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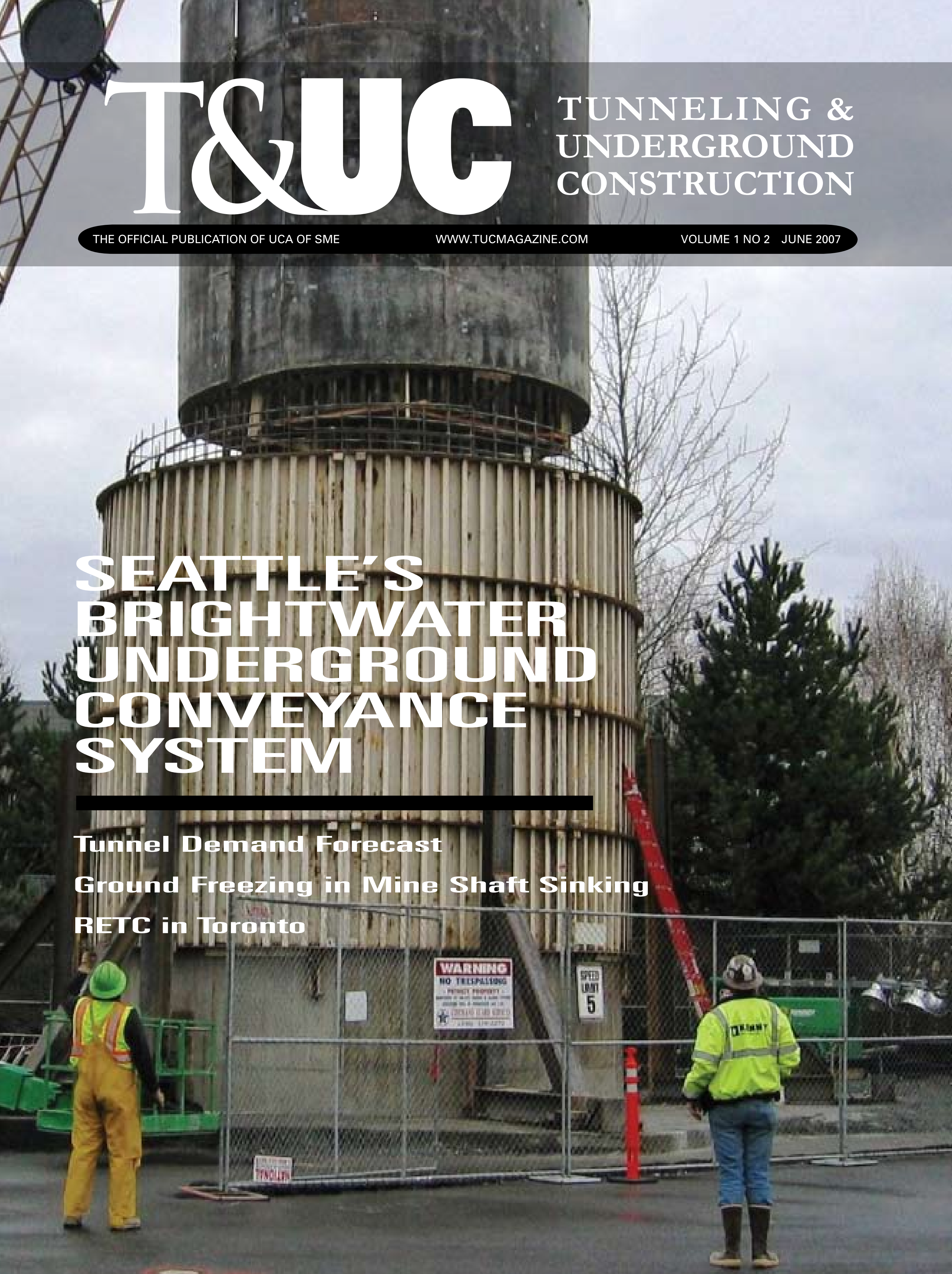
TUNNELING & UNDERGROUND CONSTRUCTION

THE OFFICIAL PUBLICATION OF UCA OF SME   WWW.TUCMAGAZINE.COM   VOLUME 1 NO 2   JUNE 2007



SEATTLE'S BRIGHTWATER UNDERGROUND CONVEYANCE SYSTEM

Tunnel Demand Forecast

Ground Freezing in Mine Shaft Sinking

RETC in Toronto

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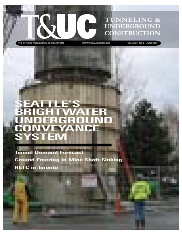

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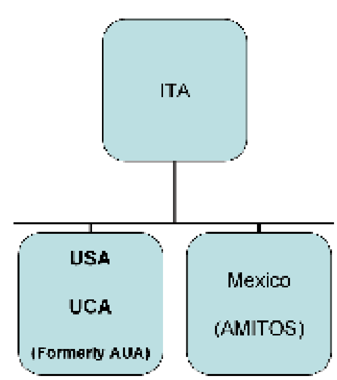

DEPARTMENTS

CHAIRMAN'S COLUMN

UCA on track for better things

This is my final Chairman's Column after two years as the first chair of the Underground Construction Association (UCA) of SME.

As I look back on these last two years, I have a sense of major happenings and changes. I presided over the dissolution of the old AUA and the creation of the organization to replace it, the UCA of SME. In addition, we are moving forward to champion the use of underground space throughout the United States and, in conjunction with the International Tunneling Association (ITA), throughout the world.

These have been demanding times and times of great promise. Some of the major accomplishments included the development of bylaws for the new organization. The balance and structure of board members is now fixed. And the rotation of board members and officers is in place.

At the June Rapid Excavation and Tunneling Conference (RETC) board meeting in Toronto, Ontario, I will turn over the office of chair to my successor, Brenda Bohlke-Myers. Her successor, Dave Klug, is also in place for an orderly transition two years from now as chairman-elect. The board's rotation is similarly in place so that we are assured of a steady progression of new talent and energy.

I would like to take this opportunity to thank SME for stepping up to the plate and enabling this new organization to develop and grow. I would also like to thank the board members for their support and encouragement throughout the startup and shakeout of the UCA of SME. And finally, I want to thank you, the members, who have stood by the transition stage. You have a great organization and I encourage you to be active and involved.

I have just returned from the ITA World Congress in Prague and have written a separate article describing that experience (see page 00). I hope you enjoy it.

I now pass the reins of a new, solid organization to a competent and capable new chair. I know that the coming years will be filled with exciting opportunities. Thank you for your continuous support.

Tom Peyton,
UCA of SME Chairman

ARTICLE SUBMISSION: The editors of *Tunneling & Underground Construction* welcome proposed feature material, as well as underground construction industry news items, and news concerning the UCA of SME and its members. Send proposed items to Steve Kral, editor, e-mail kral@smenet.org, phone 303-948-4245; or William M. Gleason, associate editor, e-mail gleason@smenet.org, phone 303-948-4234. Also, UCA of SME members are encouraged to submit projects to the online Tunnel Demand Forecast. Go to www.smenet.org, log in as a member. Click on UCA of SME and then click Tunnel Demand Forecast. The items will be posted on the online TDF once they are verified.

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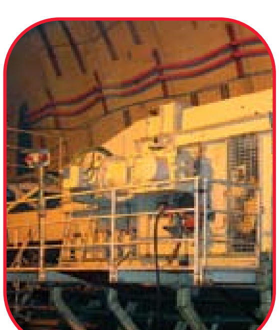

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Lovat breaks through at Olympic sites in Vancouver and London

With offices in Canada and England, it is appropriate that Lovat will have a hand in preparing those cities for the Olympic Games that they will host.

On April 4, a Lovat tunnel boring machine (TBM) in London broke through on a project to move power lines underground in advance of the 2012 Summer Games. Three days later Lovat had another breakthrough when one of its TBM's did the same in Vancouver, B.C.

The 3.2-km (2-mile) stretch of a tunnel that will carry power lines underneath London's 2012 Olympic Park was completed April 4, 2007. That tunnel is part of one of two 9.6-km (6-mile) tunnels that will be used in place of 52 pylons that will be removed from the east London skyline in Lower Lea Valley. The tunnels will enable the power needed for the games, and the future, to be carried underground. Four such tunnel stretches are due to be completed in 2007.

Lovat built two 4.15-m-(13.6-ft-) diameter tunnel boring machines. Moving in opposite directions underneath Stratford, East London, the machines bored the tunnels to divert National Grid power lines, while a pair of 2.82-m-(9.25-ft-) diameter TBMs did the same for EDF Energy power lines. One of each TBMs broke through in April.

The completed tunnels will be buried as deep as 30.5 m (100 ft) below ground and will be complete with their own rail tracks. Each tunnel will be lined with 11,000 concrete rings, and will be fitted with 12.9 km (8 miles) of cables and sophisticated ventilation during the next year.

The tunnels will free up more than 40 hm^2 (100 acres) of land, where the 2012 Olympic Village main stadium and other sports arenas will be.

Four tailor-made Lovat TBMs from Canada will remove 250,000 m^3 (8.8 million cu ft) of soil, enough to fill about 1,000 Olympic swimming pools. About 90 percent will be reused on the site.

The contractor on the GB$80 million project is Murphy, with Faber Maunsell as consulting engineer and Arup the Olympic Delivery Authority's (ODA) checking engineer.

The geology of the project is variable. It quickly moves from hard clays to very soft silts and muds. And crews have been working under three bar pressure for most of the drive. This variability forced the contractor to constantly change the additives it used to condition and stabilize the ground. By the time the Olympic flag is handed to London at the end of the 2008 Beijing Games, organizers want the 2012 site to be ready for construction to start.

Canada Line breakthrough in Vancouver

A Lovat TBM is also being used in Vancouver, British Columbia, Canada in preparation for the 2010 Winter Olympic Games by the joint venture of SNC-Lavalin Constructors Pacific and SELI.

The Canada Line rapid transit project will be a 19-km (12-mile) project that will link the city's international airport with its downtown center.

On April 7, the Lovat TBM reached a crucial milestone when it broke ground north of Pender at Granville Street. That is the future site of the new line's Waterfront station.

The breakthrough signifies the completion of the first of two tunnels to run beneath downtown Vancouver. The 6.1-m- (20-ft-) diameter EPB machine completed a 2.45-km (1.5-mile) drive through sandstone and glacial and interglacial deposits in a little more than nine months.

That section of the project had to work through difficult ground conditions including sandstones and boulders, while also executing tight curves through an urban area.

The TBM was disassembled and moved to the Second Avenue work site near False Creek in preparation for construction of the line's second tunnel. It is expected to be completed in the spring of 2008.

The TBM, the first ever used in British Columbia, was launched in June 2007 and traveled at a rate of 10 m/d (33 ft/day).

"This is an important breakthrough for us all," said Canadian Premier Gordon Campbell. "The city, the region and the province will all benefit. It shows the power of partnership in opening the Pacific Gateway while we reduce greenhouse gas emissions and stimulate economic growth. Compact and healthy urban development helps make public transit work and it's estimated that this one project will reduce greenhouse gas emissions by 12.7 kt (14,000 st) by 2021."

About 10,000 prefabricated concrete lining segments were used to make the tunnel walls. The tunnel is 5.3 m (17.4 ft) in internal diameter and varies in depth between 10 and 30 m (33 and 98 ft).

The project will include 16 stations, two bridges, more than 9 km (5.6 miles) of tunnel, parking and bus facilities and transit capacity equivalent to 10 road lanes. The Canada Line will be an important new link in the regional transportation network.

Lovat has specialized in custom design and manufacture of TBMs since 1972. The company was founded and is run by the Lovat family. It currently enjoys international success with 106 active projects around the world. ■

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Dulles Corridor Project to proceed without a tunnel at Tyson's Corner

The Dulles Corridor Metrorail Project moved forward after Virginia transportation officials announced an agreement with a construction consortium to begin construction of the extension of Washington D.C.'s Metro rail line to Dulles Airport without a tunnel at Tysons Corner. The announcement might have been a fatal blow to a group that was fighting to include a tunnel in the first phase of the project.

On March 30, the Virginia Department of Rail and Public Transportation said it would enter a $1.6-billion design-build contract for Phase 1 with Dulles Transit Partners, a joint venture of Bechtel and Washington Group International. Phase 1 consists of 18.6 km (11.6 miles) and an elevated line through the Tyson's Corner area.

A group of northern Virginia area residents and businesses fought to have the line enter the area by tunnel. That debate delayed the start of the $4.1-billion project by six months to a year.

Tysons Corner Center currently features more than 300 stores and restaurants with extensive expansion plans to coincide with the arrival of the rail. Those expansions could include 99,109 m^3 (3.5 million cu ft) of development. Work on the first phase of that project could begin in 2008 and be completed by 2012, when the Metrorail's extension arrives.

Scott Monett is the head of a group of businesses and residents that backed a tunnel.

In an April 13 letter posted at the Web site www.Tysonstunnel.org, Monett pledged to continue

DULLES, Continued on page 10

Metrorail expansion expected to increase by 91,000 people a day

DULLES, Continued from page 8

the fight for a competitive bid tunnel despite the March 30 ruling.

Tunnel supporters argued that building the line below-ground would cost no more, and possibly less than the elevated line. And a tunnel would help make Tysons Corner into a vibrant, walkable downtown.

The Dulles Corridor is home to several of the Washington D.C. metropolitan region's most dynamic and rapidly growing activity centers.

The extension, when completed, will provide an integration with the current 171-km (106-mile) Metrorail system and its 86 stations to relieve congestion in the area. Something that is needed in the area.

A study found that the average northern Virginia commuter spends the equivalent of nine working days a year stuck in traffic. It also found that five of the eight major corridor roadways are expected to be gridlocked by 2010 and that in the next 20 years, employment in the corridor will increase 63 percent while population and travel demand will each increase by 45 percent.

According to the Metropolitan Washington Council of Governments Cooperative Forecasts, in the next 25 years northern Virginia is expected to gain nearly 700,000 more people and jobs and as many as 300,000 new homes. By 2025 it is estimated that there will be 100,000 jobs within a half mile of the Metrorail stations. Dulles Airport will serve more than 55 million annual passengers. Tysons Corner is expected to provide more than 127,000 jobs.

The Metrorail extension's daily ridership is expected to be more than 91,000 people by 2025.

Phase 1 will run from the East Falls Church area to the western edge of Reston. It will feature five stations along the 18.6-km (11.6-mile) stretch. The project completion date is 2012.

The average height of the track will be 10.9 m (35.7 ft). Current plans call for 640 m (2,100 ft) of tunnel if the project decides not to tunnel into Tysons Corner. The deepest tunnel point will be 18 m (60 ft).

The estimated cost for the first phase is $2.1 billion.

The second phase of the project will feature six stations and 18.5 km (11.5 miles) of extension. It will continue the line to Route 772 in Loudoun County.

The second phase is expected to be completed in 2015 with direct access to the terminal at Dulles Airport.

The estimated cost of the second phase is $2 billion.

Overall funding is being shared at the federal, state and local levels. Marcia McAllister, communications manager of the Dulles Corridor Metrorail Project, Virginia Department of Rail and Public Transportation, said the Full Funding Grant Agreement from the Federal Transportation Authority is expected in November or December of 2007. ■

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URS JV selected for California high-speed rail contracts

The California High-Speed Rail Authority awarded two contracts to URS Corp., through a joint venture with Hatch Mott MacDonald, and Arup, to provide engineering and environmental services for the proposed California high-speed rail system.

Under the terms of the first contract, the joint venture will provide preliminary engineering services and environmental analysis for a proposed 311-km (193-mile) segment running from Fresno to Palmdale. This six-year contract has a value of $120 million to the joint venture, and a maximum value of $41 million to URS.

Under the second contract, the joint venture will provide similar services for a proposed 98-km (61-mile) segment of the rail line running from Los Angeles to Palmdale. This six-year contract has a value to the joint venture of $75 million, with a maximum value of $21 million to URS.

"We are delighted to have been selected by the California High-Speed Rail Authority to play an important role on two segments of the high-speed rail system," said URS Division president Gary V. Jandegian. "The rail line, which will be similar to European high-speed train systems, will be the first of its kind in the United States and provide significant benefits to travelers and long distance commuters in California. Few firms have the breadth of experience and professional talent required to undertake such an assignment. We look forward to helping the state successfully complete this groundbreaking transportation system."

When completed, the California high-speed rail system will allow passengers to travel from San Fran-

URS, Continued on page 14

California moves forward on first high-speed rail system in U.S.

URS, Continued from page 12

cisco to Los Angeles in just under two-and-a-half hours on trains traveling up to 354 km/h (220 mph). Travelers throughout California will be able to enjoy the benefits of this system, which is designed to connect with existing rail, air and highway systems.

The California High-Speed Rail Authority (Authority) is the state entity responsible for planning, constructing and operating a high-speed train system serving California's major metropolitan areas.

The Authority has a nine-member policy board and a small core staff. All environmental, planning and engineering work is performed by private firms under contract with the Authority.

With the certification of the statewide final program-level environmental impact report (EIR)/ environmental impact statement (EIS) in November 2005, the Authority has begun implementation of more than 1,126-km (700-miles) high-speed train system serving Sacramento, the San Francisco Bay Area, the Central Valley, Los Angeles, the Inland Empire, Orange County and San Diego.

The system is forecast to potentially carry more 100 million passengers per year by 2030.

The 2006-2007 enacted state budget provides $14.3 million "to begin project implementation." The funding is supporting the preparation of a project financial plan, project management activities, identification of critical rights-of-way acquisitions and the initiation of detailed project design and related environmental studies. However, bond funding for the project must still be authorized by voters in 2008 (AB 713's enactment in 2006 has delayed the $10 billion high-speed rail bond measure from November 2006 to November 2008).

Smooth transitions and grades of less than three percent will assure a comfortable and safe ride at high speeds. Mountainous and hilly areas often will require viaducts and tunnels, Also, in areas with many consecutive at-grade road crossings or freight railroad sidings, viaducts and tunnels may be used to separate the high-speed line, rather than building numerous bridges over the line.

URS offers a comprehensive range of professional planning and design, systems engineering and technical assistance, program and construction management, and operations and maintenance services for transportation, facilities, environmental, water/wastewater, industrial infrastructure and process, homeland security, installations and logistics, and defense systems. The company is headquartered in San Francisco and operates in more than 20 countries with approximately 29,300.

Hatch Mott MacDonald is a full service engineering and construction management firm, specializing in transit and tunneling. Hatch Mott has more than 50 years experience and combined international resources of 16,000 employees. Hatch worked on many high-speed rail and tunneling projects, including the Taiwan High-Speed Rail and the Channel Tunnel Rail.

Arup is a world leader in the design of high-speed rail systems, including the Channel Tunnel Rail Link and high-speed rail stations in Lille, France and Florence, Italy. ■


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San Vicente pipeline project progressing

The joint venture of Traylor Bros. and J.F. Shea won the bid for the San Vicente pipeline project in California in 2005 and has progressed well since.

When completed, the 2.6-m (8.5-ft) diameter pipeline will connect an existing aqueduct, feeding San Diego County, to the San Vicente Reservoir. The system will provide additional storage during wet periods and another water source during dry periods or when the main aqueduct suffers a catastrophe, such as an earthquake.

Using a 3.5-m (11.5-ft) refurbished Robbins tunnel boring machine (TBM), the joint venture of Traylor/Shea began boring on June 21, 2006.

Multiple tunnel methods were chosen. Two open face shields, equipped with excavator arms and replaceable road header type attachments, have been used to mine the conglomerates.

The 18-km (11-mile) San Vicente pipeline will be a large-diameter pipeline connecting the San Vicente Reservoir in Lakeside to the Water Authority's second aqueduct west of Interstate 15. The pipeline will be built in a tunnel at a depth ranging from 15 to 183 m (50 to 600 ft) underground and will not pass directly under any homes. Tunneling will enable the Water Authority to build the pipeline with fewer impacts to land surfaces and the surrounding communities. To provide water during emergencies, the San Vicente pipeline will function together with other Water Authority facilities and connecting pipelines near the reservoir.

The portal, Slaughterhouse shaft and Central shaft have been completed. The West shaft has reached the bottom of excavation, and a 122-m (400-ft) starter tunnel has begun. Reach 5 excavation is proceeding from the Slaughterhouse shaft, with approximately 244 m (800 ft) to the east and 122 m (400 ft) to the west complete.

The west terminus is a shaft 31 m (100 ft) deep. The east terminus is a portal, and two additional shafts are in between, with depths of around 23 m (75 ft). Depth of tunnel varies according to the surface topography. But it can be as great as 183 m (600 ft). The tunnel encounters varying geology, ranging from extremely hard granitic rock near the ends to loosely cemented conglomerate in between. Some of the conglomerate may also be tightly cemented. The water table is below the tunnel for approximately half its length, at the "peaked" middle section of the alignment.

"The San Vicente pipeline projects are key components of the Water Authority's emergency storage project and are important investments in the future reliability of San Diego County's water supply."

The San Vicente pipeline projects are key components of the Water Authority's emergency storage project and are important investments in the future reliability of San Diego County's water supply. The emergency storage project will protect San Diego County by increasing the amount of water available for use during emergencies.

Four access points will be used to dig the San Vicente pipeline tunnel and to install the pipe. Work at these sites will include inserting and extracting the tunnel boring machines; removing excavated materials from the tunnel; circulating air; and delivering equipment, liner segments, pipe sections and concrete. ■

Work on Australia's longest road tunnel gets an early start

Tunneling work on the 6.8-km (4.2-mile) Brisbane, Australia RiverCity Motorway project began two months early when Wirth delivered the first of six roadheader tunneling machines in February.

Early delivery of Wirth roadheaders helped workers get a jumpstart on the RiverCity Motorway.

The RiverCity Motorway will be longest road tunnel in Australia. It will include 4.8 km (3 miles) of dual twin lane tunnels with a total length of 10.4 km (16.7 miles) tunneled, including on ramps.

Difficult drilling conditions, an ambitious schedule and complex customer requirements makes the tunnel construction project in the inner city of Brisbane a real challenge.

Wirth will supply two tunnel boring machines (TBM's) and six road headers for the project that will eventually remove 3.5 Mt (3.85 million st) of dirt.

Brisbane is an economic metropolis in the easternmost part of Australia and capital of the state of Queensland. The city is expanding its urban road network. The RiverCity Motorway is the new central traffic artery. It includes a double, two-lane tunnel tube with a diameter of 12.4 m (41 ft) and a length of 4.8 km (3 miles).

Working in hard rock, four heavy Wirth T3.20 roadheaders are being used to drill the entrance and exit sections of the tunnel in Woolloongabba and Kangaroo Point as well as a ventilation tunnel. The machines will also be used for drilling the initial section of the main tunnel in Bowen Hill. They are equipped with transverse cutter heads and each weigh more than 120 t (132 st). The main tunnel of the RiverCity Motorway will be driven by two tunnel boring machines.

In addition to the difficult geological conditions, the project's location is directly in the center of a major city with more than a million inhabitants. So it was necessary to satisfy a host of complex customer options in a very short time.

To reduce the assembly time on site, the machines were shipped from Europe almost completely assembled. Only the cutter boom, belt conveyor and operator cabin have been dismounted, still leaving a machine weight of 95 t (105 st) to be transported.

The order was awarded at the end of July 2006. The first two machines have already been shipped in February 2007 and have been in operation since April of this year. The other two T3.20's arrived in Brisbane at the end of April in order to successfully continue what is currently the largest road tunnel construction project in Australia. ■

Great things expected for '07 RETC in Toronto

On June 10-13, the 2007 Rapid Excavation and Tunneling Conference (RETC) sponsored by SME will open at the Sheraton Center in Toronto, Canada. In 2005, the last year of the RETC, more than 1,400 people and 110 exhibitors attended in Seattle, WA. A capacity 125 exhibitors have commited to the 2007 four-day show.

Harjit Dhillon, joint venture manager of Aecon Constructors, is the scheduled featured speaker at the welcoming luncheon. He will discuss his part in the Nathpa Jharki hydroelectric project in northern India. That was a $640-million Aecon-sponsored joint venture.

Harjit was in charge of many of Aecon's large and complex joint venture projects, with special emphasis on hyrdoelectric developments and their related underground civil construction works.

He will discuss Aecon's experience in tunneling in the Himalayas and the unique challenges faced during the project.

The 1,500 -W Nathpa Jhakri Hydroelectric Power Project is located in the remote northern area of India. The project was implemented by Satluj Vidyut Nigam Limited (SVJN).

National Hockey League Hall of Famer and former Toronto Maple Leaf center Darryl Sitter is scheduled to be the featured speaker at the RETC dinner. He will focus on the

issues of development of coaching as a leadership skill, the influence of great management in maximizing performance and maintenance of great teams.

Technical programs topics include: design and planning of underground projects; difficult ground conditions; focus on Canada; pressurized face tunneling; geotechnical and ground improvements; innovations in underground construction; new and future projects; underground project case studies; sequential excavation methods; TBM case studies; tunnel lining technology; mega projects; rock tunneling project case studies; shafts and open cut – design and construction and tunnel and shaft rehabilitation.

The conference will include a special program — Better Contracting for Underground Construction Manual. And a short course — Mechanical Hard Rock and Soft Ground Tunneling Technologies.

Available field trips include chances to visit the Nickel Rim South Project: Surface and Underground Infrastructure Tour. Niagara Tunnel Project and York Region YDSS

Proceedings from the RETC conference are available from SME. Contact the SME Customer Service Department, 8307 Shaffer Parkway, Littleton, CO 80127, phone 800-763-3123, 303-973-9550, fax 303-973-3845, e-mail sme@smenet.org, Web site www.smenet.org. ■

Beijing tunnel collapse raises safety fears

Four workers were killed in a tunnel collapse in Beijing, China in April. It was the third major accident on the same subway line in 13 months. The deaths raised concerns about the safety of Beijing's huge building boom that is being pushed by the 2008 Olympic Games.

The collapse buried six migrant workers. And there is evidence of an apparent coverup following the accident.

Local police detained 10 people because of the incident, including the work supervisor and tunnel designers. But the labor contractor was believed to have fled, according to *Xinhua* news agency, the government's official news service.

Olympic officials in Beijing say the subway project is not directly related to the 2008 games. But the line is part of a massive citywide construction boom to prepare for the event to showcase the city and China.

Authorities are spending close to $40 billion for a citywide expansion tied to the Games.

Beijing's Olympic construction is ahead of schedule. A major portion of Olympic-related facilities are targeted for completion by the end of this year.

The relatively poor working conditions of migrant workers has come under greater media scrutiny in recent months. This has caused international labor groups — many already critical of China's poor human-rights record — to put greater pressure on the International Olympic Committee to improve the situation.

China Railway 12th Bureau Group is the state-owned company responsible for construction.

Construction of the subway line, the No. 10, had been dogged by accidents for months, with reports of collapses and water leakages. Last February, three migrant workers were killed in a crane accident on the eastern portion of the line. Four months later, a section of the tunnel in Beijing's university district of Haidian collapsed, killing two workers.

This recent accident occurred at a section of the tunnel located near Beijing's Renmin University.

Residents living around the area reported hearing loud noises at the site in the morning but did not see emergency workers in the area until about 4 or 5 p.m. ■

Riding the rails through Copper Canyon and its 87 tunnels

by Mike and Penny Greenberg

A camping trip to the Copper Canyon in Mexico last year provided us with yet another opportunity to travel in a caravan with friends and explore some new and exciting places.

After visiting friends in North Carolina and a stop at the Paper Clip Museum in Tennessee (a memorial to the 11 million people killed in concentration camps during World War II, the Paper Clip Museum was created by school children in a rural Tennessee town as a lesson in diversity), we drove south to New Orleans, LA. The destruction still evident almost six months after the hurricanes that devastated Mississippi and Louisiana in 2005 was beyond our wildest expectations. It will be a long time before there is any semblance of normalcy in this area. We can only hope that the engineering community can restore this region and prevent a reoccurrence of the horrific destruction that is still so evident here.

From New Orleans we headed to San Antonio, TX, a city I had heard many good things about. The engineering effort that created the famous San Antonio River Walk by controlling the river and creating a spectacular atmosphere for economic development in San Antonio is an example of a successful and innovative approach to urban development. The River Walk is an area crowded with fine restaurants, stores, museums and businesses and makes San Antonio an exciting city to visit and do business in.

As we headed for Big Bend National Park, we drove through magnificent desert countryside. The park contains desert canyons and mountains and is bordered by the Rio Grande River. We headed north towards our eventual gathering point in El Paso, TX, detouring slightly to spend some quality time underground in Carlsbad Caverns National Park.

Carlsbad Caverns is an incomparable realm of gigantic, subterranean chambers, fantastic cave formations, and extraordinary geologic features. The caverns began forming 250 million years ago with the formation of a 644-km (400-mile) long reef in an inland sea. Afterward, the sea evaporated and the reef began to rise. A few million years ago, uplift and erosion uncovered the buried rock reef. Rain water soaking down through cracks and faults combined with the migration upward of hydrogen sulfide-rich water forming sulfuric acid, which dissolved the limestone and opened up the fractures and faults into the large rooms and chambers can be seen today. It was fascinating to see the stalactites, stalagmites and the incredible variety of other formations.

The next stop was the campground in El Paso where we met our fellow travelers, ready to begin our trip through Mexico. Our caravan of 22 recreational vehicles (RVs) traveled with a police escort through Juarez, an intimidating border city and made it to Chihuahua. We spent some time viewing the Chihuahua Aqueduct, which was built in 1757 and was in service until 1958. The aqueduct is a covered arch structure that delivered water from the nearby mountains to a large plaza with a fountain. The people would come to the plaza and fill up vessels with water.

Today, water is delivered directly to the homes but it is only supplied for two hours each morning and two hours each evening. Most of the homes have tanks on the roof. They pump water into the tanks during the hours when the water is being delivered and use the tanks to supply water during the other times.

We next visited Pancho Villa's house, now a museum. Many people still consider him a hero, while many others consider him a bandit and a killer. The car in which he was assassinated is now in the museum, bullet holes and all. Of great interest to a tunnelman is the escape tunnel that Villa had constructed in his house. We got to visit this tunnel, which was built under the house and ran for a distance of about three city blocks. The tunnel ended in a ramp. Horses were kept in the tunnel. And, if necessary, Villa could jump down into the tunnel, mount his horse and ride up the ramp and escape. If you look hard enough, you can always find a tunnel to visit in your travels.

One of the highlights of the trip was the train ride through the Copper Canyon of Mexico. The Copper Canyon is actually a series of eight canyons and in some places is twice as deep as the Grand Canyon. Because it was formed by erosion of the rivers without the subsequent uplift that formed the Grand Canyon, the Copper Canyon lacks the spectacular colors and varying mineralogy of the Grand Canyon. But it is still an amazing place to visit.

To traverse the Copper Canyon, each RV was placed on its own flatcar and a train made up of an engine, 22 flatcars and a caboose spent five days traveling along the rails. This railroad is a spectacular engineering achievement. The tracks drop nearly 2,130 m (7,000 ft) in 196 km (122 miles) and it took nearly 100 years to construct. The rail trip has 36 major bridges and (of special interest to our profession)

87 tunnels. At one point, the line actually circles back over itself in a complete loop.

Not only did we get to spend the entire trip in our RV, but most of the time we were able to tie our chairs to the front of the RV and sit outside on our own flatcar as we traveled. Anyone interested in geology could view the different rock types and follow the way the rock joints cut through the strata.

It was fun driving through all those tunnels, but the lack of lights and the smell of the diesel fumes was a bit distracting. The less adventuresome can enjoy some of the most spectacular scenery on earth in the comfort of a modern railway coach instead of traveling in an RV.

We detrained in Los Mochis and then drove to Matzalan for some rest. We did manage a wonderful side trip into the Sierra Madres, which included a visit to the town of Copala, an old mining town that now survives on tourism. We ate at a nice restaurant and I noticed signs leading to an old silver mine below the restaurant. I got to walk through the old mine, now mostly abandoned, but still passable for about one-quarter of a mile.

A ferry ride took us to the Baja Peninsula, where our first stop was Cabo San Lucas. It was a wonderful place to visit and we even found a great restaurant called "Senor Greenberg's Mexicatessen." The 1,600 km (1,000-mile) ride up the Baja Peninsula was filled with great scenery, wonderful food and many adventures.

At Guerrero Negro we got not only to view 18-m (60-ft) Gray whales from a 3.6-m (12-ft) open boat, but the whales and their babies came up to the boat and we got to reach out and touch them.

Cabo San Lucas is also the site of the world's largest salt producing operation. During a tour of the salt gathering facility, our guide explained the way the high salt content of the seawater in the area combined with the strong winds and hot sun to produce the largest salt gathering operation in the world. The same highly saline sea water is the reason the Gray whales make their annual migration to Scammon's Lagoon to mate and have their babies. The buoyancy of the water helps keep the calves afloat awhile they learn to swim.

The remaining ride to San Diego and the completion of our tour took us through spectacular desert vistas, wonderful towns on the Pacific Ocean, more wonderful Mexican food and another police escort through a border town (this time it was Tijuana).

The road home took us through Death Valley, Las Vegas many of the great National Parks of Utah (Zion, Bryce Canyon, the Grande Escalante Staircase, Capital Reef, Arches and Canyonlands) and the Colorado Rockies. ■

NEW MEDIA

The Third Edition of Construction Dewatering and Groundwater Control

2007, by J. Patrick Powers, Arthur B. Corwin, Paul C. Schmall, Walter E. Kaeck. John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030-5774, phone 877-762-2974, e-mail copy@wiley.com, Web site www.wiley.com, US$175 — In the past dozen years, the methods of analyzing and treating groundwater conditions have vastly improved. *The Third Edition of Construction Dewatering and Groundwater Control*, reflecting the most current technology and practices, is a timely and much-needed overview of this rapidly changing field. Illustrated with hundreds of new figures and photographs and including numerous detailed case histories, the *Third Edition of Construction Dewatering and Groundwater Control* is a comprehensive and valuable reference for both students and practicing engineers.

Drawing on real-world experience, the authors lead the reader through all facets of the theory and practice of this fascinating and engineering discipline. Discussion includes: dozens of case histories demonstrating various groundwater by use of conventional dewatering methods as well as vertical barrier, grouted cutoff, and frozen ground techniques; contracting practices and conflict resolution methods that will help minimize disputes; alternatives and effective practices for handling and treating contaminated groundwater; innovations in equipment and materials that improve the performance and efficiency of groundwater control systems; practices and procedures for success in artificial recharge; groundwater modeling to simulate and plan dewatering projects and inclusion of dual U.S. customary and metric units throughout.

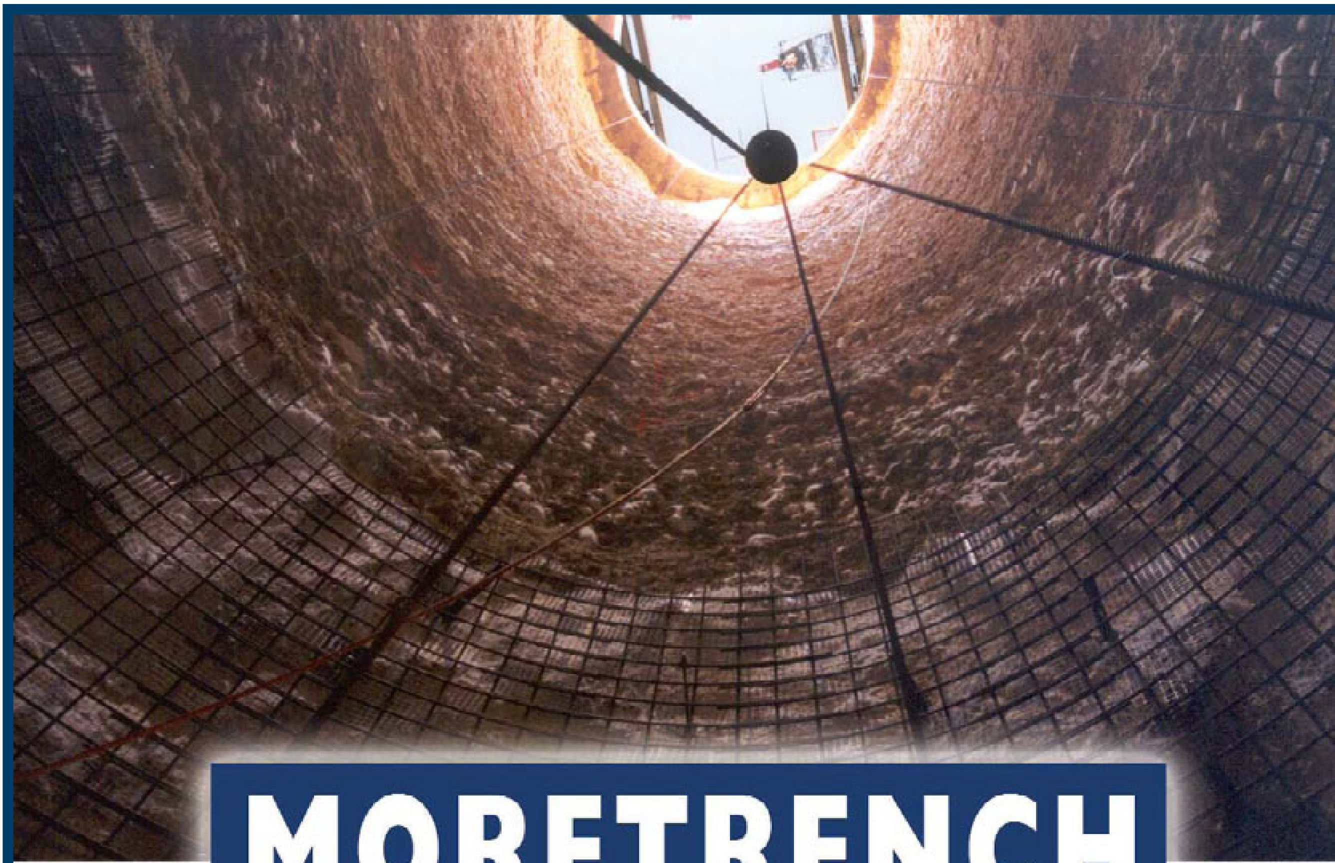
Construction Dewatering and Groundwater Control is an indispensable tool for all engineering and construction professionals searching for the most up-to-date coverage of groundwater control for various purposes, the modern ways to identify and analyze site-specific situations, and the modern tools available to control them. ■

TUNNEL NAME	OWNER	LOCATION		TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Canal St. Wet Weather Relief	Milwaukee Metro Sewerage Dist.	Milwaukee	WI	Sewer	13,500	7	2007	Advertising in May, 2007
Barclay/4th/Chase MIS Replacement	Milwaukee Metro Sewerage Dist.	Milwaukee	WI	Sewer	11,000	4-6	2007	Advertising in Aug., 2007
Mission Trails #1	SDCWA		CA	Fresh Water	4,800	11	2007	June 7 - Pre-Conf. Open House,
LIRR East Side Access - 63rd St.	NYCTA (MTA)	New York	NY	Subway	5,500	20	2007	
Near Surface Interceptors	Narragansett Bay Commission	Providence	RI	Sewer	19,500 11,000	3-6 3-6	2008	
Detroit River Crossing	Detroit River Partnership	Detroit/ Windsor	MI	Rail	9,000	28	2008	
Caldecot # 4	Cal Trans	Oakland	CA	Highway	3,600		2009	
Alum Creek Relief Sewer (1st phase of 3)	City of Columbus	Columbus	OH	Sewer	26,000	10	2011	
Mt. Olympus San Diego Six	MWDSC	San Diego	CA	Fresh Water	33,000	11.5	2011	
WASA CSO Potomac Tunnel	Washington DC Water & Sewer Authority	Washington	DC	Sewer CSO	8,000	20	2014	
WASA CSO Rock Creek Tunnel	Washington DC Water and Sewer Authority	Washington	DC	Sewer CSO	2,600	12-15	2015	
East Side Access	NYCTA (MTA)	New York	NY	Subway	10,000	20	2016	
Manhattan West Side to LaGuardia Airport	NYCTA (MTA)	New York	NY	Subway	15,000	20	2016	
Priest Reservoir Bypass	City and County of San Francisco	San Francisco	CA	Pipeline	2,500	10	2002	Complete
Dulles Airport Walkway to Terminal B and C	Metro Washington Airport Authority		VA	Pedestrian			2003	Complete
Westside Storm Water Management Facilities	Raleigh-Durham Airport Authority	Raleigh Durham	NC	Storm Water	2,000	10	2003	Complete
Alameda Tubes	Cal Trans	San Francisco	CA	Highway	4,400	37	2003	Complete relining only
North Shore Connector Extension	Port Authority of Allegheny County	Pittsburgh	PA	Light Rail	8,500	22	2003	Under construction

The editor's of Tunneling and Underground Construction encourage UCA of SME members to submit projects to the online Tunnel Demand Forecast. Go to www.smenet.org, log in as a member. Click on UCA of SME and then click Tunnel Demand Forecast. The items will be posted on the online TDF once they are verified.

TUNNEL NAME	OWNER	LOCATION		TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Water Tunnel #3 Shaft 17B	NYC Dept. of Environmental Protection	New York	NY	Fresh Water	250	30	2003	Under constuction
Habor Siphons Project	Milwaukee Metro Sewerage District	Milwaukee	WI	Sewer	13,000	16-17 OD	2003	Under construction
North Vancouver	Greater Vancouver Regional District	North Vancouver	BC	Fresh Water	Two at 25,000 each	11	2003	Under construction
North Dorchester Bay Conso. Conduit	MWRA	South Boston	MA	Sewer CSO	15,700	13	2004	Under construction
Second Ave. Subway	NYCTA (MTA)	New York	NY	Subway	42,280		2004	Under construction
Canada Line Rail Extension	Translink	Vancouver	BC	Light Rail	33,800			Under construction
Dulles Airport Concourse C Walkback	Metro Washington Airport Authority		VA	Pedestrian			2006	Under construction
Arrowhead West-East East Tunnel West Tunnel	MWDSC	San Bernadino	CA	Fresh Water	+60,000		2006	Under construction
Devil's Slide #041123U4	Cal Trans	San Francisco	CA	Highway	Two at 4,000	38	2005	Awarded
WASA CSO Anacostia Tunnel	Washington DC Water & Sewer Authority	Washington	DC	Sewer CSO	26,000	20	2005	Facility planning awarded, underway
Hudson River Freight Crossing	NYC Economic Development Corporation	New York	NY	Rail				Indefinitely Postponed
A9	North Carolina DOT		NC	Highway				Indefinitely Postponed
Seneca-North II	Rochester Pure Waters District	Rochester	NY	Sewer CSO	6,500			Indefinitely Postponed
Mount Hope Rosedale	Rochester Pure Waters District	Rochester	NY	Sewer CSO	8,500			Indefinitely Postponed
Lexington North	Rochester Pure Waters District	Rochester	NY	Sewer CSO	5,000			Indefinitely Postponed
Phoenix Airport People Mover	City of Phoenix	Phoenix	AZ	People Mover	12,850			Cancelled
Vancouver Fraser River Crossing	City of Vancouver	BC	BC	Highway	5,000			Cancelled

There is an extensive list of upcoming projects in the New York City area available on the Internet at www.mta.info under the Capital Construction, Procurement link. These are projects for the NYCT, MNR, LIRR, MTACC and B&T.
For more information see http://www.mta.info/mta/capital/eotf-allagency.htm.



FEATURE ARTICLE

Ground freezing a proven technology in mine shaft sinking

The link between artificial ground freezing and the mining industry stretches back more than 140 years, and across an ocean. Patented by the German scientist F.H. Poetsch in 1863, the technique is reported to have first been used circa 1862 in the coal mining valleys of South Wales.

In the United States, the first ground freezing application, to a depth of 30 m (100 ft), occurred in 1888 for the Chapin Mine Co. in Iron Mountain, MO.

In England in 1901, the Poetsch method was used for the first time to successfully sink two shafts through 24 to 27 m (80 to 90 ft) of wet sand and boulder clay at the Washington Glebe Colliery, near Sunderland. British mining engineer T.H. Cockin, in his 1905 *Class-Book of Practical Coal-Mining*, noted that, "This method of sinking through thick beds of very wet quicksand has met with great success; it is one of the recognized methods of sinking on the Continent."

Mine shaft freezing soon became relatively common in Europe where the project could bear the cost of a major refrigeration plant construction. However, it was not until 1952 that the second North American ground freezing project was completed to facilitate the sinking of a 4.5-m- (15-ft-) diameter, 233-m- (765-ft-) deep shaft at a Potash Company of America (PCA) mine in Carlsbad, NM.

Nowadays, ground freezing is used worldwide for both mining and civil applications. In small mine shafts of 3 to 6 m (10 to 20 ft) in diameter, excavations have been carried out to depths of more than 820 m (2,700 ft) within the protection of unbraced or unlined frozen walls. In fact, for deep mines, no better method has yet been established for sinking production shafts through deep, water-bearing ground. Major deposits of coal, potash and salt would still be inaccessible if not for artificial ground freezing.

There are several advantages of ground freezing unique to the construction of shafts. Proper instrumentation can provide complete assurance of the integrity of the freeze to full depth prior to excavation. The frozen wall allows construction to be scheduled without evaluating the in-shaft time necessary to probe ahead, place additional supports or deal with ground water. The freeze can be implemented perfectly through the soil/rock interface, which is often the most difficult geology in which to create a ground water cutoff by other methods. At increasing depths, any discontinuity

Ground freezing is used worldwide in mining and civil applications.

Paul C. Schmall and Derek Maishman

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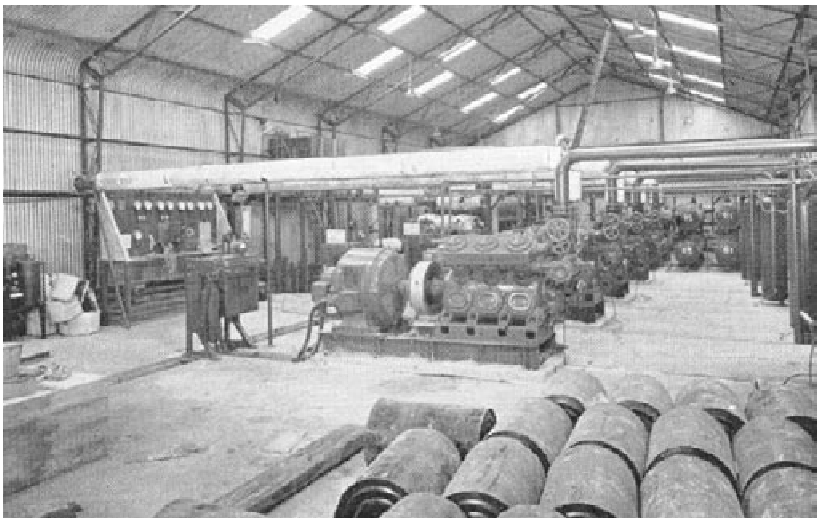
FIG. 1

An early refrigeration plant housed in a temporary building. Construction of these large plants typically required several months in advance of freezing being initiated.



in a temporary support system can be difficult to rectify unless the hydrostatic head is externally relieved, a task that cannot practically be achieved at depth. A frozen wall, by design, is continuous into the underlying cutoff and resists the loads imposed by full ground water and soil pressures.

If there is a disadvantage to ground freezing for the construction of shafts it is that specialized equipment must be used for the excavation of the frozen ground. With continued operation of the freezing system, the frozen ground will encroach further within the shaft excavation at greater depths. In deep shafts, it is common for the entire cylinder to freeze solid. Excavation is either by roadheader or by careful drilling and blasting.

Basic concepts still valid

The basic concept behind 21st century ground freezing is the same as that developed by Poetsch. When in situ pore water is frozen, it acts as a bonding agent, fusing together particles of soil or rock to create a frozen soil mass with markedly improved compressive strength and impermeability.

While advanced refrigeration technology has refined modern efforts, the core method of achieving the freeze still dates back to Poetsch. Small-diameter, closed-end freeze pipes are inserted into vertical drilled holes in a pattern consistent with the shape of the area to be improved and the required thickness of the wall or mass. As the cooling agent, typically chilled brine, is circulated through the pipes, heat is extracted from the soil, causing the ground to freeze around the pipes. The brine is returned to the refrigeration plant where it is again cooled. The frozen earth forms around the freeze pipes in the shape of vertical, elliptical cylinders. As the cylinders gradually enlarge, they intersect to form a continuous wall. With heat extraction continued at a rate greater than the heat replenishment, the thickness of the frozen wall will expand with time. Once the frozen wall has achieved its design thickness, the freeze plant may be operated at a reduced rate to maintain the condition during shaft excavation and liner placement. Monitoring of conditions during formation and maintenance is accomplished by temperature sensors installed at various levels in monitor pipes located strategically along the frozen wall. Following excavation and completion of shaft construction, refrigeration is discontinued, allowing the ground to return to its normal state.

While the principle behind the ground freezing process may appear simple, proper execution of the work, particularly at depth, is complex. Successful freezing operations require a specialist who must be skilled in refrigeration and in analysis of thermal problems. And this specialist must be experienced in ground water flow and geotechnical engineering. Understanding of the strength and behavior of frozen earth is vital.

The alignment of freeze pipes is critical to the satisfactory performance of the ground freezing system. The design, both as to strength and time of forma-

FIG. 2

Aerial view of a typical shaft freezing setup.

tion, is directly related to the spacing between pipes. If the pipes are permitted to deviate too much, unexpected windows or zones of less than design thickness can occur.

Borehole deviation is more significant for deeper work. For deep mine shafts, specialized guided drilling techniques can be employed, using locating and steering techniques similar to those used for directional drilling. A down-hole mud motor, mounted on a slightly angled flange at the end of a drill string that does not rotate, uses the drilling fluid to power the bit. The hole is surveyed concurrent with the drilling. As the drift is observed, the direction is changed by an angular adjustment of the drill string. In effect, a series of small deviations occurs within the target radius. With this method, holes as deep as 790 m (2,600 ft) have been kept within a tolerance of several feet.

FIG. 3

Roadheader commonly used for excavation of frozen ground.

Along with borehole surveying for deviation, there are other quality control measures essential to successful shaft freezing. Instrumentation, including temperature monitoring points such as borehole thermocouples or resistance temperature detectors, must be installed to confirm adequate frozen ground propagation.

The system must be leak-free. The loss of brine into the formation being frozen can result in "windows" that cannot be located by temperature monitors. The water pressure within the unfrozen core of the shaft must be relieved by a pressure relief well as the freeze continues to grow inward and the encapsulated water expands with the phase change. The relief hole also will indicate when closure of the frozen wall is achieved.

Piezometers must be installed to measure ground water gradients. Brine temperatures must be monitored to confirm proper output from the plant and heat extraction from the ground. All of these measures together are essential to confirming the single, overriding project criterion — that the ground water on the inside of the shaft is isolated from the ground water on the outside.

FIG. 4

As ground freezing technology advanced, portable brine refrigeration units, such as this, were developed, allowing ground freezing even in restricted areas.

Concreting against frozen ground

For shafts, the lining may be placed concurrent with the advance of the shaft sinking (top down) or once the excavation is complete (bottom up). Concrete walls have traditionally been cast against frozen strata. A rule of thumb used for many years was to increase the design thickness of the concrete by several inches. A proper balance will be achieved between the heat generated by the concrete and the heat extracted by the freezing process with the placement of a minimum thickness of concrete. The heat balance will be such that the heat of hydration of newly placed concrete will thaw, to some depth, the adjoining frozen

FIG. 5

At the Weeks Island site, a drill rig was placed on a rail car and moved along parallel tracks to provide access for freeze pipe installation over the sinkhole.

earth. Depending on the rate of release of the cement's heat of hydration, a thermal equilibrium will eventually be reached after which the ground will slowly refreeze, followed by a progressive freeze of the concrete itself. But, before the freezing temperatures propagate through the new concrete, the designed thickness of the concrete wall will have hydrated sufficiently to achieve its initial set. The concrete will continue to cure at a reduced rate when frozen.

Noteworthy projects

While a discussion of the principals behind, and execution of, the freezing process is undoubtedly useful to mining engineers and mine owners, the following projects, which represent just a handful of the many successful applications of the technique, provide the best testimonial.

Strategic Petroleum Reserve, Weeks Island, LA. More than 7.6 GL (2 billion gal) of crude oil has been stored at the U.S. Department of Energy's Strategic Petroleum Reserve in Weeks Island, LA. The oil has been stored in an abandoned salt mine cavern 175 m (575 ft) below the surface for more than 20 years.

During routine inspection, a 9-m- (30-ft-) diameter surface sinkhole was discovered above the cavern, indicating erosion to the protective salt dome approximately 60 m (200 ft) below the surface. This was determined to result from leakage of the overlying fresh water aquifer through mine-induced fractures in the salt. Additional investigations indicated that the ongoing leakage flow of 11 L/min (3 gpm) was displacing approximately 3 m^3/d (4 cu yd/day) of material.

Since similar fresh water leaks in other salt mines had resulted in rapid erosion and subsequent mine failure, concern about the preservation of both the environment and the oil reserve led to decommissioning of the site. During the five-year period required to pump out the oil and close the site, it was essential to halt further deterioration. Ground freezing was selected over permeation grouting for this operation since it was suited to the highly disturbed ground conditions, variable geology, complex ground water chemistry and access limitations at the sinkhole.

The intent of the ground freezing program was to form two protective structures. The first was a cylinder of frozen soil seated down into solid salt. It was designed to prevent further ground water inflow into the sinkhole area and afford emergency structural support to the surrounding soils in the event of further significant ground subsidence. The second, and ultimate, objective was to create a more energy-efficient massive frozen soil cap about 20 m (70 ft) in diameter and 10 m (32 ft) thick over the entire sinkhole/salt interface to prevent further erosion for the duration of the oil removal.

Thermal analyses were performed using a finite element ground freezing model to arrive at the optimum freeze pipe configuration, evaluate freeze wall growth and estimate thermal loads to meet project schedule demands. From these analyses, a final design was arrived at. It consisted of:

- An outer ring of 22 pipes installed on a 16-m- (54-ft-) diameter circle and drilled and socketed into the salt to ensure a positive freeze/salt seal.
- A middle ring of 22 pipes installed to the top of salt on a 14.5-m- (48-ft-) diameter circle. Together with the outer ring, it provided the formation of the cylindrical freeze with adequate thickness to temporarily support full-depth soil loading in the event of complete collapse of the interior sinkhole backfill material.
- An inner ring of 10 freeze pipes on a 12-m- (40-ft-) diameter circle installed into the backfill of the sinkhole itself to propagate growth of the freeze inward and form the solid plug of frozen material inside the frozen cylinder over the sinkhole throat.

Seven monitor holes were also installed within the frozen soil limits to gather piezometric and temperature data to demonstrate the rate of growth and final integrity of the frozen structures. The formation of the full depth cylindrical freeze and the "ice cap" required 3.5 and 10 months, respectively, very close to the model values.

Cote Blanche salt mine, Cote Blanche, LA. A niche for ground freezing has long existed in southern Louisiana. This is where massive salt deposits, known as salt domes, are overlain by the loose, wet silts and sands of the Mississippi Delta. For vertical shaft construction, ground freezing is the preferred method of ground support, promoting ideal conditions to construct the shaft "in the dry." However, before the thaw, absolute water tightness must be established in the concrete liner. Otherwise, any seepage will dissolve salt from behind the shaft lining, increasing the leakage path and ultimately flooding the mine. Salt mines have been lost this way.

Cote Blanche, on the Gulf of Mexico, is one of the prominent salt domes known as the Five Islands and is one of only three remaining active salt mines. Ground freezing was used to sink a new 5-m- (16 ft-) inside diameter production shaft 138 m (455 ft) below the surface. Subsurface soils consisted of sands and gravels saturated with brackish water to a depth of 106 m (350 ft), overlaying a 21-m (70-ft) thick stratum of sandy clay. Variable disturbed soils were present from 128 m (420 ft) to top of salt. There, the granular soils contained a saturated salt solution with a freezing point of -21° C (-6° F).

A freeze wall 3.6 m (11.8 ft) thick was required to resist soil and ground water pressures in the salt contact zone. To achieve this, 35 freeze pipes and monitors were drilled to a depth of 150 m (500 ft) on a 10-m- (33-ft-) diameter circular pattern. To freeze the salt-saturated sand, it was necessary to chill the calcium chloride brine coolant to a relatively cold -37° C (-36° F). A freeze plant with 50 percent greater capacity than normal was employed and maximum power maintained until the permanent concrete lining had been constructed to a depth of 167 m (550 ft), 29 m (95 ft) into solid salt.

White County Coal, Carmi, IL. White County Coal has been a leading producer in the Illinois Coal Basin since 1983. When the company initiated construction of a new facility to access additional recoverable reserves about 245 m (800 ft) below the surface, it was important to maintain a stable, dry excavation for the sinking of a service shaft 11 m (37 ft) in diameter.

The subsurface profile at the shaft location consisted of 36 m (120 ft) of loose, saturated sandy soils overlaying an approximately 40-m- (140-ft-) thick layer of Mount Carmel sandstone, a major regional aquifer. Beneath this was an impervious shale stratum. Ground water was just 2.4 m (8 ft) below grade. Ground freezing was the method of choice to ensure the stability in the overburden soils during excavation and to control ground water inflow through the overburden and the underlying sandstone.

The ground freezing program called for more than 40 freeze pipes to be installed around the circumference of the proposed shaft to a depth of 90 m (300 ft), terminating in the shale stratum that acted as a lower ground water cutoff. Less than four months after freezing was initiated, a 2-m- (7-ft-) thick frozen perimeter wall had been created, allowing excavation to begin.

Kansas Underground Salt Museum, Hutchinson, KS. Carey Salt is no stranger to the innovative uses of abandoned portions of its active Hutchinson Mine in Reno County, KS. Under a lease agreement, converted caverns deep below the surface have provided safe, environmentally stable, underground storage facilities for sensitive information and assets since 1959. Now the Reno County Historical Society is poised to unveil another novel Hutchinson Mine attraction — the Kansas Underground Salt Museum. Visitors will be transported 200 m (650 ft) underground by a double-deck elevator. Ground freezing was the method of choice to stabilize more than 40 m (135 ft) of sand and wet mudstone overburden to ensure completely dry and stable elevator shaft excavation.

The 115-mm- (4.5-in.-) diameter steel freeze pipes were installed through the overburden to a depth of 40 m (135 ft) around the proposed shaft perimeter and passed through weathered mudstone into the underlying shale to

FIG. 6

Excavation of the White County shaft by a muck chute.

FIG. 7

Clamshell excavation of the Salt Museum elevator shaft.

ensure that the freeze continued through the critical soil/rock interface. The temporary frozen wall, a minimum of 1.8 m (6 ft) in thickness, was formed by circulating calcium chloride brine chilled to -31° C (-25° F). The freeze was formed in 28 days. The nominal 4-m- (14-ft-) diameter shaft was excavated by Thyssen Mining and the 0.6-m- (2-ft-) thick permanent concrete liner was placed.

FIG. 8

Gibson County Coal North Portal No. 2 freezing setup.

Underground excavations in salt must always be completely isolated from ground water or catastrophic failure can occur. In the shallow rock, special water seals were, therefore, placed in and behind the concrete shaft lining so that once freezing was discontinued and the ground had thawed, ground water could not seep down into the soluble formation below.

Gibson County coal mine, Princeton, IN. Gibson County Coal is expanding its mining operations near Princeton to access additional coal reserves. Construction operations include the sinking of the North Portal No. 2 shaft. This 8.5-m- (28-ft-) inside diameter vertical service shaft will end about 170 m (550 ft) below ground. However, more than 30 m (100 ft) of saturated soils, (most of them sands lying within the flood plain of the Patoka River) overlie competent coal-bearing rocks at a depth of 35 m (115 ft). The mine owner specified ground freezing to stabilize the overburden soils during shaft excavation and liner placement.

Piezometer readings taken during a pre-freeze 40-day period revealed abrupt changes in water levels within the sand aquifer, corresponding to water level fluctuations in the volatile Patoka River, a half-mile away. To protect the project from seasonal flooding, the owner specified the construction of a raised collar to prevent inundation of the shaft with a flood. This work was completed before the freezing installation. The prime supply and return pipelines were located in a gallery built around the shaft collar and safely above the natural ground surface, which was, in fact, inundated for a brief period during the formation of the frozen wall. The freezing design called for approximately 40 freeze pipes, plus an array of piezometers and temperature monitors, installed through the overburden soils and extending 4.5 m (15 ft) into the underlying sound rock.

Ground freezing began in November 2006 and closure was confirmed in December. Shaft sinking by Frontier-Kemper, the prime contractor, is now well into the rock, having penetrated the frozen section without incident.

From the first applications up to the present day, ground freezing has consistently proved to be the best, if not the only, solution for deep shaft sinking through saturated or otherwise challenging subsurface conditions. This has been borne out through numerous successful projects worldwide, both in the mining and civil engineering industries. ■

Brightwater Conveyance System will expand Seattle's wastewater treatment

The final lining blockout forms for the influent structure to the influent pump station connector tunnels at the North Creek Portal influent structure.

Washington's King County is constructing a new regional wastewater treatment facility, called Brightwater, in response to growth in the greater Seattle region. Planning conducted in the late 1950s identified the need for two regional treatment facilities. Constructed in the 1960s, these plants have served the region well. However, an eventual need for a third facility was also recognized.

The Brightwater project implements the final phases of the long-term plan. The project includes a new treatment plant and an extensive conveyance system. When completed in 2010, the Brightwater facilities will treat sanitary sewer flows from growing populations living in northern King County and southern Snohomish County. The new system will fulfill commitments to provide wastewater services to local jurisdictions and sewer service providers in the King County Service Area. It will also provide more flexibility in the operation of the King County regional wastewater system.

The Brightwater wastewater treatment plant will provide secondary treatment capacity using membrane bioractor technology in 2010 for 36 million gallons per day (mgd), with anticipated expansion in 2040 to 54 mgd, using membrane bioreactor technology. These capacities are for average wet-weather flows. The plant will also accommodate peak hourly flows of 130 mgd by 2010 and 170 mgd by 2040.

The Brightwater Conveyance System consists of more than 8.1 km (13 miles) of tunneled influent and effluent conveyance lines, five tunnel portals/shafts, microtunneled influent and outfall connec-

John E. Newby, Mike B. Gilbert and Leon E. Maday

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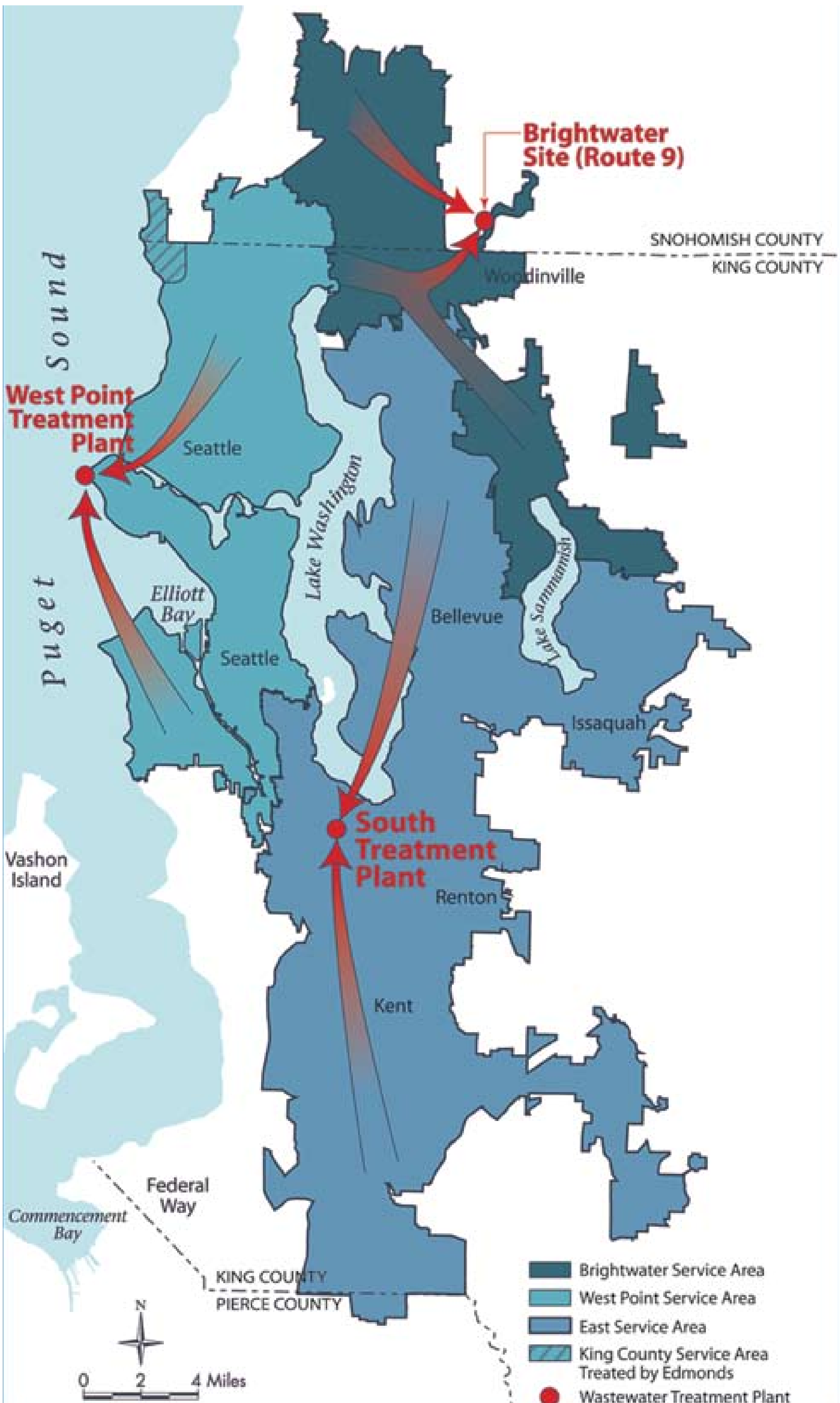
King County's wastewater service area.



Courtesy of King County, WA

tions, a large pump station, and a 1.6-km- (1-mile-) long marine outfall extending to a depth of 184 m (605 ft) in Puget Sound. The conveyance alignment traverses topographically complex terrain developed and numerous suburban residential communities. Almost all of the conveyance system pipelines are being constructed using tunnel boring machines (TBMs) and microtunnel boring machines (MTBMs) to limit impacts to roads, residences and commercial assets along the conveyance route.

The Brightwater tunnels include about 20,376 m (66,850 ft) of large diameter tunnels being constructed in four segments. And about 1,390 m (4,570 ft) of microtunnels are being constructed in six segments. Wastewater influent is conveyed through the microtunnels from existing trunk sewers in the Swamp Creek Valley and North Creek Valley to portals in the respective valleys, the North Kenmore Portal and the North Creek Portal.

Influent flows by gravity in a deep tunnel from the North Kenmore Portal to the North Creek Portal. An influent pump station constructed adjacent to the North Creek Portal will pump all influent to the treatment plant through force mains placed in another deep tunnel.

Effluent from the treatment plant will flow by gravity through effluent pipelines constructed within tunnels as carrier pipes to the North Kenmore Portal, then by the tunnel structure itself to the Point Wells Portal. Another microtunneled pipeline will carry the effluent from the portal to the cut and cover and surface laid marine outfall.

Conveyance system design and construction

To meet the requirement that the project be operational by 2010, preliminary design began in November 2002 shortly after King County identified a preferred project alternative. It included the treatment plant site and a conveyance alignment corridor generally following State Route 9 and 195th Street. The preliminary design refined the conveyance horizontal alignment within the corridor, selected a vertical alignment from a range of force main and gravity alternatives, completed other work necessary to further refine the project and develop permit applications, and determined how to contract for the construction work. The preliminary design was immediately followed by final design of the project, which included numerous contract packages. Plans and specifications for the major contract packages were completed by mid-2006.

The design and construction of the Brightwater project is being led by the King County Department of Natural Resources and Parks, Wastewater Treatment Division (WTD). It has a long history of successful tunnel projects. However, this project is the largest the department has undertaken. It involves some of the deepest tunnels and shafts in soft ground constructed in the United States.

Recognizing the importance of consistency in addressing geotechnical issues associated with the deep tunnels and shafts, WTD selected a single geotechnical engineering team to perform all the conveyance geotechnical work. This geotechnical engineering contract was awarded to CDM, which provided geotechnical services throughout the preliminary and final design. CDM is now supporting WTD during construction. Professional teams with strong tunnel design experience were also selected by King County – the preliminary design team was led by HDR and the final design team was led by a joint venture of MWH and Jacobs Associates. CDM led a collaborative effort among CDM, WTD and the final design team to prepare geotechnical baseline reports (GBRs) for each of the tunnel contracts.

MTBM launch and BT-2 TBM receiving blockout, North Creek Portal.

Slurry wall hydromill, North Creek Portal.

Construction of the tunnels and shafts is being performed under three major contracts with a single contract for the 140-mgd pump station. There are several other contracts for construction of smaller portions of the conveyance system and existing plant modifications. WTD retained a team led by Jacobs Engineering Group for construction management for all conveyance contracts except for the design-build marine outfall for which Vanir Construction Management is the construction manager.

East Tunnel contract

This contract consists of the combined conveyance tunnel between the North Creek Portal and the Brightwater treatment plant. This first Brightwater tunnel (BT-1) is 4,282 m (14,050 ft) of 5.87 m (19.25 ft) inside diameter (ID) concrete segmental-lined tunnel. It contains 1.2 m and 1.6 m (48-in. and 66-in.) ID influent force mains, a 2.13-m- (84-in.-) ID effluent pipe and a 686-mm- (27-in.-) ID reclaimed water pipe, all encased in cellular concrete. Included is an influent structure/tunnel portal excavation approximately 22.5 m (74 ft) deep and 24.3 m (80 ft) in diameter with slurry diaphragm walls 40 m (130 ft) deep; an influent pump station excavation approximately 25.3 m (83 ft) deep with twin intersecting 25.6-m- (84-ft-) diameter cells and slurry diaphragm walls 49 m (160 ft) deep; and a receiving portal at the treatment plant approximately 12 m (40 ft) deep. The contract also includes 741 m (2,430 lineal ft) of 1.8-m-(72-in.-) ID microtunneled influent sewer con-

"Y-Panel' reinforcement for the diaphragm wall between shaft lobes, Influent Pump Station.

necting the influent structure to the North Creek trunk lines at the existing North Creek pump station and two 3.66 m (12 ft) ID connector tunnels between the influent structure/tunnel portal and the influent pump station.

A joint venture of Kenny, Shea and Traylor (KST) with a bid value of $130.9 million, was given notice to proceed with the East Tunnel contract in January 2006. KST selected a Lovat Earth Pressure Balance TBM for the work. The launch shaft is complete and launch is set for the summer of 2007. Two of the three sunken caisson shafts are completed for the North Creek Connector and microtunneling is under way. The contract completion date is late 2009.

Central Tunnel contract

This contract consists of the combined tunnel between the North Kenmore Portal and the North Creek Portal (BT-2) and the effluent tunnel between the North Kenmore Portal and Ballinger Way Portal (BT-3). BT-2 is 3,536-m- (11,600-ft-) of 5.12-m- (16.8-ft-) ID long segmental-lined tunnel with a 1.8-m- (72-in.-) ID effluent pipe, 1.3-m- (54-in.-) ID influent pipe and 607-mm- (24-in.-) ID reclaimed water pipe. BT-3 is 6,126-m- (20,100-ft-) of 5.12 m (16.8 ft) ID, long segmental-lined tunnel with two 356-mm- (14-in.-) ID reclaimed water pipes encased in concrete with a 1,280-m (4,200-ft) section of 3.2-m- (126-in.-) ID effluent pipe. Included is a 15.8-m (52-ft) finish ID, launch portal structure 27 m (90 ft) deep. It is constructed using a slurry diaphragm wall. The 7.31-m (24-ft) finish ID receiving portal structure is more than 61 m (200 ft) deep and was constructed using a shallow ground water contamination cutoff wall and a full-depth frozen soil wall. This contract also includes the Swamp Creek Connector. It consists of 488 m (1,600 lineal ft) of 1.2-m- to 1.8-m- (48-in.-to 72-in.-) ID microtunneled influent sewer and 549 m (1,800 lineal ft) of 914-mm- to 1.2-m- (36-in.- to 48-in.-) ID open-cut influent sewer pipeline.

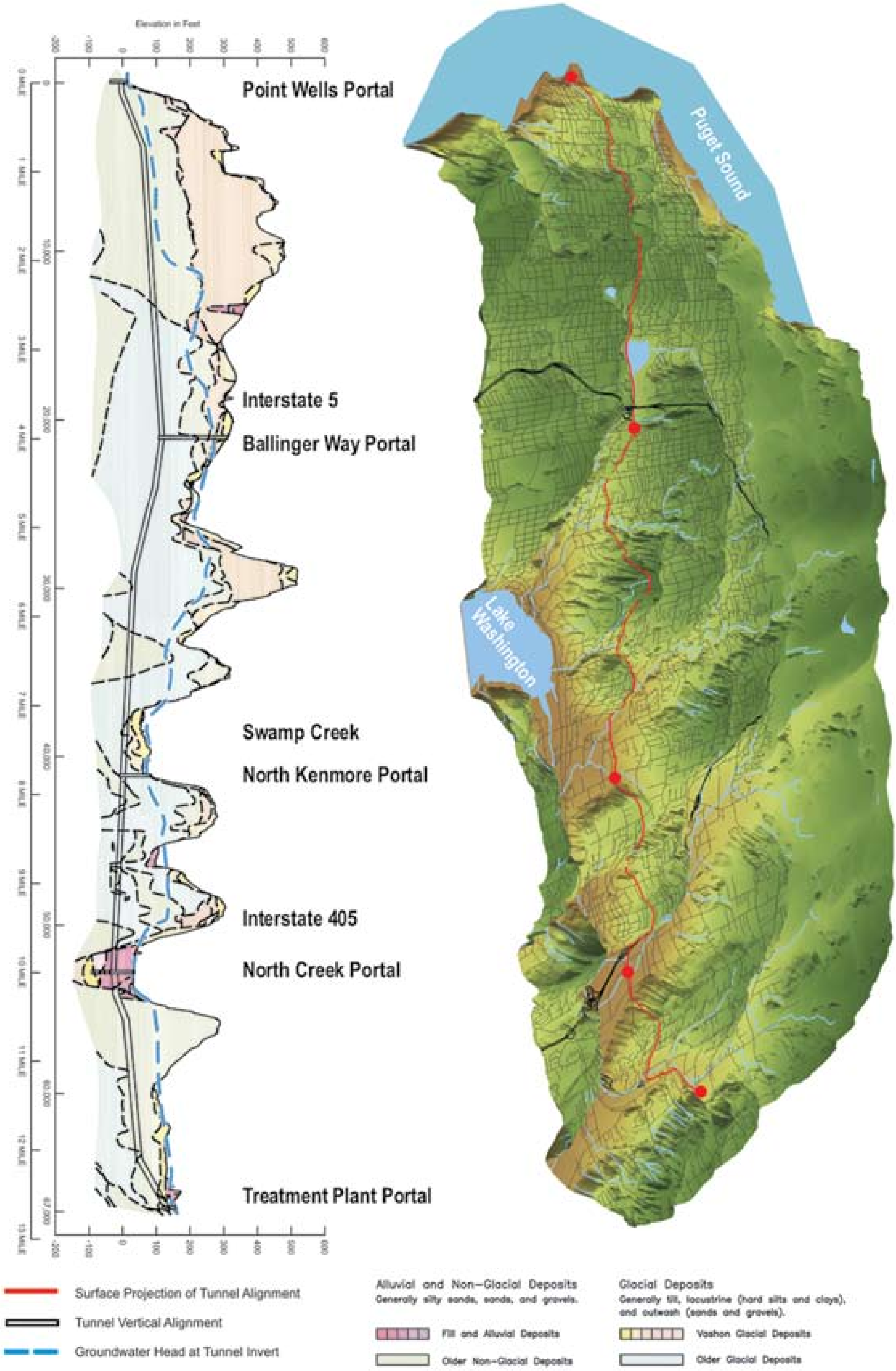
In July 2006, a joint venture of Vinci, Parsons and Frontier-Kemper (VPFK) with a bid value of $209.8 million, was given notice to proceed with the Central Tunnel Contract. VPFK selected Herrenknecht mixshield slurry TBMs to excavate the highly variable ground conditions with ground water heads varying up to 4.9 bars (165 ft) at the tunnel invert along BT-2 and 7.3 bars (245 ft) along BT-3. Slurry TBMs have been a successful technology in Europe for years and have recently been successfully used in Portland, OR. The launch shaft is nearly complete with TBM launch of BT-2 planned for this summer. The Swamp Creek Connector construction is in progress. Ground freezing was selected by VPFK for temporary support of the 62.5-m (205-ft) Ballinger Way Portal excavation, which has been designed by Moretrench American. The completion date for the Central Contract is late 2010.

West Tunnel contract

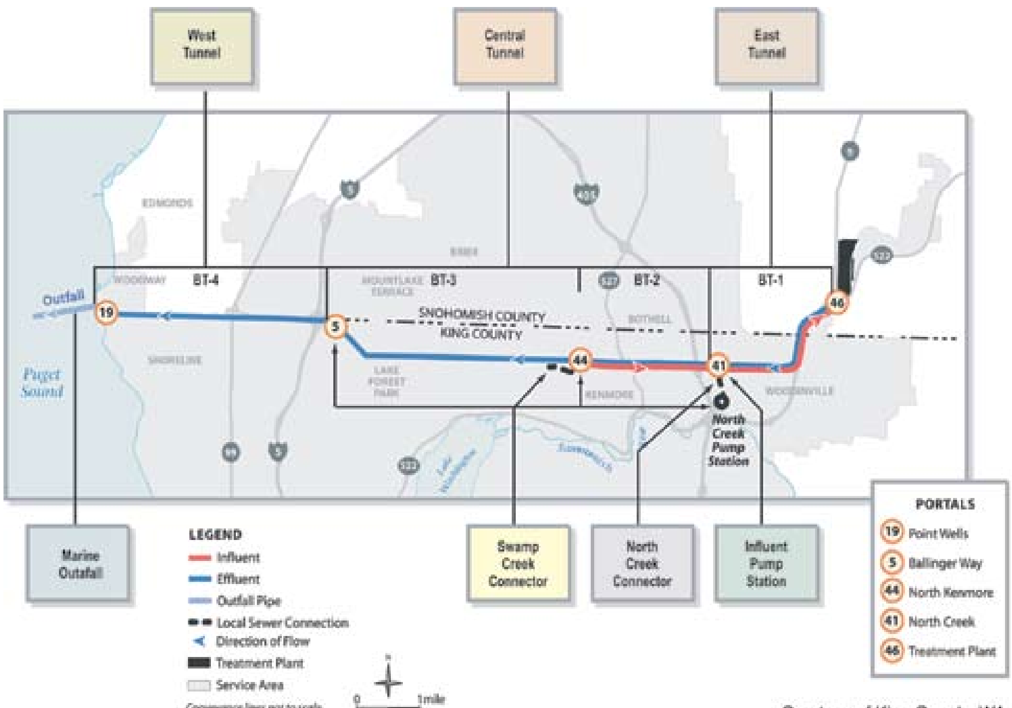
This contract consists of the effluent tunnel between the Ballinger Way Portal and the Point Wells Portal (BT-4). BT-4 is 6,431 m (21,100 ft) of 4-m (13-ft) minimum diameter segmental-lined tunnel, 762 m (2,500 ft) of which is secondarily lined with steel to a 3-m (10-ft) minimum ID. Included is a launch portal at Point Wells approximately 11 m (35 ft) deep with watertight shoring. A below-grade sampling facility and flowmeter vault will be constructed

Clamshell with a boulder removed from the slurry wall excavation, North Kenmore Portal.

Brightwater Conveyance perspective view and geologic section.



King County's wastewater service area.



Courtesy of King County, WA

within the portal excavation. This contract also includes 165 m (540 ft) of 2.1-m (84-in.) microtunneled effluent sewer between the portal and the marine outfall.

In February 2007, a joint venture of Jay Dee, Coluccio and Taisei, with a bid value of $102.5 million, was given notice to proceed with the West Tunnel contract. The joint venture plans to use a Lovat EPB TBM. The completion date for this contract is early 2011.

Other conveyance contracts included:

- Influent pump station: Construction of the 140-mgd expandable to 170 mgd influent pump station within the lined excavation installed by the East Contract. It includes above-grade structures for generators, odor control and chemical storage. Bids have been received and the awarding was expected in the spring 2007.
- Marine outfall: A design-build contract for the outfall, including the diffuser (about 152 m or 500 ft long) located in about 184 m (605 ft) of water and the 1,500 m (4,920 linear ft) of outfall pipeline consisting of about 274 m (900 ft) of buried pipe constructed near and onshore and about 1,256 m (4,120 ft) laid directly on the Puget Sound seabed offshore. This contract is currently in the request for proposal (RFP) stage with selection of the design builder anticipated this summer.
- Other conveyance facilities: Three additional contracts are in the final design, bidding or solicitation stage for above-grade facilities at the North Kenmore and Ballinger Way portal sites, the reuse pipeline in the North Creek Valley and improvements at the existing North Creek pump station and improvements to the nearby Hollywood pump station.

Tunneling challenges

Complex geological conditions. At least three different glacial advances and retreats have created a series of north-south trending ridges and valleys perpendicular to the general east-west conveyance tunnel alignment. The tunnels and shafts will be excavated through a variety of glacial deposits and interglacial deposits, which include regional aquifers. Each of these deposits varies with respect to soil type and consistency. The complex geology, depth of the tunnels and shafts and high variation of overburden and ground water head along the tunnel alignment all contribute to one of the most challenging soft ground tunnel projects in the United States tunneling practice.

Geotechnical investigation. The exploration program included more than 200 exploration borings to an average depth of 81 m (265 ft). Drilling was done primarily by mud rotary and sonic drilling methods with continuous sampling near the tunnel zone and for the full depth of the portal excavations. In addition to these borings, cone penetration testing (CPT), pressuremeter testing (PMT), slug testing and pumping tests were performed at selected locations along the overall alignment to evaluate in situ soil characteristics, ground water and ground permeability. The high degree of glacial consolidation, along with the artesian conditions in the valleys, made sampling of the soils a challenge during the site investigations.

The depth and number of geotechnical explorations across the entire conveyance alignment provided a unique regional understanding of the complex glacial and interglacial deposits. They also allowed a better correlation between various geologic units and physical soil properties. As additional data was collected, the GDR was updated. A separate GBR was prepared for each contract because of the varying design and construction issues. Data used to develop the baseline parameter values was biased based on the location of the data for each contract.

Addressing ground condition risks

Because of its experience with tunneling, WTD felt comfortable with setting expectations on ground conditions for the contractors and accepting a reasonable amount of risk. The GBRs establish a baseline for various geotechnical conditions that the owner and contractor used to plan the work. Risks associated with the baseline conditions have been accepted and planned for by the contractors while risks outside the baseline are the responsibility of WTD. In some cases, WTD has elected to include in its contracts a certain level of equipment and equipment spares, TBM inspection stops and TBM operational requirements, all to reduce risks by setting minimum requirements in the specifications. Some of the more complex issues addressed in the design and preparation of the GBRs are presented here.

Sunken caisson for the microtunnel receiving pit, North Creek Connector.

Tunnel soil groups. Baseline soil properties were developed for soil groups selected with similar physical properties and tunnel behavior related to tunnel and microtunnel systems. These tunnel soil groups (TSGs) are distinct from and do not directly correlate with the geologic deposits. To enable the contractors to determine operational requirements and production, baselines were established for ranges in the percentage of different face conditions comprised of the TSGs that will be encountered within entire tunnel segments. Uncertainty is expressed by the fact that the sum of the ranges does not equal 100 percent for each segment (typically varying between about 80 and 120 percent). This reflects the level of risk the contractor must assume for uncertainty in making this evaluation for any individual face condition occurring within the entire length of each tunnel segment. To enable measurement for comparison with the baseline percentages, the specifications require that regular samples be taken as the excavation advances through the ground.

Ground water head. Although ground water head at the tunnel elevation is high, up to 7.3 bars (245 ft) and 3 bars (100 ft) or more over the majority of the alignment, establishing a baseline was relatively straightforward. Ground water elevations monitored throughout the alignment during the several years-long preliminary and final design period generally showed little variation (typically less than 1 m or 3 ft).

Dewatering. Impacts to aquifers and streams were identified as a significant risk early in the environmental impact evaluation. Therefore, it was decided to require construction methods that would have little impact on ground water levels including the required use of pressurized face TBMs and MTBMs for the tunneling and watertight excavation support methods for the portal excavations. Exceptions were made for a couple of the portals where temporary depressurization of deeper aquifers was predicted to have limited impact on shallow aquifers.

Boulders. Boulders are known to be present in the glacial deposits. However, the small diameter of soil drilled in exploration borings makes them essentially useless for predicting boulder sizes and quantities. In fact, only one possible boulder was encountered in the explorations while historic excavations show that numerous boulders can be expected. Surveys of exposed bluffs and nearby excavations and reviews of recent local tunnel projects in similar geologic deposits were performed to develop baseline values for boulder quantities. The baseline number and strength of boulders were conservatively set to assure that the TBMs, excavation equipment and contractor means and methods would be capable of handling boulders. While the majority of predicted boulders are less than 1 m (3 ft) in maximum size, several larger boulders will be encountered. The specifications require TBMs to be capable of handling boulders up to a boulder strength that is at the upper end of the commonly reported range for fresh granite.

Abrasion. Tool life for tunneling machinery and the need and frequency of tool changes is a function of soil abrasivity, tool materials and hardening, and the use of polymers or other ground conditioners. With working conditions in soft ground, especially under high ground water pressure, access to the excavation chamber for tool change can affect tunneling activities and weekly production.

CDM recognized that soil abrasion has been a concern for tunneling in Seattle area granular glacial deposits. While several abrasivity test standards are established

MTBM operation in secant pile wall jacking pit, Swamp Creek Connector.

for rock, few of these test methods are directly applicable for soft ground tunnels. In addition to basic index testing of grain size and soil mineralogy, CDM worked with the design team and Sintef Rock and Soil Mechanics in Trondheim, Norway to adapt the Abrasion Value Cutter Steel test method typically used to evaluate rock abrasion for use in evaluating soil abrasiveness. These test results are provided in the GDR. With experience on the Brightwater project and other projects, this modified test method could evolve into a standard for predicting soil abrasion.

Sticky clays. Sticky clay can adversely affect the rate of production by clogging moving parts of the TBM and by adhering to the exposed steel. It can also increase TBM thrust requirements. About 5,790 m (19,000 linear ft) of the BT-2 and BT-3 tunnel alignments will be driven with a partial or full-face of fine-grained soils that have either moderate or high stickiness potential. The potential for a clay to behave as a sticky material to the exposed steel can be related to the Atterberg Limits of the clay. This issue was evaluated by performing numerous Atterberg Limits tests. They focused on the fine-grained soils within the Central Contract tunnel limits and providing this information in the GDR and a baseline in the GBR for the proportion of the alignment in plastic clays and silts where the stickiness potential is either medium or high. The contractor can use this to evaluate the type and quantity of conditioners, such as polymers, that are required to mitigate this problem, the production rates, the separation plant design and operational issues.

Inspection and maintenance stops. The Brightwater Conveyance tunnel drives are long – BT-3 and BT-4 exceed 6,100 m (20,000 linear ft). This requires good planning and execution of the tunneling systems for this project's tunnels with no intermediate shafts allowed.

Given the abrasive soils and high pressures, even properly designed and operated TBMs will require scheduled inspection and maintenance to complete the tunnels without requiring major repair. The specifications have been prepared with the requirement that the contractor make a minimum number of stops to inspect the TBM face. The number and spacing of required stops varies based on geotechnical conditions and TBM operations.

A stipulated unit price has been established for each of these inspection stops to compensate the contractor for each inspection. The stipulated price is intended to provide a reasonable amount for the contractor to inspect for wear, and then determine its maintenance plans and modify TBM operations as appropriate to ensure the TBM can complete the drive within the scheduled timeframe.

Ground freezing. The Central Contract allowed temporarily support of the deep Ballinger Way Portal excavation by either slurry wall or ground freezing. Experience with ground freezing to this depth of more than 61 m (200 ft) is limited in the U.S.

WTD's philosophy is that the contractor should be responsible for temporary excavation support design as long as the schedule and permanent facilities are compatible with this specifying method. WTD and the design team took advantage of CDM's European experience with ground freezing design for very deep shafts in soft ground to help mitigate the risk of having an inadequate design.

The geotechnical investigation and laboratory testing program (including frozen soil testing) was executed to develop the data necessary for the contractor to prepare a thorough ground freezing design. This led to the minimum ground freezing design requirements being developed based on a preliminary ground freezing system design.

Summary

Construction is now under way on most of the Brightwater Conveyance System. It includes more than 21,700 m (71,400 ft) of tunnels in complex soft ground conditions with a large proportion of the TBM tunnels located 61 m (200 ft) or more below the ground surface and mined under 3 bars or greater ground water head.

Experience gained during the construction of this challenging project will contribute to the advancement of soft ground tunneling technology in the United States and provide valuable lessons in managing underground risk. ■

The United States' role with the International Tunnelling Association

The International Tunnelling and Underground Space Association (ITA) is a nonprofit organization that represents all aspects of the tunneling and underground space industry worldwide.

The United States has had a prominent role in ITA since its 1974 inception. ITA was formed as a result of a worldwide survey conducted in the early 1970s by the Organization for Economic Cooperation and Development (OECD). Bill Lucke was in charge of tunnels for the U.S. Federal Railroad Administration and was a member of the organizing committee that created ITA. He became a vice president of ITA. Jack Lemley served as President of ITA from 1983 to 1986. Dick Robbins was very active in ITA and served for many years both as a member of the Executive Council and as First Vice President. Harvey Parker has served as President of ITA for the last three years and will serve as Past President for the next three years.

Moreover, there are many individuals and companies from the United States that have contributed significantly to the activities and the success of ITA. There have been several active Working Group Animateurs from the U.S. and there have been significant contributions from many individuals as well as companies from the U.S. Several engineers from the U.S. are currently serving ITA in a leadership role. The Underground Construction Association of SME (UCA of SME) is the official organization representing the U.S.. SME Executive Director Dave Kanagy and UCA President Tom Peyton were instrumental in the U.S.'s role at ITA during the last few years. Peyton has been the official delegate to ITA. Henry Russell and Christian Ingerslev are both Animateurs of ITA working groups. This article will introduce ITA and its activities. A subsequent article will describe the ITA in more detail and will discuss the significant role the U.S. has played in the development and success of ITA.

FIGURE 1

International Tunnelling Association Member Nation organization.

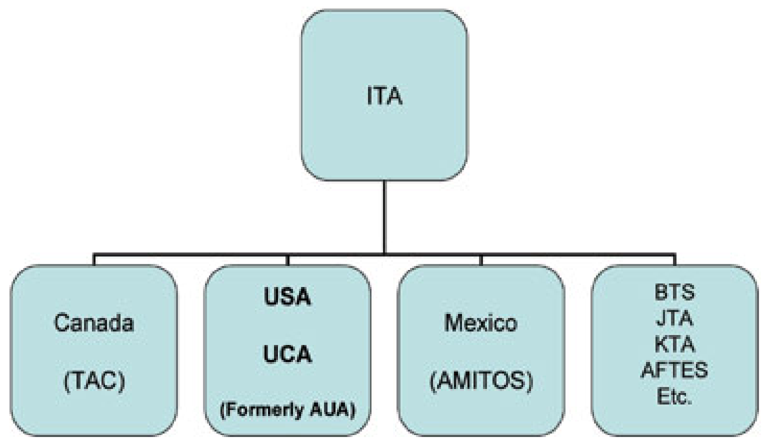


Table 1

ITA participation in meetings.

Annual meetings:
Annual World Tunnel Congress
- **Two have been in the USA**
  - 1979 with the Atlanta RETC
  - 1996 with the NAT in Washington, D.C.
- **Regionally**
  - TAC has hosted one in Toronto (1989)
  - Toronto will host the 2010 Meeting
  - AMITOS hosted one in Acapulco in 1992.

Assisting organization and participation in:
Regional, national and specialized meetings
- Technical meetings, workshops, colloquia
- Training sessions
- Participation in meetings organized by Member Nations such as lectures by ITA Executive Council members, animateurs and other ITA leaders.

What is ITA?

ITA has something for everyone involved in the tunnel and underground space industry. ITA decided at its annual meeting in Prague, May 2007 to change its name to the International Tunnelling and Underground Space Association. The abbreviation, ITA, and logo will remain the same.

ITA is an organization of 52 Member Nations with a wide-ranging geographic representation throughout the world. Each Member Nation is represented by one organization as illustrated in Fig. 1. In the U.S., the official representative to ITA is the UCA of SME. In Canada and Mexico the comparable organizations are the Tunnelling Association of Canada (TAC) and the Asociación Mexicana

Harvey Parker

Harvey Parker, member SME, was President of ITA for three years, Harvey Parker & Associates Inc, 10900 NE 8th Street, Suite 900, Bellevue WA 98004, e-mail harveyparker@compuserve.com

de Ingeniería de Túneles y Obras Subterráneas (AMITOS). It is estimated that the combined network of ITA extends through these Member Nations to some 20,000 people.

In addition to the main Member Nations, ITA also has Corporate Affiliate Members and Individual Affiliate Members. There are also two levels of sponsorship, the Prime Sponsor Level and Supporter Level. The USA has one prime sponsor, The Robbins Company and one supporter, Lemley International.

The ITA Secretariat is currently located on the university campus of EPFL in Lausanne, Switzerland.

What does ITA do?

ITA is a professional organization that represents the industry worldwide. The aims of ITA are:

- To encourage the use of the subsurface for the benefit of public, environment and sustainable development.
- To promote advances in planning, design, construction, maintenance, operation and safety of tunnels and underground space, by bringing together information thereon and by studying questions related thereto.

The ITA Vision statement is: "ITA, the leader in tunnelling and underground space."

ITA accomplishes its goals through a range of activities that include organizing meetings and working group and committee studies, experiments and activities. ITA is also involved in the publication of proceedings, reports, documents as well as interaction among its membership and with relevant organizations and decision makers.

ITA organizes and sponsors numerous meetings and workshops all over the world each year on the full range of topics associated with tunnels and underground space as outlined in Table 1.

During annual meetings, and now between meetings due to e-mail and other forms of communication, ITA's working groups meet and develop reports and guidelines for their particular field of expertise (Table 2a). Working groups are composed of individuals designated by the Member Nations as well as volunteers from the industry at large.

Recently, some new committees (Table 2b) have been formed to address issues of importance on a different level than what can be accomplished by working groups. Committees are composed of corporations and organizations interested in the particular topic. Unlike working group members, committee members pay a fee for their membership. One committee, the Committee on Operational Safety of Underground Structures (COSUF), has been successfully launched and now has more than 40 members. Committees on Education and Training and on Underground Space were being formed at the 2007 World Tunnel Congress in Prague, Czech Republic in May.

ITA continually publishes the results of its activities as outlined on Table 3. It publishes all of its information for the benefit of its members and the public. An enormous amount of valuable information has been pub-

Table 2a

ITA working groups.

- WG-02: Research
- WG-03: Contractual Practices in Underground Construction
- WG-05: Health & Safety in Underground Works
- WG-06: Maintenance and Repair of Tunnels
- WG-11: Immersed & Floating Tunnels
- WG-12: Shotcrete Use
- WG-14: Mechanized Tunneling
- WG-15: Underground Works and the Environment
- WG-17: Long Tunnels at Great Depth
- WG-18: Training
- WG-19: Conventional Tunneling
- WG-20: Urban Problems, Underground Solutions

Table 2b

ITA committees

- ITA-COSUF — Committee on Operational Safety of Underground Facilities.
- ITA-CET — Committee on Education & Training
- ITA-CUS — Committee on Underground Space

Table 3

Publication of proceedings, reports and documents.

Publications available from publishers.
- Proceedings of all World Tunnel Congresses.
- Scientific Journal: Tunnels & Underground Space Technology (TUST) (sent to all ITA Members).

Electronic Newsletter "ita@news"
- Covers activities of Member Nations, Prime Sponsors and Supporters and relevant news regarding tunneling and underground space.
- Sent every two months free to everyone who provides ITA with name and e-mail address.

Publications and presentations available from ITA Web site www.ita-aites.org
- Working Group reports (Published in TUST but the individual reports are available free on ITA Web site).

Position papers.
- Papers and presentations from all ITA training sessions.
- Selected workshop and conferences proceedings (papers and presentations).
- 30-year CD-Rom of all available formal ITA publications since ITA was formed.

lished and archived by ITA. Essentially, all the available documents published in the last 30+ years are available on the ITA Web site.

Finally, ITA is a forum for exchange of information among its members and for informing official bodies such as the United Nations, European Union, governments, owners and planners of the benefits of tunnels and underground space (Table 4)

A subsequent article will describe some of the valuable information available from ITA and a description of the significant contributions that the USA has made toward the success of ITA. ■

Table 4

Interaction with relevant decision makers.

- United Nations (NGO with UN since 1987)
- European Union
- World Bank and Development Banks worldwide
- Governments
- Owners and planners of tunnels and underground space

Chairman's report on ITA World Tunnelling Congress

by Tom Peyton, UCA of SME Chairman

I have just come back from the ITA's 33rd World Tunnelling Congress 2007 held in Prague, Czech Republic, and I have much to report. The International Tunnelling Association (ITA) is an organization of member states much like the United Nations. The UCA of SME is the United States' representative to the ITA. I attended as UCA Chair and as the voting delegate of the United States' contingent. I was accompanied by Dave Kanagy, UCA of SME Executive Director, and several other folks from the U.S..

For me, the work of the Congress started at 9 a.m. on Sunday May 6 with the first session of the General Assembly. The Executive Council was seated on a dais and the 52 member nations were seated around a large "U" shaped table. The business of the General Assembly is presided over by Harvey Parker, ITA President, and Claude Berenguier, Secretary General. All speakers are translated into French and English for the delegates.

This first session was taken up by routine activities such as approval of the week's agenda, reports on the May 4-5 training sessions and the auditor's report. Then, each member nation presented a brief update on significant activities in their country. I reported that the underground industry in the U.S. is very strong, that there are billions of dollars of new work starting to materialize, and that there are significant opportunities for both design and construction firms interested in perusing the opportunities during the next 10 to 15 years.

There were three important tasks for the General Assembly. The first was to elect a president, four vice presidents, and five members of the Executive Council. (The two candidates for president were Martin Knight of Great Britain and Harald Wagner of Austria). The second was to choose a location for the World Tunneling Congress in 2010. And a vote was needed to accept a new name and strategy for the organization going forward. This was all decided in the second session of the General Assembly on May 9.

After the General Assembly session ended, it was time for the working groups (WG) to meet. As the U.S. representative to Working Group No. 5 – Health and Safety in Works, we had been revising the "Guidelines for good occupational health and safety practices in tunnel construction." After discussing the guidelines, the group decided that this document could be presented to the General Assembly as complete. In addition, I suggested that the WG look at "Excavation in Contaminated or Hazardous Material" from a case study perspective and develop a database of experience. This suggestion was adopted and the working group leader will report on this new effort to the General Assembly. We also entertained a request from ventilation duct manufacturers to have the WG look at setting minimum recommendations for material flame retardant standards.

UCA held a Monday night dinner for U.S. attendees to the Congress. After dinner, I asked the group about their thoughts on the two candidates for ITA president. There was spirited debate on the merits of both candidates.

During the next two days, we attended the opening ceremony, keynote address and open sessions. The Congress papers, presented during the open sessions, are all published in a three-volume set and the keynote address was published in special issues of *Tunel*, the magazine of the Czech Tunneling Committee, our hosts for this 2007 Congress. These volumes will be available in the UCA of SME library. In addition, the ITA Web site will also publish the keynote lectures in a few weeks. WG No. 5 met with representatives of three vent line manufacturers and agreed to review the first draft of recommendations which will be prepared by the manufacturers. Kanagy and I also met with each of the candidates for ITA president to determine their views on issues of concern to us and other U.S. delegates during the few days prior to voting.

As you may know, ITA derives a large portion of its revenue from a group of Prime Sponsors that contribute 15,000 euros per year. As a result, ITA listens very carefully to the requests of these sponsors. Kanagy and I attended meetings with two of these Prime Sponsors that would like to conduct informational conferences in the U.S. during the next year. The UCA, at the request of ITA, will hold a New York City conference on "Fireproofing of Underground Structures" sponsored by BASF in October and a conference on "Shotcrete and Waterproofing in Underground Facilities" sponsored by Sika in May of 2008.

On Wednesday May 9, the second session of the General Assembly was held. Voting was first on the agenda. Martin Knight was elected president, succeeding Harvey Parker. All candidates for vice president and members of the Executive Council were elected. The names of these new officers and Council Members can be found on the ITA Web site. Vancouver, Canada, the only country that bid for it, was awarded the ITA World Congress in 2010.

One issue that turned out to be a difficult one for me was the strategy for ITA going forward. The first part of the strategy was to change the name of the organization from the International Tunneling Association to the International Tunneling and Underground Space Association. This passed since it better described the mission of the organization, which is to promote the use of underground space. The second part was the approval of the budgets going forward. Part of the strategy is to find someone to replace the secretary general who is expected to retire in the next few years. We were all provided with copies of the budget. There was little detail given that described how the revenues were derived or how the expenses were going to be controlled. In addition, there were insufficient operating reserves allocated. I asked the Executive Committee for additional information, but none was provided. A close look at the expenses indicated that there would be a shortfall in revenue to cover the expenses of the new secretary general and a transition period where two people would occupy the position. So the shortfall was going to be covered by taking money from the small reserves.

I could not, in good conscience, support the measure without more detail so I voted against the proposal and the budgets for 2007 and 2008. The U.S. vote was the only "no" vote. This raised some concern in the organization since no one had ever done this before. After the meeting, I had a discussion with the secretary general and the treasurer to review the backup to the income and expenses in general. We decided that we will sit down at RETC in Toronto to thoroughly review the budget.

On a social note, Prague is a storybook city, surrounded by history and music. And our hosts treated us royally. I think everyone was especially pleased (and awed) by the dinner held in the Prague Castle.

Hope to see you all in Toronto this month.■

Company profile

Robbins TBM will be used on Jinping-II Hydropower station

A Robbins Main Beam TBM will bore through a steep mountainside on the Jinping-II Hydropower Station in Sichuan Province, China. Robbins signed the contract on March 1, 2007 for the 12.43-m-(40.1-ft-) diameter TBM, backup, conveyors, cutters and related components.

Robbins and owners Ertan Hydropower Development plan to begin boring on the 16.7-km (10.4-mile) long headrace tunnel in March 2008 after an onsite assembly. Engineering and fabrication of key components will take place in Robbins' U.S. locations, while much of the steel structure will be coordinated for fabrication at the Robbins China manufacturing facility in Shanghai. Assembly will take place in January 2008 in an underground launch chamber pre-excavated by drill-and-blast.

Once completed in 2010, the Jinping-II Hydropower station will use a 150-km (93-mile) long natural drop in a bend of the Yalong River to generate 4,800 MW of electricity per year. Jinping-II is located 17 km (10.5 mile) downstream from the Jinping-I Hydropower station. It is slated for completion in 2014 and will have a generating capacity of 3,600 MW.

Jinping-II will be the largest power station in an ambitious 21-station project for Ertan Hydropower Development. The project will harness up to 25 million MW per year from the Yalong River for China's West-East Electricity Transmission Project.

The Jinping-II station will use four parallel 16.7-km (10.4-mile) headrace tunnels to generate electricity. Robbins will bore headrace tunnel No. 1, while headraces 2 and 4 will be excavated by drill-and-blast. All four tunnels are located in a complex geology of marble, shale and limestone with up to 80 MPa (11,600 psi) UCS. The high overburden, up to 2,500 m (8,200 ft) in height, creates a risk of squeezing ground, while faults and fractures as well as karst patterns revealed in the adjacent access tunnel and probe tests indicate the potential for high water inflows.

The entire TBM, backup and continuous conveyor setup in the tunnel will be raised to allow the expected large water inflow of 5 m^3/sec (1,300 gallons/sec) to pass under the backup. In addition, a water discharge pump will relay water from the cutterhead support to the end of the backup. Reserve saddles located under the gage area on the TBM cutterhead will allow for overboring if squeezing ground is encountered.

Robbins recently opened a new manufacturing facility next to its offices in Shanghai, China in late 2006. The new workshop was built specifically for industry-related fabrication and machine assembly. Currently, the facility is being used for TBM assembly for projects in the region. The workshop joins other Robbins facilities with manufacturing capabilities currently located in several places throughout the U.S. (in Ohio, Washington and West Virginia). ■

July 2007

• **8-11, International Pipelines 2007 Conference: Advances and Experiences With Trenchless Pipe Projects,** The Westin Boston Waterfront Hotel, Boston MA. Contact: Elaine Watson, ASCE 1801 Alexander Belt Drive, Reston, VA 20191-4400, phone 703-295-6030, fax 703-295-6144, e-mail ewatson@asce.org, Web site www. content.asce.org/conferences/pipelines2007.

September 2007

• **10-12, No-Dig Rome '07,** Leptis-Magna Conference and Exhibition Center. Contact: Organizing Secretariat Roma '07, LSG, Piazzale degli Eroli, 1600136 Rome, Italy, phone 39-06-39-73-13-94, fax 39-06-39-73-62-94, e-mail nodig2007@lsg-roma.it, Web site www. no-dig2007.com

• **10-13, 11th ACUUS Conference - Underground Space: Expanding the Frontiers,** Zita Congress & Travel Conference & Exhibition Center, Lavrion Technological Cultural Park, P.O. Box 504 Postal Code 19500 Lavrio, Attica, Greece, phone 30-22920-60610, Fax 30-22920, e-mail gerasimosk@zita-congress.gr, Web site www.zita-congress.gr.

More meetings information can be accessed at the SME Web site — http://www.smenet.org.

October 2007

• **11-12, 56th Geomechanics Colloquim,** Salzburg, Austria. Contact: Austrian Society for Geomechanics, Bayerhamerstrasse 14, 5020 Salzburg/Austria, phone, 43 -662-875519, fax 43-662-886748, e-mail salzburg@oegg. at, Web site www.oegg.at.

• **16-19, ICUEE 2007, The Demo Expo,** Kentucky Exposition Center, Lousville, KY. Contact: ICUEE Registration, CompuSystems, P.O. Box 465, Brookfield, Illinois 60513-0465, phone 800-867-6060 or 1-414-298-4144, e-mail info@icuee.com, Web site www. icuee.com.

November 2007

• **5-7, International Congress - Tunnels, Drivers of Change (AETOS),** Palacio Municipal de Congresos, Madrid, Spain. Contact: Congreso AETOS 2007 - Presencia Internacional - C/ Fuencarral 86, 3°A 28004 Madrid, phone 91-531-06-00, fax 91-531-05-41, e-mail aetos07madrid@presencia-inter.com, Web site www. congresoaetos.es.

• **27-29, STUVA-TAGUNG '07 - Connections by Tunnel,** Congress-Centrum Koelnmesse, Cologne, Germany. Contact: Mathias-Brüggen-Strabe 41, 50827 Köln Cologne, Germany, phone 49-0-2-21-59-79-5-0, fax 49-0-2-21-5-97-95-50, e-mail: info@stuva.de, Web site www. stuva.de ■

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Wireless system provides communications in rugged environments

The Airspec RN-1000 from Airspan Networks delivers high performance mobility by a number of key innovations not available in traditional 802.11 or Wi-Fi or other such wireless systems. ViaNet is based on 802.11. However, it provides enhanced mobility with zero-delay "fault tolerant" connection handovers.

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MineCom leaky feeder offers voice and video communications

The MineCom1000 is a very high frequency, analogue-based, full duplex mine-wide leaky feeder communications system. MineCom1000 offers up to 32 voice and or data channels, with the option of up to 16 video channels over a single leaky feeder cable. The MineCom1000 leaky feeder system provides "mine-wide" radio communications covering more than 100 km (62 miles) of tunnels.

The MineCom1000 leaky feeder system is completely flexible. It can be adapted to suit any mine tunnel system whether it is a coal mine, "hard rock" mine or even road, rail or sewage tunnels. The MineCom1000 leaky feeder system is easy to install, simple to operate and is even easier to maintain and expand by the mines own trained personnel.

www.minecom.com

Software provides environmental noise monitoring

The Larson Davis, a division of PCB Piezotronics, has released SoundTrack LxT firmware version 1.3, with added functionality for occasional and semi-permanent outdoor noise monitoring of city, factory and construction site noise.

This latest release provides a lower-cost alternative to the high performance Model 831. It allows for overall statistical history. And it provides enhanced data interval logging to measure every 100 milliseconds, allowing events to be captured with sufficient resolution. Community noise calculations may also be conducted right from the sound level meter itself.

SoundTrack LxT Version 1.3 is fully supported by the Windows-based Larson Davis Data, Navigation and Analysis (DNA) software for sound and vibration exposure measurement, analysis and reporting. Data can be logged directly onto a USB Thumb Drive for easy collection and analysis with DNA.

In addition to increased data collection capability and software support for SoundTrack LxT, the Model EPS030-LxT will allow SoundTrack LxT to take routine field data measurements over the course of one week. The Model EPS029-LxT extends this timeframe to two weeks. ■

www.larsondavis.com

The Larson SoundTrack LxT is supported by Windows-based Larson Davis Data.

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