REBUILD OF A VETERAN TBM FOR MARYLAND'S ELLICOTT CITY NORTH TUNNEL: LONG-RUNNING PARTNERSHIP ENABLES EFFICIENT REFURBISHMENT OF 34-YEAR-OLD MAIN BEAM

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ABSTRACT: A veteran Main Beam Machine is set to bore Maryland's 0.9 mi (1.5 km) long Ellicott City North Tunnel, a major flood mitigation project designed to protect the historic town from future flash floods. Through a long-standing partnership with contractor Kiewit on TBM rebuilds, the 18.4 ft (5.6 m) diameter Main Beam TBM, originally built in 1991 and since used on multiple tunnels around the world, was refurbished in Robbins' Solon, Ohio, USA facility. In this paper, the authors detail the rebuild process used and the use of the TBM on the historic project.

INTRODUCTION

Throughout its history, the town of Ellicott City, Maryland, has experienced significant flash-flooding events along Main Street and the Ellicott City Historic District. At least 15 significant flood events have been recorded, dating back to the 1700s. One noted flood in the 1800s destroyed much of what was then called Ellicott Mills, and spawned construction of most of the district as it is known today. Over the last 15 years, three flood events have affected Ellicott City, including two major flash floods. The most recent flash-flood events have been referred to as "top-down" flood events, in which stormwater ran from adjacent topography through the Main Street area. Top-down flooding has occurred in Ellicott City throughout history. These flood events cause significant damage, as the flood waters travel at a high velocity, collecting anything in their path. Storms in 2011, 2016 and 2018 resulted in significant damage to infrastructure and buildings and took lives.

In efforts to prevent a recurrence of these flooding events, Howard County Department of Public Works (HCDPW) adopted the "Safe & Sound" flood mitigation plan in December 2018. The Ellicott City North Tunnel is the centerpiece of the Safe and Sound plan. Designed to divert stormwater runoff away from the historic downtown area, the new tunnel will convey up to 26,000 gallons (98,000 liters) of water per second during major storm events to the Patapsco River, helping protect Ellicott City's historic Main Street from flooding by safely channeling water underground.

The project design includes the construction of tunnels, drop shafts, near-surface conveyance and diversion structures, and an outfall/energy dissipation structure to minimize flooding along Lower Main Street and the West End.

The North Tunnel alignment begins on the north side of Frederick Road (~500 ft/150 m east of Papillon Drive) and terminates at the Patapsco River shoreline (~500 ft/150 m north of Main Street) in the west end of Ellicott City and runs for 0.9 m (1.5 km). The tunnel will travel 150 ft (46 m) below ground in certain areas and is located in a built-up and historic environment; hence, minimizing surface disruption and preserving historic structures were objectives of the design. The extension of the tunnel alignment (from a prior plan) allowed the elimination of several West End building-removal projects and reduced surface impact (see Figure 1).

The Tunnel Boring Machine (TBM) that will bore the tunnel is expected to begin tunneling in early 2026 following TBM assembly and launch from the completed shaft. Its performance will be supported by an experienced field service team to ensure smooth operations throughout the project's duration.

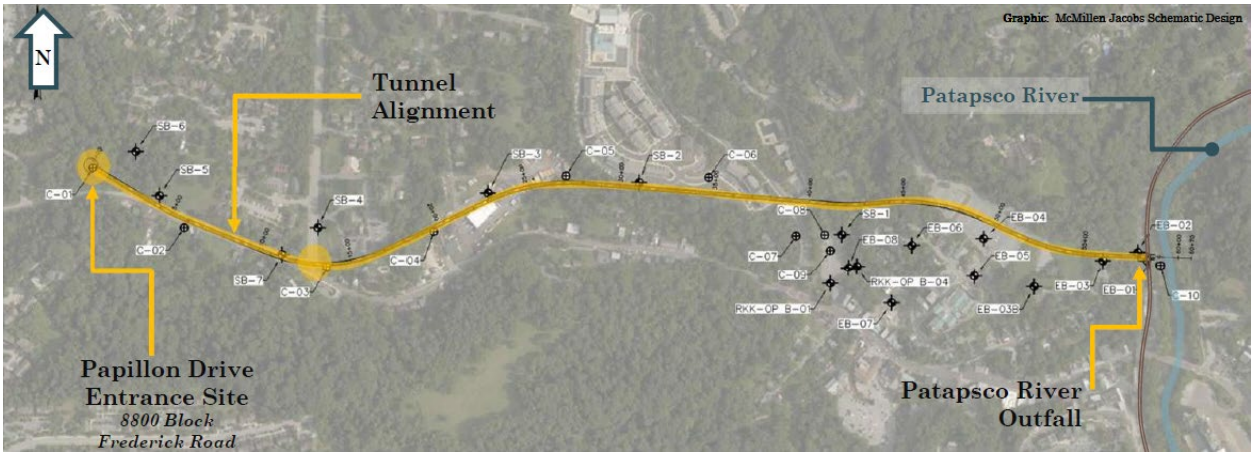


Figure 1. Ellicott City North Tunnel Alignment.

GEOLOGY

Ellicott City is within the Piedmont Physiographic Province on the eastern edge of Howard County along the border of Baltimore County. The eastern Piedmont is generally characterized by relatively low, rolling topography, with major streams incised into narrow, steep-sided valleys. Thin soil deposits are underlain by igneous and metamorphic rock. The Howard/Baltimore County line is delineated by the Patapsco River, which locally runs south. The city and the project extents are underlain by the Ellicott City Granite of the Silurian Period. Ellicott City Granite is typically characterized as a uniform, medium- to coarse-grained, weakly foliated to massive granite. Inclusions of fine-grained gneiss are common and elongated in the plane of foliation. The granite body in Ellicott City generally strikes northwest–southeast, discordant to the general strike in the Piedmont region. The granite is an intrusive igneous formation that contacts the Wissahickon schist and Baltimore Gabbro Complex. A characteristic outcrop of the Ellicott City Granite is depicted in Figure 2, near the tunnel outfall location.



Figure 2. Granite outcrop near the tunnel outfall location.

A phased geotechnical investigation was conducted from 2020 to 2022 and consisted of 29 soil borings and rock cores ranging from 92 to 284 ft (28 to 87 m) below ground surface (bgs). The investigation identified top-of-rock depths ranging from 5.0 to 150 ft (1.5 to 46 m) bgs. The granite bedrock is typically hard to very hard, slightly weathered to fresh, with very close to wide fracture spacing. A transition zone of highly to completely weathered

rock was identified at the contact between soil and bedrock. Dip angles range from 5 to 85° with a minimum of six joint sets.

These include a sub-horizontal set and five steeper sets dipping between 30 and 85 deg. Rock mass classes (RMC) along the tunnel alignment vary from Class I to Class IV with corresponding descriptions of Intact to Moderately Joint, Moderately Jointed, and Blocky & Seamy (both III & IV) with various degrees of weathering and discontinuity condition. (Bieniawksi, 1989).

The soil overlying the granite bedrock typically consists of silty sands and sandy silts with some clays and gravels. Typical standard penetration test (SPT) N values range from 7 to 45 blows per ft with some values exceeding 50 blows over 6 in (15 cm) close to top of rock. Additional test pits and UAV-based photogrammetry has been completed to further characterize the ground conditions (Nelsen, et. al., 2022).

Potential Challenges

Ground support

Portions of the tunnel are located in decomposed to intensely weathered granite. Localized overbreak is possible where intensely to slightly weathered, blocky and seamy to moderately jointed rock is present in the crown and sidewalls. Ground support will be required to address the poor ground conditions, and supplementary initial support consisting of spiles may be required for some tunnel reaches.

Railroad crossing/outfall

The outfall of the tunnel will cross under a single-track CSX railroad line that runs parallel to the Patapsco River. The tracks are bedded in 6 in (15 cm) compacted subbase overlying the Ellicott City granite. A staged construction approach will allow for the construction of a load transfer slab between the tracks and the tunnel prior to excavation. This will allow installation of vertical rock dowels and a reinforced concrete slab. After the load transfer slab is in place, the TBM will mine under the tracks with just 8 in (20 cm) of natural cover remaining below the slab. This will allow for TBM excavation of the entire tunnel alignment without the need for alternative excavation methods at the outfall or TBM extraction from a blind heading while mitigating the risk of adverse impacts to the CSX tracks.

Historic considerations

Immediately adjacent to or atop the alignment are numerous historic and architecturally significant structures. To limit the adverse impact of the project, the county and its consultant teams extended the length of the tunnel, in the process eliminating several proposed structure removals, as well as changed the originally anticipated drill-and-blast method of construction to a proposed tunnel-boring machine method of construction to reduce impacts from noise and vibration. Monitoring is stipulated throughout the tunnel construction.

TBM SELECTION

A hard rock, 18.4 ft (5.6 m) diameter Main Beam TBM was selected by the Kiewit-Traylor Bros. Joint Venture as the preferred tunneling method. The TBM, now owned by Kiewit, was originally built in 1991 (see Figure 3).



Figure 3. Original Manufactured machine 1991.

The -261 machine was used on multiple tunnels around the world totaling approximately 21 mi (33 km) of tunnel (see table 1 below).

Table 1. Projects of the Robbins -261 TBM

Year	Model No.	Project Name	Diameter	Geology / Ground Type	Tunnel Length
1991	MB152-261	Cable Tunnel (Hong Kong)	4.8 m	Granite / Volcanic Rock	18 159 Ft - 5535 m
1997	MB152-261-1	Quarry Bay Tunnel (Hong Kong)	6.2 m	Granite	8202 Ft - 2500 m
2001	MB152-261-2	Cobb County Water Transfer Tunnel (USA)	5.6 m	Gneiss / Schist	25 853 Ft - 7880 m
2003	MB152-261-2	Chattahoochee (North & South Drives, USA)	5.6 m	Gneiss / Schist	47 225 Ft - 14 390 m
2010	MB152-261-3	South River Tunnel (USA)	5.0 m	Gneiss / Schist	8640 Ft - 2630 m
2025	MB152-261-4	Ellicott City Tunnel (USA)	5.6 m	Granite / Gneiss	5500 LF - 1676 m

The -261 machine is a “Classic Robbins Open Gripper Main Beam” design operated at several different diameters, from 15.7 ft to 20.3 ft (4.8 m to 6.2 m) (see Figure 4).

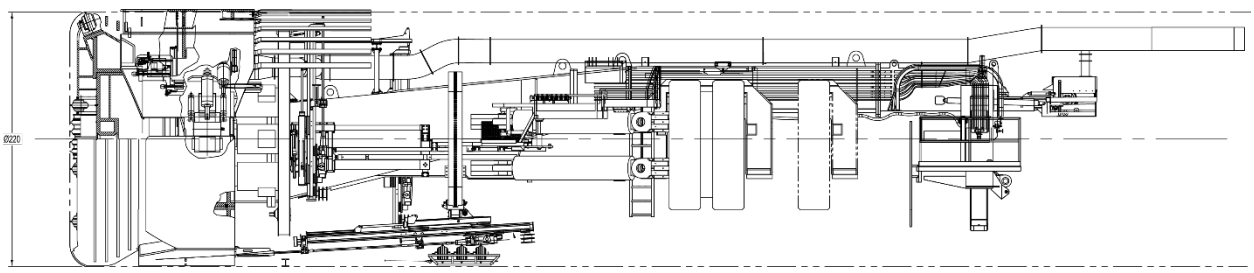


Figure 4. Schematic of the rebuilt Main Beam TBM.

Use of a Rebuilt Machine

Use of a rebuilt machine was seen as an advantage. While time and cost savings for a rebuilt machine can be highly variable, this depends on the extent of the rebuild and the number of projects the machine is used on. But there is general agreement that under the right conditions, savings and advantages can be significant.

TBMs are still in operation in the industry that have lasted over five decades—one machine of note, an 8.9 ft (2.7 m) diameter Robbins Main Beam TBM, was originally built in 1968 and is still in operation in Canada. With contractor-led refurbishment at the start of each project rebuilt TBMs can continue boring tunnels for many years. With each subsequent tunnel the savings in terms of time and cost multiply.

As for the savings of using rebuilt machines vs. new ones for each project, this is highly variable and can range from 75% cheaper for a simple machine and a tunnel project with tried and tested ground conditions, to around 20% cheaper for a project with more complex requirements (a high-pressure EPB for example).

The advantages of rebuilt machines aren't just in the costs, however. Contractors have stated that the time savings of using a rebuilt machine can be six months or more (as long as the TBM truly fits the project specifications and is not a compromise, and major changes aren't required).

The other benefit is in owning the machine itself: Familiarity of the TBM is a big plus, and operators and maintenance crews are familiar with the equipment, all of which can greatly improve performance during the initial learning curve.

TBM REBUILD PROCESS

Due to the long duration (nearly 15 years) between the South River project where the machine last operated in 2010 and the new Ellicott project, the machine underwent an extensive remanufacturing process.

As Kiewit owned the machine, the remanufacturing of the machine was done under a Partnering concept where Kiewit/Robbins worked together. The basis of the agreement was that the Parties work together jointly to provide a technically sound rebuild at an economical price.

The process included a full machine evaluation performed by Kiewit/Robbins with every component completely inspected against the original drawings and design tolerances.

During the process all the machine systems including hydraulic, lubrication, electrical, water and operating systems were reviewed with components being replaced and modernized and upgraded based on current technology and availability of component parts. The focus was on modernization, safety and compliance with current operating and safety codes (see Figure 5).

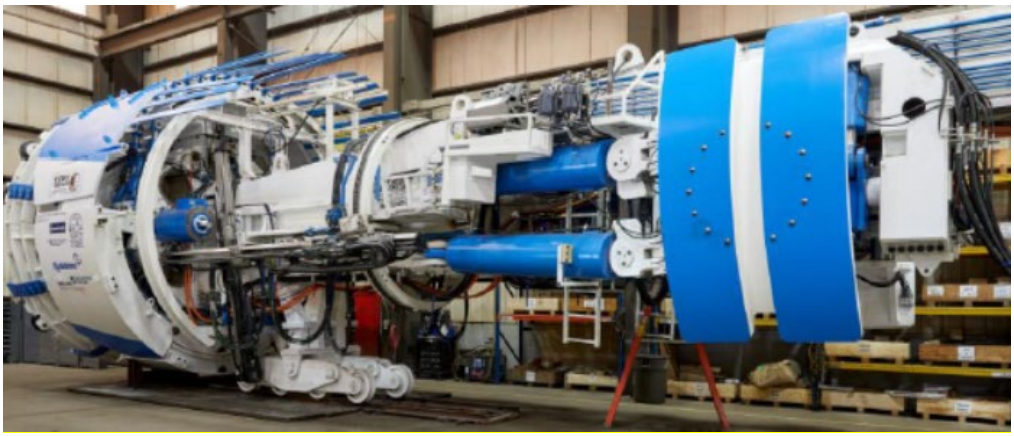


Figure 5. Machine undergoing refurbishment for Ellicott project in Robbins Workshop.

Some of the major modifications included the following:

- Diameter change to 18.4 ft (5.6 m)
- Installation of Variable Frequency Drive (VFD) for cutterhead operation
- New upgraded main bearing and seal system
- Added L1* ground support area behind the cutterhead for roof and probe drilling operations
- New modernized operators cabin complete with new PLC and operating systems

These modifications are meant to support robust excavation in hard rock - Variable Frequency Drives (VFDs) and planetary gear reducers allow for infinitely adjustable torque and speed control based on the encountered ground, which can optimize the TBM advance rate and reduce damage to machine components. Large diameter 3-axis main bearings, with the largest possible bearing to tunnel diameter ratio, have larger dynamic capacity and therefore are capable of withstanding more load impacts and giving longer bearing life. Flexible ground support and probe drilling options provide versatility if ground conditions change.

With the modifications complete the expected operational improvements follow in Table 2.

Table 2. Expected Operational Improvements

Aspect	1980s Baseline	After Modernization	Benefit
Controls & Monitoring	Analog	PLC & HMI	Precision & visibility
Safety	Legacy	Modern interlocks & LOTO	Safer operation
Productivity	Limited access	Improved platforms	**Efficiency**
Ventilation/Fire	Basic	Modern systems	Better crew safety
Documentation	Incomplete	As-built & QA/QC records	Traceability

The remanufactured machine completed a successful Factory Acceptance Test (FAT) in October of 2025 with expected start of site assembly February of 2026 (see Figure 6).

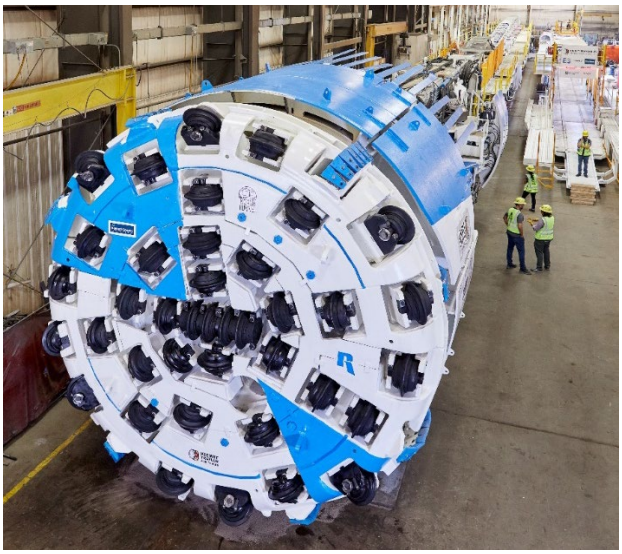


Figure 6. The rebuilt Main Beam TBM for the Ellicott City North Tunnel.

NEXT STEPS

With the rebuild complete, the machine will be transported to Maryland to be assembled in a 160 ft (48.8 m) deep shaft currently being constructed at the Papillon Drive entrance site (see Figure 7). The Kiewit-Traylor Bros. Joint Venture has made significant progress since breaking ground in June 2024. Shaft excavation is more than 50% done and will serve as key access points for the upcoming tunneling phase.

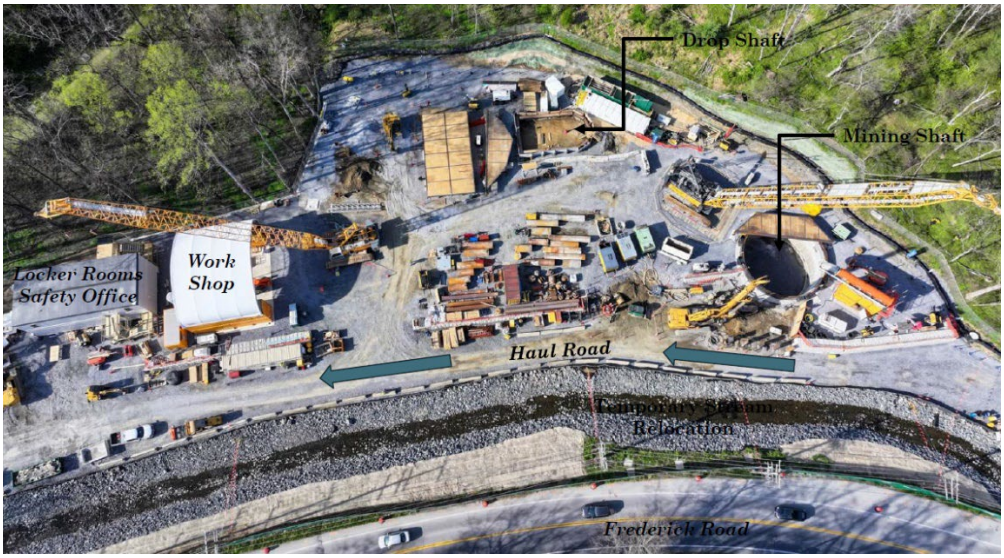


Figure 7. Papillon drive tunnel entrance, with shaft under construction as of May 2025.

CONCLUSIONS

The Ellicott City North Tunnel project offers a compelling case of how a major civil infrastructure project can benefit from the reuse of a veteran TBM. By refurbishing a Main Beam machine originally built in 1991, the

contractor and owner are able to capitalize on machine familiarity, supplier-contractor synergy, and cost/time savings versus a new procurement.

From a broader industry perspective, this example reinforces the viability of long-life TBM asset strategies: machines built decades ago are valuable with proper inspection, refurbishment and adaptation to new projects. The benefits—in cost, schedule, and risk mitigation—are significant. However, it is also imperative to perform rigorous refurbishment planning, condition assessment, and integration with logistics to align the machine capabilities with geologic and site conditions.

REFERENCES

Ball, Calvin (2025). Ellicott City Safe and Sound Flood Mitigation Projects Council Update, May 2025.

Bieniawksi ZT (1989). Engineering Rock Mass Classifications: A Complete Handbook for Engineers and Geologists. John Wiley & Sons.

Brandoni, Enrico & Maghari, Mohamed (2025). Ellicott City Refurbished Hard Rock Machine. Cutting Edge Conference, Norfolk, VA.

Nelsen, Hollenbeck & Dobbels (2022). Design and construction challenges for the Ellicott City North Tunnel. Proceedings of the North American Tunneling Conference: pp 364-371.