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# MIXED CHALLENGES AT BLACKLICK

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# Mixed challenges AT BLACKLICK


## BLACKLICK CREEK SANITARY INTERCEPTOR SEWER

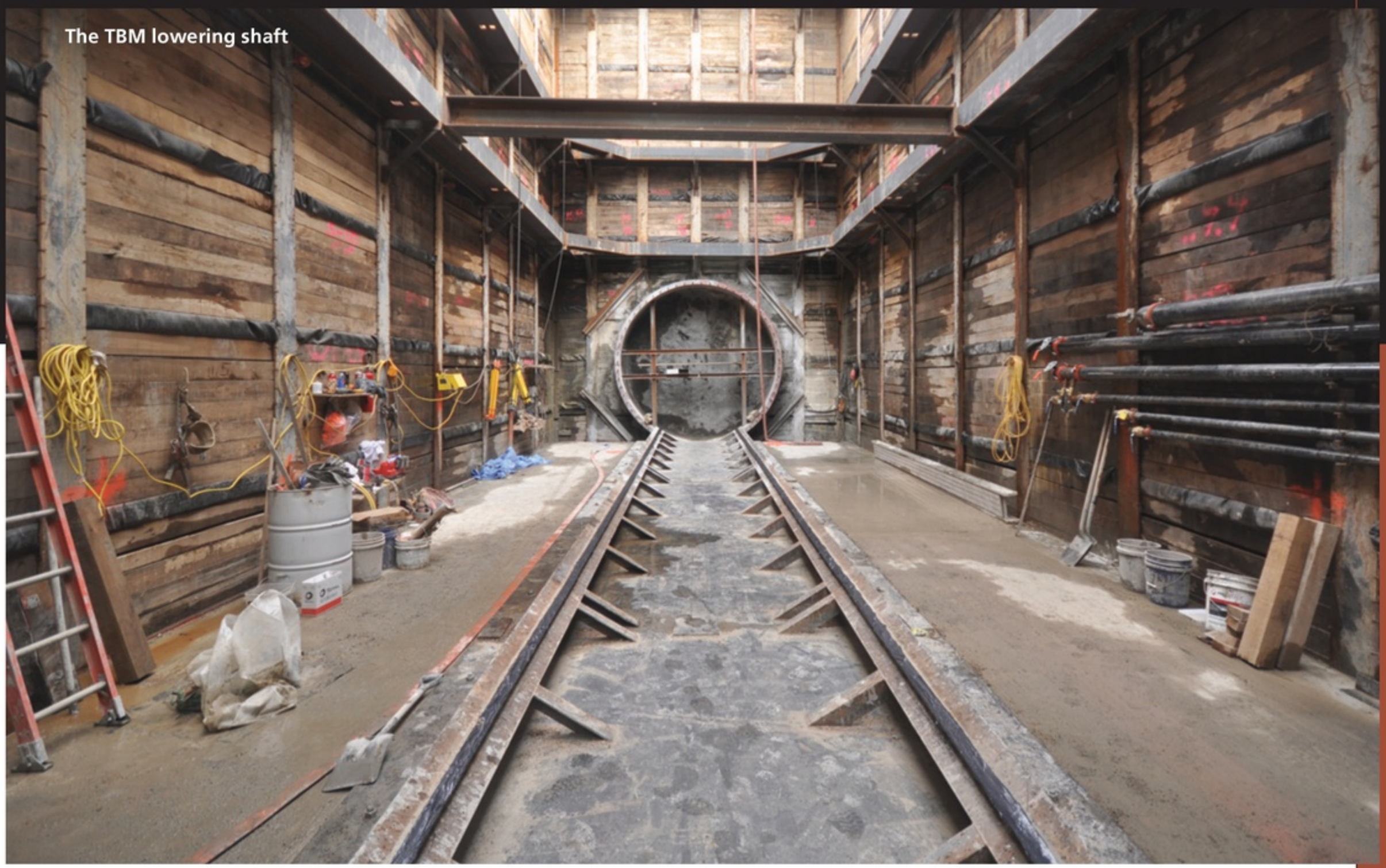
| | |
|---|---|
| Client: | City of Columbus |
| Contractor: | Blacklick Constructors (Michels/ Jay Dee LLC) |
| Designer: | EMH&T with AECOM, Aldea, Eagon and associates and HR Gray |
| Construction Manager: | Black & Veatch with iTunnel inc, Hatch Chester, Dynotec, HR Gray and Prime |
| Procurement: | design-bid-build |
| Notice to Proceed: | May 2016 |
| Completion: | 2020 |
| Cost of construction: | $109m, including 15% contingency |

**With the TBM fully launched, the team on Blacklick Creek Sanitary Interceptor Sewer is preparing to tackle a whole host of different ground conditions. Kristina Smith caught up with contractor, designer and construction manager to ask about the challenges ahead.**

**THERE ARE AROUND** 240 wells within a quarter-of-a-mile of the alignment of the new Blacklick Creek Sanitary Interceptor sewer in Franklin County, Ohio, and 610 within a half-mile radius. The water table here lies just 10 feet below the surface and much of this largely rural population rely on wells for their water supply.

"That number of wells within the project corridor led us to put a lot of focus on con-

**Figure 1 – The Blacklick alignment**


The TBM lowering shaft

trolling the water inflow into the tunnel when specifying the machine," says Mike Keller, partner of lead designer EMH&T. The specifications set a maximum limit for inflows into the heading and shaft of between 10 gpm and 30 gpm depending on the location.

To make life more interesting for contractor Blacklick Constructors, a joint venture of Michels Corporation and Jay Dee Contractors, Inc, the ground conditions along the 4.5mile (7.2km) route are extremely variable. The TBM can expect to encounter silt, sand, gravel, cobbles, boulders, clay, decomposed shale, weathered shale, unweathered shale, and any combination of these, with changes occurring frequently. Over 34,000 cobbles and 1,000 boulders ranging from 1 to 6 ft (0.3 to 1.8m) are expected within the tunnel face along the alignment.

Blacklick Constructors is using a Herrenknecht EPBM to create the 10ft (3m) ID tunnel. "We chose Herrenknecht because they offered the most attractive solutions to some of the challenges," says Ed Whitman, project manager for Blacklick Constructors. "We went with the machine we thought would be the most efficient for this job.

"We intend operating in EPB mode for the soft ground portion of the alignment. When we get to the shale sections, we will have to find out how the ground behaves to determine the appropriate method. At this stage, we are uncertain whether the shale will swell, flake, be dusty, sticky, expand in water, and generally speaking, how well it will excavate."

Since it may encounter water pressures of over 4 bar, the small-diameter EPBM has a 50 foot-long (15m) shield to accommodate a hyperbaric man lock, should it be required for interventions to the cutter head.

"We are most concerned about the soft ground portions. If we were to encounter a boulder or boulder field and the cutterhead suffered significant damage, we would have to do an emergency intervention," says Whitman. "The permeability of the ground is greater than $10^{-3}$(cm/sec)$^2$ which would preclude a free air intervention."

**Serving a growing community**

The new sewer will serve a 27,000-acre (11,000 hectare) area in the Northeast of Franklin County, one of the region's fastest growing areas. The population here, which reached 2 million in 2015, is now no longer concerned only with farming and rural life; new office developments, light manufacturing facilities, data centres and master planned communities are now part of the mix.

The sewer, which largely runs under the Reynoldsburg New Albany Road, will tie into an existing 66inch (1.7m) diameter sewer just south of Blacklick Ridge Boulevard (see map). From here it will head North and will connect to the Rocky Fork Diversion in the future, once that has been built. As well as serving North eastern areas of the City of Columbus, the sewer will also take wastewater from the Jefferson Water and Sewer District and the City of New Albany. (FIG 1)

"New Albany is one of the fastest growing areas for technology manufacturing so the need to support that ongoing growth is important," says Keller. "There's a lot of economic and regional benefit in the project." The City of Columbus is funding the $109M construction costs through a low-interest loan from the Ohio Water Pollution Control Loan fund.

For the design team, one of the challenging aspects was co-ordination. "As well as a number of different designers, the process was multi-jurisdictional; we had to interact with lots of different stakeholders to co-ordinate the overall design," says Keller.

Planning for the Blacklick Creek Sanitary Interceptor Sewer began back in 2006, but the project stalled in 2009 due to the global financial crisis. In 2012, the City of Columbus asked EMH&T to dust off the designs and move it on to final design stage.

The traditionally procured design-bid-build, lump-sum fixed price contract was awarded to Blacklick Constructors, LLC in early 2016, with the Notice to Proceed following in May that year. Having started on site just after that NTP date, Blacklick Constructors have to date constructed two shafts at the launch point of the TBM run, and is close to completing the first of two intermediate shafts.

The Herrenknecht machine arrived on site

January 12 and by mid-May was 450 feet (137m) into its drive, fully assembled. "According to the GBR, we have encountered almost all the variety of geologies we are supposed to be expecting throughout the drive," says Whitman. "So far the TBM has been working very well, with no surprises."

Blacklick Constructors used Shaft 1, 25 feet (8m) by 50 feet (15m) and the adjacent manhole 12, which is 20 feet (6m) by 35 feet (11m) (see map). The connection tunnel between Shaft 1 and Manhole 12 was initially going to be constructed by cut-and-cover, but in the event was hand dug.

"The starter/tail tunnel runs under a fairly busy road and when we got here and looked at it we decided there would be too much traffic disruption including emergency vehicles, and too many problems due to multiple buried utilities including (2) 35 KV power lines, so we opted to do a hand tunnel," says Rich Houghton, Construction Manager at Black & Veatch which leads the Cities management team.

The TBM was assembled in Shaft 1, with blind rings installed through the shaft which were removed once the back end of the TBM's ancillaries was clear of the shaft. Muck was extracted through Manhole 12 during the first 400 ft as the machine launched.

"This operation was not very efficient because Manhole 12 was not designed for production, it was intended to install the manhole structure," says Whitman. "We had to modify the shaft to make it large enough to serve the TBM launch, but whereas a ring typically needs 3.5 to 4 muck boxes to do one push, we could only fit one locomotive and a muck box in the shaft."

However, Whitman points out that the first few hundred feet of a drive are typically slow anyway as the miners got up to speed with how everything works. "Towards the end we were able to do five or six rings a shift, despite the impediments, so it worked out pretty well," he says.

Blacklick Constructors elected to use loci's and muck boxes, rather than conveyors, to bring the muck out simply due to the restrictive size of the tunnels. "We generally prefer conveyor belts because they are more efficient but in this case there were not a lot of options," says Whitman. "Once we install the ventilation into the tunnel, there isn't much room for anything else. We also had to procure custom muck boxes and locis."

Mining Equipment provided the locis, switches, muck cars, segment cars and ventilation equipment. "We have a long-standing relationship with them," says Whitman. "If we don't have it ourselves and we need to buy it, we typically go through them."

The intermediate shafts, Shaft 2 at 5,000 feet (1500m) into the drive and Shaft 3 at 14,000 feet (4270m) into the drive, involve multiple structures: a shaft which connects to existing sewers which flows into a drop shaft with a vortex structure and dissipation pool at the bottom, connected itself to the main tunnel by a smaller diameter tunnel.


**The TBM being lowered and readied for launch in the starter shaft**

Blacklick Constructors is drilling Shafts 2 and 3 but hasn't decided yet how Shaft 4 will be constructed. "We are planning to do a preliminary investigation, drilling around the shaft in June to get a better idea of how to tackle the current ground conditions," says Whitman. "Then construction will start later in the summer". Nonetheless there has been discussion from the City on redesigning this shaft for future connections.

Meanwhile the contractor will construct a bulkhead at the end of the tail tunnel between Shaft 1 and Manhole 12, construct the Manhole 12 structure, and restore the top of the shaft so that the area can be used as storage for the tunnel segments.

**Fibre reinforced segments**

The segments travel around 350 miles (560km) to site from where they are manufactured by Technopref. By mid-May 1,400 rings had been case and 500 were on site or installed.

"They are high quality segments and the finish is really good," says Houghton. "The way they insert the fibres into the mix using a conveyor seems to work well."

The segments are reinforced with Bekaert Maccaferri's Dramix 5D high-strength steel fibres which were designed for structural applications. The original specification called for a mix of steel fibres and a curved rebar ladder, but this approach was abandoned.

"We had a problem finding someone who could do the welding of the curved rebar ladders," says Keller. "We calculated that we could go with full fibre design and seems to be working out pretty well."

"For a sewer, steel fibres are a better product than rebar from a corrosion standpoint," says Houghton. "It's likely that the tunnel will last a lot longer than if it had been reinforced traditionally. And there are also less breakages during installation."

As well as ensuring that the City of Columbus' design team were convinced and supportive of the steel fibre reinforced concrete, the team had to apply for a special waiver of the American Iron and Steel provisions to use fibres which are currently manufactured outside the US.

**Over 100 boreholes**

The biggest challenge for the constructors is the same as for the designers: how to ensure the local residents' wells remain suitably charged whilst mining through difficult and changeable ground.

In a bid to mitigate this risk, EMH&T conducted a wide-ranging geotechnical investigation programme on behalf of the City. The programme comprised vertical and inclined auger drilled borings, rotosonic drilled borings, groundwater monitoring well installation, hydrogeological investigation, downhole geophysics loggings, geophysical probes, a geophysical pilot study and a large scale geophysical study.

A total of 107 bore holes were drilled, 100 along the final alignment. "The design-

The TBM gantries with segments being delivered

ers have done an extensive investigation campaign and we have lots of borings and information to go through," says Whitman. "But there's always a level of uncertainty: a boring only gives you the geological conditions at that location, but the sections in between borings might hold surprises."

It's the transition points that will be interesting says Whitman. Here the miners will be switching between soil conditioning agents: surfactant-based where the ground is sticky or polymers where high volumes of water is encountered. Project engineer Dr. Ehsan Alavi, whose Ph.D. research was focused on soil conditioning and cutterhead wear in EPB tunneling, will be on hand to advise and instruct the crew on judicious use and adjustment of soil conditioning regimen in different geologies.

The area's geological history provides an explanation of the many variations along the tunnel run. First the bedrock, which includes Cuyahoga Formation, Sunbury Shale, Berea Sandstone, and Bedford Shale was eroded and weathered by a river system. Then came the glaciers, filling the valleys created by the rivers with glacial material which includes large cobbles and boulders as well as glaciofluvial and glaciolacustrine soils.

The predominant bedrock along the alignment will be the Sunbury Shale, accounting for around 46% of the drive. The TBM should pass through five sections of the shale, alternating with softer ground.

Blacklick Constructors is fortunate to have experienced miners in its crews, some of whom came from the OSIS Augmentation and Relief Sewer (OARS) project which was finishing as this one began. The contractor has also been able to bring its TBM operators and key personnel from other jobs. "The unions are really good to work with on that aspect as well," comments Whitman.

To deal with the changing ground conditions, the contractor has chosen Tungsten Carbide Insert Pressure Compensated Mono Block Disc cutters that perform in the diverse geologies as the main cutting tools. In addition, and based on the contractor's previous experience, it is using additional precutters manufactured by Japanese supplier Starloy, as face cutters and overcutters to protect the cutterhead further.

"State-of-the-art engineering and tremendous effort has put in place under the supervision of Dr Alavi to armour the cutterhead for the diverse geology in this project," says Whitman.

Should an intervention be required in a soft ground section with high water pressures, the first choice would be to limp to the nearest safe haven: one of the two intermediate shafts. If that wasn't possible, grouting ahead 30 to 40 feet (9 to 12m) in front of the TBM would be the next step, says Whitman." If that's not possible, we would likely have to resort to grouting the face in to perform an emergency intervention and repair the damaged tools to get to the next safe haven."

A last resort would be to work under compressed air. Hence the manlock and facilities at ground level which can accommodate hyperbaric workers and physicians, and a DART (Diver Attendant Recompression Transportable) vessel which could be used to transport divers from the cutter head to a hyperbaric chamber on the surface. Blacklick Constructors has employed a specialized commercial diving company to oversee the diving operation and to control the decompression process, but is training up its workforce to do the work on the cutter head.

This type of intervention would be made even more challenging due to the small diameter of the machine. This is something the designers thought long and hard about before deciding to increase the specified size of the sewer to a minimum 10ft (3m) I.D; since this tunnel is tying into the 66inch (1.7m) sewer it didn't need to be any bigger than that to accommodate the flows.

Due to the subsurface conditions and hydrogeology, we wanted to use an EPBM and we evaluated everything from 9 feet up to 14 feet diameter machine," says Keller. "We bid it with the opportunity to build a 10 ft (3m) or 12 ft (3.7m) diameter finished tunnel to provide flexibility for the contractors."

"The size of the tunnel does restrict some of the available muck removal methods but it isn't much different than the conventional methods used in tunneling decades ago," says Whitman. "Space is very limited, if you need to upsize a pump on the machine, per say, it is difficult because there's not much room to fit it in, but that's just another challenge of the job."

Miners must also be on the alert for the presence of gases, as some of the boreholes indicated the presence of methane and several others contained carbon monoxide.

"We have to plan ahead and have contingencies for every anticipated problem," says Whitman, adding: "The bigger problems you have are often the ones you hadn't anticipated."

Some $750,000 has been put aside to deal with potential groundwater issues; 10 mobile water tanks have already been purchased with a plumber on hand and a well company which could drill new wells if necessary as some of the existing ones are shallow or semi-shallow. "It's important that we are as responsive as possible to the residents," says Houghton. "We have to ensure that people are back with water within 24 hours."

Diligence will be the order of the day for the entire drive, not only because of the groundwater issues but also because the road they will be tunneling under is one of the busiest in the County. "We have to be extremely vigilant to ensure we don't have any volume losses," says Whitman.

If all goes to plan, the TBM should break through into the reception shaft in 17 months' time, around December 2018. The project is well ahead of contractual milestones, says Whitman, which required the connecting tunnel between Shaft 1 and Manhole 12 to be complete by July this year and the launch to be done by September.

"It is a challenging project but we think we can make it a great job and finish early," says Whitman.