 and is open for an engineer. The UCA Executive Committee consists of members representing contractors, engineers, owners and suppliers. This is a six-year commitment. This position will advance to Chair (term 2028-2030) and then Past Chair (2030-2032).



Erika Moonin
2024-2025 UCA Chair

The open positions for the UCA Executive Committee are for the 2026-2030 term and are open to one contractor, two engineers and one supplier.

The executive committee consists of engineers, contractors, suppliers, owners and educators. Each year we rotate to bring on new volunteers to fill each slot to maintain a certain number in each category. This enables us to be sure that each area is represented on the executive committee to better serve our membership and the industry.

Requirements for the position include being a current UCA member and you must be willing to commit to attending, in person, a minimum of two executive committee meetings annually held in conjunction with the George A. Fox Conference (this year on Jan. 7, 2025 at the Marriott Marquis in New York City) and the North American Tunneling (NAT) Conference or the Rapid Excavation and Tunneling Conference (RETC) biennial conference. Members are also expected to attend quarterly virtual meetings.

The UCA Executive Committee seeks professionals who possess a desire for greater involvement in the

(continued on page 10)

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MUMBAI SEWAGE DISPOSAL PROJECT

TERRATEC is delivering a 3.85m diameter Rock Slurry Machine for the Mumbai Sewage Disposal Project (MSDP) Stage-II – PST1.

The comprehensive package includes the Slurry Transportation System and Slurry Treatment Plant, ensuring seamless and efficient project execution. These custom-made systems are backed up by TERRATEC's highly skilled team, who offer specialized TBM support and prompt onsite assistance throughout tunnelling operations.

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Gateway Development Commission implements $3.8 billion Federal-State Partnership grant

The Gateway Development Commission (GDC) announced that it has executed the $3.8 billion Federal-State Partnership (FSP) grant agreement with the Federal Railroad Administration (FRA), completing the $12 billion federal contribution for the Hudson Tunnel Project (HTP). The action also immediately obligates the initial $1.9 billion from the grant.

Together with the $800 million in New Starts Capital Investment Grant (CIG) program funding that has already been obligated, GDC now has $2.7 billion in grant funds immediately available for construction of the HTP.

In addition to these amounts, the local share of the HTP comprising $4 billion is available to advance construction.

In a joint statement, Alicia Glen, New York GDC commissioner and co-chair, Balpreet Grewal-Virk, New Jersey GDC commissioner and co-chair and Tony Coscia, GDC Amtrak commissioner and vice chair, said, "The HTP is already starting to bring huge economic benefits to the Northeast and the nation as a whole, starting with the jobs and economic activity resulting from GDC's direct spending during construction. While we have had the full funding for the HTP committed for months, today we received one of the first major infusions of funds that enables us to turn these commitments into reality. With nearly $3 billion in the bank, the full economic impact of this massive project is beginning to be felt."

GDC chief executive officer Kris Kolluri said, "The entire $16 billion funding commitment we need to complete the HTP has been secure since GDC signed our full funding grant agreement this summer. With this dramatic infusion of immediately available cash, GDC is well prepared to execute the next phase of major construction, and continue moving forward with confidence as we ramp up and prepare to begin tunnel boring activity next year."

"Thanks to President Biden's Bipartisan Infrastructure Law, the Biden-Harris administration continues to advance projects of national significance along America's busiest rail corridor, and this month's finalized funding agreement on the Hudson Tunnel Project is another sign of progress," said FRA administrator Amit Bose. "The Biden-Harris administration is investing billions of dollars in the Northeast Corridor to upgrade aging infrastructure that will allow for higher speeds, shorter travel time, and greater reliability for a growing number of riders. These improvements will be felt in New York, New Jersey and beyond, while creating jobs and growing the economy. FRA appreciates the partnerships and planning that are critical to making progress on the

(continued on page 13)

Sound Transit Board selects route to be built for West Seattle Link Extension

Seattle's Sound Transit Board has selected route and station locations for the West Seattle Link Extension (WSLE) that will include the light rail route, profile and station locations for WSLE. The action advances the project to the final design phase, with construction anticipated to begin in 2027.

The Sound Transit Board said the selection was "based on years of technical analysis and community feedback through our study of multiple routes and station alternatives since 2017."

The final alignment selected includes the West Seattle Junction segment: Medium Tunnel 41st Avenue Station West Entrance Station Option; Delridge segment: Andover Street Station Lower Height South Alignment Option; Duwamish segment: South Crossing Alternative and SODO segment: At-Grade Lander Access Station Option.

WSLE would add 6.5 km (4.1 miles) of light rail service from SODO to West Seattle's Alaska Junction neighborhood. This project includes four new stations in SODO, Delridge, Avalon and the Alaska Junction. WSLE is part of the Sound Transit 3 (ST3) plan of regional transit system investments, approved for funding by voters in the region in 2016. WSLE will provide fast, frequent and reliable light rail connections to dense residential and job centers throughout the region.

"This extension will reduce travel time from Alaska Junction to Westlake station by 50 percent at peak hours once the Ballard Link Extension is complete, taking only 16 minutes," the Sound Transit Board said in a statement. "The extension will improve transit service frequency, reliability and capacity. Partnering on opportunities for development near stations, including affordable housing and other equitable transit-oriented development, will help support communities with direct access to transit. Additionally, WSLE will provide a travel alternative if the West Seattle Bridge is congested or closed for repairs. By 2042, WSLE will carry an estimated 24,000 to 27,000 riders daily."

The board said it anticipates the Federal Transit Administration to issue a record of decision later this year under the National Environmental Policy Act. With that, the project will begin final design as well as develop and implement a workplan to improve the agency's financial situation and move WSLE through design to inform a financially sound project to be baselined. It expects to start construction in 2027. ■


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Feasibility study to increase capacity at New York Penn Station released

Amtrak, the Metropolitan Transportation Authority (MTA) and NJ Transit have released the engineering feasibility study, "Doubling Trans-Hudson Train Capacity at New York Penn Station" (NYP), which analyzes the potential of four concepts to double train capacity at the station during the peak period, as well as expand Amtrak Empire Service, without expanding the current station's footprint. The study concludes none of the concepts achieve this capacity goal, a significant milestone which determines that the focus going forward will be on options that expand the station physical footprint.

"This study demonstrates that to meet the needs of the region, we must expand the station beyond its existing footprint to deliver the passenger capacity promised by the Gateway Program," said Amtrak chief executive officer Stephen Gardner. "The feasibility study is part of a long-term collaboration between Amtrak, MTA and NJ Transit to seek ways to transform the busiest train station in the Western Hemisphere into a modern, world-class facility with the capacity to provide 200,000 more passenger trips."

"This is an important step for the future of Penn Station," said MTA Construction and Development president Jamie Torres-Springer. "This detailed analysis lays the groundwork on how the region can work together to meet long-term capacity needs while also clearing the way for immediate improvements for the 600,000 daily customers in the existing Penn Station."

"The findings of this study highlight the critical need for a comprehensive approach to increase capacity at New York Penn Station," said NJ Transit president and chief executive officer Kevin S. Corbett. "NJ Transit is committed to the goal of delivering a Penn Station that transforms the customer experience and maximizes the benefits of the Gateway Program."

The station and its operational infrastructure, including the North and East River Tunnels, currently function at maximum capacity. The Gateway Program is a series of infrastructure improvements built around increasing train capacity in the 16 km (10 miles) between Newark Penn Station and NYP. Significant additional train capacity at NYP is needed to accommodate existing and anticipated passenger demand,

(continued on page 12)




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Fourth tunnel boring machine confirmed for Australia's Snowy 2.0 project

A new tunnel boring machine (TBM) will be deployed to help keep Snowy 2.0 on its delivery timeline, subject to approval by the New South Wales (NSW) Department of Planning, Housing and Infrastructure.

New ground-testing techniques have provided a better understanding of the full extent of a complex fault zone on the route of the 17 km (10.5 miles) of tunnel that will connect Snowy 2.0's upper reservoir to its underground power station.

Snowy Hydro chief executive officer Dennis Barnes said activating a fourth TBM is the right course of action, given that what is now known about the tunneling challenges ahead has provided the opportunity to mature the design.

"We've always known the fault zone was there and I've said in the past we will need to take action," Barnes said. "While the fault zone is not a surprise, further ground testing since the project reset has revealed it is far more geologically challenging than earlier investigations indicated.

"We've carefully considered a range of options to get through the fault zone and overcome the initial design immaturity. Bringing in a fourth machine is the best way to keep the Snowy 2.0 on track for its target completion date of December 2028."

A modification for Snowy 2.0's project approval has been submitted to the NSW Department of Planning, Housing and Infrastructure, and will be subject to the department's independent community consultation and assessment processes.

The planning modification seeks approval for a change to construction methods within the project's already approved work zone. There is no proposal to increase approved land clearing areas, surface or ground-water impacts. Local communities will be consulted about relevant changes to construction methodologies.

"We're mindful that we are building Snowy 2.0 in a precious and protected national park. We have worked diligently to arrive at a proposal that does not step outside our existing construction area or increase our already approved impacts," Barnes said.

Barnes said he remains committed to transparency regarding the project, given the inevitable challenges ahead.

"Just like the construction of the original Snowy Scheme, this is one of the most challenging and complex mega projects underway in the world," he said. "The fourth tunnel boring machine is an example of adapting to the situation in front of us, so we are doing everything we can to safely meet Snowy 2.0's delivery timeline."

While the need for a new TBM is driven by new information about the fault zone, Barnes acknowledged that the disappointing performance of Florence, the TBM excavating the same tunnel that the new machine will also work on, has contributed to the need to take significant action.

"It's difficult to say with certainty whether the same action would be needed if Florence had performed as we had hoped. However, it's likely that the fourth machine would still be needed," Barnes said.

Snowy 2.0 will help underpin Australia's transition to renewable energy through its ability to generate enough flexible, fast-dispatch energy to power 3 million homes continuously for a week.

The unmatched scale and duration of Snowy 2.0's storage and generating

(continued on page 13)

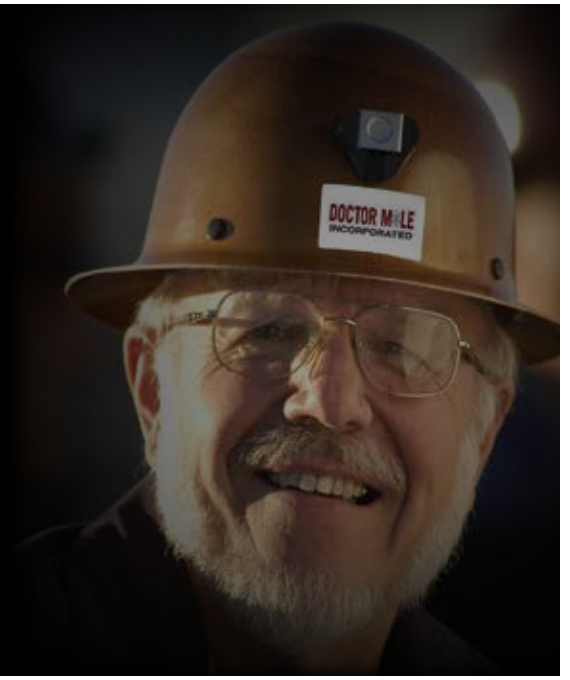
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Terra Verde wins $1.7 billion tunnel contract for Suburban Rail Loop project in Victoria, Australia

Global consortium Terra Verde has been awarded a $1.7 billion tunneling contract for the $34.5 billion eastern section of the Suburban Rail Loop line in Victoria, Australia.

The deal is to build 10-km (6-mile) twin tunnels between Glen Waverley and Box Hill, with another consortium already signing a $3.6 billion deal to tunnel the rest of the 26-km (16-mile) stretch from Cheltenham.

The Guardian reported that the Labor state government said the latest tunneling deal came in under what was initially budgeted, but the Victoria Premier Jacinta Allan did not say by how much.

"It demonstrates there is huge competitive interest from these global construction companies," Allan told reporters.

The entire 90-km (56-mile) orbital rail line is designed to run from Cheltenham to Werribee via Melbourne airport. Boring on the first phase of the loop is expected to begin in 2026, with completion slated for 2035.

The transport infrastructure minister, Danny Pearson, said there was "simply no stopping" the project as early works power ahead at all six station sites.

Victoria has pledged $11.8 billion to build the eastern section, with a third of funding expected to come from the federal government and the rest from unexplained "value capture" revenue.

The Albanese government has only committed $2.2 billion for the project so far, leaving a $20 billion funding hole. The entire project was initially estimated to cost up to $50 billion in 2018, before its 2021official business case showed the east and north sections could cost between $30.7 billion and $57.6 billion.

The state's independent Parliamentary Budget Office cast doubt on that estimate, putting the cost to build the first two sections at $125 billion. ■

Chair column: Leadership opportunities now open

(continued from page 2)

leadership of UCA and have an interest in one or more UCA activities including educational conferences, publications, promotion and outreach of the tunneling business, and/or interest in international activities such as the International Tunneling Association.

In addition, nominees for the executive committee must show a record of service to UCA, have held senior positions and with a record of accomplishments within their industry, have previously served other committees reporting to the executive committee, and demonstrate a willingness to bear the financial burdens of travel to meetings.

Please forward any recommendations to Genny Homyack, SME Board Relations Administrator and Executive Assistant at homyack@smenet.org no later than Feb. 28, 2025. All materials will be collected, vetted for qualifications and submitted to the UCA Nominating Committee for review. Final selection will take place at the UCA Executive Committee Meeting in April.

The application should include a bio (300 words or less); resume (three pages maximum), headshot and a statement including your UCA history of involvement, why you want to be on the executive committee, and a commitment to attend all meetings and make this committee a priority.

We look forward to continue to grow UCA in membership, services and resources, and to be the "go-to resource" for tunneling and underground construction. Help us achieve our goals and volunteer today. We look forward to hearing from you. ■

ITA Award finalists announced

The International Tunnelling Association (ITA) evaluated more than 100 applications from 29 countries in seven categories to come up with the list of finalists for its 2024 awards.

The winners were announced and awarded on Nov. 28, 2024 at the annual ITA Awards conference in Genoa, Italy.

The LIRR Grand Central Madison project in New York City was nominated in the category of Major Project of the Year. It is a landmark $11.1 billion project by New York's Metropolitan Transportation Authority (MTA), providing direct Long Island Rail Road (LIRR) access to Manhattan's East Side. The underground terminal spans more than 65,000 m², with eight new tracks and four platforms housed in two massive caverns. The project involved 9.7 km of hard rock tunneling under Manhattan and 3.2 km of soft ground tunneling in Queens. It was completed using innovative techniques like ground freezing. By transporting materials through tunnels to Queens, thousands of trucks were removed from the streets, reducing urban impact. Opened in 2023, it increases LIRR capacity by 40 percent and reduces daily commute times.

Other Major Projects were Signapore Thomson-East Coast Line (TEL), Contracts T222 to T310, Singapore. Single-bore Double-deck Municipal Tunnel with Super Large Diameter, China and the Thames Tideway Tunnel — London's New Super Sewer, United Kingdom. ■

Frontier-Kemper awarded $1.1 billion Kensico-Eastview Connection tunnel project

The New York City Department of Environmental Protection (DEP) announced that it has awarded Tutor Perini Corp. and its subsidiary, Frontier-Kemper Constructors, a $1.1 billion contract for the construction of the Kensico-Eastview Connection (KEC) tunnel project.

The scope of work entails the construction of a new 3.2-km (2-mile)-long deep rock tunnel between the Kensico Reservoir and the Catskill/Delaware Ultraviolet (CDUV) Light Disinfection Facility, both in Westchester County, NY. The new tunnel will provide an additional means of conveying water between the Kensico Reservoir and the CDUV facility, enhancing operational resiliency and redundancy for New York City's water supply system.

The project will include subsurface utility easements along the tunnel corridor; construction of a new KEC Screen Chamber; construction of connection tunnels to the new KEC Screen Chamber and modifications to the existing Dike Grade Tunnel; consolidation of the electrical supply to the Kensico Campus and construction of a new electrical building; redevelopment of the Kensico Campus including the relocation of Westlake Drive, regrading of the overall site, a new DEP Police booth and other security improvements; modifications to the chemical feed system at Delaware Shaft 18; modifications to the existing Catskill Upper Effluent Chamber (UEC) located within and adjacent to the Kensico Reservoir; construction of a new Eastview Connection Chamber and interconnection to the CDUV facility; management of excavated material from construction; shoreline stabilization efforts along Kensico Reservoir south of the UEC; and mitigation as needed for the project.

The KEC tunnel would provide an additional means of conveying water between the Kensico Reservoir and the CDUV facility. Completion of this project would enhance operational resiliency and redundancy for the water supply system.

Work is expected to begin in the coming months with substantial completion expected in 2030. The contract value was added to the company's backlog in the third quarter of 2024.

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Learn about UCA committees and volunteer opportunities, and submit a volunteer interest form at: **smenet.org/uca/volunteer-portal**

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Penn Station: Study focuses on four concepts

(continued from page 6)

improve reliability and support future cross-regional rail service.

As it is within the most congested segment of the Northeast Corridor (NEC), one of Gateway's key objectives is to double passenger train service between New York and New Jersey from 24 to 48 trains per hour, or more, during peak hours. This approach is also consistent with the long-term vision for expanded intercity and regional passenger rail service on the NEC established by the Federal Railroad Administration's NEC Future program.

The study focuses on two alternatives with two design concepts each to evaluate their potential to at least double the station's existing rail capacity between New York and New Jersey in the peak direction during rush hours. The "Under Penn Station" concepts evaluated in the study involve adding 10 station tracks directly below the existing facility. The "Through-Running" concepts include a "Full Reconstruction" option that requires complete demolition of existing tracks and platforms and reconstruction of fewer tracks with wider platforms, and a "Limited Track and Platform Reconfiguration" option, which also envisions wider platforms and fewer tracks but would require only partial demolition and reconstruction of existing tracks and platforms.

The study concludes that all concepts evaluated suffer from constructability, operational, safety and/or connectivity challenges and flaws that render them infeasible for further evaluation. During the design and the environmental evaluation phases, the railroad partners will continue to develop options for expanding the station's capacity that have the potential to meet the Gateway goal of doubling cross-Hudson train capacity.

Amtrak, MTA and NJ Transit are committed to a robust public engagement process in support of the two Penn Station projects — reconstruction, which will improve the existing facility, and capacity expansion, which will increase rail capacity — including convening a Station Working Advisory Group (SWAG) of more than 50 regional stakeholders who will meet regularly to discuss and provide input on the railroad partners' vision for the station complex. The SWAG is co-chaired by Regional Plan Association president and chief executive officer Tom Wright and NYU Rudin Center for Transportation director and assistant clinical professor of public service Sarah Kaufman.

The railroad partners commissioned the WSP USA/FXC JV team to develop the feasibility study. More information, including access to the study, details about the reconstruction and capacity expansion projects, and the complete list of SWAG participants, is available on the Penn Station Projects website. The website also features a section for members of the public to provide relevant feedback about both Penn projects. ■

The Moles announce 2025 award winners

Paul C. Schmall and Anthony J. Binsfeld have been selected to receive outstanding achievement awards by The Moles, a national heavy construction industry professional organization. The awards will be presented at The Moles' Annual Award Dinner at the New York Marriott Marquis on Jan. 8, 2025. Schmall will accept The Moles Member Award and Binsfeld will receive the Moles Non-Member Award.

Schmall, vice president at Keller Specialty Services, received his BSCE from Bucknell University in 1988 and has 36 years of experience since he started his career at Moretrench. Schmall has worked on a significant number of tunnel blow-ins, underground emergency responses, and the engineering and maintenance of complex groundwater control for projects throughout the country and internationally, including the recovery and reconstruction of the World Trade Center. He received his Ph.D. from the University of Nottingham in 2013, publishing his thesis on ground freezing. Since Keller purchased Moretrench in 2018, Schmall's unit has been largely responsible for tunneling and big dam work in North America.

Schmall is active in industry organizations, including serving on the board of the UCA since its inception and on the industry advisory boards for Bucknell University and Manhattan College. He is a member of the National Academy of Construction (NAC). Schmall is a fellow of the ASCE and received its Wallace Hayward Baker Award in 2015.

Binsfeld is The Moles 2025 Non-Member Awardee for Outstanding Achievement in Construction. He is chairman of the board of The Brennan Group, a heavy civil construction, dredging, commercial diving and marine transportation company based in La Crosse, WI. Binsfeld is a third-generation leader of the family business founded by his grandfather and great-uncle in Lansing, IA in 1919. He received his civil engineering degree from Marquette University.

Binsfeld joined J.F. Brennan Co. in 1976 and became its president in 1991. Under Binsfeld's leadership, the company expanded into commercial maritime transportation, hydraulic dredging and large-scale commercial dive work and became a key service provider to the U.S. Army Corps of Engineers for many of the major rehabilitations of their Mississippi River locks and dams. Binsfeld's leadership has fostered the company's growth and innovation, securing more than a half dozen patents, two of which revolutionized thin layer removal and the subaqueous capping of impacted sediments.

These two patents allowed for the economical cleanup and closeout of many impacted sites throughout the Great Lakes region, including the remediation of the Fox River, the largest domestic riverine cleanup project to date. ■

Eglinton Crosstown West Extension moves forward request for proposal

A request for proposal (RFP) has been issued for the stations, rail and systems (SRS) contract for the Eglinton Crosstown West Extension — which will bring future Eglinton Crosstown LRT service 9.2 km (5.7 miles) farther west, creating a rapid transit line that will run from Scarborough all the way into Mississauga.

The Ontario government announced that the package of work includes design and construction of all seven new stations, fitting the tunnels and 1.5-km (1-mile) elevated guideway with track and signals, and installing and commissioning communications, ventilation and other support systems for the new line.

The contract also includes utility work and road modifications along Eglinton Avenue West to accommodate construction and changes at Mount Dennis Station that will help connect the extension to future Eglinton Crosstown LRT service.

Submissions from the three shortlisted teams were evaluated through a request for qualifications (RFQ) process that asked interested companies to submit their qualifications and expertise.

The three teams invited to bid on the SRS contract are:

Integrated Transit Partners:
- Applicant leads: Sacyr Canada Inc., NGE Contracting Inc. and Siemens Mobility Ltd.
- Primary design team members: Siemens Mobility Ltd., Hatch Ltd., Egis Canada Ltd. and Weston Williamson Partners Ltd.
- Primary construction team members: NGE Contracting Inc., Sacyr Canada Inc. and Siemens Mobility Ltd.

Trillium Rail Partners:
- Applicant leads: Amico Major Projects Inc., Alberici Constructors Ltd. and Acciona Infrastructure Canada Inc.
- Primary design team members: WSP Canada Inc.
- Primary construction team members: Amico Major Projects Inc., Alberici Constructors Ltd. and Acciona Infrastructure Canada Inc.

WestEx Transit Solutions:
- Applicant leads: Aecon Infrastructure Management Inc., AtkinsRéalis Major Projects Inc., Pomerleau Major Projects Inc. and Dragados Canada Inc.
- Primary design team members: AtkinsRéalis Canada Inc. and Arcadis Professional Services.
- Primary construction team members: Aecon Infrastructure Management Inc., AtkinsRéalis Major Projects Inc., Pomerleau Major Projects Inc. and Dragados Canada Inc.

After the proposals are evaluated, Metrolinx and Infrastructure Ontario will select a partner to work with over an 18-month development phase to further refine design, costs and project schedules. Metrolinx will then have the option to sign a final agreement with the proponent. ■

Gateway: Grant is part of $12 billion package

(continued from page 4)

Hudson Tunnel Project and other Gateway Program projects possible, and we look forward to our work together."

The FSP grant program was established by the Infrastructure Investment and Jobs Act (IIJA) to fund capital projects that reduce the state of good repair backlog, improve performance, or expand or establish new intercity passenger rail service. GDC applied for an FSP grant in March 2023 and all $3.8 billion requested was committed in November 2023.

This grant is part of an historic $12 billion in federal funding to the HTP — the largest federal funding commitment to a rail transportation project in modern history. This federal commitment will cover 70 percent of the HTP's cost, saving New York and New Jersey billions compared to the original plan to split costs 50-50 between the federal and local partners.

GDC has also made significant progress on construction of the HTP since securing full funding for the project in July.

Construction crews recently poured the first concrete for the new tunnel at the Tonnelle Avenue Bridge and Utility Relocation Project in North Bergen, NJ, and work is underway on phase two of the Hudson River Ground Stabilization (HRGS) Project, which is preparing the Hudson riverbed for tunnel boring. ■

Snowy 2.0: Mega project remains on pace

(continued from page 8)

ability will effectively provide the network with critical electricity supply insurance against extended periods without enough wind and sunlight. Most other forms of storage, including batteries, can only generate power for a handful of hours.

According to the Australian Energy Market Operator (AEMO), Snowy 2.0 will supply a majority of the National Electricity Market's storage needs, greater than every other storage asset combined.

"Snowy 2.0 is critical to Australia's energy future. We need to get this job done," Barnes said.

Subject to planning approval, the new machine will be tunneling before the end of 2025. ■

Slurry shield cutterhead torque characterization using AI machine learning and mechanics-based modeling

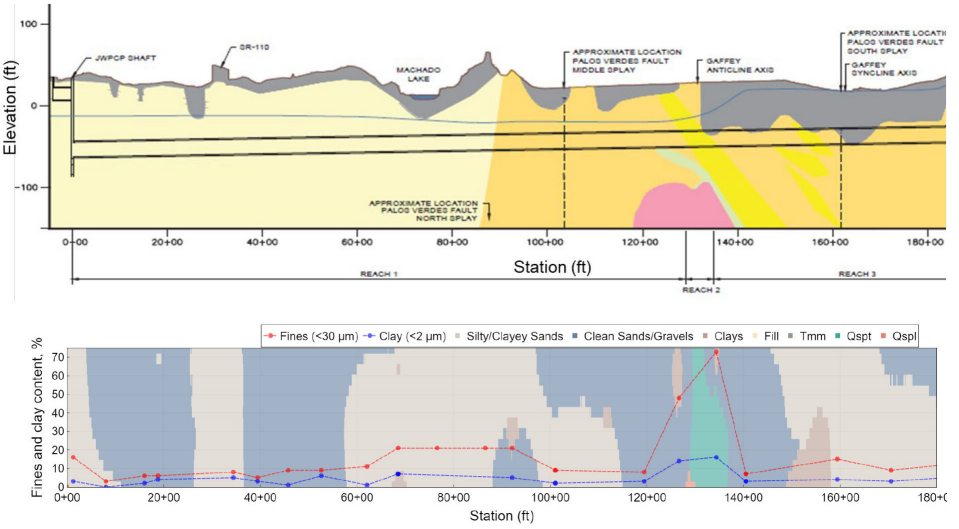
Mike Mooney, Vitaly Proshchenko, Hongjie Yu, Rakshith Shetty, Claudio Cimiotti, Matt Kendall and Nick Karlin

Mike Mooney, member UCA, is Grewcock Chair Professor for underground construction & tunneling, Colorado School of Mines, Vitaly Proshchenko, Hongjie Yu and Rakshith Shetty are formerly of Colorado School of Mines and Claudio Cimiotti, Matt Kendall and Nick Karlin are with Dragados USA, email mmooney@mines.edu.

The management of cutterhead torque on tunnel boring machines (TBMs) is important for a number of reasons, such as for reducing power consumption, reducing tool wear and generally keeping the operating torque below the installed capacity. A few published analytical models exist to estimate the cutterhead torque on earth pressure balance (EPB) TBMs and slurry pressure balance TBMs, including Godinez et al. (2015), Shi et al. (2011), Han et al. (2017), Zhang et al. (2014) and Zhou and Shai (2018). All of these models utilize straightforward mechanics-based representations of cutterhead torque components, including cutting action of the tools on the face and perimeter, cutterhead perimeter friction, ground-cutterhead front interface friction, paste/slurry cutterhead rear interface friction, mixing action of rear cutterhead bars and upsets, as well as inertial, gear resistance and loss aspects in the drive motors. Slurry TBM cutterhead torque is typically low compared to EPB TBMs of similar size.

FIGURE 1

(a) Geological cross-section for the soil portion of the Los Angeles outfall tunnel. (b) Characterization of USCS soil groups within the tunnel horizon along the soils portion of the tunnel.



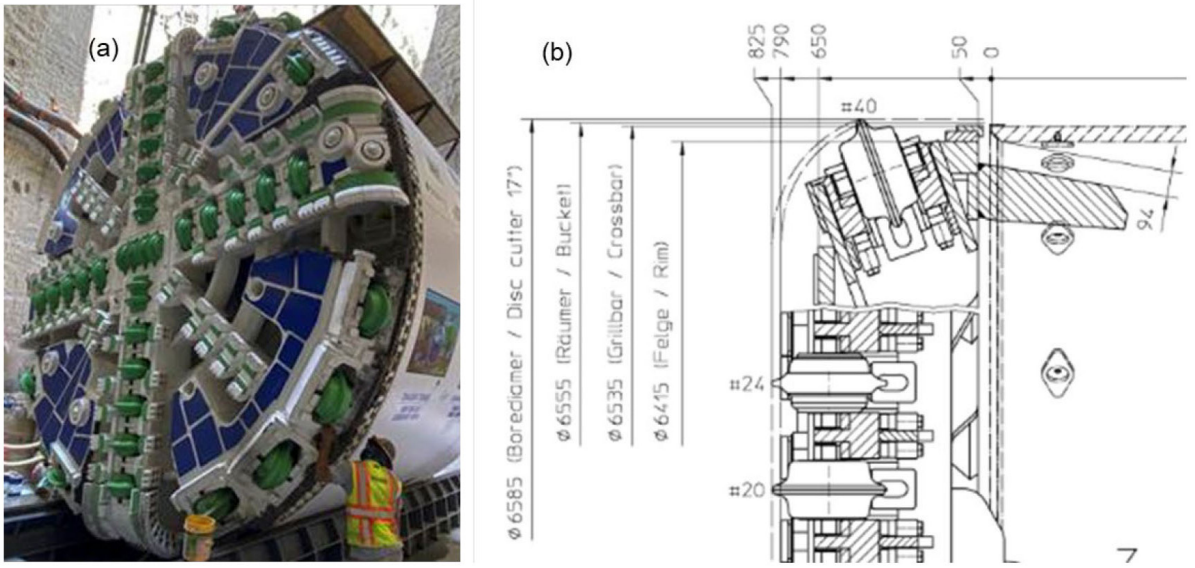
Occasionally, such as in the case of the Los Angeles Clearwater project slurry TBM, the observed cutterhead torque is not explained well by analytical models, indicating the analytical models are missing key aspects of cutterhead torque. In this case, data-driven models such as those based on artificial intelligence (AI) machine learning, can be employed to learn the parameters that influence cutterhead torque. This article summarizes such an effort in which cutterhead torque is modeled using AI machine learning. The article (1) introduces the alignment, ground conditions and slurry TBM of the project, (2) presents the analytical model-based estimation of cutterhead torque, parts of which are learned from the slurry TBM data, (3) presents the machine learning-based model for cutterhead torque and an analysis of factors contributing to the observed torque and (4) discusses the observed limitations of analytical models in not capturing observed cutterhead torque.

Project background

The Sanitation Districts of Los Angeles County's Clearwater project includes a 11-km (7-mile) effluent outfall tunnel constructed by Dragados USA. The tunnel, with a nominally 5.5 m (18 ft) inside diameter, is being constructed with a single slurry TBM with 6.6 m (22 ft) excavated diameter. The northern portion of the north-south alignment is in soft ground and is the topic of this article. The southern portion is in rock beneath the Palos Verdes Hills. The soft-ground northern portion is shown in Fig. 1. Reach 1, from Station 0+00 to 129+00, consists of Lakewood and San Pedro Sand formation alluvial flood plain and alluvial fan deposits. The Lakewood formation is predominantly sand, sand with silt, silty and clayey sands, with local layers of

FIGURE 2

(a) Cutterhead of Herrenknecht mixshield TBM. (b) Cross-section view of cutterhead perimeter showing the 6,585 mm cut diameter, 6,555 mm bucket lips diameter and 6,415 mm diameter rim.



clays, silts and gravels (Hyde, 2018). The San Pedro Sand is predominantly sands, silty and clayey sands and occasional layers of silts and clays (Hyde, 2018). From a Unified Soil Classification System (USCS) perspective, both formations contain similar soil types. The minus 30 µm content and clay content determined from borehole data within the tunnel horizon is presented in Fig. 1. The alignment includes a section of Timms Point Silt (Reach 2, beginning 129+00) that has higher fines content. This article addresses behavior in Reach 1 only.

A 6.6-m (22-ft) diameter Herrenknecht mixshield (slurry TBM) was used for the project. A picture of the cutterhead prior to launch as well as a section view of the perimeter detail is provided in Fig. 2. The cutterhead was outfitted with soft-ground tools and disc cutters for the northern Reach 1 section. The slurry TBM has a cutterhead opening ratio of 25 percent. The nominal torque capacity is 4.6 MN-m with breakaway torque capacity of 5.6 MN-m.

Cutterhead torque analytical modeling

Theoretical cutterhead torque ($\hat{T}_t$) on a slurry TBM consists of five components, as conceptualized in Eq. (1). Here, the hat symbol represents theoretical or analytical model-estimated torque as compared to measured torque T_t:

$$\hat{T}_t = \hat{T}_{cut} + \hat{T}_{rim} + \hat{T}_{ff} + \hat{T}_{rf} + \hat{T}_{mix} + \hat{T}_{inert} + \hat{T}_{misc} \quad (1)$$

$\hat{T}_{cut}$ is the cutting torque generated from cutting tool-soil interaction on the front face, including disc cutters, knife bits and scrapers. The mechanics of cutting by disc cutters, knife bits and scrapers is different: for example, rolling force in disc cutters versus shearing/ploughing force in scrapers. Somewhat surprisingly, $\hat{T}_{cut}$ provides only a small fraction of the total cutterhead torque.

$\hat{T}_{rim}$ is the torque generated on the perimeter or rim of the cutterhead, including by the rolling gage cutter interaction with the ground, bucket lip scraping and frictional resistance from the rim-ground interaction itself. Logically, $\hat{T}_{rim}$ would be highly dependent on gage cutter wear, bucket lip wear, and convergence of the ground that itself is a function of the applied slurry face pressure and ground stiffness.

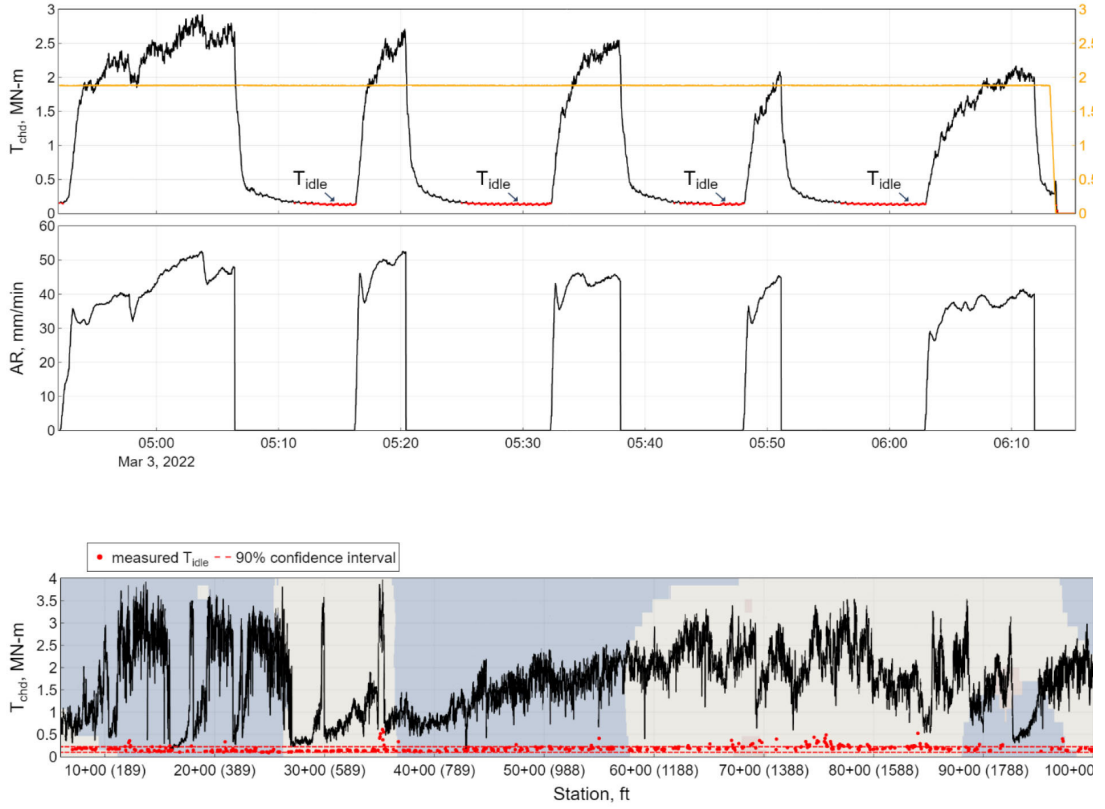
$\hat{T}_{ff}$ and $\hat{T}_{rf}$ reflect the interface friction on the front surface and rear surface of the cutterhead, respectively. The mechanism of $\hat{T}_{ff}$ and $\hat{T}_{rf}$ are similar; however, the cutterhead-slurry interface shear stress and surface roughness are different and hence are treated separately. Further, the front and rear surfaces of the cutterhead are not planar. There are many upsets and recesses that generate resistance when rotated through slurry with cuttings. In this regard, we lump the rotational resistance due to friction, upsets and recesses in a similar way as approached with interface friction between soil and geosynthetics. $\hat{T}_{mix}$ is the torque generated by resistance of rotating the mixing bars and cutterhead support columns through the material in the excavation chamber. $\hat{T}_{inert}$ is the inertia torque and $\hat{T}_{misc}$ reflects the miscellaneous torque due to gearbox friction, motor losses and so on.

While the individual components of $\hat{T}_t$ can be estimated from first principles, we take a data-driven approach here to estimate some terms. During stable excavation with constant cutterhead rotation speed (N_{chd}), $\hat{T}_{inert} = 0$ and during TBM idling, where the penetration rate (PR) = 0 and N_{chd} = constant, $\hat{T}_{cut} = \hat{T}_{inert} = 0$. The resulting idling torque (Eq. (2)) includes multiple components:

$$\hat{T}_{idle} = \hat{T}_{rim} + \hat{T}_{ff} + \hat{T}_{rf} + \hat{T}_{mix} + \hat{T}_{misc} \quad (2)$$

FIGURE 3

(a) Example ring advance where cutterhead is idling and $\hat{T}_{idle}$ can be measured. Note the advance rate (AR) = 0 and cutterhead rotation speed (N_{chd}) = 3 rpm, indicating idling behavior. (b) The evaluation over 10,000 ft showing generally constant $\hat{T}_{idle}$, yet varying and much higher $\hat{T}_t$.



During subsequent excavation where N_{chd}= constant, total torque can be represented as shown in Eq. (3), allowing for the estimation of $\hat{T}_{cut}$:

$$\hat{T}_t = \hat{T}_{cut} + \hat{T}_{idle} \quad (3)$$

The slurry TBM enters into idle mode on a regular basis, at least at the end of each excavation cycle, and often multiple times within an excavation cycle, as shown in Fig. 3a. An assessment of data during idling over rings 103 to 422 showed T_{idle} to range from 0.10 to 0.21 MN-m (90 percent confidence) with an average of 0.13 MN-m. T_{idle} was found to decrease slightly with increasing cutterhead rotation speed, with a data-driven near relationship $T_{idle} = 0.2 - 0.03\ N_{chd}$, where N_{chd} (rpm) varied from 1 to 3.

The cutting torque, T_{cut}, was assessed over a four ring advance section immediately following a cutterhead intervention. This section was used to insure unabated performance where the cutterhead was free from clogged openings and with no appreciably worn cutting tools. Figure 4 shows the measured T_t over the four ring advance section, where N_{chd} was constant. As is evident, T_{cut} is small in magnitude, varying from 45 kN-m at PR = 15 mm/rev to 55 kN-m at PR = 20 mm/rev. The resulting T_t is on the order of 0.2 MN-m for PR = 15–20 mm/rev. This torque response is explainable by the model $\hat{T}_t$. What is evident from the cutterhead torque response conveyed in Fig. 3 is that T_t is considerably greater than the theoretical model that Eq. (2) suggests.

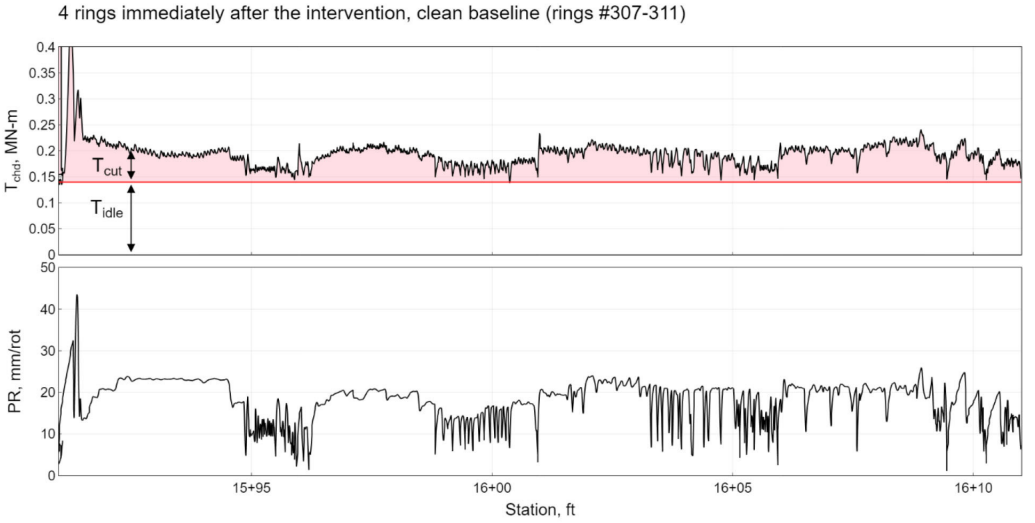
Cutterhead torque machine learning

In an attempt to provide insight into the causes of cutterhead torque that is not predicted by the analytical model, a data-driven machine learning (ML) model was developed. AI machine learning (ML) is a field of study that gives computers the ability to learn without explicitly being programmed. When fed with data, ML algorithms learn patterns from data to either (a) be escriptive to explain what happened, (b) predictive to predict what will happen, or (c) prescriptive to make suggestions about what action to take. In our case, we were interested in ML modeling to be descriptive and prescriptive. While many families of ML algorithms exist, the extreme gradient boosting method (XGBoost) is adopted here. XGBoost builds upon supervised ML, decision trees, ensemble learning and gradient boosting.

A cutterhead torque ML model, referred to here with the symbol $\hat{T}$ was developed using XGBoost. Standard ML modeling practice involves training a model with 80 percent of the available labeled data (input parameters and corresponding cutterhead torque) and validating with the remaining 20 percent of labeled data. Figure 5a shows conceptually the approach adopted in this study.

FIGURE 4

(a) Assessment of T_{cut} from cutterhead torque response during four ring advances immediately following a cutterhead intervention. (b) Penetration rate data during four ring advances.



Data from full ring advances were included in the model; ramp-up and ramp-down data were excluded. The input parameters used to train the $\hat{T}_t$ model are summarized in Table 1. These parameters were selected based on a combination of exploratory analysis (for example, correlation analyses) and engineering judgement (for example, knowledge of TBM-ground interaction mechanics).

One example instance of trained $\hat{T}_t$ model performance is shown in Fig. 5a, where the $\hat{T}_t$ model was trained with 80 percent of ring advances from 700–1900. The results of model validation are shown in Fig. 5b, visually conveying good accuracy and with RMSE = 0.19 MN-m (compared to an average torque of 2 MN-m. The results of model testing over the subsequent ring advances 1901–2040 are shown in Fig. 5c. Here, the RMSE = 0.24 MN-m. $\hat{T}_t$ model prediction is reasonable in general, with many areas of increase and decrease that are predicted well, but with some high torque areas that are underestimated. The soil through which the slurry TBM excavated was included in the model in two ways — namely, the percentage of silty sand or clayey sand

FIGURE 5

(a) Approach used to train the ML model using 80 percent of ring advances for training, 20 percent for validation and a future number of advances for model testing. (b) Validation results of model trained with data from advances 700–1900. (c) Model testing over 140 advances, 1901–2040.

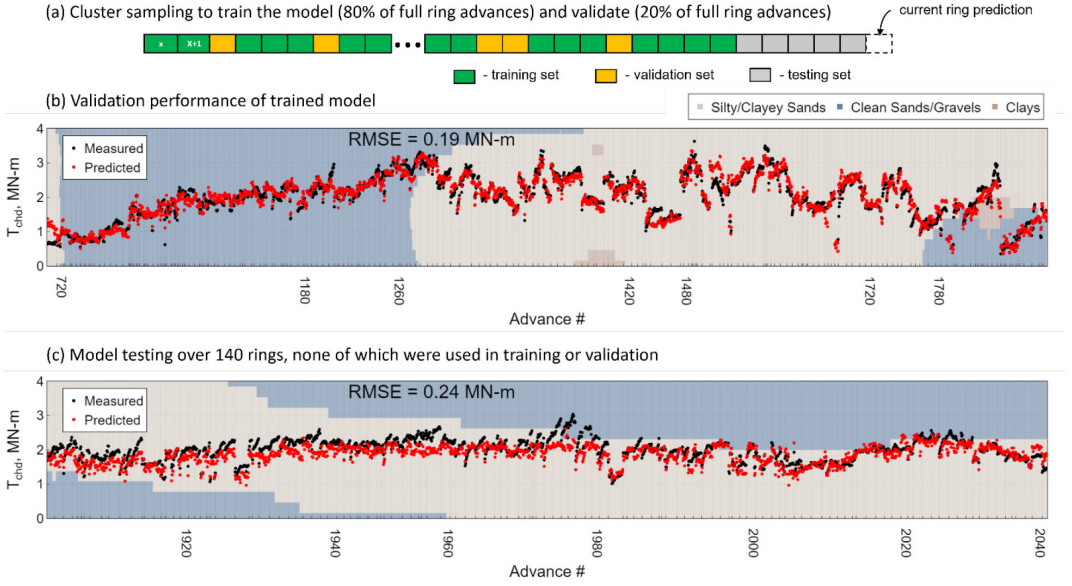


TABLE 1

Summary of ML torque model input parameters and their prediction importance for the $\hat{T}_t$ model trained over advances 700–1900.

Parameter	Importance (MN-M)
F_{chd}	0.37
Fines content	0.18
PR	0.17
P_{ch}	0.07
Proportion of silty/clayey sands	0.05
Feed density	0.04
Other parameters	<0.02

(SM or SC) in the tunnel horizon and the percentage of minus 30 µm fines estimated in the tunnel horizon. The former is based on the geostatistical analysis of borehole data and the latter is estimated from slurry circuit data. The analysis to estimate both of these is not discussed here due to page limitations. As shown in Table 1, fines content and proportion of SM/SC were found to be important parameters.

Figure 6 shows the model-predicted $\hat{T}_t$ versus measured T_t scatterplots from the validated and tested ring advance sets. The RMSE and R^2 values show very good training model performance over the entire 0.4 to 3.6 MN-m range of the measured $\hat{T}_t$. The RMSE and R^2 degrade when the model is compared to the validation data set; however, the model still performs well. When applied to the testing set, the model performance degrades further. Here, the $R^2 = 0.42$ conveys the model is only capturing 42 percent of the variation in the observed torque. In this testing set, the model does not predict the full range and is particularly underestimating when the measured $T_t > 2$ MN-m. It is worth noting that the testing set is essentially predicting ahead of where the TBM has been. If the ground, TBM operating parameters or TBM-ground interaction change, it creates new data that are not in the trained model. A significant limitation of ML models is that they are only as good as the data; they cannot accurately predict beyond the data they were trained with.

Using the trained $\hat{T}_t$ model, contribution plots as shown in Fig. 7 were developed to quantify the influence of each input parameter on cutterhead torque. These contribution plots are created using the Shapley additive explanation (SHAP) framework. Specifically, the framework leverages the concept of Shapley values, a method from cooperative game theory, to assign each feature (input parameter) an importance value for a particular prediction. This is performed by considering all possible combinations of features and their contributions to the prediction. These plots typically show how the SHAP values for each feature contribute to shifting the model output from the base value (the average model output over the dataset) to the actual prediction.

Cutterhead thrust force, F_{chd}, fines content and *PR* have the most significant influence on cutterhead torque. F_{chd} is the longitudinal force between the cutterhead tool face and the ground and is calculated as the measured articulation force minus the chamber pressure force. Horizontal resistance around the cutterhead perimeter is included in F_{chd} and not subtracted because its magnitude is unknown. It is intuitive that $\hat{T}_t$ increases with increasing F_{chd}, analogous to increasing torque when hand drilling through a piece of wood with increased axial thrust force. Specifically for the LAO slurry TBM through the encountered ground, the adoption of $F_{chd} = 2$ MN reduces $\hat{T}_t$ from 1.95 MN-m to less than 1.0 MN-m, while the adoption of $F_{chd} = 10$ MN increases $\hat{T}_t$ to 3.0 MN-m.

Similarly intuitive is the influence of *PR* on $\hat{T}_t$ in that a greater *PR* — that is, bite of the ground — leads to

FIGURE 6

A comparison of ML model-predicted $\hat{T}_t$ versus measured $\hat{T}_t$ for (a) the training set data set that uses 80 percent of ring advances to develop/train the model, (b) validation set data consisting of 20 percent of ring advances held out for independent assessment and (c) forward-looking testing set, in this case involving 140 ring advances ahead of the training zone.

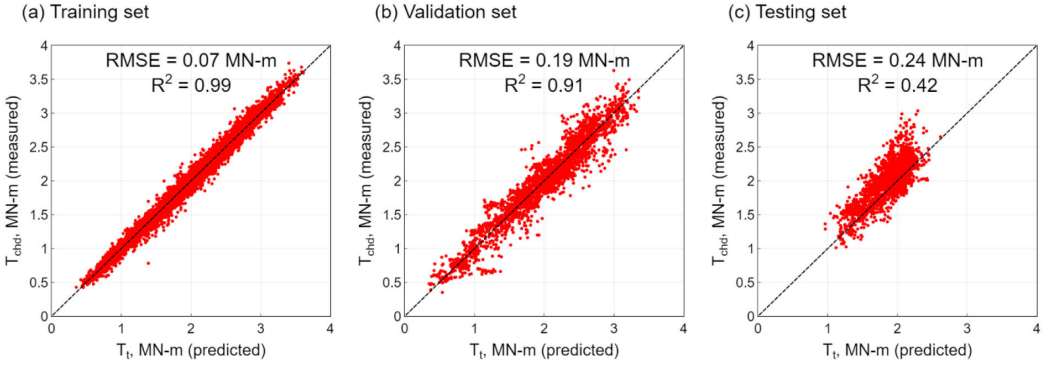
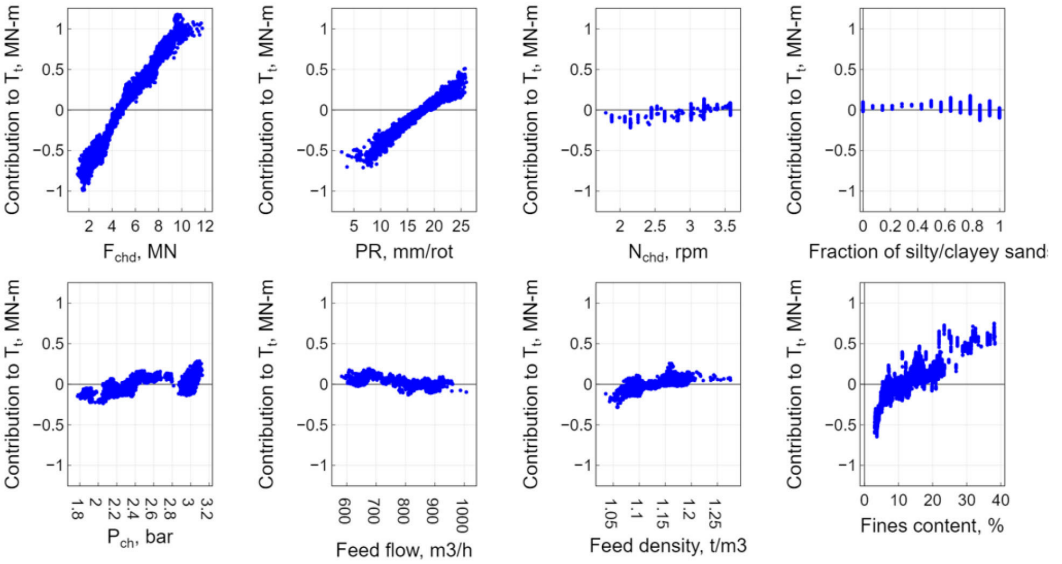


FIGURE 7

An ML model showing the contribution of the most influential input parameters to cutterhead torque. The average contribution is reflected by the importance in Table 1. The average cutterhead torque (zero line) is 1.95 MN-m.



higher $\hat{T}_t$ and vice versa. Of note is that the *PR* influence on $\hat{T}_t$ is less in magnitude than the influence of F_{chd}, at least over the ranges of *PR* and F_{chd} experienced. It is also worth noting that the increase in $\hat{T}_t$ due to increasing *PR* from 15 to 25 mm/rev is not concerning. This is important to note because there is a desire to be productive and 25 mm/rev is a reasonable aspirational *PR*.

Figure 7 also shows the influence of N_{chd}, springline chamber pressure, P_{ch}, feed slurry density and feed slurry flow rate, each of which demonstrates a measurable but lesser influence on $\hat{T}_t$. The increased torque due to increasing N_{chd} is likely related to the higher flow resistance with increasing rotation speed (viscosity) of the slurry. The same logic also explains the feed slurry's contribution to $\hat{T}_t$. A higher-density feed slurry has higher viscosity, and therefore greater torque is required to rotate the cutterhead through this medium. Indirectly, higher-density slurry has lower cuttings carrying capacity. It is likely that this indirectly leaves cuttings in the tool gap that contributes to greater cutterhead torque. A similar logic holds for the feed slurry flow rate.

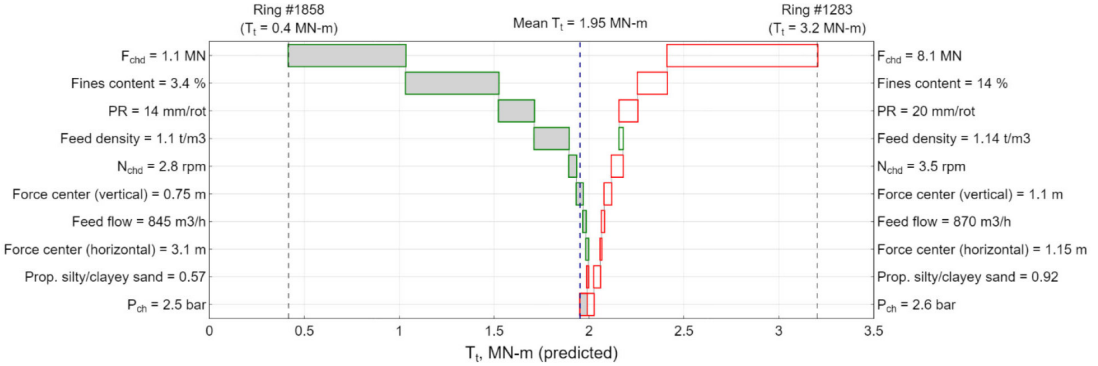
Higher fines content contributed to greater $\hat{T}_t$. Over the 5 to 40 percent fines content observed during this model range, the influence on $\hat{T}_t$ was ±0.5 MN-m. The fraction of SM/SC in the tunneling horizon, compared to the baseline clean sand/gravel comprising the remaining portion of the tunneling envelope.

Discussion

The actual T_t response was found to be considerably greater than that predicted by the analytical model $\hat{T}_t$ most of the time, indicating erroneous assumptions or missed components in the analytical model. The ML cutterhead

FIGURE 8

Example section showing the influence of key input parameters on low and high cutterhead torque.



torque model $\hat{T}_t$ explains instances of very low torque that are predicted correctly by analytical expressions (for example, 0.4 MN-m) as situations when F_{chd}, fines content, *PR* and feed density are very low, as shown in Fig. 8. Higher levels of F_{chd} and to a lesser degree fines content, and *PR* are responsible for $\hat{T}_t$ levels of 3.0 MN-m and larger (Fig. 8). Such magnitudes of F_{chd} and *PR* were used in the analytical expressions but did not predict corresponding high levels of cutterhead torque.

The ML model results provide insight into a plausible reason for the actual mechanism of high T_t. The increasing $\hat{T}_t$ as a function of F_{chd} is amplified beyond what mechanics would suggest. In other words, increasing the normal contact force between the tool face and the ground should not directly cause this level of cutterhead torque increase according to mechanics. However, it is possible that this increased F_{chd} relates to and with material packing in the tool gap that (1) would cause large cutterhead torque increase due to frictional resistance over the entire cutterhead face and (2) is not explicitly captured by analytical models because the tool gap is assumed to be primarily slurry filled. Justification for tool gap packing is evident in Fig. 3a that shows it takes a few minutes of cutterhead rotation without advance to reduce T_t to idling levels. This exponential decay in T_t could be explained by a release of packing due to material flow through the cutterhead openings.

Conclusions

An analysis of slurry TBM cutterhead torque observed during excavation through the soft ground of the Clearwater tunnel project was performed using analytical modeling and AI machine learning. The published analytical mechanics-based models significantly underestimated the observed levels of cutterhead torque. An ML model was trained on the data and performed very well during validation testing, indicating that the key input factors that explain cutterhead torque have been captured.

For the region trained, the ML model analysis revealed that F_{chd}, fines content and *PR* have the greatest overall influence on cutterhead torque.

The chamber pressure, feed slurry density and pro- portion of silty/clayey sands were of measurable but lesser importance/influence. The ML model is able to predict the very low (0.4 MN-m) levels observed sparingly and predicted regularly by the analytical model. A combination of model comparison and review of torque reduction data suggests the cause of elevated cutterhead torque is material packing in the tool gap.

It is worth mentioning that the ML model develops descriptive understanding of cutterhead torque based only on the data provided. If an important parameter that influences cutterhead torque is not measured or not included in the model training, then the model is inaccurate to some degree. Clearly, some important direct parameters at the cutterhead-ground interface are not directly measured. For example, we cannot tease out the perimeter torque from the overall torque. The gage cutter wear was insignificant throughout Reach 1, suggesting this perimeter component to be negligible, but this is secondhand information. We also do not have first-hand knowledge of what occurs within the tool gap, within the cutterhead openings, for example, clogging, and how behavior such as material flow and possible packing varies radially from the cutterhead center to the perimeter. This disclaimer, notwithstanding, like any regression-based analysis, ML modeling does not guarantee that a relationship will be discovered. Because a strong relationship was learned here, the results convey that the most influential parameters are either directly or indirectly related to cutterhead torque. ■

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OneTunnel.org

The Anacostia River Tunnel System in Washington, DC; Construction and performance of one of the world's largest CSO reduction infrastructures

DC Water is implementing the Clean Rivers Project to control combined sewer overflows to district waterways, improving water quality and supporting recreational uses and economic development. In 2018, after seven years of underground tunneling, pump station construction and surface facilities construction, the first phase of DC Water's Clean Rivers program was commissioned. Since 2018, the water quality of the Anacostia River has improved significantly, and the performance of the tunnel system has met expectations. This article will examine the performance of the system and will highlight the benefits of spending $2.9 billion on the large tunnels known as the Blue Plains Tunnel, the Anacostia River Tunnel, the First Street Tunnel and the Northeast Boundary Tunnel. The planning, design and construction of these tunnels and other parts of the DC Clean Rivers system, have been covered in numerous previous papers. This article will look back and review performance and the benefits now being realized in the waters of the District of Columbia.

FIGURE 1

The Anacostia River — a tidal estuary — its inlet is a small stream.



Legacy

The Anacostia River is on the south side of the District of Columbia. It has a relatively low flow rate, with portions of the river subject to backflow during high tides. The main streams that feed the Anacostia discharge into the river at Bladensburg, MD, a location outside the district. The River (estuary) played an important role for the U.S. Navy in the early days of the United States. It was available for shipping in the 1800s (to Bladensburg, MD) and was a key transportation waterway on the south-eastern edge of the District of Columbia when ships were smaller.

John Beesley, Jeffrey Peterson, John Cassidy and Martino Scialpi

John Beesley, member UCA, and Jeffrey Peterson are senior manager, Construction and director, respectively, DC Clean Rivers Project, DC Water, John Cassidy is program manager, Greeley & Hansen and Martino Scialpi is project engineer, Pini Group USA Inc., email jbeesley@dcwater.com.

Pollution has been a problem for many years. Figure 1 shows the river currently. The edges of the river were once wetlands. Portions of the wetlands were filled and developed over time and pollution from numerous sources has plagued the river. A consent decree mandated that DC Water take action to control combined sewage discharges into the river. In addition to combined sewers, there are many sources of pollution to the river. On Oct. 3, 2023, the District of Columbia Attorney General announced another consent decree with an industrial enterprise on the river that requires a $57 million cleanup of Anacostia River contamination it caused.

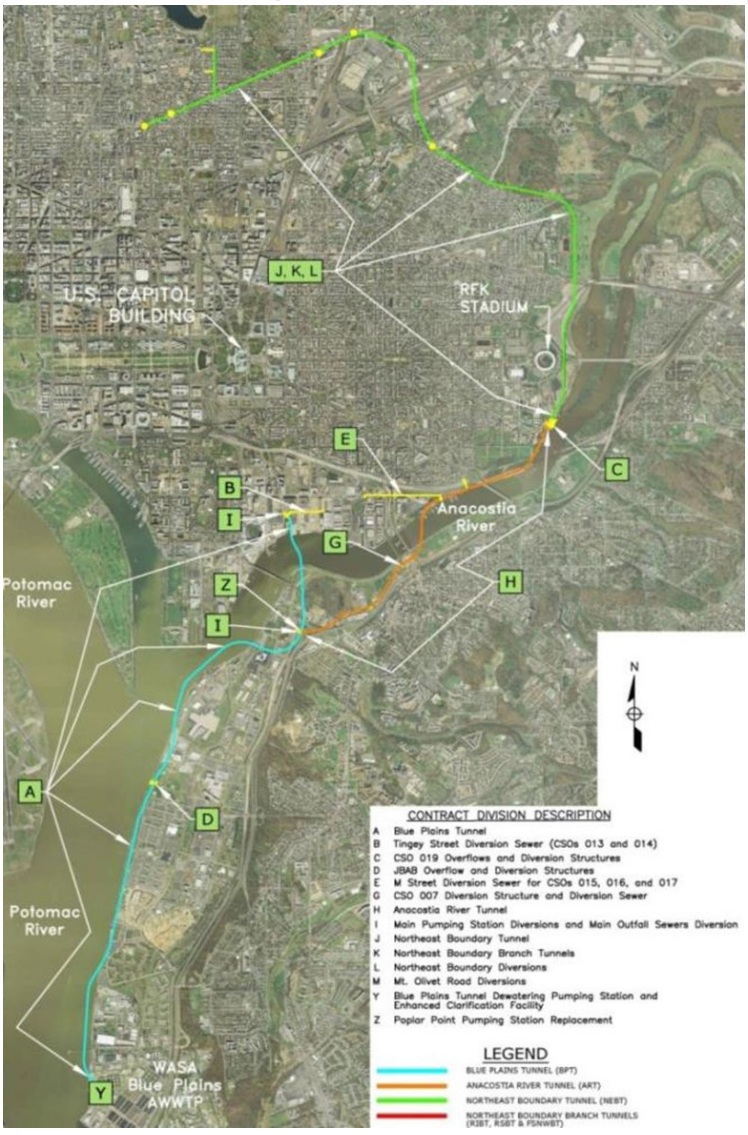
The District of Columbia banned swimming in the Anacostia River in 1971 due to concerns about water quality. Now, there are high expectations that swim days would be announced in the future and that DC residents will once again be allowed to swim in the Anacostia River.

DC Clean Rivers program

There are two primary tunnel systems in the long- term control plan for DC Water that were established to address combined sewer overflows (CSOs) in the district. They are the Potomac River Tunnel System and the Anacostia River Tunnel System. The Anacostia River Tunnel System came first when construction began in 2011. The backbone of the system is a 21-km (13.1-mile) tunnel, 9.7-m (23-ft) inside diameter, that was constructed in three parts. Part one of the backbone tunnel system goes from Blue Plains to Poplar Point. Part two goes from Poplar Point to a site near RFK Stadium. Part three goes from the RFK Stadium site

FIGURE 2

Anacostia River Tunnel System.



to northwest DC at the corner of Rhode Island Avenue and R Steet NW.

Anacostia River Tunnel System. There were two phases to the Anacostia River Tunnel System. The first phase was placed into operation in March 2018. The second and final phase was placed into operation in September 2023. Figure 2 shows the Anacostia River Tunnel System.

The system contains four large tunnels greater than 6 m (20 ft) in diameter, and about a dozen smaller tunnels varying in size from 2 to 3 m (6 to 10 ft). These tunnels all capture and convey combined sewage to DC Water's Blue Plains Advanced Wastewater Treatment Plant (BPAWWTP). The CSO tunnel system is an entirely gravity system until it reaches Blue Plains. At Blue Plains the Tunnel Dewatering Pump Station (TDPS) pumps CSOs to the surface for treatment. The Anacostia River Tunnel System was required to store at least 157 million gallons and be placed in service by March 23, 2025. Now that the system is complete, the actual storage volume is about 190 million gallons, roughly 20 percent more than the U.S. Environmental Protection Agency (EPA) required, and its in-service date was Sept. 15, 2023.

Performance of the Combined Sewer Treatment Facility

Since the original phase one startup in 2018, the tunnel system has prevented over 15 billion gallons of CSOs from flowing into the Anacostia River. Figure 3 shows the volume of sewage that has been captured and treated by the system. This total volume, captured over five years, is approximately the same volume of water that would go over Niagara Falls in about six hours. As noted in the graph, 2018 was the wettest year on record in the District of Columbia, so startup was never affected by waiting for rain events to test the system. The system, so far, has captured approximately 91 percent of CSOs versus a predicted capture rate of 80 percent at the phase one stage of implementation. With the commissioning of phase two, a 98 percent reduction in CSO volume in an average year of rainfall to the Anacostia River is expected.

At Blue Plains, the TDPS station is required to treat all CSO stored volume in the tunnel system within 59 hours of a rain event. The TDPS has a wet-weather capacity of 225 million gal/day (156 kgal/min). The TDPS may discharge flow to either the complete treatment process at Blue Plains or to a 225 million-gal/day wet-weather treatment facility. The wet-weather treatment facility uses a high-rate ballasted flocculation treatment process with disinfection and dechlorination. Flows to complete treatment are first maximized. After flow to the complete treatment system is maximized, the wet-weather treatment facility may be utilized to treat flow captured by the tunnel. The removal of nitrogen from wastewater is providing a large benefit to the Chesapeake Bay by limiting excess nutrients that are normally discharged in treated wastewater. DC Water is exceeding its mandated nitrogen removal limits from the EPA and has removed more than 65 kt (72,000 st) of nitrogen from wastewater since startup of the nitrogen removal facility at Blue Plains.

Trash removal performance. In addition to combined sewage, at the time of this article the tunnel system has captured more than 8.9 kt (9,800 st) of trash since commissioning in March 2018. The trash and floatable material removal success has produced a noticeable benefit to users of the river. DC Water has skimmer boats, shown in Figs. 4 and 5, that have been "skimming" trash

from the river since October 1992. In the five years since Phase one of the tunnel system went into operation, 2018–2022, the skimmer boats have removed 1,713 t (1,915 st) of trash. The tunnel system removed roughly 8,100 st (9,000 st) over the same period, because it is capturing material at the source prior to discharge. With the startup of tunnel system phase two in September 2023, future boats will see even less floatable trash in the river, but they will continue to operate.

The problem with "floatable" trash is well known and there are ways to improve floatable retention. All of the DC Water diversion and capture systems are designed to trap and stop floatable debris from reaching the river. CSO flows that overcome the capacity of the system and flow to the river must flow through stainless-steel-bar screens and/or baffles. The screens stop in-flow debris, plastics and floatables from going to the river. They are designed to be self-cleaning when flows subside and the debris is carried to Blue Plains by receding flows. There are still storm sewers from roadways that are not part of the DC Water system, and they still carry floatable debris to the river, but there has been a noticeable improvement since 2018.

Figure 6 shows the clamshell removal system that is employed to load trucks at the TDPS. With an average truck carrying 22 t (25 st) of trash and solids, hundreds of trucks have left Blue Plains for the local landfill.

Flood mitigation performance. Phase two of the Anacostia River Tunnel System will also mitigate flooding that has occurred regularly in various areas of the district. The first tunnel to be completed and commissioned by DC Water was the First Street Tunnel in 2015. The tunnel played a major role in reducing flooding but was limited since the tunnel was a storage facility, emptied using a pump station. When the Anacostia River Tunnel System was fully commissioned on Sept. 15, 2023, the First Street Pump Station became obsolete. At the time of this article, there has been no severe flooding in the areas where the tunnel is diverting flows that had previously been subject to flooding. Performance of the flood control features has been acceptable, though flooding is always subject to storm intensity. Figure 7 shows a preconstruction flood along First Street NW that obviously shows a situation to be avoided. Since the First Street Tunnel went online in 2015, flood mitigation performance along First Street NW has been successful. Construction of the First Street Tunnel was accelerated due to a severe flood in 2012 that flooded an area at Rhode Island Avenue and First Street NW. Flooding of that magnitude (Fig. 7) has not happened since the First Street Tunnel was commissioned.

The flood control features and work for Clean Rivers was primarily along Rhode Island Avenue NW and NE, and at First Street NW. Figure 8 depicts before and after conditions at First Street NW. It was a challenging, highly urbanized environment that required significant public outreach. The performance of DC Water's outreach team

FIGURE 3

Anacostia River Tunnel System SO capture.

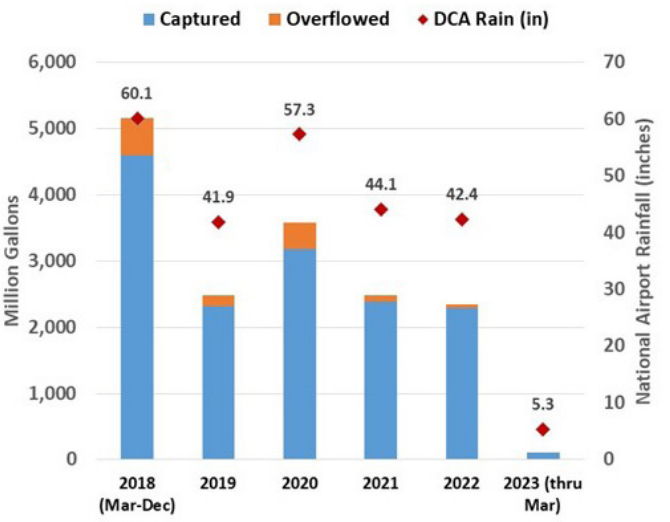


FIGURE 4

Trash in Anacostia River prior to Clean Rivers.



FIGURE 5

DC Water skimmer boats.



FIGURE 6

Trash removal at the Blue Plains TDPS.



helped ensure that the project could be completed without "show-stopping" impacts to a congested community.

Contract and schedule performance. When evaluating the performance of systems, we often only think of physical performance and how the system is operating. Tons of trash removed and millions of gallons treated are key parameters for measuring the project's success. DC Water is also very proud of how the DC Clean Rivers program has performed from a contractual and administrative perspective. Table 1 lists the contracts to date that have been completed for DC Water in executing the long-term control plan.

FIGURE 7

Surface flooding along First Street NW.



Cost. The contract total to date for the Anacostia River Tunnel system is approximately $1.84 billion, and the project was completed on budget. Contract amounts included project contingency allowance amounts that were included in the pre-bid request for proposal (RFP) documents that DC Water determined to be risks to the project and that a had a likelihood of occurring. The amounts were determined based on a quantitative risk assessment performed for each project on the program. The approach using a quantitative risk assessment has been very effective and the vast majority of contracts have been completed at or less than the original contract amount. The program, when considering all contracts through all major phases, was completed on time over the course of 12 years, within budget and ahead of each consent decree milestone. Figure 9 shows the performance of the budget versus expenditures for the Clean Rivers program.

Schedule. The consent decree required that phase one of the Anacostia River Tunnel System be placed in operation by March 23, 2018. That deadline was achieved with a few days to spare, but the program was on time and the first tunnels were placed in operation as required by the EPA. Phase two of the system was required to come online by March 23, 2025. The phase two portions of the system went online Sept. 15, 2023, over a year and a half before the deadline established by the courts. Suffice to say that schedule performance for any project is always a critical component to measure and DC Water is extremely proud to have met this second milestone well ahead of schedule.

A completion celebration for the Anacostia system was held in the District of Columbia on the south shore of Anacostia River Park on Oct. 21, 2023. Attendees at the gathering included officials from the United States Congress, the National Park Service (NPS), the EPA, environmental groups such as the Anacostia Riverkeeper and the Anacostia Watershed Society, and other dignitaries from local and regional governments and organizations. There was a joint feeling of pride among all that this phase of clean-up is complete. More work can be done, and now the focus shifts to the Potomac River side. As a much larger river, the Potomac has been able to fight off the negative influences of pollution much easier than the Anacostia River.

Next phase: The Potomac River Tunnel System

The Potomac River Tunnel (PRT) is the next major phase of the DC Clean Rivers program. The $819 million, design-build PRT project, with notice to proceed issued in November 2023, includes a 8.8-km (5.5-mile), 5.4-m (18-ft) internal diameter, tunnel, seven shafts and two underground connections to existing structures.

The PRT will be a 8,945-m (29,350-ft) CSO tunnel excavated approximately 22 to 45 m (75 to 150 ft) below grade. The tunnel will have an internal diameter of 5.4 m

FIGURE 8

During construction and after along First Street NW.



(18 ft) and a single-pass liner composed of concrete segments with ethylene propylene diene monomer (EPDM) perimeter gaskets. The tunnel will be constructed using a tunnel boring machine (TBM) supported from the mining shaft in West Potomac Park, which is located within the central third of the alignment.

The northern tunnel drive will be entirely in rock, although a short segment of mixed-face conditions may be encountered when the drive passes below a paleo channel. The terminus of the northern tunnel will be at CSO 029, where there is sufficient space to retrieve the TBM. The southern tunnel drive will be advanced through rock, mixed-face, and soft-ground conditions to its terminus in the existing Blue Plains Tunnel and drop shaft located on Joint-Base Anacostia Bolling (JBAB). Specific requirements have been developed for the two different machines needed to complete the project.

Major elements and location. In addition to the tunnel, the PRT project includes the design and construction of four in-line shafts that range in diameter from 12 to 18 m (42 to 60 ft), and in depth from 27 to 54 m (90 to 180 ft). The upper 10 to 60 percent of the in-line shafts will be in soil, while the rest will be excavated through rock using drill-and-blast methods. In-line shafts at the CSO 022,

TABLE 1

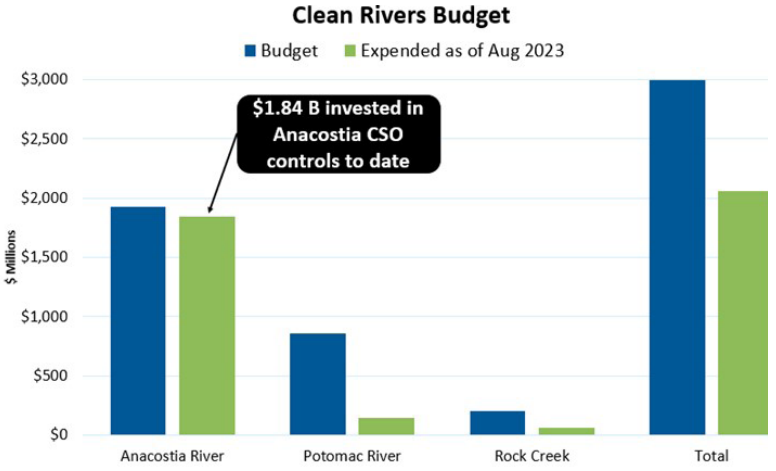
Contracts and contractors for the DC Clean Rivers program.

	Div	Description	Cost (M)	Construction	Design
Design-Build	A	Blue Plains Tunnel	$330	Traylor/Skanska/JayDee	Halcrow
	H	Anacostia River Tunnel	$254	Impregilo/Healy/Parsons	Parsons
	P	First Street Tunnel	$158	Skanska/JayDee	Parsons-Brinckerhoff
	I	Main Pumping Station Diversion	$53	Corman	Parsons
	D	JBAB Outfall and Diversions	$40	Corman	Whitman-Requardt
	J	Northeast Boundary Tunnel	$580	Salini/Impregilo	Brierley Assoc.
	RC-A	GI Contract	$27	Anchor	AKRF/Nitsch
CMAR	B	Tingey Street Diversions	$16	Forest City	CDM
	PR-B	Kennedy Center Shaft/Diversion	$34	Davis Construction	PCO
Design-Bid-Build	W	Blue Plains Demolition	$7	Ulliman-Schutte	PCO
	C	CSO-019 Outfall	$28	Ulliman-Schutte	Whitman-Requardt
	G	CSO-007 Diversion	$5	Skanska/Facchina	PCO
	E	M Street Diversions	$33	Corman	CDM
	Z	Poplar Point Pumping Station	$53	EE Cruz	O'Brien & Gere
	U	Advance Utility Relocation	$17	Fort Myer Construction	PCO & Utilities
	PR-A1	GI Contract	$6	Fort Myer Construction	PCO

**Divisions RC-A and PR-B are not connected to the Anacostia System that was commissioned in 2023.*

FIGURE 9

DC Clean Rivers budget and spending.



CSO 028 and CSO 029 sites include diversion chambers, approach channels, and drop structures to divert water into the tunnel. In addition, in-line shafts at the mining site and CSO 028 include emergency overflows to the Potomac River.

The PRT project includes design and construction of three off-line drop pipe sites and associated vent pipes, diversion chambers and approach channel structures. The new drop and vent pipes at each site vary from 1 to 2.4 m (3 to 8 ft) in diameter and will be connected to the PRT via adits excavated in rock. The PRT project will also include the construction of an adit to the existing drop and vent pipes that were installed as part of a previous contract at the CSO 021 site.

The PRT has been developed as a design-build contract, similar to the approach used on the preceding projects that were part of the Anacostia River Tunnel System.

The design has been developed in coordination with the NPS and numerous other external stakeholders. NPS owns the land at many of the PRT surface construction sites. While NPS is one of the earliest and most involved partners, approvals from the District Department of Transportation (DDOT) and Department of Energy and Environment (DOEE), Washington Metro Area Transit Authority (WMATA) and multiple other federal and local agencies have also been obtained. In parallel, outreach efforts have been made and will continue toward local stakeholders for each site such as the advisory neighborhood commissions, community groups, and adjacent residents and businesses so that potential impacts due to construction can be communicated and mitigated efficiently.

The alignment and major work sites for the PRT are shown in Fig. 10.

FIGURE 10

PRT alignment and location of work sites.



Anticipated performance

There are currently seven large, combined sewers that discharge to the Potomac River, as shown in Fig. 10. Installation of inflatable dams nearly 20 years ago was a quick improvement that reduced CSOs to the Potomac River at some locations.

The inflatable dams maximize the capacity of the sewers and can prevent CSO overflows during minor rain events. However, in an average year the CSO system still discharges to the river approximately 1,063 million gallons of combined sewage during 74 rain events. The PRT is required by the EPA to store 40 million gallons and will convey, via gravity, overflows to the Blue Plains Advanced Wastewater Treatment Plant (BPAWWTP). The expected performance is to reduce the number of overflows on the Potomac to only four per average year, totaling 79 million gallons. The system will begin operation in 2030. ■

UCA updates Tunnel Watch List to elevate the visibility of important tunnel projects

In 2021, the Underground Construction Association (UCA), formed a committee to identify the top 20 tunneling and underground construction projects that will provide sustainable economic and environmental benefit to the communities in which they are built. The Tunnel Watch List is a forward-looking list of tunnels and underground construction projects that are being considered but have not yet secured funding. The goal of the Tunnel Watch List is to elevate the visibility of these important tunnel projects.

Greg Hallett chairs the Tunnel Watch List committee that is publishing the 2024 version in this issue of T&UC. The updated list includes four new projects and removes four others including the $16 billion Gateway Tunnel Project, which has finally begun construction after decades of delays.

In October, the Gateway Development Commission executed a $3.8 billion Federal-State Partnership Grant agreement with the Federal Railroad Administration, completing the $12 billion federal contribution for the Hudson Tunnel Project, a new two-track tunnel that is expected to be completed in 2035.

The Hudson Tunnel Project exemplifies the intentions of the Tunnel Watch List.

"The point of the Tunnel Watch list is to have that list so people can see what projects are out there and are in need of funding," said Hallett "This list will help generate visibility and hopefully we can assist in helping those projects get funding or get public approval that is needed."

All projects are ranked based on

(continued on page 28)

2024 Tunnel Watch List

Project	City	State	Owner	Tunnel use
Last Chance Grade Highway Project	Wilson Creek	CA	California DOT	Highway
Savannah River Crossing	Savannah	GA	Georgia DOT	Transit
Second Avenue Subway – Phase 2	New York City	NY	MTA	Transit
Crenshaw North	Los Angeles	CA	LA Metro	Transit
Sandag Del Mar Tunnel	San Diego	CA	San Diego	Transit
US 64 Corridor K Tunnel	Polk County	TN	Tennessee DOT	Highway
Delta Conveyance	Sacramento	CA	California Department of Water Resources	Water
Sepulveda Transit Corridor Project	Los Angeles	CA	LA Metro	Transit
Red Line Blue Line Connector	Boston	MA	Massachusetts Bay Transit Authority	Transit
Ontario International Airport (ONT) Connector Project	San Bernardino	CA	San Bernardino County Transportation Authority	Transit
Horizon Lateral Project	Las Vegas	NV	Southern Nevada Water Authority	Water
CSO Control Parallel Interceptor	Newark	NJ	Passaic Valley Sewerage Commission	Wastewater
White Pine Pump Storage Hydropower Project	Ely	NV	White Pine Waterpower LLC	Energy
California High Speed Rail	Los Angeles to San Francisco	CA	California HSR Authority	Transit
Steel Bridge Replacement Tunnel	Portland	OR	Tri-County Metropolitan Transportation District of Oregon (TriMet)	Transit
Houston Flood Control Tunnels	Houston	TX	Harris County Flood Control District	Wastewater
West Seattle Extension	Seattle	WA	Sound Transit	Transit
Ballard Extension	Seattle	WA	Sound Transit	Transit
Amtrak Hub – redevelopment	Chicago	IL	Amtrak	Transit
Eastside Transit Corridor – Phase 2	Los Angeles	CA	LA Metro	Transit

Tunnel Watch List: Four new projects added

(continued from page 27)

five criteria and each project is then scored against those criteria to identify tunnels that will provide the most benefit to society. The rankings help the committee determine the importance of each project to the environment and to the people who live in the area in which it will be built.

Among the many benefits tunnels provide are transportation tunnels that can help reduce carbon emissions, and water tunnels that provide freshwater or provide for the storage of wastewater for treatment.

Projects added to the 2024 list include the Last Chance Grade Highway Project in Wilson Creek, CA; the Savannah River Crossing in Savannah, GA; Second Ave. Subway – Phase 2 in New York City, NY; Crenshaw North in Los Angeles, CA and the Sandag Del Mar Tunnel in San Diego, CA. ■

ITA names new executive director

After an international search, the International Tunnelling and Underground Space Association (ITA) is welcoming Helen Roth as its new executive director to steer the ITA's vital work and its programs.

Roth will take the helm as ITA's executive director on Jan. 1, 2025.

Roth, a Norwegian national, will bring a wealth of knowledge and a proven track record in transport infrastructure and organization administration to the position and will join the ITA at a pivotal time for the association and the demands on the global tunneling and underground infrastructure industry.

"Helen's leadership and experience qualities are precisely what the ITA needs to navigate the evolving growth and administration of our association," said ITA president Arnold Dix. "Her proven ability to drive innovation, foster collaboration, and achieve results makes her the ideal steward for our activities and ambitions. We are thrilled to welcome her and excited to chart the way forward with her."

Fluent in English and German and with a knowledge of French and other languages, Roth will oversee the smooth and efficient operation of the association's executive council and the services of its central secretariat to ensure the interconnectivity of the ITA federation of 80 member nations, its committees, working groups and members, and its association with the United Nations and other global partners and collaborators.

"I am eager to embark on this new journey for me and the ITA," said Roth on accepting the position. "The tunneling industry is at the forefront of solving some of the world's most pressing infrastructure challenges, and I am honored to lead an organization that plays such an influential role in shaping a sustainable future for the world."

Roth's transition to the ITA comes after eight successful years as chief executive officer of VIA, a national Norwegian transportation infrastructure network created to facilitate collaboration, entrepreneurship and innovation throughout the value chain for safe, smart and sustainable road solutions, including over bridges and through tunnels — areas where Norway has tremendous global experience and knowhow. Under her leadership, VIA has become a key player in shaping Norway's future transport infrastructure.

Roth joins the ITA at a time of exponential growth in global urbanization and critical demand on infrastructure to meet huge global challenges including the consequences of rapid climate change, the rise of humanity on the move as refugees, and the aspirations to meet the 17 Sustainable Development Goals of the United Nations. Founded in 1974, the work of the ITA today is to support these efforts from an underground solutions perspective and to bring together industry leaders, engineers, contractors and public agencies to address the particular challenges and advantages of the underground environment, providing expertise and knowledge-sharing platforms to benefit communities worldwide. With 80 member nations and members throughout the world, the ITA supports the global effort to create efficient and sustainable infrastructure for the future. ■



Helen Roth

Coming Events

George A. Fox Conference

Jan. 7
New York Marriott Marquis, New York, NY

Meetings Department, SME, phone 800-763-3132, 303-948-4200, fax 303-979-4361, email sme@smenet.org

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TUNNEL NAME	OWNER	LOCATION	STATE	BID YEAR	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	STATUS
Minneapolis Central City Parallel Tunnel	City of Minneapolis	Minneapolis	MN	2024/2025	CSO	4,200	10-19	Final planning
CA High Speed Rail (Northern Section)	CA High Speed Rail Authority	Fresno	CA	2026/2027	Transit	TBD	TBD	Design 1Q 2025
CA High Speed Rail (Southern Section)	CA High Speed Rail Authority	Bakersfield	CA	2026/2027	Transit	TBD	TBD	Design 1Q 2025
Eastside Connection	LACMTA	Los Angeles	CA	2025/2026	Transit	TBD	20	Under design
Potomac River CSO Tunnel	San Bernardino Co. Trans. Authority	San Bernardino	CA	2025	Transit	22,000	24	Under procurement
Alameda Street Wet Weather Conveyance	SFPUC	San Francisco	CA	2024	CSO	3,800	12	Under procurement
The Portal Downtown Extension (DTX)	Tranbay Joint Powers Authority (TJPA)	San Francisco	CA	2025	Transit	3,400	TBD	Shortlist announced
Gateway Manhattan Tunnel	Gateway Development Commission	New York	NY	2024	Rail	2 x 700	varies	Shortlisted firms announced
Gateway Hudson River Tunnel	Gateway Development Commission	Hoboken/ NYC	NJ/NY	2025	Rail	2 x 7,400	25.17	Under final design
Gateway Systems and Fit Out	Gateway Development Commission	Secaucus to NYC	NJ/NY	2026	Rail	2 x 22,000	varies	Under final design
Gateway NJ Surface Alignment	Gateway Development Commission	Secaucus to North Bergen	NJ	2025	Rail	2 x 7,400	N/A	Under design
Gateway Existing Tunnel Rehabilitation	Gateway Development Commission	Union City/ NYC	NJ/NY	2036	Rail	2 x 13,000	varies	Final design completed
2nd Ave. Phase 2	NYS-MTA	New York	NY	2024/25	Subway	16,000	20	On hold
2nd Ave Phase 3	NYS-MTA	New York	NY	2025/26	Transit	89,600	20	On hold
2nd Ave Phase 3& 4	NYC-MTA	New York	NY	2027/29	Subway	varies	20	Under study
Piney Branch Tunnel	DC Water & Sewer	DC	MD	2024	CSO	2,200	18	RFQ May 2024
Three Creeks Tunnel	City of Columbus	Columbus	OH	2027	Sewer	12000	14	Planning
Lower Olentangy Phase 2	City of Columbus	Columbus	OH	2030	CSO	18,000	12	Planning
DELCORA Wastewater Tunnel	DELCORA	Chester	PA	2024	CSO	45,500	13	Under design
Mill Creek Trunk Improvements	City of Nashville	Nashville	TN	2026	CSO	13,800	10	Under design
Nose Hill Project	City of Calgary	Calgary	AB	2024	CSO	10,800	10	Under design
Silver Line Extenstion	Boston Transit Authority	Boston	MA	2024	Transit	8,400	22	Under design
ALCOSAN Ohio River Tunnel #1	Allegheny Co. Sanitary Authority	Pittsburgh	PA	2025	CSO	20,000	18	Under procurement
ALCOSAN Ohio River Tunnel #2	Allegheny Co. Sanitary Authority	Pittsburgh	PA	2025	CSO	5,800	14	Under procurement
ALCOSAN Allegheny River Tunnel	Allegheny Co. Sanitary Authority	Pittsburgh	PA	2028	CSO	33,000	18	Under design
ALCOSAN Monongahela River Tunnel	Allegheny Co. Sanitary Authority	Pittsburgh	PA	2030	CSO	28,000	18	Under design

To have your major tunnel project added to the Tunnel Demand Forecast, or to update information on a listed project, please contact Sanja Zlatanic at szlatanic@hntb.com.

TUNNEL NAME	OWNER	LOCATION	STATE	BID YEAR	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	STATUS
Germantown Winghocking Relief	City of Philadelphia Water	Philadelphia	PA	2025	CSO	28,000	20	Under design
Cemetery Brook Drain Tunnel	City of Manchester	Manchester	NH	2024	CSO	11,600	12	Under design
Project Connect Subway Program	City of Austin	Austin	TX	2025	Transit	8,500	20	Delayed
West Seattle to Ballard Extension	Sound Transit	Seattle	WA	2026	Transit	2,800	18	Under design
Downtown to Ballard Extension	Sound Transit	Seattle	WA	2027/28	Transit	22,500	18	Under design
Del Mar Bluffs Tunnel	SANDAG	San Diego	CA	2025	Rail	TBD	TBD	Under design
Stormwater Control Program	Harris Co. Flood Control District	Houston	TX	2028	CSO	52,800	25-40	Under study
LA Metro Sepulvada Pass Corridor	LACMTA	Los Angeles	CA	2026	Transit	55,000	TBD	LOI received
D2 Subway - 2nd light rail alingment	Dallas Area Rapid Transit	Dallas	TX	2028	Transit	7,230	22	Delayed
Flushing Bay CSO Tunnel	NYC-DEP	New York	NY	2026	CSO	16,500	22	Under study
Schuylkill River Crossing (SRX)	City of Philadelphia (PWD)	Philadelphia	PA	2027	Water	12,000	10	Planning
Cross Harbor Freight Tunnel	NYC Regional Develop. Authority	New York	NY	2028	Rail	25,000	30	Under study
Superconducting Maglev Project -	TNEM/BWRR	Washington	DC	TBD	Rail	146,500	43	Under design
Big Creek Storage Tunnel	NEORSD	Cleveland	OH	2026	CSO	22,450	20	Under design
Metro Tunnel Program - Northern Tunnel Southern Tunnel	MWRA	Boston	MA	 2027 2028	 Water Water	 24,800 53,300	 10 10	 Under design Under design
Horizon Lateral Tunnel	Southern Nevada Water Authority	Las Vegas	NV	2027	Water	42,000	9	Delayed
Stanley Park Water Supply Tunnel	City of Vancouver	Vancouver	BC	2024	Water	5,000	15	Bidding
Fraser River Tunnel	BC Ministry of Transportation	Vancouver	BC	2024	Highway	3,000	TBD	Awarded Bouygues Construction
Taylor Massey Tunnel	City of Toronto	Toronto	ON	2025	CSO	20,000	15	Under study
Quebec City - Levis Tunnel	Quebec Transportation Ministry	Quebec City	QC	2026	Transit	27,300	60	Under design
Queensway Tunnel	Region of Peel	Toronto	ON	2025	Sewer	18,000	9	RFQ Ongoing
West Vaughn Sewage Servicing Project	York Region	Toronto	ON	2024	Sewer	36,000	10	Awaiting award
Yonge North Subway Extension	Toronto Transit Commission	Toronto	ON	2024	Subway	40,000	20	Shortlist announced
Blue Line Extension	Societe de transport de Montreal	Montreal	QC	2024	Transit	19,000	33	Shortlist announced
REM-S Project	Societe de transport de Montreal	Monteal	QC	2024	Transit	23,000	33	Under design

Tunneling & Underground Construction
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Business Profiles

A special advertiser-sponsored advertorial section

December 2024



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makers of **Underground** history

Akkerman Inc....63
Antraquip Corporation....46
BabEng....34
Barnard Construction Co....62
Bradshaw Construction Corp....58
Brookville Equipment Corp....68
CAB....54
CREG TBM Germany....52
Daigh Company....69
David R. Klug & Associates, Inc....60
Drill Tech Drilling & Shoring....66
Envirosystems, LLC....70
Equipment Corp of America....32
Gall Zeidler Consultants....64
Gallovich Consulting....71
Hager-Richter....57
Herrenknecht Tunneling Systems USA....35
Jennmar....50
Keller....38
Kelley Engineered Equipment LLC....67
Kiewit Infrastructure Co....42
MAPEI Corporation....48
Master Builders Solutions....36
Michels Construction, Inc....65
Mining Equipment Ltd....55
Mueser Rutledge Consulting Engineers....69
Naylor Pipe Co....44
Northwest Laborers-Employers Training Trust Fund....61
Putzmeister....39
Sentinel Solutions....59
Terratec....45
Tunnel Radio of America....40
United Rentals Trench Safety....33



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Tunnelsoft, a division of BabEng, brings expert-driven software solutions tailored for tunnel construction. Backed by decades of engineering expertise, our team understands the intricate challenges faced in the tunnel construction industry. At Tunnelsoft, we don't just create software; we deliver solutions tailored to address the real, everyday needs of engineers on-site.



BabEng's skilled engineers bring invaluable insights from the field, allowing us to focus on practical features that simplify complex workflows, enhance safety, and optimize project timelines. By bridging engineering know-how with cutting-edge technology, our Tunnelsoft solutions empower construction teams to work smarter, faster, and with greater precision. Fully compatible with all interfaces and independently of TBM manufacturers, TPC brings unmatched flexibility to your project.

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PIONEERING UNDERGROUND TOGETHER

With the experience of more than 6,700 projects, Herrenknecht is a technology and market leader in the area of mechanized tunnelling technology. Herrenknecht is the only company worldwide to deliver cuttingedge tunnel boring machines for all ground conditions and in all diameters – ranging from 0.10 to 19 meters. The product range includes tailormade machines for traffic, supply and disposal tunnels, technologies for pipeline installation as well as drilling equipment for vertical and inclined shafts and deep drilling rigs.

The Herrenknecht Group achieved a total output of 1,296 million euros in 2023. The independent family-run business employs 5,125 people worldwide, including around 200 trainees. With more than 60 subsidiaries and associated companies working in related fields in Germany and abroad, Herrenknecht is able to provide a comprehensive range of services close to the project site and the customer, quickly and in a targeted way. Under the umbrella of the Herrenknecht Group, a team of innovative specialists offers integrated tunnelling solutions with project specific equipment and service packages upon request: separation plants, belt conveyor systems, navigation systems, rolling stock systems as well as segment moulds and even turnkey segment production plants.

As a reliable project partner, Herrenknecht supports its customers with an extensive range of services from the beginning of the project to breakthrough. From the initial project idea through manufacturing, transport, assembly, tunnelling support and spare parts service to disassembly, Herrenknecht accompanies the process at the customer‘s side. Even personnel solutions for the temporary supplementing of jobsite crews are provided if required. With competent service specialists and more than 45 years of experience in the tunnelling industry, the company regularly supports around 300 jobsites worldwide and offers customized service packages tailored to individual project requirements.

Road, metro, and railway tunnels for efficient traffic network. By the middle of this century, the world´s population is expected to reach nine billion, and two thirds of these people will live in large conurbations. To keep people and goods on the move, the way ahead for new efficient infrastructures is leading underground. With stateoftheart technologies, efficient infrastructures are created exactly where they are needed, even in cramped and complex jobsite conditions. Herrenknecht technology pushes the boundaries of feasibility and creates new tunnelling standards worldwide. Herrenknecht technology extends existing transport networks and creates new connections in urban and rural areas – under mountains or deep beneath water.

Innovative solutions for underground supply and disposal systems. As the world’s population grows the need for underground supply tunnels is also increasing; in emerging and developing countries as well as in modern metropolises. That is why more than 1,000 Herrenknecht Utility Tunnelling Machines are in operation around the world constructing or laying water and wastewater systems, gas and oil pipelines, as well as conduits for electricity and telecommunications. Here, trenchless tunnelling technology offers a range of advantages compared to conventional construction procedures: transport, business and the environment remain mostly undisturbed when Micromachines, HDD rigs or shaft sinking equipment are being used. Innovations such as Direct Pipe® set new standards in the semitrenchless installation. The new technology EPower Pipe® allows the secure and quick installation of underground cable protection pipes with smaller diameters and long advance lengths. Innovative HDD tools simplify pipeline construction operations at key sections. The Herrenknecht product portfolio is completed by a broad range of equipment for the areas of mining (construction of underground infrastructures around raw material deposits) and exploration (oil, gas and geothermal energy).

Herrenknecht Tunnelling Systems USA Inc.
1613 132nd Avenue East, Suite 200
98390 Sumner, WA
USA
Phone +1 (253) 447-2300
pr@herrenknecht.com
www.herrenknecht.com

HERRENKNECHT
Tunnelling Systems

Master Builders Solutions

Master Builders Solutions continues to break new ground in addressing the needs of tunneling professionals and the needs of the industry for carbon reduction. Our Underground Construction team brings a total solutions approach to your projects, providing an added resource to help meet your challenges underground. Our solution-based systems enhance the efficiency and performance of the TBM operations and offer performance-based ground support solutions, from novel soil conditioning technologies to innovative anchoring systems; no matter the tunneling method. Throughout the life of your project, our team of specialists work with all relevant stakeholders to help maximize your production rates and to ensure the most successful product and system selection, including sustainability tools and resources, such as EPDs.

The MasterRoc® product line offers a wide range of solutions for TBM excavation in soft ground and hard rock, with high-performance products including soil conditioners, polymers and anti-clay agents. Our full line of greases and sealants help to maximize efficiency for every excavation method and soil type. Sprayed concrete, Rock Bolt Anchoring systems, Injection and water management systems are also widely considered, selected and used for ground support and enhancement in Tunneling and Mining applications. Master Builders Solutions offers customers innovative product solutions and experienced technical resources to tailor cost-effective solutions to specific project needs. These solutions dramatically improve working environments, production, safety and sustainability.

The Master Builders Solutions product line is designed to be a single source for all your underground construction needs. In addition to the wide range of products and systems, our globally connected team assists our customers in selecting the right systems and combinations, allowing for successful operations, coupled with the highest safety standards. Master Builders Solutions, a world leader in reliable products specifically designed to address the requirements of tunneling projects worldwide with a focus on reducing global warming potential (GWP). Utilizing our global expertise, we are steadfastly focused on the needs of tunneling professionals.

Main Office
23700 Chagrin Blvd
Beachwood, OH 44122 United States of America
Phone: (216) 839-7500
www.master-builders-solutions.com/EN-US



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Keller – The leading geotechnical specialty contractor

Facing challenging subsurface conditions is a familiar scenario for tunneling contractors, and as the leading geotechnical specialty contractor, Keller has provided solutions to these challenges for almost 100 years. Our solutions for tunneling include diaphragm walls, ground freezing, secant piles, dewatering, jet, permeation and compensation grouting, and instrumentation and monitoring.

By connecting global resources and expertise with local knowledge and focus, Keller develops innovative, practical, and cost-effective solutions to geotechnical challenges. Keller builds projects designed by others and offers full design-build services for any geotechnical construction application.

Sector challenges we can solve

- Stabilizing soil for tunneling operations
- Earth retention for break-in and break-out shafts
- Controlling settlement of structures overlying tunneling operations

Contact us today about your next tunneling project.

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www.keller-na.com



Northgate Link Extension, Seattle, WA, ground freezing for groundwater control and support of excavation



DC Clean Rivers Project, Washington, DC: Division A - Blue Plains Tunnel, reinforced concrete slurry diaphragm wall shafts (pictured); and Division I Diversion Structure, jet grouting for underpinning, support of excavation, and groundwater control

PUTZMEISTER – your partner for underground projects

Putzmeister is a worldwide leader in the development and manufacturing of concrete pumping equipment. Applying this knowledge in concrete pumping, Putzmeister has been designing, developing and producing concrete spraying equipment for mines and tunnels for the past 30 years.

What distinguishes Putzmeister's spraying equipment from others is knowledge and control over the main elements, in both design and production. The concrete pump, spraying arm, chassis and control software are developed and produced internally by Putzmeister. With a global vision for the product, Putzmeister creates machines that are perfectly synchronized and aligned with the harsh working conditions and unique needs associated with this industry.

The experience acquired over the years, along with ongoing investments in research and development, has made Putzmeister a leading company in this field of application. While the underground construction industry advances, Putzmeister will continue to offer state-of-the-art equipment while exploring product range expansion in this field.

With an extensive network of after sales service technicians, Putzmeister provides rapid assistance to ensure efficient solutions in any situation, whether it be for commissioning, break down repairs or inspections. Putzmeister also offers a reliable supply of genuine Putzmeister parts and accessories in over 120 countries.



TUNNEL RADIO

Making clear and reliable communication a safety priority

Dangerous situations can occur in any remote, enclosed, or confined space. The ability to access comprehensive stay-in-touch technology is critical in a variety of infrastructure situations, including:

- Maintenance and service tunnels
- Tunnels running beneath dams
- Municipal access tunnels
- Railroad and subway tunnels
- Water mains
- Underground facilities used by government agencies, such as the Department of Defense.

In fact, nearly any tunnel or underground facility can benefit from a wireless communication strategy as part of their safety and risk management profile.

That's where having a dependable partner that you can turn to, one with deep expertise and years of experience in confined-space communications, is key.

Trust the experts

Tunnel Radio of America has distinguished itself as a trusted provider of specialized radiating-cable antennas and 2-Way radio systems. We design, manufacture and install critical communication systems to meet your needs in difficult-to-reach areas, such as dams, mines, tunnels, and basements for federal, state, municipal and industrial clients worldwide.

Tunnel Radio provides RF Communication solutions to construction companies and tunnel owners that work on tunneling and underground projects, that require worker safety and operational efficiency from voice communications, as well as companies that offer services to site locations.

With nearly 40 years of expertise in confined space communications, Tunnel Radio knows firsthand that reliable connectivity and communication isn't just a matter of convenience—it's a critical component of worker safety.

Tunnel Radio communication solutions keep your people connected and in touch in even the most isolated and remote locations of your system. When the harshest environments require the most rugged and reliable equipment, Tunnel Radio has you covered.

www.tunnelradio.com





STAYING CONNECTED IS EVERYTHING...

Especially below the surface.

Jay Murray
541-760-5735
jay.murray@tunnelradio.com

TUNNEL RADIO

Kiewit

OVERVIEW

Kiewit is one of North America's largest and most respected construction and engineering organizations. With our roots dating back to 1884, our employee-owned organization operates through a network of subsidiaries in the United States, Canada, Mexico and Guam. Kiewit offers construction and engineering services in a variety of markets including transportation; oil, gas and chemical; power; building; water; marine; industrial and mining.

OUR COMMITMENT

Kiewit's commitment to safety, quality and environmental stewardship is engrained in everything we do. To us, nothing is more important than the safety of anyone who works on our projects, as well as the neighboring public. Our quality program enables us to design and build work right the first time and focuses on continuous improvement to meet client expectations. And we take our responsibility as good corporate citizens seriously – with the highest regard for environmental stewardship and compliance.

KIEWIT UNDERGROUND

Kiewit, through its tunneling division (Kiewit Underground) has been constructing and engineering some of North America's most complex underground facilities for over 80 years. Our extensive tunneling resume includes a wide range of projects in the markets of water, sewer, transportation, and power transmission. At Kiewit, no job is too big or small; we've constructed and engineered numerous projects from under $1M to over $1B in value, under various contract models.



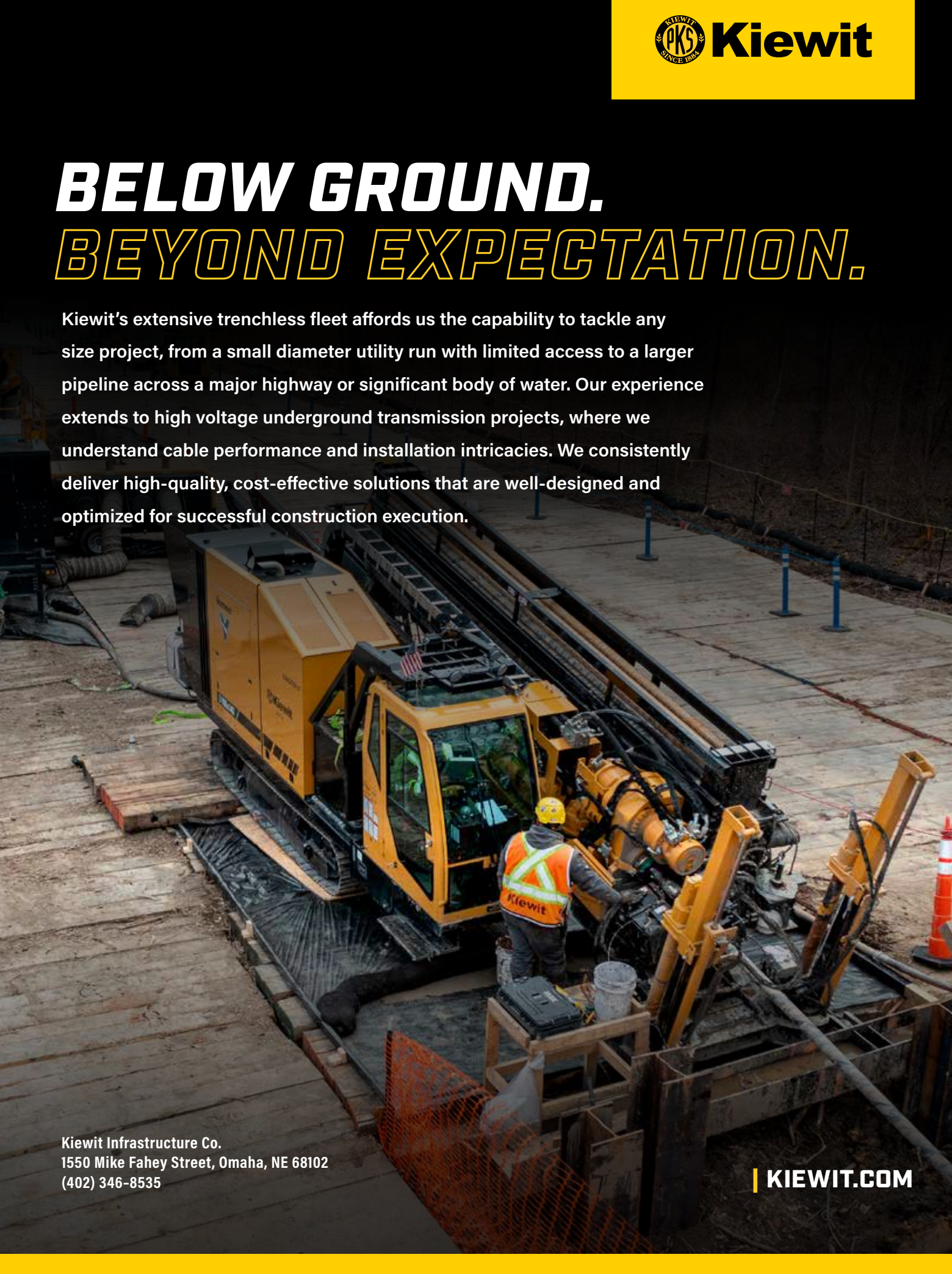
Website: https://kiewit.com/

Address: 1550 Mike Fahey Street, 3rd Floor, Omaha, NE 68102

Kiewit

BELOW GROUND.
BEYOND EXPECTATION.

Kiewit's extensive trenchless fleet affords us the capability to tackle any size project, from a small diameter utility run with limited access to a larger pipeline across a major highway or significant body of water. Our experience extends to high voltage underground transmission projects, where we understand cable performance and installation intricacies. We consistently deliver high-quality, cost-effective solutions that are well-designed and optimized for successful construction execution.



Kiewit Infrastructure Co.
1550 Mike Fahey Street, Omaha, NE 68102
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KIEWIT.COM

Premier Pipe Systems Manufacturer for Over 95 Years

Since 1925, Naylor Pipe Company has been the premier manufacturer of Spiralweld pipe systems.

Naylor Spiralweld is available in diameters from 4" through 96" and wall thickness from 14 Ga. through 1/2" wall. The Spiralweld pipe is complemented with all types of fittings, fabrications to specification, and joint connections, including the exclusive Naylor Wedgelock Coupling, to complete your pipe system.

Naylor Spiral Buttweld pipe features two welds along the spiral seam. This creates a pipe structure in which the weld is as strong or stronger than the parent metal.

The Naylor manufacturing process creates a pipe that maintains an accurate diameter throughout its length. The uniformity of the pipe ends speed connection, whether mechanically coupled or welded.

Uniform wall thickness is assured because tolerances of steel strip are governed by the standards established by the American Iron and Steel Institute. In addition, the pipe is furnished in any required length with a cutting tolerance of plus or minus 1/8". In addition to carbon steel, spiralweld pipe can be formed from many steel grades, including abrasion resistant, weathering (A-588/A-606) and stainless.

Every length of Naylor Pipe is inspected and where required hydrostatically tested to applicable ASTM specifications. The pipe is available in lighter weights than other pipe making it possible



to save money, not only on initial cost, but also in transportation, handling and installation. By sizing the diameter of the pipe to the exact requirements, with exact lengths and factory-sized ends, the greatest economies can be realized.

Quotations are immediately available on inquiry.

Naylor Pipe Company
1230 East 92nd Street
Chicago, IL 60619 USA
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Email: sales@naylorpipe.com
www.naylorpipe.com

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Terratec

Incorporated in 1990, TERRATEC is a world renowned designer & manufacturer of Tunnel Boring Machines, encompassing all ground conditions and diameters – ranging from 0.60 to over 16 metres – as well as TBM back-up equipment, Raise Boring Machines and other custom-engineered products for the tunnelling and mining industries. TERRATEC's success is based on the experience and excellence of its global engineering team. TERRATEC is also fully managed by engineers enabling quick and efficient solutions that meet customer expectations.





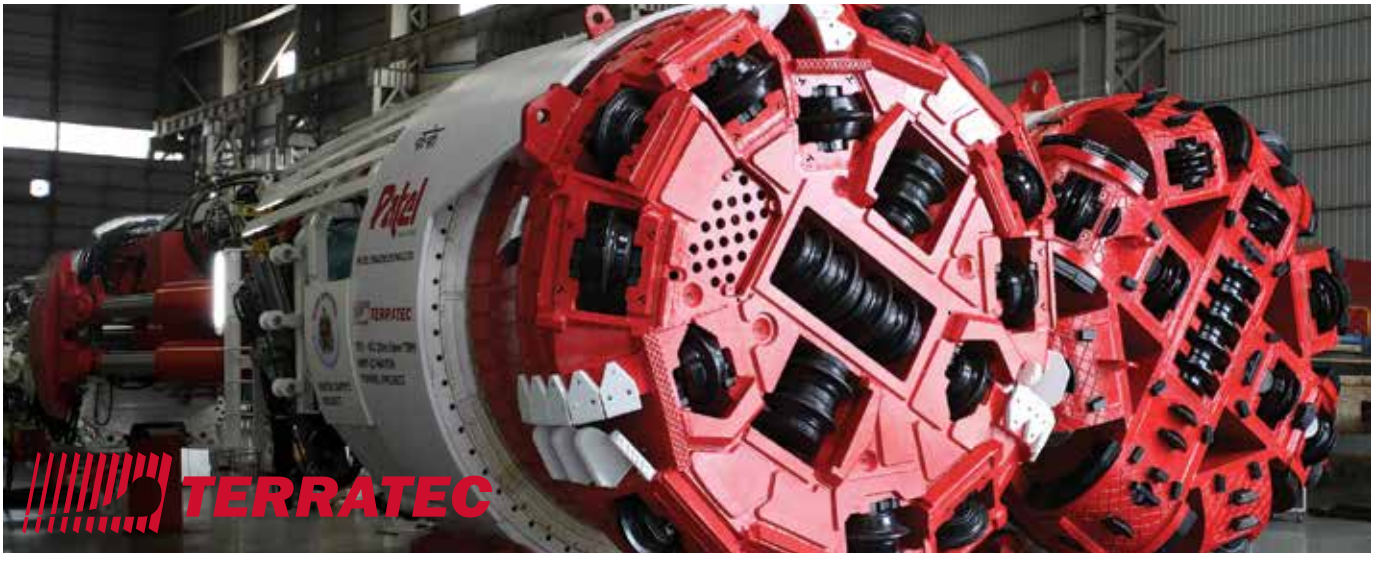
TERRATEC products are well-known in the industry as Robust, Durable and Safe, basic principles that must prevail in the design of any equipment made to work in the extreme conditions encountered underground. As a provider of Total Tunnelling Solutions, TERRATEC's scope of work extends to custom engineering, as well as the operation and maintenance of tunnel boring equipment and the supply of ancillary equipment.

TERRATEC's capacity to provide a wide range of services means that it is not only an equipment supplier but a qualified and experienced partner in the execution of tunnelling works.

As a result, it is becoming more and more common for TERRATEC to supply a Total Tunnelling Solution package consisting of the TBM/s, other main equipment in the tunnel (Trains, Conveyors, Segment Moulds and Ventilation), spares and consumables for the equipment and a team of TERRATEC field personnel who can assist in the operation and maintenance of the supplied equipment throughout the duration of the project.

TERRATEC offers full range of equipment from pipe jacking machine to open TBM, soft ground to very hard rock machine. TERRATEC's continuing success on global projects is a result of tailor-made robust TBM design, prompt onsite assistance, readily available stock of TBM spares and highly-skilled specialised TBM support throughout tunnelling operations.

Company address:
171 Davey Street, Hobart, Tasmania 7000, AUSTRALIA
Company email address:
info@terratec.co
Company telephone number
+ 61 362233282



ANTRAQUIP CORPORATION – your reliable, innovative partner

Antraquip Corporation continues to solidify its position as a leading designer, manufacturer and supplier of roadheaders, hydraulic rock cutting attachments, shaft sinkers, specialty tracked machines with a variety of boom options as well as ground support solutions for NATM tunnels.

Within Antraquip's rock cutting attachment product line, Antraquip has introduced diamond and carbide saw attachments for excavators ranging from 1 to 60 tons.Additionally, Antraquip has designed and manufactures the world's most powerful rock cutting attachment with 400 kW+ cutting power for excavators in the 80+ ton weight class. By continuing to invest heavily into research and development Antraquip strives to be able to cut hard rock which has previously not been possible with mechanized excavation methods.

As to roadheaders, Antraquip offers not only standard roadheaders in the 12 – 85 t on class but is proud to offer project oriented engineering solutions whenever requested and necessary. Some of the recent projects have included AQM roadheaders equipped with customized drilling attachments, fully automated remote control systems and automated guidance systems.

Within its ground control program, Antraquip specializes in any support product needed for NATM as well as drill and blast tunnels like lattice girders, steel ribs, specialized rock bolts, spiles, wire mesh and arch canopy systems (barrel vault system or arch pipe system).

In addition to offering project consultations, innovative cutting and support solutions, Antraquip recognizes the importance of after sales service. This commitment to offering the best service and technical support is carried out by highly proficient and experienced service engineers and technicians, all reinforced with large spare part inventories at hand. Innovation, reliability and experience offered by Antraquip makes them a reliable partner for any tunneling project.

Antraquip's main goal is: SAFETY, SAFETY and again SAFETY! Antraquip continues to strive to offer innovative products to make any job safer, faster and increase the bottom line for any contractor and owner.

Antraquip is well represented all over the world, but takes pride in paying detailed attention to any local tunneling challenge small or large.

IN THE FUTURE, THE WORLD WILL NEED MORE AND MORE TUNNELS – AND ANTRAQUIP INTENDS TO BE AN IMPORTANT, RELIABLE PARTNER FOR ANY UNDERGROUND PROJECT!



AQ6 Hydraulic Cutting Attachment



AQC180 on CAT336



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ANTRAQUIP® CORP

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DRUM CUTTER ATTACHMENTS



ROADHEADERS 13 - 85 TONS





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PROVIDING INNOVATIVE SOLUTIONS FOR TUNNELING, SCALING, TRENCHING, & SOIL REMEDIATION PROJECTS

MAPEI Corporation

MAPEI's Underground Technology Team (UTT) provides the construction market with a range of products dedicated to underground construction work. MAPEI's UTT group and the products it represents were created to meet the expectations of these challenging environments. From the project specification to the admixtures for shotcrete and concrete to the final protective coatings, MAPEI's UTT group and technology are there "for the whole job," said Cristina Onate, PhD, UTT Business Development Manager — Tunneling.

The UTT group is a successful division of MAPEI Group, which has provided proven construction system solutions for more than 80 years. Established in 1937, MAPEI Group is a global corporation, based in Milan, Italy, and with 91 subsidiaries that include 84 plants in 35 nations. MAPEI is the world-leading manufacturer of mortars, grouts and adhesives, as well as complementary products for installing floor and wall coverings. MAPEI manufactures chemical products for building, including waterproofing products, admixtures for concrete and repair products, and decorative and protective exterior coatings — as well as the UTT product line.



MAPEI's UTT products were used to help a tunnel boring machine dig the Anacostia River Tunnel, which extends for 2.37 miles from Robert F. Kennedy Stadium in northeast Washington, D.C., to Poplar Point in southeast D.C.

"The UTT group started in earnest in the U.S. in 2015," stated James Pinkley, Country Manager UTT – North America. "But the business has grown substantially since then." In the underground industry, speed is essential – not only of the products themselves, but also of the evolution of technology. MAPEI reinvests a considerable percentage of its annual profits back into research and development to maintain a leading technological advantage. MAPEI's commitment to R&D ensures that the UTT line comprises the most innovative and technologically advanced products available. In addition to the latest in cutting-edge products, the UTT team is trained in their use, with decades of experience in the underground marketplace.

The UTT product line is divided into six categories: Mechanized Tunneling; Injections for Heavy Civil and Mining Applications; Waterproofing & Water Membranes; Shotcrete Products; Renovation, maintenance and repair; and Coatings for underground construction. No matter the division or the product line, MAPEI is known for quality products and for providing system solutions. As Pinkley stated, "The distinguishing point for UTT is our field support, and our applied technology in the field. Simply put, we don't just sell a product, but rather we go into the field and help our customers use our products – on their jobsite, with their conditions, personnel and equipment. MAPEI UTT services a project from the very beginning to the very end like no one else in the industry does," he said. "UTT also has the agility to adjust to the customers' needs when necessary per the demands of changing geological settings"

For more information, contact MAPEI's UTT group at www.utt.mapei.com.





YOUR DURABLE TUNNELING PARTNER.



Underground works have unique characteristics that can be different in every project. This is why the MAPEI UTT team stands side by side with the professionals in the tunneling and mining industries, offering not only quality and environmentally friendly products, but also consistent technical services. **For every product, there's a team at your service.**

Learn more at
utt.mapei.com
hq.utt@utt.mapei.com

utt
MAPEI

Jennmar

We are a diversified manufacturer and services provider for above and below ground infrastructure that sets standards in terms of quality and safety for our stakeholders. Our mission is total customer support and satisfaction.

Our portfolio of brands is rebuilding America's infrastructure. We understand the ever-changing and demanding conditions above and below ground. That's why we've built the richest portfolio of diverse and complementary brands. From engineering to resin manufacturing, rolled-steel and drill-steel manufacturing, custom steel fabrication, precision wear parts, tools and bits, chemical roof support and sealing products, staffing solutions, transportation, and more - we ensure the customer has support at every stage of their projects. Visit our diverse portfolio of brands at www.jennmar.com.

JENNMAR continues to grow, but our focus will always be on the customer. This commitment to our clients is exemplified through the recent acquisition of DSI Tunneling in Louisville, KY. DSI Tunneling, a long-time competitor with a rich history in providing mining and tunneling products, has now been rebranded as JENNMAR Specialty of Louisville. This marks a significant expansion in our offerings to the civil and tunneling markets across the US and Canada.

This strategic acquisition follows a century-long legacy for the Louisville Operation in the manufacturing and supply of mining and tunneling support products. This operation expands our footprint and manufacturing capacity to support the tunneling industry across North America and beyond. DSI Tunneling brings not just an additional operational facility but also a wealth of industry expertise, technical sales staff, and structural and geotechnical engineers.

Our commitment remains strong to our customers and is guided by three words: SAFETY, SERVICE, and INNOVATION. It's who we are.

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MINING • INFRASTRUCTURE • MANUFACTURING

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Pittsburgh, PA 15238
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SAFETY, SERVICE, AND INNOVATION



DEMANDING CONDITIONS DEMAND JENNMAR

JENNMAR has been the innovative leader in ground control for the mining industry for more than forty years. Over the past decade, our growth has led us to structural support in tunneling and civil construction projects, implementing the same vigor and detailed processes. Because we understand the ever changing and demanding conditions above and below ground we have built the richest portfolio of diverse and complementary brands.

JENNMAR sets the bar in every industry we serve and as we continue to grow, our focus will always be on the customer. Our products are made in the U.S.A. and backed by experienced engineers and technicians who are with you every step of the way, from initial consultation to qualified instruction and on-going technical support. We support and are dedicated to rebuilding infrastructure worldwide.

JENNMAR

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XCAL

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CREG Underground Solutions

WIRTH

CREG

MAKE TUNNELLING BETTER, FASTER AND SAFER.

With projects in the EU, Asia and all around the world, CREG has established itself as one of the leading TBM suppliers for innovative TBMs tailored and suited to the complex and challenging geology of each project and contractors.

CREG TBM Germany GmbH based in Düsseldorf, Germany, manages projects from the starting phase all the way until the breakthrough ensuring the satisfaction of the customers.

All main construction companies in the world hire CREG for our high-level service and our ability to create, design and provide new equipment for them. Because we base our efforts on meticulous research of innovative solutions for the tunnelling market, we've contributed to excavate over 100 Km of tunnel worldwide only over the past two years.
The TBMs provided by CREG ensure the safety of the personnel, efficiency and success of the project in European countries. We have supplied various TBMs for the Lonato tunnel, Kühtai Tunnel (Austria); Cefalu Tunnel, Paris Line 16.2 tunnel, Copenhagen Metro, Swinoujscie Tunnel, Hamburg Fernwärm Tunnel, as well as a large number of other TBMs, which are in manufacturing.

Just recently our TBMs have successfully finished the first tunnel in Paris, Poland, Copenhagen, Dubai and Doha where our TBM has succeeded in breaking through, ensuring a convenient daily life for the people of the countries and a well-connected infrastructure. There are many more projects in the planning phase and many more to come, executing our mission of "better, faster and safer tunneling".







Willstätterstr. 15,
40549 Düsseldorf
Germany
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CREG

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Water Diversion Inclined Shaft Project

CREG

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With over 1,500 Tunnel Boring Machines (TBMs) manufactured, CREG TBM GERMANY GmbH is at the forefront of tunnelling innovation.

Our machines have conquered challenging terrains, from soft to hard rock, with diameters ranging from 3 to 15 meters.

Driven by a international team based in Germany, we provide comprehensive solutions that include Roadheaders and Drilling Jumbos, ensuring your projects succeed from start to finish.

MAKE TUNNELLING BETTER, FASTER AND SAFER.

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Terratec

Incorporated in 1990, TERRATEC is a world renowned designer & manufacturer of Tunnel Boring Machines, encompassing all ground conditions and diameters – ranging from 0.60 to over 16 metres – as well as TBM back-up equipment, Raise Boring Machines and other custom-engineered products for the tunnelling and mining industries. TERRATEC's success is based on the experience and excellence of its global engineering team. TERRATEC is also fully managed by engineers enabling quick and efficient solutions that meet customer expectations.





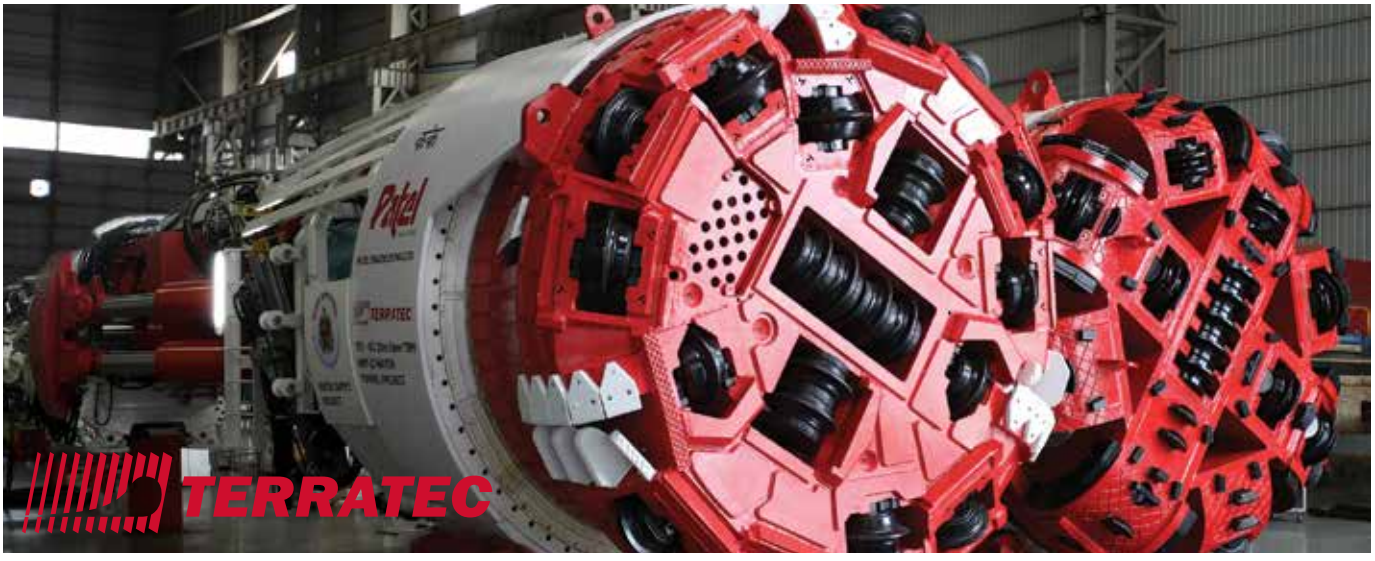
TERRATEC products are well-known in the industry as Robust, Durable and Safe, basic principles that must prevail in the design of any equipment made to work in the extreme conditions encountered underground. As a provider of Total Tunnelling Solutions, TERRATEC's scope of work extends to custom engineering, as well as the operation and maintenance of tunnel boring equipment and the supply of ancillary equipment.

TERRATEC's capacity to provide a wide range of services means that it is not only an equipment supplier but a qualified and experienced partner in the execution of tunnelling works.

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TERRATEC offers full range of equipment from pipe jacking machine to open TBM, soft ground to very hard rock machine. TERRATEC's continuing success on global projects is a result of tailor-made robust TBM design, prompt onsite assistance, readily available stock of TBM spares and highly-skilled specialised TBM support throughout tunnelling operations.

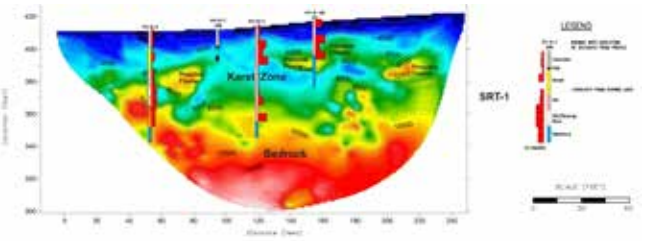
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Sentinel Solutions

UCA 2022 Project of the Year Award

The Underground Construction Association (UCA) awarded the Bergen Point Southwest Outfall Replacement project in Suffolk County, NY with the 2022 Project of the Year Award at the North American Tunneling Conference award ceremony in June of 2022 ($50-$500 million). This award is presented to an individual or group "that has shown insight and understanding of underground construction in a significant project, which may include practices, developing concepts, theories, or technologies to overcome unusual problems within a project, resulting in little to no outstanding issues." – **CDM Smith**

"This 2.6-mile-long outfall replacement tunnel. The project team overcame slurry challenges created by the sandy and clay soils along the alignment". – **UCA Awards Video**

"Sentinel provided exceptional soil control as well as cost saving measures during the Bergen Point Outfall Tunnel Project. Their centrifuge equipment, engineering and analytical process was a tremendous benefit to the projects schedule and overall success." – **Jim Gray, Wastewater Division Manager – Posillico Inc. from team OHLA USA/Posillico/SELI Overseas USA**

"Our capabilities relative to drilling fluid engineering, solids control and the dewatering of spent fluids was an excellent match to the Bergen Point project. The team on the ground was very receptive to our suggestions and we were able increase production while simultaneously reduced disposal costs to virtually nothing." – **Chuck Skillman, Operations Manager – Sentinel Solutions "Got Muck…Call Chuck!"**



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David R. Klug & Associates, Inc.

Since 1996, David R. Klug & Associates, Inc. has provided international and national manufacturer's representative services to the underground heavy civil and mine construction industries. The company specializes in the sale and coordination of specialty products, equipment and services for soft ground, conventional and NATM/SEM tunneling practices. Expertise is offered in the supply of various componentry used in the manufacture of one pass precast segmental tunnel linings inclusive of EPDM gaskets, plastic and steel connectors, grout lifting assemblies and precision steel segment casting moulds plus final lining forming systems for C-I-P final lining applications. Through their distribution company, Klug Construction Systems, LLC offers Nittetsu ultrafine cement, GFRP rock bolts and soft-eyes, steel and synthetic fiber reinforcement, prefabricated welded wire fabric and rebar reinforcing panels, and specialty grout systems for various tunnel backfill grout requirements for highway, rail, subway, water and CSO tunnel construction applications.

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Northwest Laborers-Employers Training Trust – Safety and Hazard Awareness for Tunnels (SHAFT) program

The Safety and Hazard Awareness for Tunnels (SHAFT) program, developed by the Northwest Laborers-Employers Training Trust with input from a team of industry experts and stakeholders, is comprised of a blend of classroom discussion and interactive use of materials and mockups.

The curriculum offers comprehensive safety training for both new and experienced tunnel professionals; classes focus on tunnel safety, rail, and utilities.

The training facility, located in Elma, Washington, features a TBM mockup, rail, and access to 1,400' of 12' diameter tunnel – providing students with a unique educational experience.

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Whether we're tunneling through the mountains of northern British Columbia or below the streets of downtown San Francisco, our people arrive at projects determined to do the best for their communities and be the best in the industry. We self-perform heavy civil and underground construction including TBM tunneling, drill and blast, and sequential excavation methods. Our work also encompasses power transmission, dams and reservoirs, pipelines, and environmental construction. We have built our reputation on skill, innovation, reliability, safety, and our ability to complete projects on budget and ahead of schedule.

This work has been conducted under a wide range of contracts, including one of the first Progressive Design-Build tunnel projects in the US, the Silicon Valley Clean Water Gravity Pipeline Project in Redwood City, California. On the Lake Mead Low Lake Level Pumping Station Project, a CMAR contract for Southern Nevada Water Authority, our project team was onboard from the Early Contractor Involvement phase and through construction. Our teams stick with projects from start to finish, serving on a bid team and then heading into design or directly to the field to construct the project they've bid. We live where we work and know our projects personally. We build for People.

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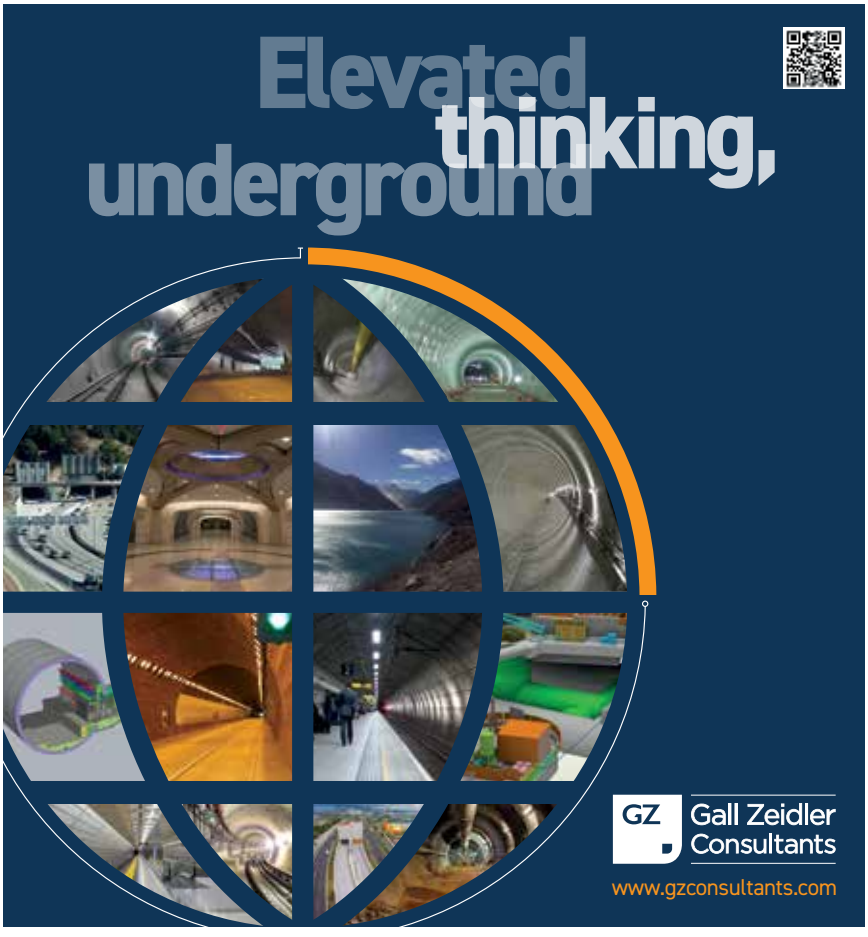
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On the Barrick Range Front Declines, DTM&T has almost completed over 18,000 feet of twin declines almost six months ahead of schedule. Rock conditions varied in strength along the decline and while the contract was initiated using Roadheader excavation methods, DTM&T has utilized both drill & blast and roadheader techniques to overcome these varied rock strengths. Throughout the execution of the work, DTM&T focused on building a safe project ahead of schedule that met the quality expectations of Barrick. Drill Tech's efforts were recognized by Barrick and additional work was issued to Drill Tech's contract.

In addition to the twin declines, DTM&T performed contract work for other contractors on the project site that included Mass Excavation of 129,314 CY of rock and the application of 15,995 CY of shotcrete. During the course of these projects, DTM&T has performed safely for 814 days.

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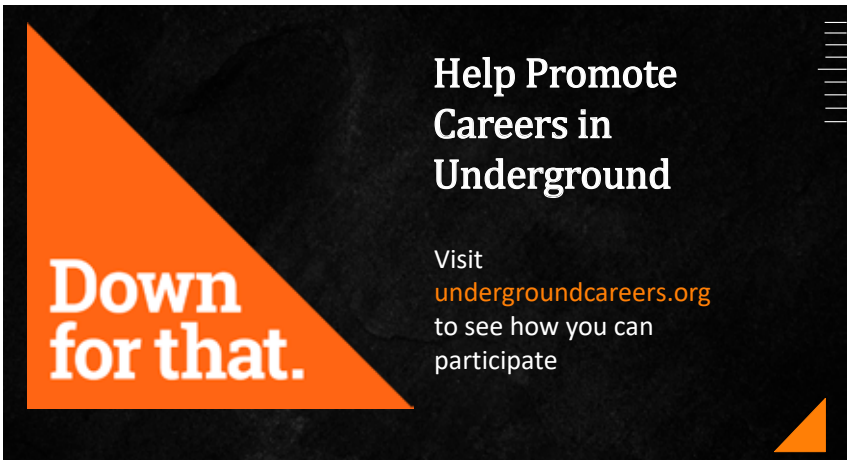


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Brookville Equipment Corporation (BROOKVILLE) recently shipped three 27-ton MSHA-permissible tunneling locomotives to the Walsh-Shea Corridor Constructors for use on the Crenshaw/LAX Transit Corridor Tunnel Project in Los Angeles. By design, the locomotives reduce the risk of explosion due to geological conditions that may host the presence of methane and other combustible gases. Cal-OSHA has classified the tunnel drives on this project "gassy", mandating the use of MSHA permissible locomotives.

The 27-ton locomotives' special safety features include air start, an enclosed engine block, an exhaust filtration system, wiring and piping guards, and an intake flame arrestor, among other upgrades, to fully comply with MSHA's permissibility requirements. Featuring an 8.3L Cummins six-cylinder diesel engine and four-speed transmission, the 185-horsepower locomotives operate on 36-inch rail gauge underground for Walsh-Shea Corridor Constructors.

"BROOKVILLE was selected based on past performance, simplicity of operation and diagnostics, their ability to communicate locally with MSHA, and knowing we would be dealing with the good people of Brookville, PA, U.S.A," said Walsh-Shea Corridor Constructors Tunnel Construction Manager David Girard, P.E.

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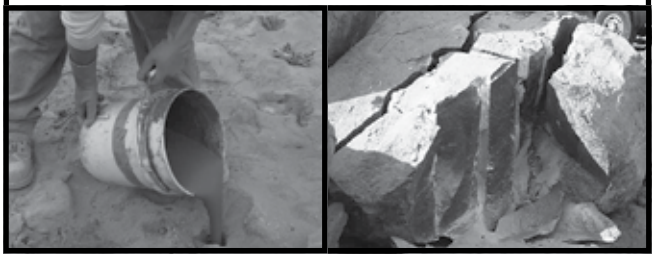
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Current tunneling projects include design of shaft support of excavation (SOE) in soil and rock for the Narragansett Bay Commission's Pawtucket Tunnel, a 1.5-mile long CSO tunnel; ground freezing of overburden soils to provide SOE for construction of two deep, large diameter shafts that will connect to the New York City Water Tunnel No. 3; and (SOE) design for the East Bound Re-Route Construction for the LIRR East Side Access project. Other projects include the Charleston SC Fishburne Drainage Improvements Outfall and Pump Station, MD 355 Crossing in Bethesda for WMATA's NIH Medical Center station; the CSX Virginia Avenue Tunnel, VDOT Midtown Tunnel, DC Water's Blue Plains and First Street Tunnels; PSE&G Crossing #2 - Southern Reinforcement Project in Newark NJ; Toronto Subway Yonge-Eglinton Station, and New York City's NYCT Canarsie Tunnel, NYCT 2nd Avenue Subway, and the DEP Catskills and Delaware Aqueduct Rondout-West Branch Tunnel and Brooklyn to Staten Island Harbor Siphon Tunnel.

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Ad Index

Tunneling & Underground Construction
Delve..... 06
Dr. Mole..... 08
Geoform..... 05
Herrenknecht.....Inside front cover
Keller.....Outside back cover
Terratec..... 03

UCA Underground Construction Association
A Division of SME
UCA RETC..... 09
UCA DFT..... 29
UCA George Fox Conference..... 07
UCA Career Center.....Inside back cover

Business Profiles

Akkerman Inc. 63
Antraquip Corporation..... 46
BabEng..... 34
Barnard Construction Co 62
Bradshaw Construction Corp..... 58
Brookville Equipment Corp. 68
CAB 54
CREG TBM Germany 52
Daigh Company..... 69
David R. Klug & Associates, Inc. 60
Drill Tech Drilling & Shoring 66
Envirosystems, LLC..... 70
Equipment Corp of America..... 32
Gall Zeidler Consultants..... 64
Gallovich Consulting 71
Hager-Richter 57
Herrenknecht Tunneling Systems USA 35
Jennmar..... 50
Keller 38
Kelley Engineered Equipment LLC..... 67
Kiewit Infrastructure Co..... 42
MAPEI Corporation 48
Master Builders Solutions 36
Michels Construction, Inc..... 65
Mining Equipment Ltd 55
Mueser Rutledge Consulting Engineers ... 69
Naylor Pipe Co 44
Northwest Laborers-Employers Training Trust Fund..... 61
Putzmeister 39
Sentinel Solutions..... 59
Terratec..... 45
Tunnel Radio of America 40
United Rentals Trench Safety..... 33

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