



How a tunnel boring machine works

Energy heats our homes, cooks our food, and powers industry. The light oil and natural gas liquids (NGL) that Enbridge moves through Line 5 are transformed into propane, gas, diesel and jet fuel. While energy delivery is important, safe energy delivery is paramount. Enbridge is investing in Michigan to build a tunnel under the Straits of Mackinac and replace the current segment of our pipeline through the tunnel to make a safe pipeline even safer.

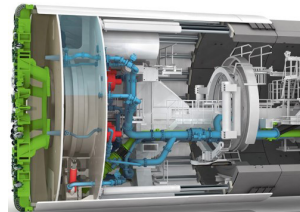
For more than 65 years, Line 5 has safely and reliably operated in Michigan. Enbridge has entered into an agreement with the State of Michigan to further protect the State's waters for decades to come. We plan to replace the Line 5 Straits crossing with a pipeline secured in a larger tunnel deep under the Straits. The tunnel will be bored through rock and soil using a tunnel boring machine.

Tunnel stability during construction

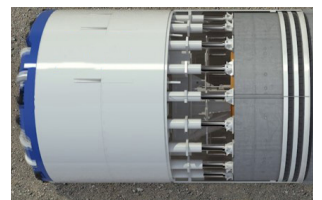
The tunnel will be constructed using a state-of-the-art pressurized face tunnel boring machine (TBM) which will be custom-designed and fabricated specifically for this project. The water, soil, and rock will be continually supported as tunneling advances.



The face or the shield of the TBM prevents water, soil and rock from entering the tunnel during construction.



The concrete segments are assembled into a water-tight lining inside the shield; under the protection of the shield. No water, soil or rock enters the tunnel during construction.

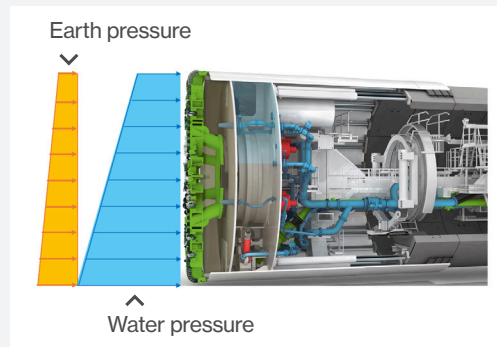


As the shield advances during tunneling, three tail seals at the back, or "tail", of the TBM prevent water from entering the TBM.

What's a slurry and why is it important in tunnel construction?

In the tunneling world, slurry is an engineered mixture of bentonite (a clay-like mineral) and water. It will be injected under high pressure into the front chamber of the tunnel boring machine (TBM) to balance earth and water pressures and carry the excavated material back to the surface.

The face or the shield of the TBM will be supported by slurry under pressure, as illustrated below. The precast concrete tunnel lining segments will be assembled and erected within the shield of the TBM. Grouting will be performed as the TBM moves forward and the tunnel lining emerges from the back ("tail") of the advancing shield.



Bentonite slurry under pressure to counterbalance water and earth pressures.

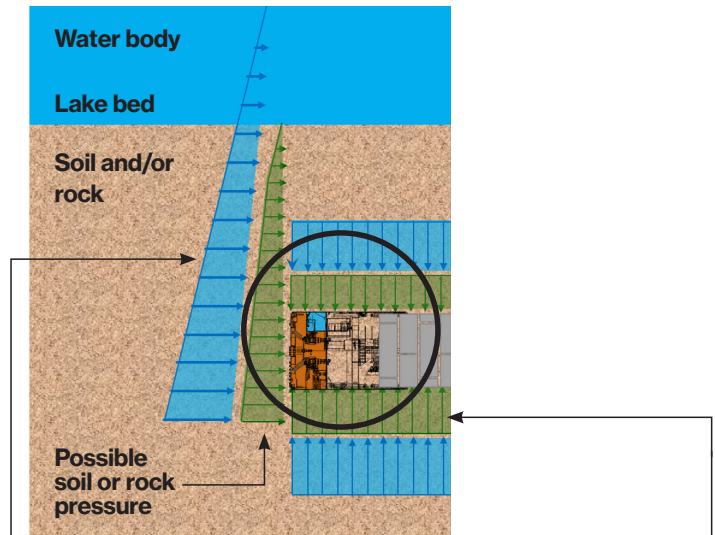
Periodically, the cutting teeth at the face of the TBM require maintenance, which requires workers to enter the cutterhead chamber. First, the slurry will be removed from the chamber and, depending on the ground conditions, compressed air may be applied to maintain the void and prevent groundwater inflow. When compressed air is used, workers who have been exposed to the same pressure that exists in the excavation chamber, are brought underground in a sealed capsule. The capsule is pressure locked to the tunnel face, and once the pressures are equal, the workers enter the excavation chamber to work.

During construction, the concrete tunnel lining will be monitored to check for deformation, cracking, or leakage, to confirm that the tunnel lining is performing as expected. With this tunneling technology and monitoring, stable conditions will be maintained throughout construction.

Tunneling with a pressurized TBM and a precast concrete tunnel is entirely different from historic mining and tunneling methods where the excavation was exposed and there was a risk of a cave-in or collapse.

Protection of the lakebed during tunneling

Tunneling beneath waterbodies is a common construction practice. The Great Lakes Tunnel Project (GLTP) is being designed to avoid impacts to the bottomlands of the Straits. The alignment is specifically offset from project boreholes that could connect the tunnel to the water above and will be located at a depth of approximately 60 feet to 250 feet below the lake bottom.

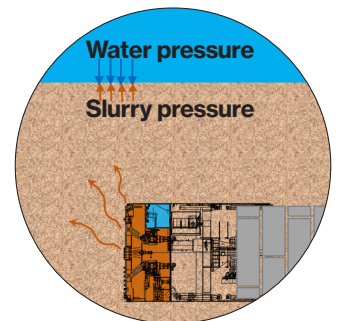


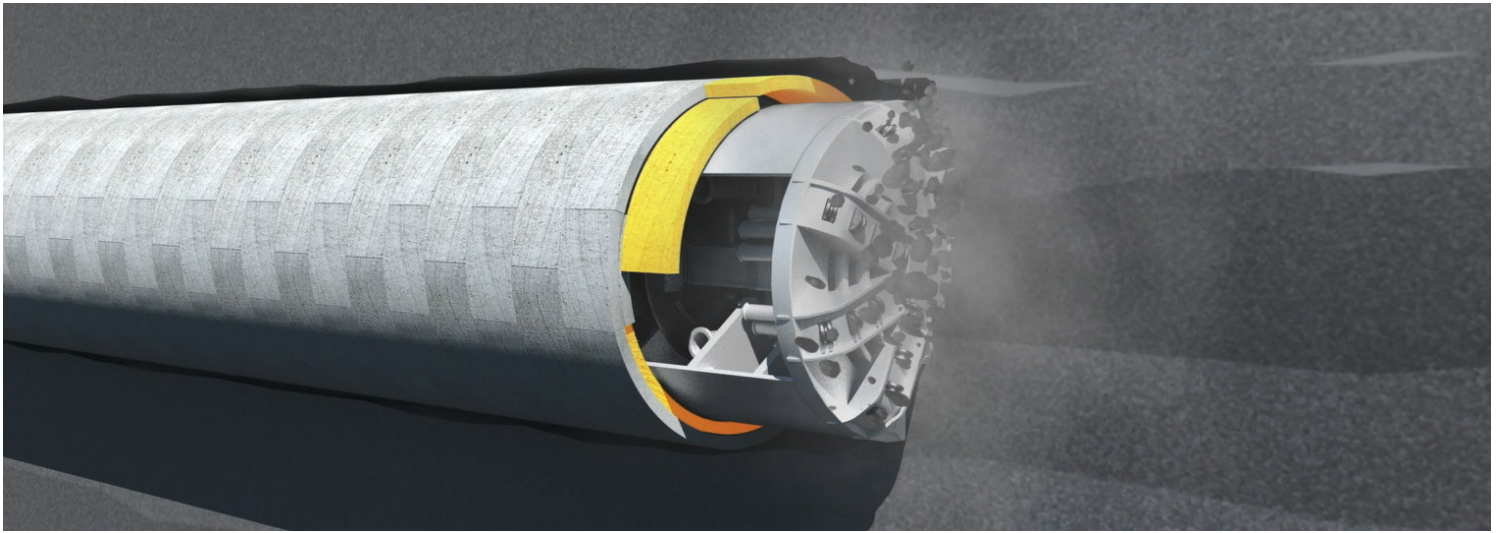
This is the maximum possible water pressure realized if the pores or fractures in the ground are fully connected to the lake water above.

This is a slurry pressure balanced TBM, specifically designed to counterbalance the water pressure at the face and counterbalance any soil or rock pressures, thereby creating stable conditions.

Typically, the tunnel boring machine (TBM) operates with slurry pressures that are not significantly above water pressures. On those occasions when the slurry pressure is higher than the water pressure, the slurry can penetrate the ground, although typically a bentonite slurry tends to "cake up" and prevent flow.

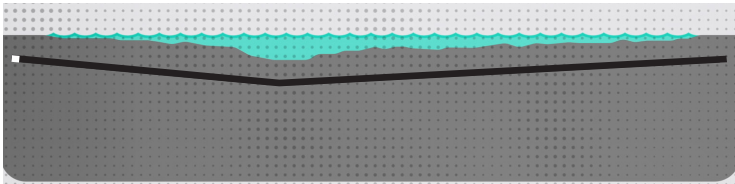
In addition, this project manages a slurry breakout risk by designing the tunnel with sufficient rock and soil cover and monitoring the flows and volume of the slurry circulation system.





Tunnel stability following construction

Everyday people safely use transportation tunnels located below waterbodies. The risk of collapse of the completed tunnel is extremely low. Planned inspections will verify the tunnel is safe and identify maintenance needs in a timely manner. Just as bridges are routinely inspected, so are transportation tunnels regularly being inspected to ensure safety.



The tunnel will be constructed on the south side of the Straits heading north. This orientation will minimize environmental impacts while allowing safe construction, operation and maintenance of the tunnel.

Tunnel as secondary containment

Based on an independent report completed for the State of Michigan, it was determined that the probability of a tunnel failure impacting both the pipeline and the tunnel is not a credible risk.

Considering the proposed design of the tunnel, it is reasonable to conclude that the probability of oil escaping the tunnel and entering the water in the Straits is so low that it is considered virtually zero. There is no credible scenario that would result in a release of product into the Straits.

The concrete lining of the tunnel will provide secondary containment, preventing any leakage of liquids from the pipeline into the lakebed or Straits. The concrete lining system includes high strength, high quality pre-cast concrete elements and durable, chemical-resistant, high pressure resistant gaskets (see picture below), with the rings around the concrete elements filled with low-permeability grout. Additionally, the tunnel will be constructed well below the lakebed with soil and/or rock separating the tunnel from the Straits. Finally, existing groundwater pressure in the soil and rock pores around the tunnel further prevents any liquids within the tunnel from migrating into the lakebed or Straits, since the pressure outside the tunnel exceeds any pressure within the tunnel.

Gasketed segments

The gaskets prevent water from entering the tunnel during and beyond construction.

