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TUNNELING
Fact Sheet

Metro

Shedding Light on Tunnels

New public transportation projects, whether rail or highway, may include construction of tunnels. This fact sheet provides an overview of some of the factors that help determine when tunnels are appropriate for a project, as well as information on tunnel technology, engineering, construction and safety.

Overview

To build or not to build (a tunnel)?

Tunneling is one option when planning a new transportation project, although not appropriate in all situations. The costs, benefits and impacts of a tunnel must be evaluated in comparison to alternative alignments at or above ground level. Some factors that are used to determine whether to build tunnels include:

> **Physical environment:** Tunnels may be appropriate when a transportation project needs to cross physical or topographical barriers, such as mountains or waterways.

> **Dense environment:** Some areas may not have enough space above ground to accommodate the new transportation project. This could be due to the width of the right-of-way or street where the project is planned, or existing buildings or other structures in the area.

> **Demand, ridership and speed:** Travelling below ground can be faster than ground-level alternatives that need to slow down or stop to accommodate vehicle traffic. Tunnels may be considered for projects where there is a need to move large numbers of people swiftly to meet forecasted demand.

> **Community input and feedback:** During project study phases, the community is encouraged to participate in the overall review process. Metro staff and board directors hear and consider public input when making decisions about the project.

> **Local, state and federal regulations:** Metro follows all applicable regulations, including relevant environmental, construction, health and safety regulations. These regulations often have bearing on project planning, the choice of the type of infrastructure and the construction methodology.

> **Federal funding criteria/cost-benefit analysis:** Metro often seeks federal matching funds for major projects. We will therefore look to identify a project that ranks well for these highly competitive funds following set federal guidelines for cost-benefit analysis.

> **Real estate acquisition:** All projects typically require Metro to acquire real estate. The acquisition could be temporary if property is needed only during project construction. Real estate may also be acquired permanently for stations, right-of-way, other project features or underground easements. Projects built at or above ground level will typically need to purchase more ground-level property than below ground projects. *Please see our Property Acquisition Fact Sheet for more information at* metro.net/resources.

As a part of a project's environmental review process, various studies are completed to determine whether a proposed project warrants construction of a tunnel. *Please see our Environmental Review Fact Sheet for more information at* metro.net/resources.

Current Tunnel Projects in Los Angeles

As Metro continues to expand its rail transportation network, tunnels have been constructed for the following projects:

> Metro A/E Lines: Includes a short tunnel segment between 7th St/Metro Center and Pico Stations. *Opened 1990.*

> Metro B/D Lines: Fully underground from Union Station to North Hollywood and Wilshire/Western Stations. *Opened in phases between 1993–2000.*

> Metro A Line: Includes tunnel sections in Highland Park and Pasadena, and a tunnel between Pico/Aliso and Soto Stations. *Opened in phases 2003–2016.*

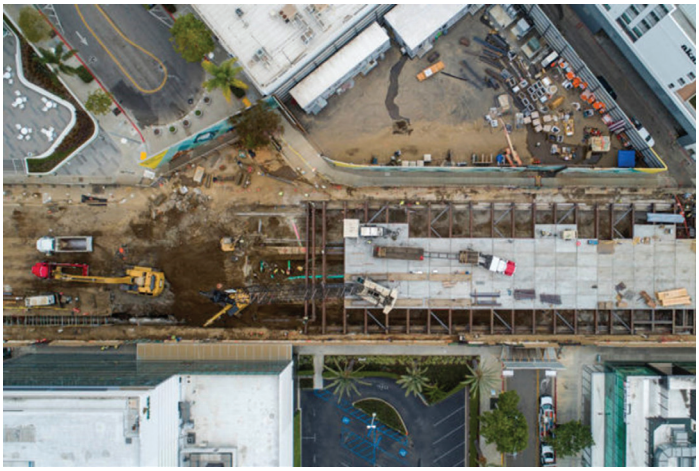
> Metro E Line: Includes a tunnel section near USC. *Opened in 2009.*

> Metro K Line: Includes a tunnel section between Expo/Crenshaw and Leimert Park Stations. *Opened in 2022.*

> Metro Regional Connector: Fully underground connection between 7th St/Metro Center and Little Tokyo/Arts District Stations in downtown LA. *Opened in 2023.*

In addition, Metro currently has three projects under construction that incorporate tunnels:

> Metro D Line Subway Extension Project: Fully underground nine-mile extension between Wilshire/Western and Westwood/VA Hospital Stations. *Scheduled to open in phases between 2025–2027.*



Metro D Line tunneling at the future Wilshire/Rodeo Station

Deciding Where to Locate Tunnels and Tunnel Depths

In most cases, the tunnels noted above are below public rights-of-way. In some cases, it is necessary to locate tunnels under private property for a variety of reasons, including:

> Need to connect to stations located at major centers and destinations.
> Large radius turns required for train operations and tunnel construction.
> Shortest and straightest route between stations, which speeds travel time for higher ridership, and reduces construction and operating costs, and wheel-wear and noise.

Most tunnels are located at depths of 50-70 feet underground. In some rare cases, tunnel depths are shallower. However, below hills and mountains, depths can be significantly deeper.

Metro trains currently operate in tunnels below single-family and multifamily residences, commercial and retail establishments, parks, schools, performance venues and religious institutions. We do not receive noise or vibration complaints from those above the tunnels. Our tunnels are also adjacent to hospitals and commercial recording studios, both with highly sensitive equipment, that have been able to continue operating with no concerns. Property owners have also been able to construct projects above our tunnels and stations.

When a rail project is beneath private property, Metro will work to obtain an underground easement from the property owner. *Please see our Property Acquisition Fact Sheet for more information at* metro.net/resources.

Tunnel Safety

Safety is Metro's top priority. Along with evaluating whether a tunnel is appropriate for a project, many factors are considered to ensure a tunnel will be safe for adjacent buildings and their occupants located above and near the project. Numerous tests are conducted to analyze ground conditions to select the best design for the tunnels, identify the most appropriate tunneling method(s) and engineer the machinery that will be used. During tunneling, the excavated ground is supported and the ground above, around and in front of the tunneling activity and machinery is monitored continuously to ensure that safety is maintained. Tunnels and underground stations incorporate other safety measures, including ventilation, air monitoring and emergency access.

Underground construction processes continue to improve as evidenced by recent Metro projects including the successful and safe completion of tunnels for the Regional Connector, Metro K Line, and Purple Line Extension. The building of underground sewer projects, as well as new construction of buildings with deep basements and underground parking structures in Southern California and worldwide has also helped advance tunnel construction methods. Metro continually seeks to take advantage of new developments in tunnel engineering and technology. In some cases, our projects have also set new standards for the industry.

All Metro tunnels are evaluated, planned and designed with input from industry leading experts, including an independent Tunnel Advisory Panel comprising globally recognized geotechnical, earthquake and engineering tunneling experts.

Tunnel Construction Methods

There are three primary methods for building tunnels. The methods used will depend on a variety of factors, including the depth and length of the tunnel or tunnel segment, soil conditions, the built environment, construction cost and others. In many cases, a project will utilize more than one of these methods. The tunnel construction methods, including potential impacts and any needed mitigations, are evaluated as a part of the environmental planning for a new project. *See our Environmental Review Fact Sheet at* metro.net/resources.

Twin tunnel boring machines (TBMs) being used on the D Line Subway Extension Project currently under construction.

Tunnel Boring Machine

A Tunnel Boring Machine (TBM) is like a giant drill. The TBM slowly drills through the earth, digging tunnels needed for an underground project. As the TBM moves forward, it excavates the full diameter or cross section of the tunnel. Once the TBM is below ground doing its work, it is unlikely that people on the surface will see, hear or feel its operation. Metro continually monitors the progress of the TBM underground, and the ground above and around it to ensure it's operating safely at all times.

All of Metro's operating rail lines with tunnels, as well as projects currently under construction involving TBMs, incorporate twin-bore tunnels. Twin-bore means that two companion tunnels are created, one for each set of tracks. Tunnels created using this methodology are generally about 20 feet in diameter. Analysis of future tunnel projects in LA County may determine that a larger, single-bore tunnel is appropriate. With single-bore, one machine creates a tunnel generally 40–50 feet in diameter that can accommodate both sets of tracks. There are other single-bore tunnel projects around the United States and the world. These projects are generally deeper than those built with twin-bore TBMs.

Regardless of whether it's a single-bore or twin-bore tunnel, Metro uses the latest TBM technology to maintain pressure in the ground surrounding the tunnel and protect workers inside the TBM. As the TBM advances, concrete tunnel liners are immediately installed supporting the newly drilled portions of the tunnel.

Beginning with construction of the Metro Gold Line Eastside Extension in 2004, Metro has used this construction method successfully for tunneling projects in a variety of soil conditions. Each TBM is engineered for the specific ground conditions where it will be operating.

Several acres of property are needed to launch the TBM at the start of the tunnel. That location is often used to remove excavated dirt from the tunnels. A smaller property is typically needed to remove the TBM at the endpoint. Between these starting and ending points, TBMs are generally sufficiently deep to avoid any impact above ground, including to underground utilities.

Exact locations for launching and extracting the TBM, as well as how much space will be needed to do so is, determined as part of the environmental process.

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Future Metro D Line tunneling

Cut-and-Cover

Cut-and-cover tunnel construction generally begins by opening the ground surface to an adequate depth to support or relocate existing utilities, and install soldier piles or other earth-retaining structures. The surface opening is then covered with a temporary concrete deck so traffic and pedestrian movement can continue overhead, while excavation proceeds beneath the street decking. The temporary excavation will be retained by an approved excavation support system, known as a shoring system. Adjacent building foundations will also be supported as necessary. Once the tunnel is built, the remaining excavated space is backfilled and the street is restored. This methodology is typically employed when tunnels are quite shallow or other conditions preclude the use of TBMs.

Sequential Excavation Mining

Sequential Excavation Mining (SEM), also known as the "New Austrian Tunneling Method (NATM)," is an option for constructing a tunnel, cavern or similar underground structure that is either independent of or connected to traditional TBM tunnels. It can be used in a variety of soil conditions and in lieu of traditional cut-and-cover methods when top-down construction is not feasible due to the depth of the tunnel, or to avoid disturbance of surface features. SEM tunnels may also be used on very short tunnels where mobilization of a TBM is not cost-effective.

SEM tunnels are generally oval shaped with mining excavation progressing approximately five to 10 feet at a time. Over this length, the tunnel is divided into segments that are supported and excavated separately utilizing a variety of machines.

An image of Sequential Excavation Mining that was used to create a portion of the tunnel for the Metro A/E Lines in downtown LA.

Once excavation for each segment in the designated length is completed, they are then joined together to form that portion of the tunnel. For longer tunnels, SEM excavation can occur simultaneously at multiple locations along the tunnel length.

SEM requires access from the surface to bring in workers and equipment, and to remove excavated materials. However, it typically results in less surface disturbance than traditional cut-and-cover construction.

Metro has used SEM most recently to excavate a 300-foot cavern for crossover tracks in downtown LA for the Regional Connector light rail project.

Underground Stations

Underground stations are also typically constructed using cut-and-cover, even when the tunnels are built using TBMs or SEM. *Please see our Station Construction Fact Sheet for more information at* metro.net/resources. Because construction is not fully below ground, it is likely that people at the surface level will see, hear and feel station construction activities.

Vent Shafts

Underground trains push the air as they move through the tunnels. This air can be vented to the surface in a variety of locations. Venting occurs at stations, and where tunnels come to the surface. Sometimes ventilation shafts at other locations are also needed. The requirements for the number, size, design and location of ventilation shafts will vary with the length of the underground sections, the tunnel size and design, and the number and frequency of trains. The environmental study for the project will evaluate the number of vent facilities required, potential locations, any environmental impacts and needed mitigations.

Vents may generate noise, but the amount of noise associated with a vent is dependent on its size and several design variables including distance to sensitive receptors. The means of ventilation and any potential impacts, including noise, emissions, and property impacts, will be analyzed in the environmental document along with any associated mitigation measures. Vent facilities may require property acquisition. *Please see our Property Acquisition Fact Sheet for more information at metro.net/resources.*

For more information about tunneling, visit *metro.net/tunneling*.