TUNNEL ACHIEVEMENT AWARD: JEFFERSON BARRACKS TUNNEL

▲ The Jefferson Barracks Tunnel spans 17,800 lf near the banks of the Mississippi River.

Tunnels are a crucial element in the Metropolitan St. Louis Sewer District's efforts to improve water quality in the region. During heavy rain or snow melt, excess stormwater enters the wastewater system, exceeding the capacity of both the sewer system and treatment plants. To prevent overflows, MSD is undertaking Project Clear, a $7.26 billion, 28-year-long initiative to improve water quality and lessen wastewater concerns in the St. Louis region.

Under this initiative, MSD's construction partners will dig tunnels into the limestone bedrock underlying the St. Louis area using a combination of tunnel boring machine technology and drill-and-blast excavation. Once complete, the tunnels are lined to keep groundwater out and wastewater in, and to support the excavations.

MSD's tunnel and underground program as part of Project Clear includes:

Project (Length, inside diameter)

- Lemay Redundant Force Main (0.6 miles, 8 ft) - Complete
- Maline Creek CSO Storage Facility (0.6 miles, 28 ft) - Complete
- Deer Creek Sanitary Tunnel (4.3 miles, 19 ft) - Complete
- Jefferson Barracks Tunnel (3.5 miles, 7 ft) – In Construction
- Lower & Middle River Des Peres Storage Tunnel (8.6 miles, 30 ft) - Upcoming
- University City Sanitary Storage Facility (1,250 ft, 30 ft) - Upcoming
- Lower Meramec Tunnel (6.8 miles, 8 ft) – In Construction
- River Des Peres Tributaries CSO Tunnel (3.1 miles, 17 ft) - Upcoming
- Upper River Des Peres CSO Storage Tunnel (2.6 miles, 22 ft) – Upcoming

The Lower Meramec Tunnel is actively under construction while the Jefferson Barracks Tunnel is in the finishing stages. Excavation on the Jefferson Barracks Tunnel is complete, despite unforeseen challenges that required the project team to work collaboratively to devise a new path forward. The ability of the team to navigate the difficulties and complete the project that provides immense value to the community has resulted in the Jefferson Barracks Tunnel being given the 2024 Tunnel Achievement Award for Project Excellence.

Established in 2012, the Tunnel Achievement Award recognizes successfully completed projects that demonstrate innovation and teamwork and provide benefits to the community. The award is presented annually at the Breakthroughs in Tunneling Short Course, which is scheduled for Sept. 9-11, 2024, on the campus of the University of Denver in Colorado. The award is presented in partnership with the organizers of the Breakthroughs in Tunneling Short Course and TBM: Tunnel Business Magazine.

JEFFERSON BARRACKS TUNNEL

Designed to address sewer overflows in the Lemay/South St. Louis County area, the Jefferson Barracks Tunnel extends from just south of I-255 at Koch Road to the Lemay Wastewater Treatment Plant at the confluence of the River des Peres and the Mississippi River.

After performing a thorough evaluation of alternatives, MSD selected a deep tunnel as the best solution to modernize the sewer system in this area. The new tunnel and additional construction will improve the current sewer system, adding more capacity to collect, transport, and store wastewater, preventing overflows that threaten to pollute waterways.

Stretching 17,800 ft (3.37 miles) parallel to the Mississippi River, the Jefferson Barracks Tunnel is 11 ft ID and lined with 7-ft Hobas fiberglass pressure pipe. Adding to the complexity of the project, the route runs through an area of river bluff karst, a porous limestone containing numerous caves and sinkholes caused by erosion. The tunnel had to be carefully aligned to avoid the difficulty and expense of building in such challenging conditions. Engineers determined the best solution was to bore below the karst zone and tunnel into limestone bedrock at 150–230 ft below the surface.

"By selecting a deep tunnel option, we were able to avoid disruption that would have been caused vs. replacing the aging shallow force mains in the area," said Allen Muehlher, Assistant Director of Engineering for MSD. "Not only would tunneling be less disruptive, but eliminating force mains in the area minimizes the potential impacts in this sensitive area."

Additionally, the site traversed sensitive areas that could not be disturbed, including the Jefferson Barracks National Cemetery, Jefferson Barracks Park (the site of an old Army base which is listed on the National Register of Historic Places), a VA hospital, a high school and an interstate highway.

"This project required an extensive amount of public outreach during the design phase because of the restraints involved in interfacing with the park, the military, the hospital, the cemetery and others," said Bill Haag, Project Manager with Jacobs Engineering. "The project team made a concerted effort to meet with all of the stakeholders and discuss what the impacts would be so that when it came time to sign easements there was a level of comfort."

One of the main challenges recognized by the planning and design team was the presence of karst features in the area. The site is adjacent to the Mississippi River and sinkholes are present and visible from the surface in the area, so a thorough geotechnical investigation program, including the use of geophysics, was conducted.

"During design, we recognized the potential for karst and water intrusion given that we were right next to the Mississippi River," said Patricia Pride, Project Manager for Design at MSD. "After conducting several evaluations, we decided to lower the tunnel during the design stage to reduce the likelihood of encountering potential problematic areas."

The extensive investigation program included a geophysical survey in addition to vertical borings. "Geophysical surveys can help define geological boundaries," said Tom Abkemeier, Project Manager for Shannon & Wilson Inc., which served as the Construction Manager for MSD. "With the geophysical survey, however, there are limitations the deeper you go. In this case the project team took into account surface features and results from the vertical borings to help interpret the geophysical survey information."

A field site survey to note surface features, notably sinkholes, and a review of historic records were also used to paint as complete of a picture of the subsurface as possible.

With an alignment selected that was believed to be below the karst features in good limestone bedrock, Affholder (formerly SAK Construction) was hired as the tunneling contractor to build the tunnel. Affholder commenced tunneling for the project using an 11-ft diameter Robbins open-face rock TBM. The 11-ft TBM diameter was specified as the minimum size, to enable installation of steel ribs and lagging if needed to support

PROJECT-AT-A-GLANCE

Name: Jefferson Barracks Tunnel

Location: St. Louis, Missouri

Scope of Work: 17,800 ft of 11-ft ID TBM tunnel, lined with fiberglass pressure pipe. Depth ranges from 150-230 ft below the surface.

Ground: Limestone

Owner: Metropolitan St. Louis Sewer District Dallas

Contractor: Affholder

Tunnel Designer: Jacobs Engineering Group

CM: Shannon & Wilson

Contractor's Consultant: Brierley Associates

TBM Manufacturer: Robbins

Subcontractors: Case Foundation (shafts), ACT (pre-excavation grouting), Williams Tunneling (tunnel construction and carrier pipe installation), Goodwin Brothers Construction (intake construction)

Bid value: $63.3 million

▲ To rescue the stranded TBM, Affholder constructed a recovery shaft and tunneled back toward the machine.

▲ The completed tunnel will help MSD achieve its goal of improving water quality in the area.

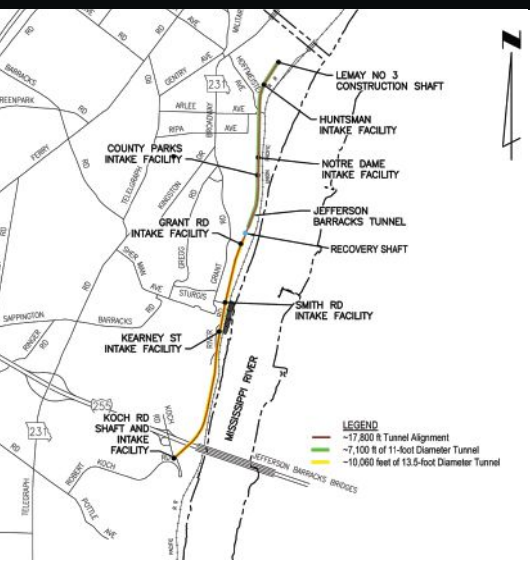
zones of low quality rock, and to accommodate ventilation and electrical needs in a tunnel this length, according to Andrew Bursey, Global Principal-Tunneling at Jacobs Engineering.

SETBACK AND RECOVERY

In May 2019, the contractor was making good progress through the first third of the tunnel alignment when a karst feature was encountered. Inflows from the void put a stop to mining and forced the team to consider their options for going forward.

The first step was to pump grout in front of the TBM through grout holes on the surface to stabilize the area. During the process and in further investigation of the vicinity, it was discovered that two karst features – one at the tunnel level and another at a higher elevation – were present. As a result, it was decided that the best course of action would be to construct a recovery shaft in stable geology in front of the machine, tunnel back to rescue the TBM, and re-launch with a different TBM that had the capability of probing and grouting in front of the machine.

Concurrently with the surface grouting work, Brierley Associates on behalf of Affholder performed a geotechnical investigation between the proposed shaft and the stalled TBM. The investigation included rock coring and downhole packer testing. Based on information gathered, Brierley designed a 200-ft deep by 40-ft diameter recovery shaft approximately 200-ft ahead of the TBM, in a location identified by the geotechnical investigation as being likely to have limited or no voids at the tunnel depth and minimal voids above the proposed alignment. Shaft support consisted of ring beams and lagging in soil, and rock bolts and shotcrete in rock. Ground support in the recovery tunnel consisted of rock bolts and mesh for initial support in the good rock, and a pipe canopy (spiling) with steel sets through



▲ **Jefferson Barracks Tunnel alignment.**

the karst features that extended 65 ft in front of the stalled machine.

Affholder excavated the recovery shaft to the tunnel elevation and conventionally excavated the recovery tunnel to a point approximately 75-ft ahead of the machine, where additional karst features were encountered. At this location, a temporary 8-ft thick reinforced concrete bulkhead was installed to allow probe-hole drilling and high-pressure grouting from inside the recovery tunnel. This resulted in placing 200 CY of low-mobility cement grout to further fill in-situ void space, cut off groundwater, and consolidate loose infill materials.

Once the initial grouting through the temporary bulkhead was complete, a double row pipe canopy of spiling was installed through the bulkhead. Installation of the inner spile row was carefully logged to document the grouted and un-grouted features. These karst features were mostly infilled with organic clay, although some coarse alluvium was also encountered.

Affholder was prepared to advance sequentially with a partial heading if necessary. However, based on the probing and grout takes at the bulkhead, it was decided to remove the bulkhead and continue carefully with full face drill-and-blast excavation. The final 65-ft of rock in front of the stalled TBM was shot in relatively short rounds with mechanical excavation of void infill material. Numerous karst features, typically 4 to 8 ft across, were encountered along this final reach of the excavation. Some contained grout in addition to the alluvial materials, but very little water was encountered. Steel sets and shotcrete were installed within the canopy to complete the tunnel initial ground support.

In July 2021 the team celebrated a reverse hole-through when the Jefferson Barracks recovery tunnel was successfully excavated to the face of the stalled TBM. The machine was advanced to the recovery shaft and removed for refurbishment.

A replacement 13.5-ft Robbins Main Beam TBM was relaunched out of the same shaft in Spring 2022 – commencing what became Phase 2 of the project. The new machine was designed to detect karst and other underground features by probing. The unique machine was equipped with enhanced 360-degree probe drilling capabilities, as well as versatile ground support options including McNally crown support, wire mesh, ring beam erector and roof drills.

The TBM holed through at the reception shaft on Dec. 20, 2022, with no major additional karst zones being encountered. One smaller karst area was encountered after the re-launch but was successfully handled with grouting from inside the tunnel, as designed.

All carrier pipe has been placed and grouted into place. In areas where significant groundwater inflows were present, the project team used a denser grouting formula to prevent washout. As of late June, Affholder was in the process of backfilling the shaft, with only restoration work and pressure testing remaining.

Ray Scherrer, Division Inspector for the MSD, cited teamwork and communications as keys to the successful completion of tunneling. "It took a great deal of coordination of the entire project team to not only deal with the technical issues, but third parties as well," he said. "Even something as seemingly straightforward as building the recovery shaft was challenging due to coordination between parties including the Missouri Historical Society, Great Rivers Greenway, Union & Pacific railroad, and others. Every time we put a shovel in the ground we were facing a delay to get approvals."

Boyd Hirtz, President of Affholder's tunneling division said: "There was great collaboration between Affholder, MSD and the consultants in figuring out how to complete the tunnel after the karst void was encountered. Everyone worked well together to finish the project in difficult conditions."

TUNNEL ACHIEVEMENT AWARD WINNERS

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2024:
Jefferson Barracks Tunnel, St. Louis, MO

2023:
Mill Creek Drainage Relief Tunnel, Dallas, TX

2022:
Kemano T2 Tunnel, Kitimat, BC

2021:
DigIndy Tunnel System, Indianapolis, IN

2020:
Regional Connector, Los Angeles, CA

2019:
Ohio Canal Interceptor Tunnel, Akron, OH

2018:
Northgate Link Extension, Seattle, WA

2017:
Blue Plains Tunnel, Washington, DC

2016:
Lake Mead Intake No. 3, Las Vegas, NV

2015:
Bay Tunnel, San Francisco, CA

2014:
Port of Miami Tunnel, Miami, FL

2013:
East Side CSO, Portland, OR

2012:
No. 7 Extension, New York, NY

2012:
Dr. Martin Herrenknecht, Herrenknecht AG