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All systems go for the Second Narrows Crossing

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With the launch shaft constructed and the TBM on site at the Second Narrows crossing in Vancouver, NATJ asked the project team about the challenges that lie ahead.

The Second Narrows Water Supply Tunnel is the second of five tunnels that Metro Vancouver is building to increase the resilience and capacity of its system. The 0.7mile (1.1km) tunnel will carry three water mains from North Vancouver, under the Burrard Inlet to the city of Burnaby.

It will be a varied drive for the Herrenknecht Mixshield which was due to arrive on site in early February 2020. Starting in alluvial and glacial soils, with anticipated water pressures of up to 7 bar, the geology then transitions into sedimentary rock for the last third of the drive.

"There could be some boulders at the transition from soil to bedrock, where there's a layer of glacial till on top of the bedrock," says Frank Huber, who heads up major projects for Metro Vancouver's Greater Vancouver Water District.

Boulders can be bad news. They certainly were for sister project the Port Mann Water Supply tunnel. The Caterpillar TBM had made it around 80 percent through the 1km-long drive when huge boulders wreaked havoc on the machine, resulting in delays. Contractor McNally-Aecon JV had to freeze the ground from a platform on the river before it could get in to do repairs and continue.

With the experience of Port Mann behind it, Metro Vancouver has added some elements to the Second Narrows contract. The contract calls for the TBM to be equipped for hyperbaric interventions and there is also the requirement to create a safe haven by freezing the ground at a point where the tunnel will run under a little spit of land.

On the Second Narrows tunnel project, contractor Traylor-Aecon has already had a sneak preview of the geology, as specialists subcontractor Malcolm-Petrifond constructed the launch shaft at the North end of the drive (see box). Spoiler alert: there were boulders.

Building resilience

The five new supply tunnels are part of a $4bn, 10-year capital program which also includes upgrades to pump stations, reservoirs and other infrastructure. In the 1990s Metro Vancouver identified the need to assess and enhance the resiliency of its water system.

"It really was not until the 1980s that people really understood the significance of earthquakes in the greater Vancouver area, because they don't happen very often," explains Huber.

Metro identified five river or marine crossings that needed to be replaced. The old system sees pipes running in shallow trenches in the river bed, covered by a layer of protective material. This is an outdated design that makes them vulnerable to earthquakes, scour and, in some cases, shipping damage.

Port Mann Supply Tunnel, which is a key link between Metro Vancouver's Coquitlam watershed and the communities south of the Fraser, was the first new crossing to be constructed because the old crossing has been damaged in the 1990s by a large freshet, or snow melt on the River Fraser. "We repaired the damage as well as possible under the challenging circumstances but knew that if we had another really large freshet in the Fraser River, significant scour of the river bottom could happen again. So, we needed to establish a new, more reliable water supply crossing," says Huber.

Construction of the Port Mann Supply Tunnel

Malcolm-Petrifond constructed the slurry walls for the North shaft of the Second Narrows Water Supply Tunnel, from which the TBM is due to launch in May this year.

North shaft previews ground conditions

During the design phase the construction of the slurry walls that form the 275 ft (84m) deep, 52 ft (16m) diameter North shaft from which the TBM will launch, was identified as one of the riskiest activities of the Second Narrows project. Cutting a 48 inch (1220mm)-wide trench through ground that contains cobbles and boulders is no mean feat.

"We knew the ground conditions were going to be challenging but we did not think they would be that challenging," says Ihab Allam, slurry wall director at Malcolm.

Below the layer of made-up ground at the surface, there layers of cobbles and boulders down to around 110 feet (33.5m). Below that were silty sands, a silty layer, organics and clayey material at the bottom.

Malcolm-Petrifond excavated using a combination of a clam bucket (grab) and hydrocutter, using bentonite slurry to support the excavation until the concrete was placed through tremie pipes. "We used the grab to remove the boulders in the top layer up to about 30 feet but then there were cobbles and boulders extending to a depth of up to 110 feet," says Allam.

The tolerance required by the Engineer to meet the design requirements for the slurry walls limits deviation at the bottom of the shaft to 0.4 percent which is 13 inches (330mm). There is no reinforcement in the slurry walls because they will not be part of the permanent structure. The final shaft wall will be a 33 ft (10m) ID, 39ft (12m) OD free-standing concrete tube, with pea gravel backfilling the void between the permanent shaft and the slurry walls.

It was important to maintain the verticality of each slurry wall panel, particularly towards the bottom of the shaft where Traylor-Aecon will need to seal its launch lock through which the TBM will start mining. "We performed verticality checks with the Koden ultrasonic drilling monitor every 50 feet," says Allam. "There are also instruments mounted on the hydrocutter to provide real-time monitoring – an inclinometer and gyroscopes - so the operator can see what's happening during excavation."

The secret to maintaining verticality and quality is to keep production rates steady, says Allam. "It's about educating the operators that slower sometimes is better. It's better to go slowly than to lose a couple of days backfilling panels to start again." Only two 10m-deep sections within two panels had to be re-done, he says.

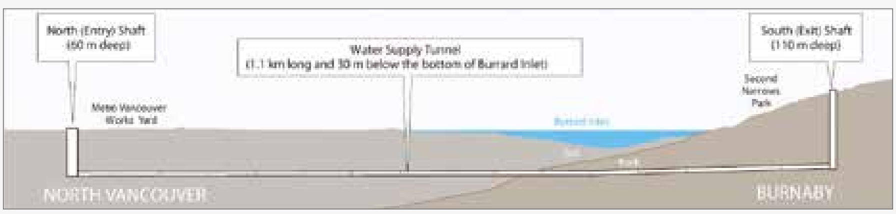
Malcolm-Petrifond did have to install a shear key at the bottom of the slurry walls into which the reinforcement for the base of the shaft would tie. "It was a challenge to put the shear key at the correct elevation at such a deep depth," says Allam. "The whole thing was about close control, taking our time and getting it right."

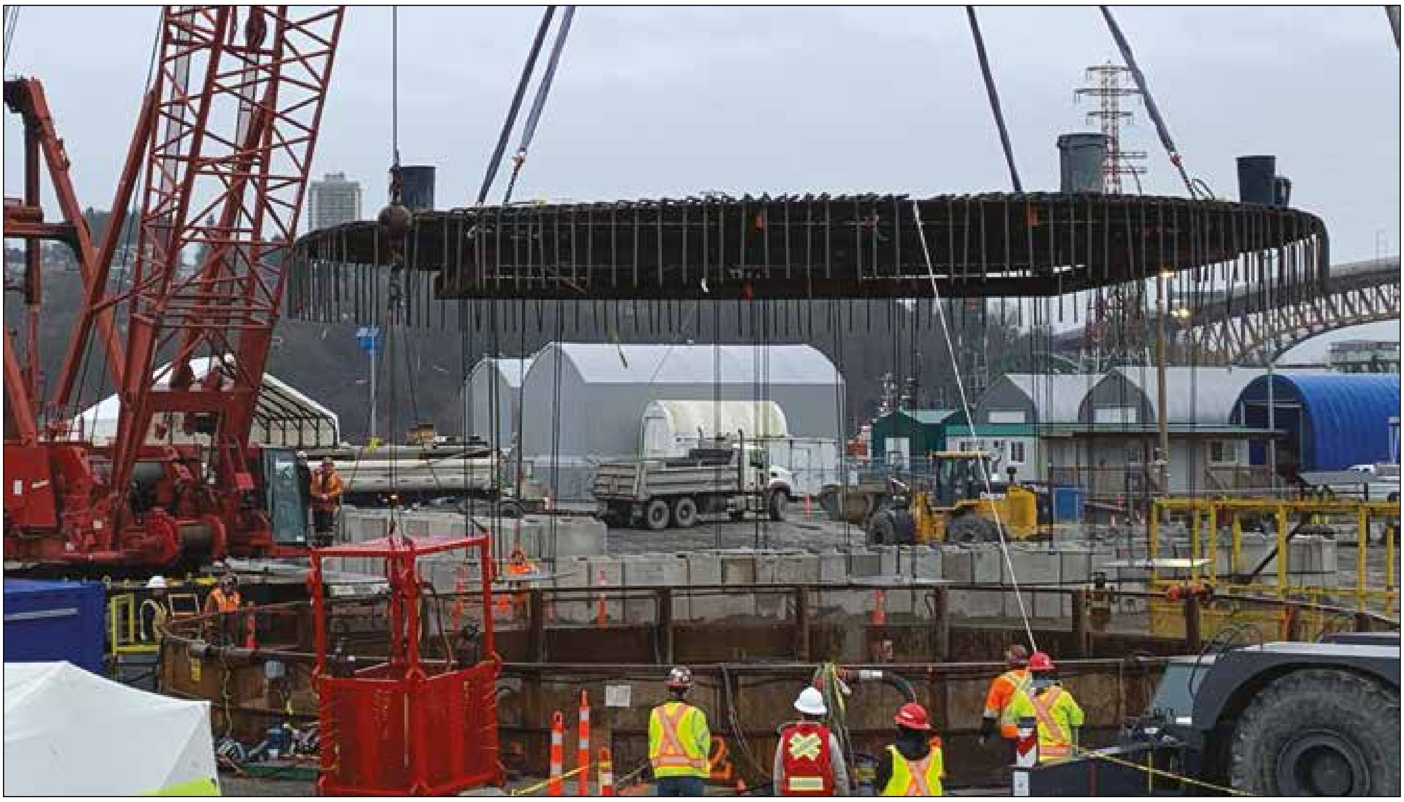
The concrete for the slurry walls, delivered through tremie pipes, was poured in 300 cu m batches. "We had several iterations of trial mixes prior to starting construction before we got to the right one," says Allam.

Once Malcolm-Petrifond had completed the slurry walls, Traylor-Aecon moved in to mass excavate the shaft using a grab. The first 100 ft (30m) could be excavated in the dry with the aid of pumps, after that everything was under water.

Traylor-Aecon employed divers from ASI Marine to blow out the shear keys and then attach 'L' shaped bars which tied into the reinforcement cage for the base slab. The concrete for the tremie slab was placed at the very end of 2019 and left to cure over Christmas.

Cross-Section of the Second Narrows Water Supply Tunnel





This is the tremie cage being lifted down shaft to provide reinforcement for the base slab

began in mid-2011 and finished late in early 2017. Once the Second Narrows Tunnel is complete, next up will be the 2.3km Annacis Water Supply Tunnel which will run between New Westminster and Surrey. The Request for Qualifications (RFQ) and Request for Proposals (RFP) for this project are expected later this year with the other two tunnels – Cambie Richmond and Haney – still in the early phases of design.

Metro Vancouver awarded the Second Narrows project to Traylor-Aecon, with their bid of $267m, in 2018 with work on site beginning that November. Although Traylor-Aecon's was the lowest-priced bid, the award wasn't made solely on that basis, says Huber.

Although Metro Vancouver used a traditional design-bid-build procurement route – McMillen Jacobs with Golder Associates and Aecom are the designers - it also assesses competency with its bidding process. After a short-listing process through RFQs, Metro Vancouver assessed proposals across several factors, with price accounting for around 50 percent of the tender marks. The other 50 percent goes to aspects such as methodology, staff and corporate experience.

"What we learned years ago was that for complex projects like tunnels, going the low bid tender route is not the best way," says Huber. "We want to make sure we have the right team with the right skill set."

Before it awards the contract to the highest-scoring contractor, Metro Vancouver goes into a negotiation period with that contractor to iron out any concerns. "With Port Mann, negotiations took three months, but that was back in 2010, so it was early days for that approach," says Huber. "Second Narrows negotiation only took only a few weeks."

Both projects have benefitted from a formal partnering process, too, says Huber. "We have regular meetings at the management level and among the broader team to work through any issues that the team may have. We also have social events for everyone to get to know each other better – it makes a big difference when solving problems."

Tricky launch

Following on from site preparation works, Malcolm-Petrifond began constructing the slurry walls for the 84m-deep North Shaft in April 2019 and finished in September 2019 (see box). Traylor-Aecon is currently constructing the 360 ft (110m) deep, 33ft (10m) diameter South Shaft, which is located in Second Narrows Park in Burnaby. Traditionally constructed through the sandstone and mudstone bedrock at increments of 1 metre, the shaft should be finished in the Spring.

Though the construction of the South Shaft is more straight-forward than that of the North Shaft, it caused Metro Vancouver some headaches at the planning stages. There were concerns about potential impacts to the Second Narrows Park and to nearby residents. After meeting with the municipal authority and local residents, Metro Vancouver came up with the solution of burying the 82ft by 66 ft by 33ft deep (25m by 20m by 10m) valve chamber at the top of the shaft, so that it won't be visible.

"Some of the most significant challenges we have faced have been with the many regulatory agencies we have to interact with," says Huber. "Over the last 20 years, there has only been an increase in regulations and regulators."

The next big milestone for Second Narrows was the planned arrival of the Herrenknecht Mixshield in early 10 February 2020, with an expected launch date of May 2020. Since the shaft is just 52 ft (16m) ID, the launch of the 22 ft (6.7m) diameter TBM and its gantries will be laborious. Traylor-Aecon

Divers had to install the L bars to link the slurry walls to the shaft slab. The water table was just a few metres from the top of the shaft, with pumps keeping it to around 30m below ground level.

will launch the machine bit by bit, mining for 50m, adding the first three gantries, moving a further 70m, and then adding the last three gantries. "This is not a high production show," says Matt Burdick, Traylor-Aecon's project manager.

The design suggested either a grout block or ground freezing to launch the slurry TBM through. However, Traylor-Aecon has opted to use a 'launch lock', which involves constructing a short section of tunnel in the shaft bottom, sealed against the slurry wall, and launching at full-face pressure of 6.5 bar through that.

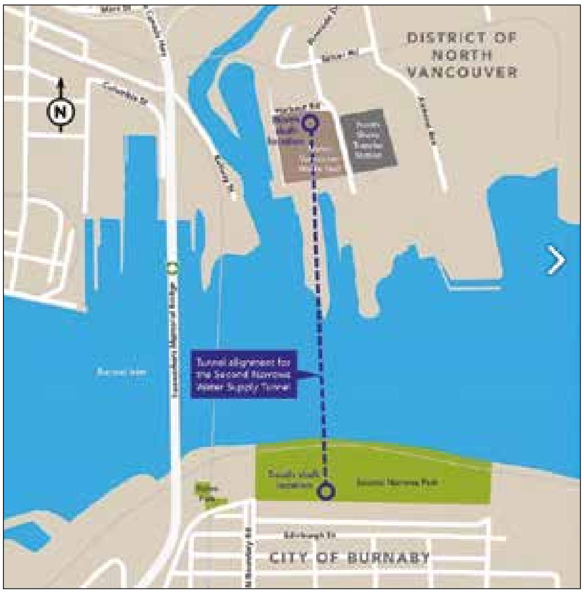
Given the ground it may face, the design of the TBM's cutterhead and its tools is vital. The outside rim of the cutter head will be heavily reinforced to counter wear that the Caterpillar EPB TBM suffered whilst mining through mixed ground on Vancouver's Evergreen Line, says Burdick. The machine will start with eight disc cutters in its central section which can all be changed to fish hooks if required. Tungsten carbide coatings will help improve the wear and the cutter head will be equipped with a robotic snake arm that can pressure wash the tools and photograph wear.

Much of the space inside the machine is taken up by the saturation access tube and manlocks which allow divers to access the excavation chamber in under saturation to carry out hyperbaric interventions. The lone vertical curve of the tunnel had to be adjusted to accommodate the hyperbaric shuttle which would carry divers from their pressurised living quarters to the TBM.

Although all the equipment will be on site, divers from Traylor company Ballard Marine will only be brought in when needed. "They would need a couple of weeks' notice to mobilize staff and to buy the gases," says Burdick. He adds that there will likely be a hyperbaric intervention before the machine reaches the frozen safe haven, which is at 1312ft (400m) in, and others are planned too.

It isn't just the large boulders which could cause problems along this drive. It is the fine stuff too. "There's a layer of very fine material that will cause advance rate problems with the slurry treatment plant," says Burdick. "There's a 15m stretch where we can only mine at 15mm per minute without doubling the capacity of the slurry plant." The plant, supplied by Schauenburg, will have a capacity of 1,200 cu m per hour.

Any delays at any point will have an impact on the whole job, says Burdick. "The challenge is the linear nature of the job, the inability to make up for errors later on," he says. "We are only mining for six or seven months. It makes it more important to figure out exactly how you are going to do everything."



The tunnel's alignment map

Mature approach

Metro Vancouver is no stranger to tunneling projects. Huber has been quoted in the local press as saying that Port Mann came in under budget because Metro Vancouver had allowed an appropriate contingency on top of the contract sum which was sufficient to cover the additional work during the project delay.

That means that, even though the Port Mann tunnel took longer to mine than planned, it is still chalked up as a success. Huber won't say how much the contingency is for Second Narrows, but he does say that it is more than the 10 percent applied to standard projects. The contingency sum was established based on a risk assessment, experience from past tunneling projects, and estimates from the design team and construction manager, says Huber.

The Port Mann Supply Tunnel can also be considered a success from another perspective: there are no outstanding claims between the main contractor and the client. "There were a few significant claims, but we resolved them without going through a long, drawn-out process," says Huber. That's something that the team will hope to replicate on Second Narrows.

One thing that Huber doesn't want to bring from Port Mann is innovation that creates additional risk. "On Port Mann, the designer tried to be very innovative and as a result, some of the tolerances were difficult to achieve which made it very difficult for the contractor," he says. "We have tried to avoid anything that is state-of-the-art, any new methodologies or new equipment on Second Narrows. We do want to try new things, but on smaller projects with lower risk, not on this type of complex and expensive project."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