

PROTECTING METRO INFRASTRUCTURE

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3 August 2017

Source: London Transport Museum, undated. *Piccadilly Circus* - Gavin Dunn (1989). [online] London Transport Museum. Available at: <http://www.ltmuseumshop.co.uk/posters/london-transport-poster-archive/gallery/gallery-product/poster/piccadilly-circus-gavin-dunn-1989/posterid/32/1062-32.html> [Accessed: 28 January 2016].



CONTENTS

- Introduction to London Underground
- The sub-surface railways
- The tube railways
- Protecting metro infrastructure
- Summary
- Suggested bibliography



INTRODUCTION TO LONDON UNDERGROUND



INTRODUCTION TO LONDON UNDERGROUND

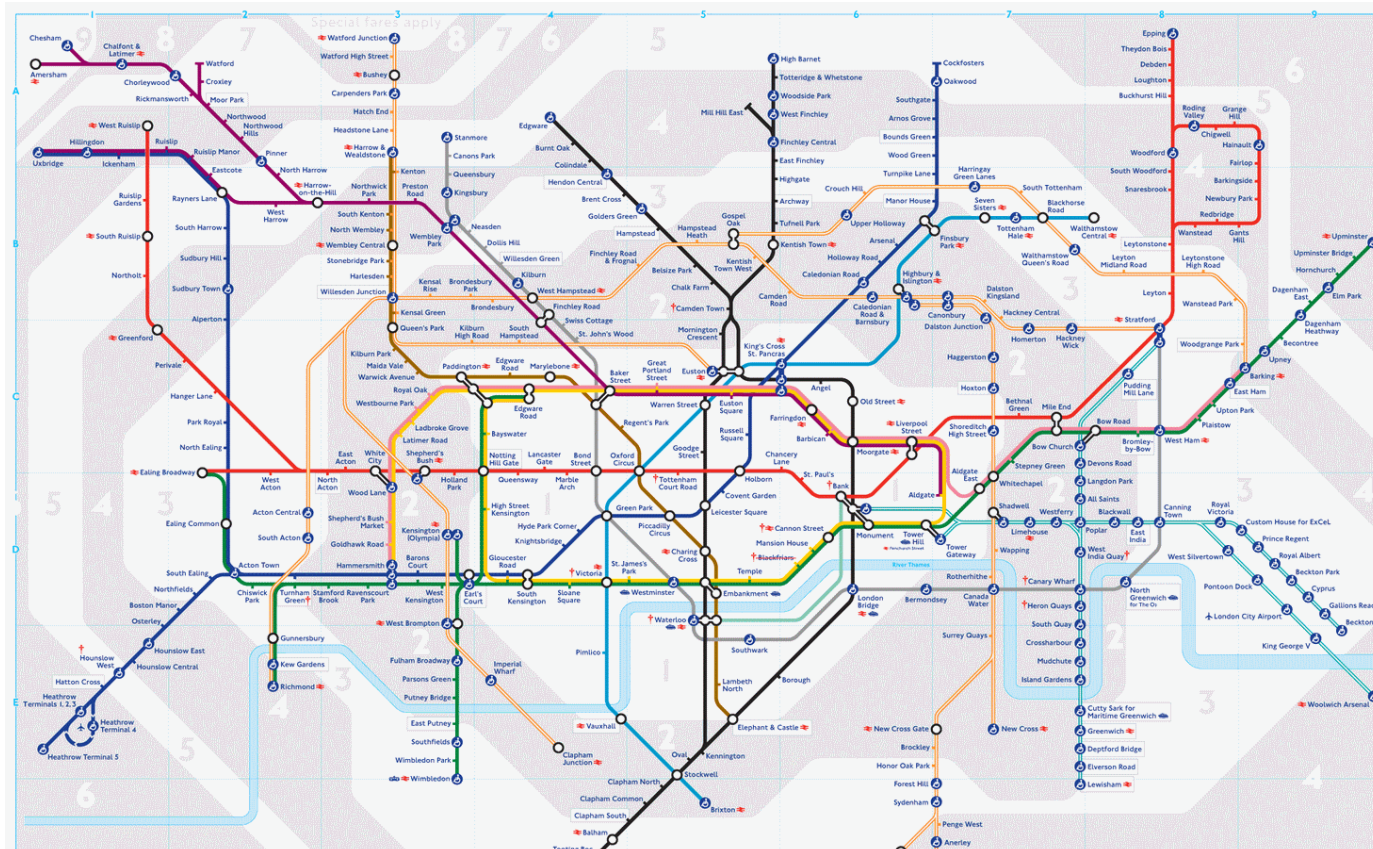
“Metros are the backbone of public transportation systems in cities of different sizes around the world. 148 cities have a metro system and there are close to 540 lines in total. Together, they carry over 150 million passengers per day.

Two-thirds of the world's metro systems are located in Asia and Europe (50 and 45 respectively). There are 16 systems in Eurasia, 16 in Latin America, 15 in North America and 6 in the Middle East and North Africa (MENA) region.”

INTRODUCTION TO LONDON UNDERGROUND

- London Underground is a rapid transit metro system
- It uses trains, rails, bridges, earth works and tunnels to carry passengers on, above and below the ground
- It was the first such system in the world - *the Metropolitan Line*
- It also has one of the newest lines in the world - *Crossrail now known as the "Elizabeth Line"*
- Working with other metro systems globally, it led and still leads development in changes to technology to improve passenger transit
- It affects, and is affected by, its urban environment
- Its operation requires engineering, legal, financial, urban and transport planning, and many other disciplines, to be effective...

INTRODUCTION TO LONDON UNDERGROUND



...it has 11 lines covering 402km - TfL

Source: TfL, 2016. Tube Map. [online] Transport for London. Available at: <<https://tfl.gov.uk/maps/track/tube>> [accessed: 2 February 2016].

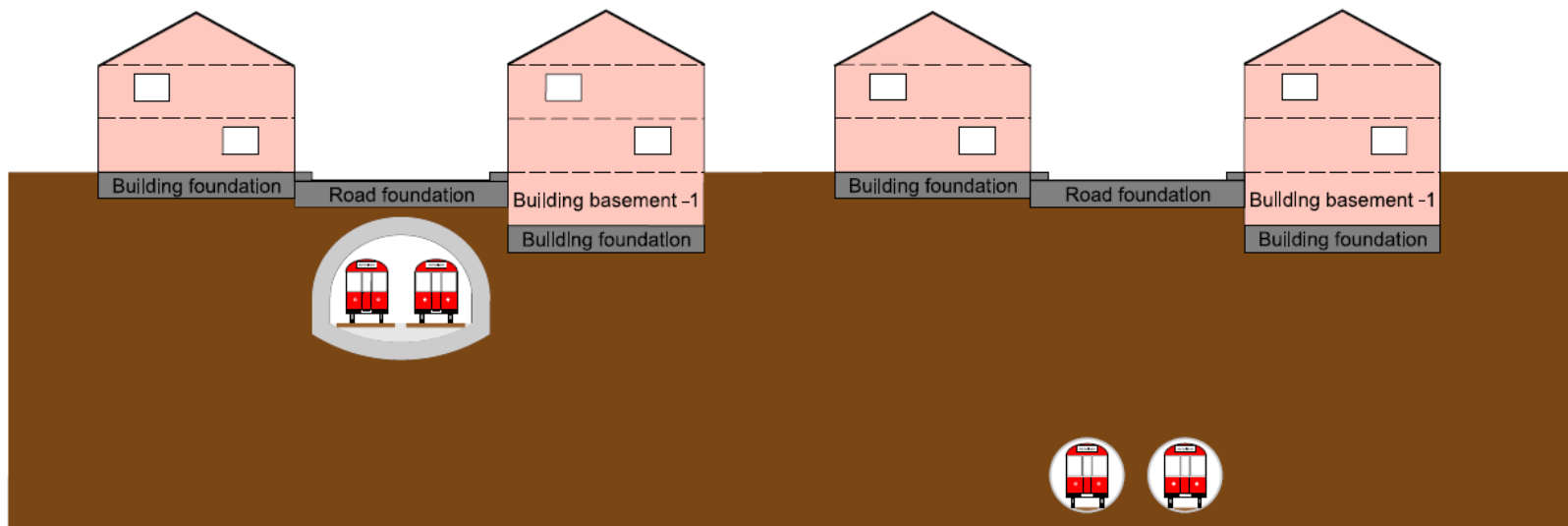
INTRODUCTION TO LONDON UNDERGROUND



...serving 270 stations - TfL

INTRODUCTION TO LONDON UNDERGROUND

...only 45% of the network is actually in tunnel; most, but not all, are in the central zone...

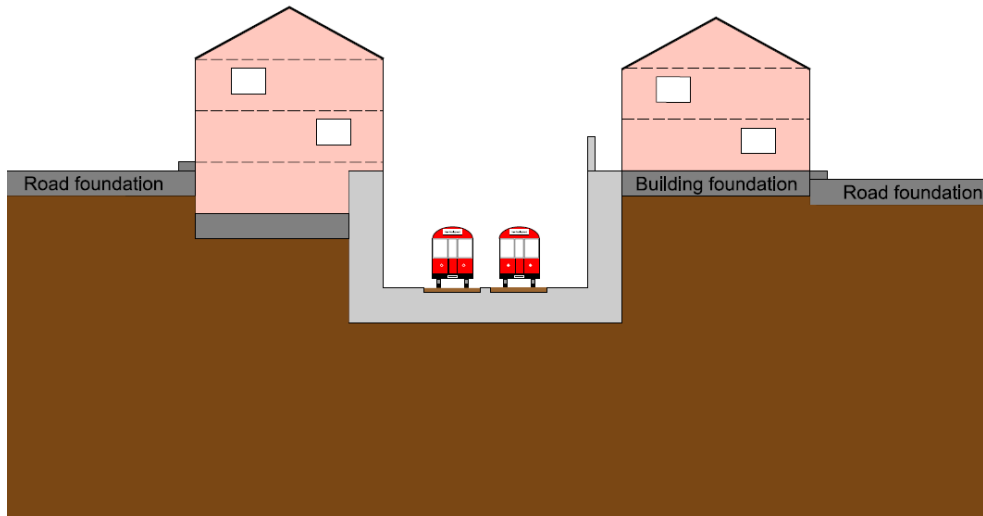


Sub-surface tunnel below highway
with buildings either side
(0.2m to 5m below ground level)

Tube tunnels below highway
with buildings either side
(0.2m to 30m below ground level)

INTRODUCTION TO LONDON UNDERGROUND

...some of the earlier sections in the central zone are also in cutting...



Typical cutting with building over cutting retaining wall, and building offset from top of retaining wall



Image showing railway cutting to the rear of Leinster Gardens, Bayswater

INTRODUCTION TO LONDON UNDERGROUND



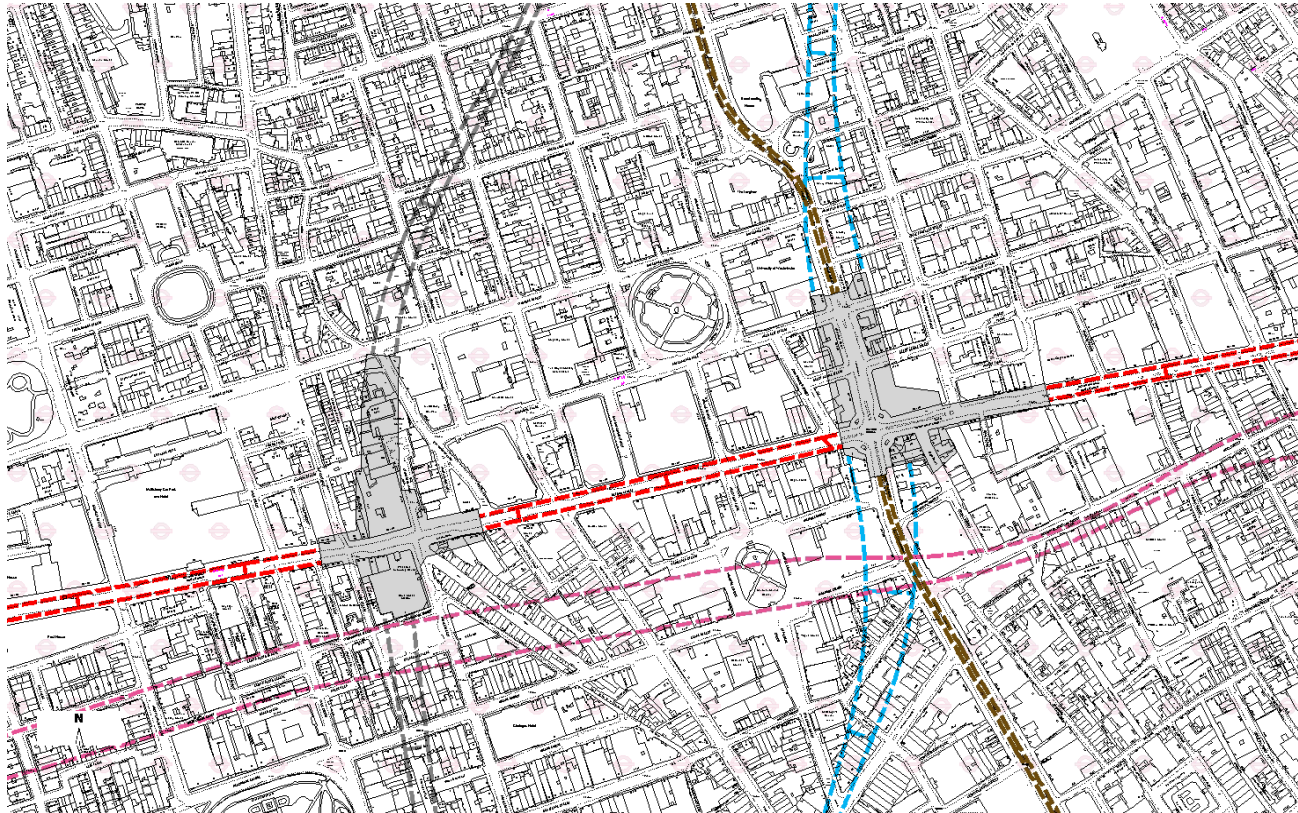
...the remainder is on, just below, or above the surface...



Source: Author's collection.

INTRODUCTION TO LONDON UNDERGROUND

...there are hundreds of thousands of interfaces between the railway and its neighbours...



Source: London Underground, 2016. 1:1250 plan at A4 showing the Central, Jubilee, Bakerloo, and Victoria lines, dashed red, grey, brown and blue respectively. Shaded areas represent underground infrastructure.

INTRODUCTION TO LONDON UNDERGROUND

...on 4 December 2015: 4.821 million passengers carried in one day - TfL



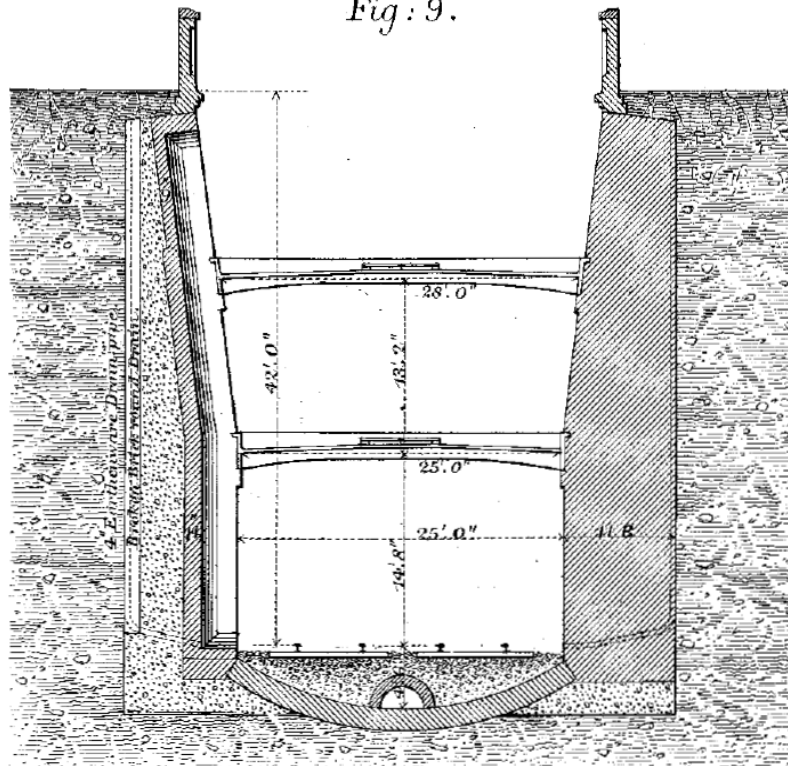
Source: Alamy, undated. *Rush hour at Oxford Circus station entrance.* [photograph] Available at:

<http://www.theguardian.com/uk-news/davehillblog/2013/nov/15/tomorrow-tube-london-underground-stations-commercial-development> [accessed: 2 February 2016].

Source: REX, undated. *Commuters at Earls Court tube station.* [photograph] Available at: <http://www.express.co.uk/news/uk/472986/Millions-of-commuters-face-delays-on-London-Underground-as-tube-strike-cripples-London> [accessed: 2 February 2016].



Fig: 9.



THE SUB-SURFACE RAILWAYS

Sources: Baker, B., 1885. The Metropolitan And Metropolitan District Railways. *Proceedings of the Institution of Civil Engineers*, 81; Ian Visits, undated. *Proposed Station at Baker Street*. [online] Available at: <<http://www.ianvisits.co.uk/blog/2012/12/28/how-the-worlds-first-underground-railway-was-built/>> [accessed: 2 February 2016]; Baker, B., 1885. The Metropolitan And Metropolitan District Railways. *Proceedings of the Institution of Civil Engineers*, 81; Authors collection, 2017, Smithfield Market portal.

THE SUB-SURFACE RAILWAYS

Built between 1859 and 1884, the sub-surface railways carved their way around central London...



Source: The Illustrated London News , 1861. *Construction of the Metropolitan Railway close to King's Cross station in 1861.* [photograph] Available at: <https://upload.wikimedia.org/wikipedia/commons/c/c8/Constructing_the_Metropolitan_Railway.png> [accessed: 2 February 2016].

Source: Google Maps, 2016. Google Streetview. Available at: [online] Available at: <https://www.google.co.uk/maps/@51.5304273,-0.1210157,3a,75y,313.51h,86.97t/data=!3m6!1e1!3m4!1szKKMbfnR_WQqP5ZLiAKPQ!2e0!7i13312!8i6656> [2 February 2016].

THE SUB-SURFACE RAILWAYS

The construction of the railway not just affecting buildings, but rivers, sewers and roads...

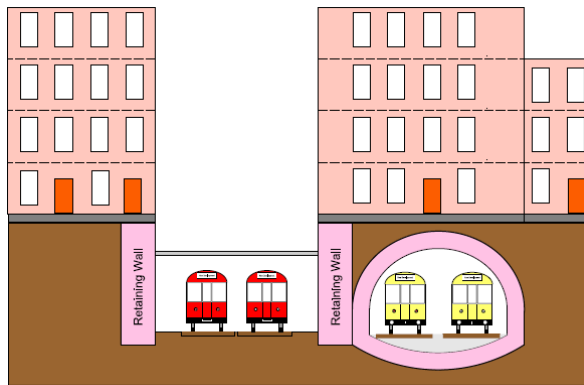


Source: London Underground, 2012. PC100, carrying the King's Scholars Pond Sewer, through the roof of tunnel TL53, west of Baker Street.
[photograph] London Underground survey.

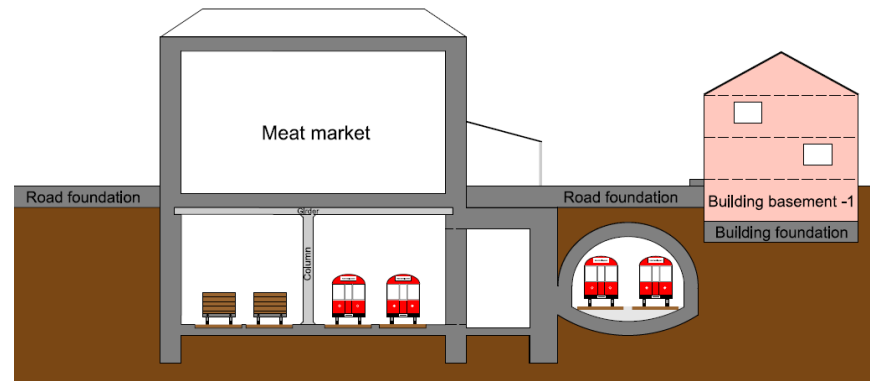
Source: Bing Maps, 2016. Britannia Street and environs, Kings Cross, London. [online] Available at: <<http://www.bing.com/maps/>> [accessed: 2 February 2016].

THE SUB-SURFACE RAILWAYS

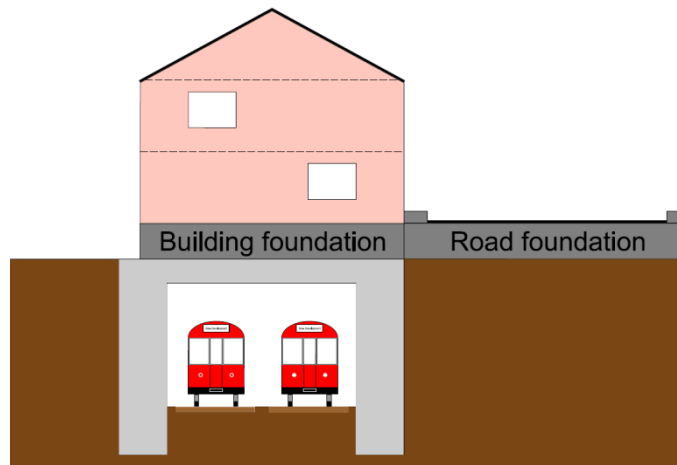
The presence of shallow below ground structures creating complicated relationships with their neighbours...



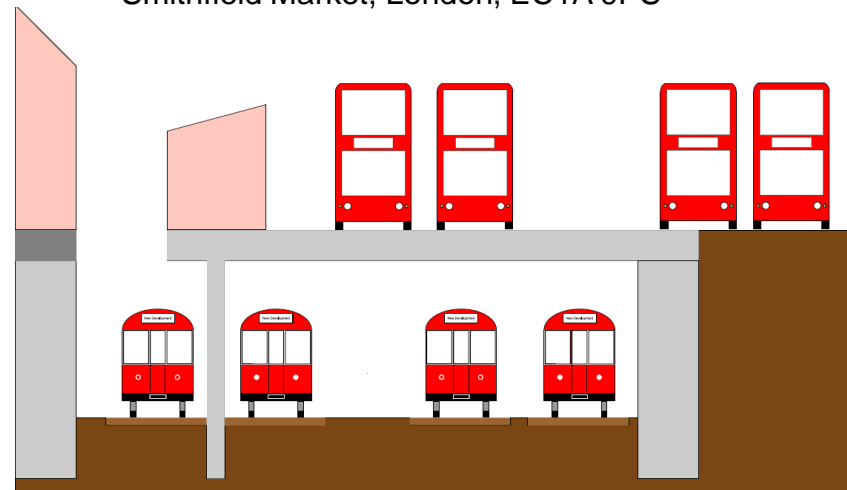
Swinton Street, London, WC1X 9NX



Smithfield Market, London, EC1A 9PS



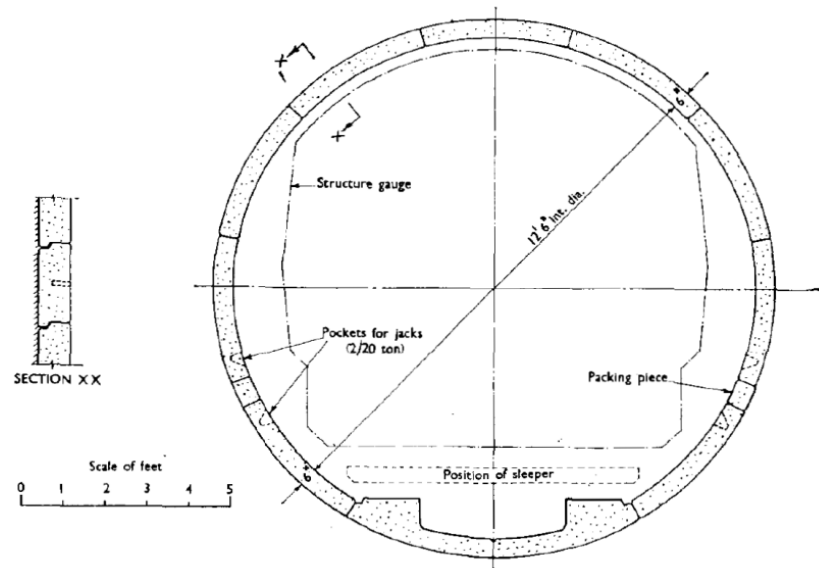
Moscow Road, London, W2 4EW



Aldgate Bus Station, London, EC3N 1BD



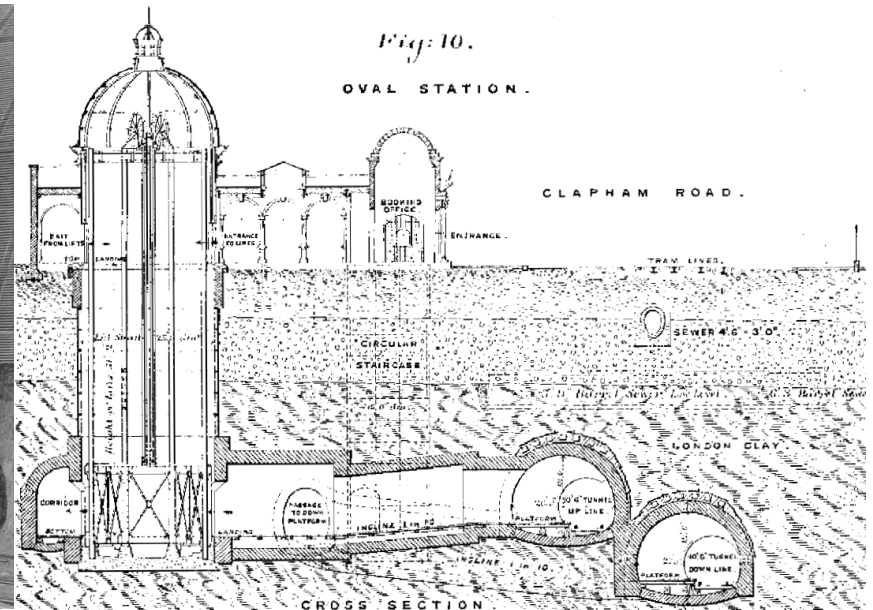
THE TUBE RAILWAYS



Sources: Dunton, C.E., Kell, J., Morgan, H.D., 1965. Victoria Line : Experimentation, Design, Programming, And Early Progress. *Proceedings of the Institution of Civil Engineers*, 31(1); SPSmiller, 2014. *The nickname "Tube" comes from the almost circular tube-like tunnels through which the small profile trains travel.* [online] Available at: https://simple.wikipedia.org/wiki/London_Underground [Accessed 4 July 2017]; Wire, P.A. 2015. *Night Tube launch postponed.* [online] Available at: <http://www.itv.com/news/london/update/2015-08-27/night-tube-launch-postponed/> [Accessed 4 July 2017].

THE TUBE RAILWAYS

From 1886, shield technology enabled construction of railway tunnels deeper underground than cut and cover methods.



Source: Alamy, undated. *The Beach Hydraulic Tunnelling Shield at work.* [electronic print] Available at: <http://c8.alamy.com/comp/D027HT/the-beach-hydraulic-tunneling-shield-at-work-in-the-great-railway-D027HT.jpg> [Accessed: 18 February 2016].

Source: Greathead, J., H., 1893. The City and South London Railway. *Proceedings of the Institution of Civil Engineers*, 112(1893), pp.39-73.

THE TUBE RAILWAYS

Tunnelling deeper enabled the railway to pass under 19th century and early 20th century property without adversely affecting it, physically.

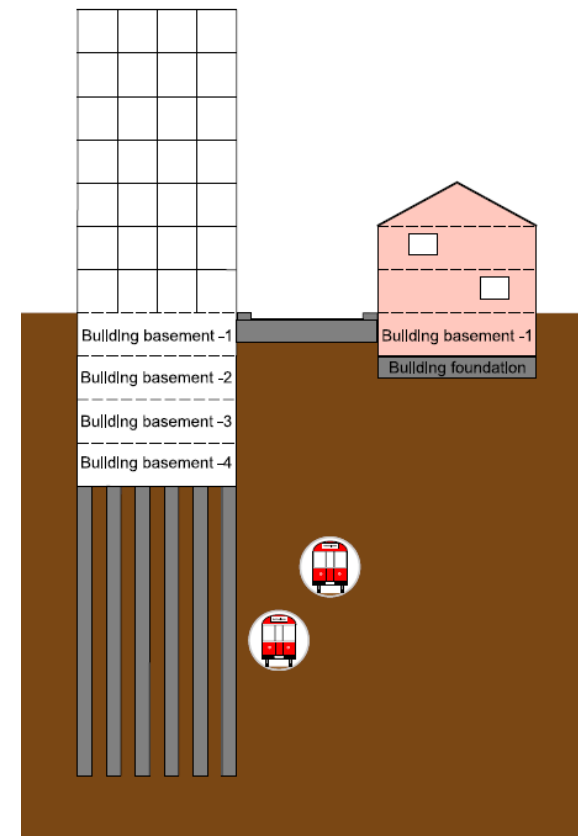


Source: London Underground, 2016. Modern Ordnance Survey mapping, c.2014, showing the Piccadilly line (dashed blue) near Alexander Place, London.

Source: London Underground, 2016. Modern Ordnance Survey mapping, c.2014, showing the Northern line (dashed black) at Kennington Station, London. Shaded areas represent underground station infrastructure.

THE TUBE RAILWAYS

Since the 1950s, buildings have been getting taller and their foundations deeper...



The tube railways:

...seeing greater need for use of the subsoil for foundations and metro infrastructure, increasing the physical and legal interfaces...

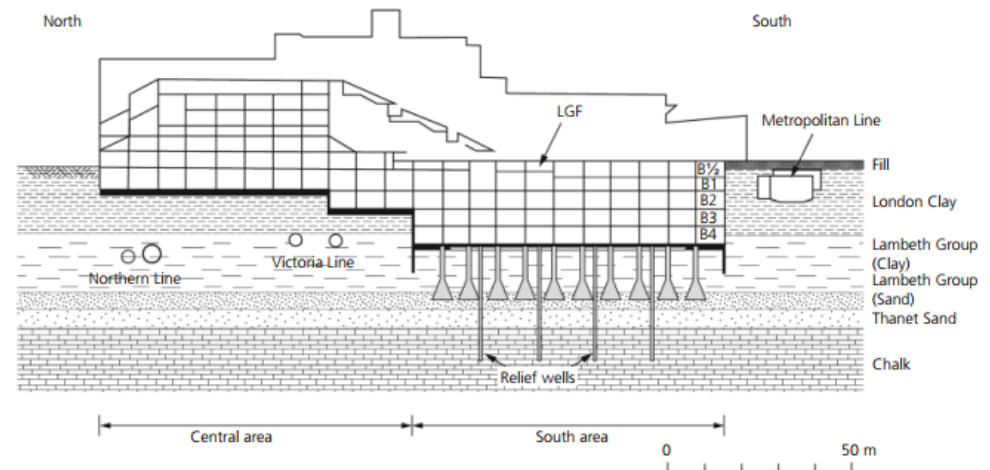


Figure 2. North-south section through the structure. (LGF, lower ground floor)

THE TUBE RAILWAYS

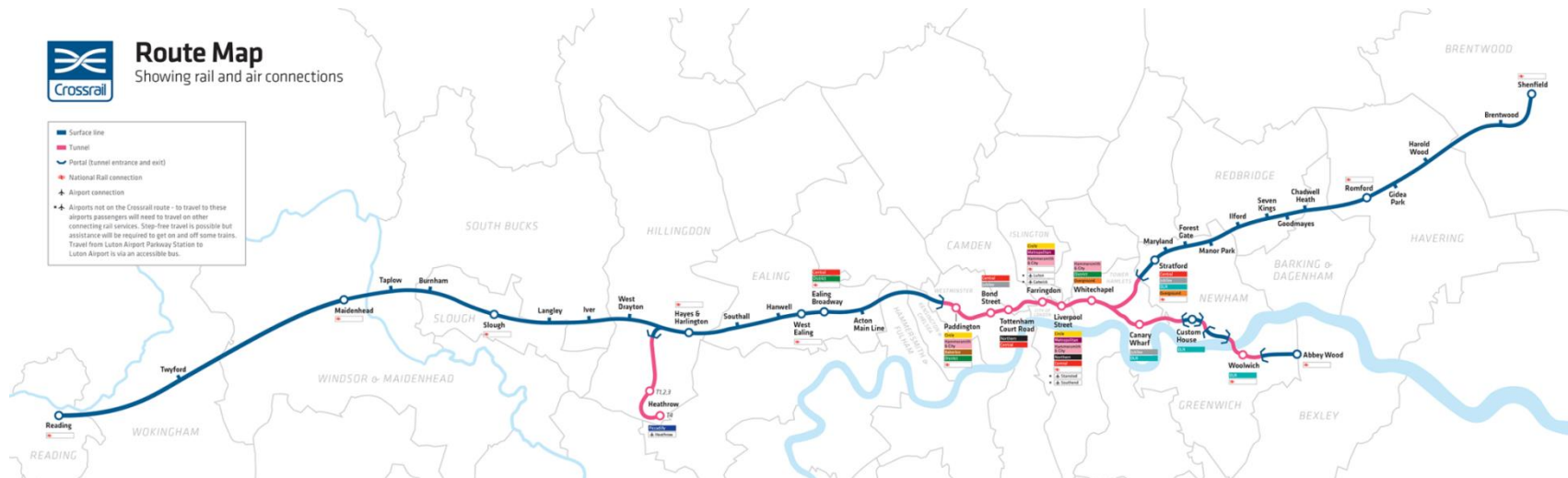
..this is the 'new' Tottenham Court Road station for the Elizabeth Line...



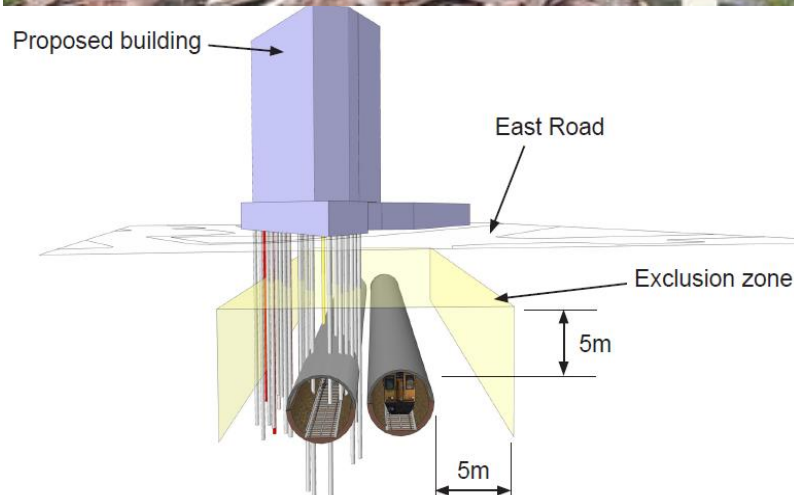
Source: London Underground, 2016. Modern Ordnance Survey mapping, c.2014, showing the Central, Northern and Crossrail lines (dashed red, black and purple respectively) in relation to Tottenham Court Road station and environs, London.

THE TUBE RAILWAYS

...which will bring people from further afield *directly to the central core of London*, with little or no change of train.



Source: Crossrail, 2016. *Regional Map*. [online] Available at: <<http://www.crossrail.co.uk/route/maps/regional-map#>> [accessed: 2 February 2016]

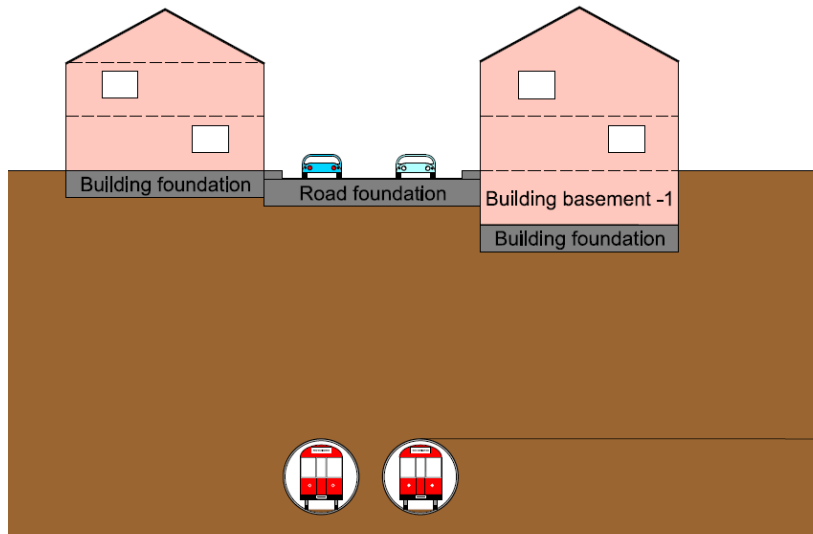
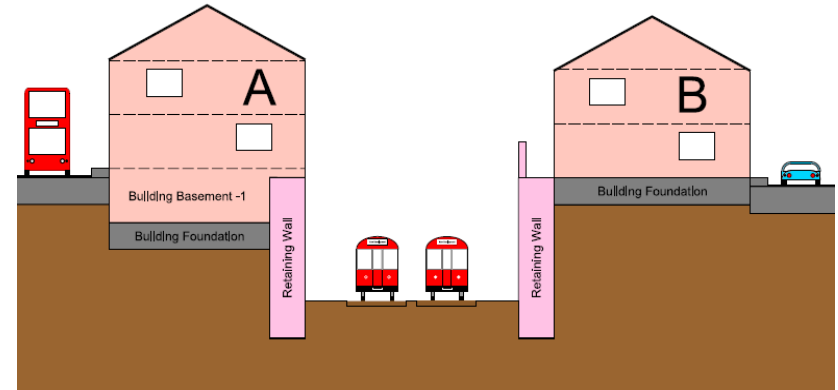
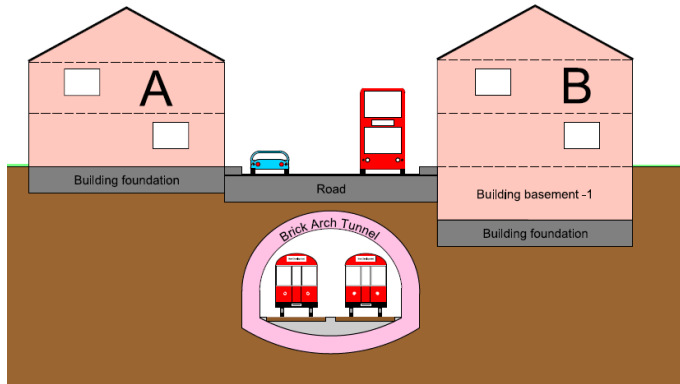


PROTECTING METRO INFRASTRUCTURE

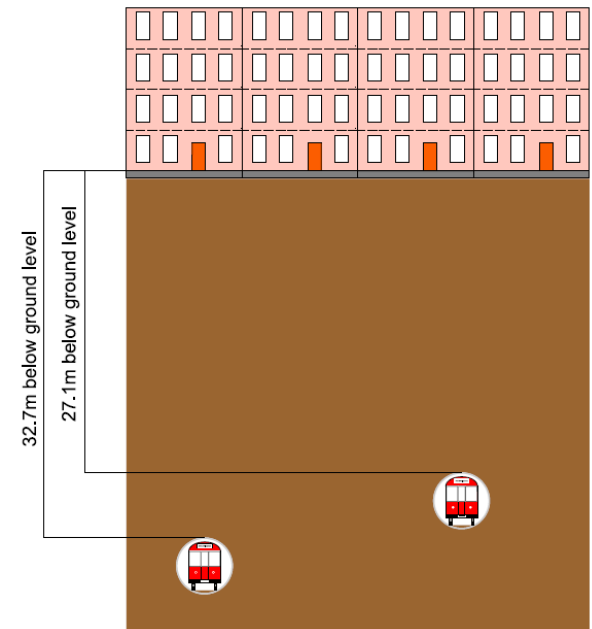
Sources: Anon, 2017. *Image showing partial bridge collapse at Barrow upon Soar*. [online] Available at: <<https://www.gov.uk/government/news/partial-bridge-collapse-barrow-on-soar>> [Accessed 4 July 2017]; Railway Accident Investigation Branch, 2014. Penetration and obstruction of a tunnel between Old Street and Essex Road stations, London, 8 March 2013. [pdf] Derby: Railway Accident Investigation Branch. Available at: <http://www.raib.gov.uk/cms_resources.cfm?file=/140213_R032014_Old_Street.pdf> [Accessed 4 July 2017]; Anon, 2017. *Lime Street Wall Collapse 6 March*. [online] Available at: <<https://www.placenorthwest.co.uk/news/council-knew-of-lime-street-containers-but-owner-was-immune-from-enforcement-action/>> [Accessed 4 July 2017].

PROTECTING METRO INFRASTRUCTURE

The railway has *physical* interfaces...

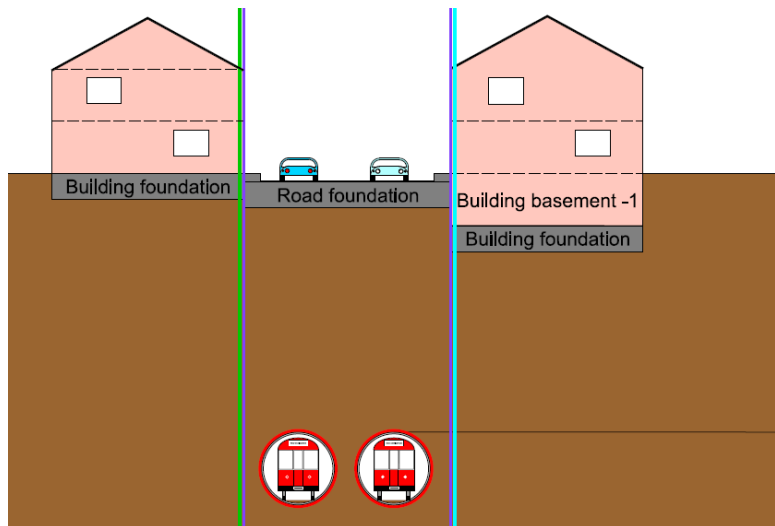
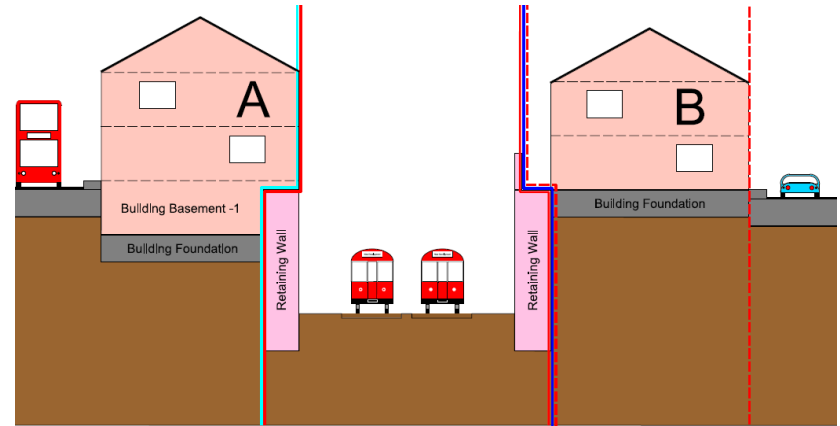
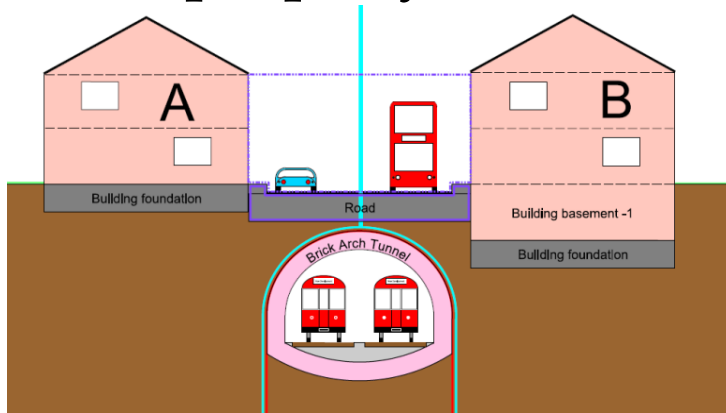


Example depth of tunnel crown
-15m below ground level

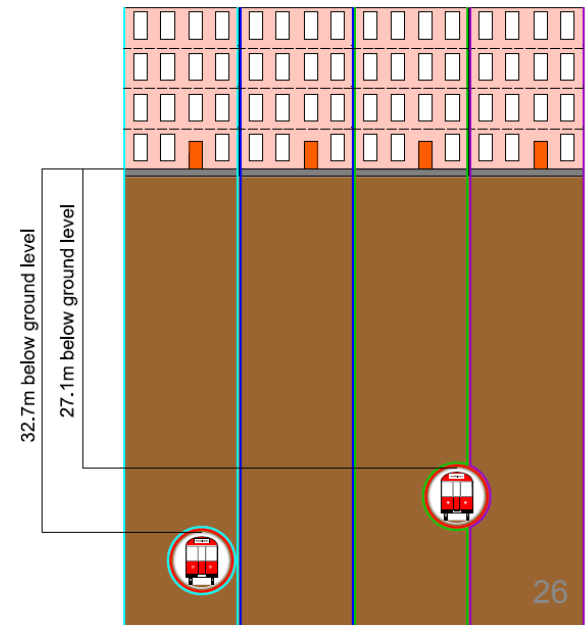


PROTECTING METRO INFRASTRUCTURE

...and property interfaces...

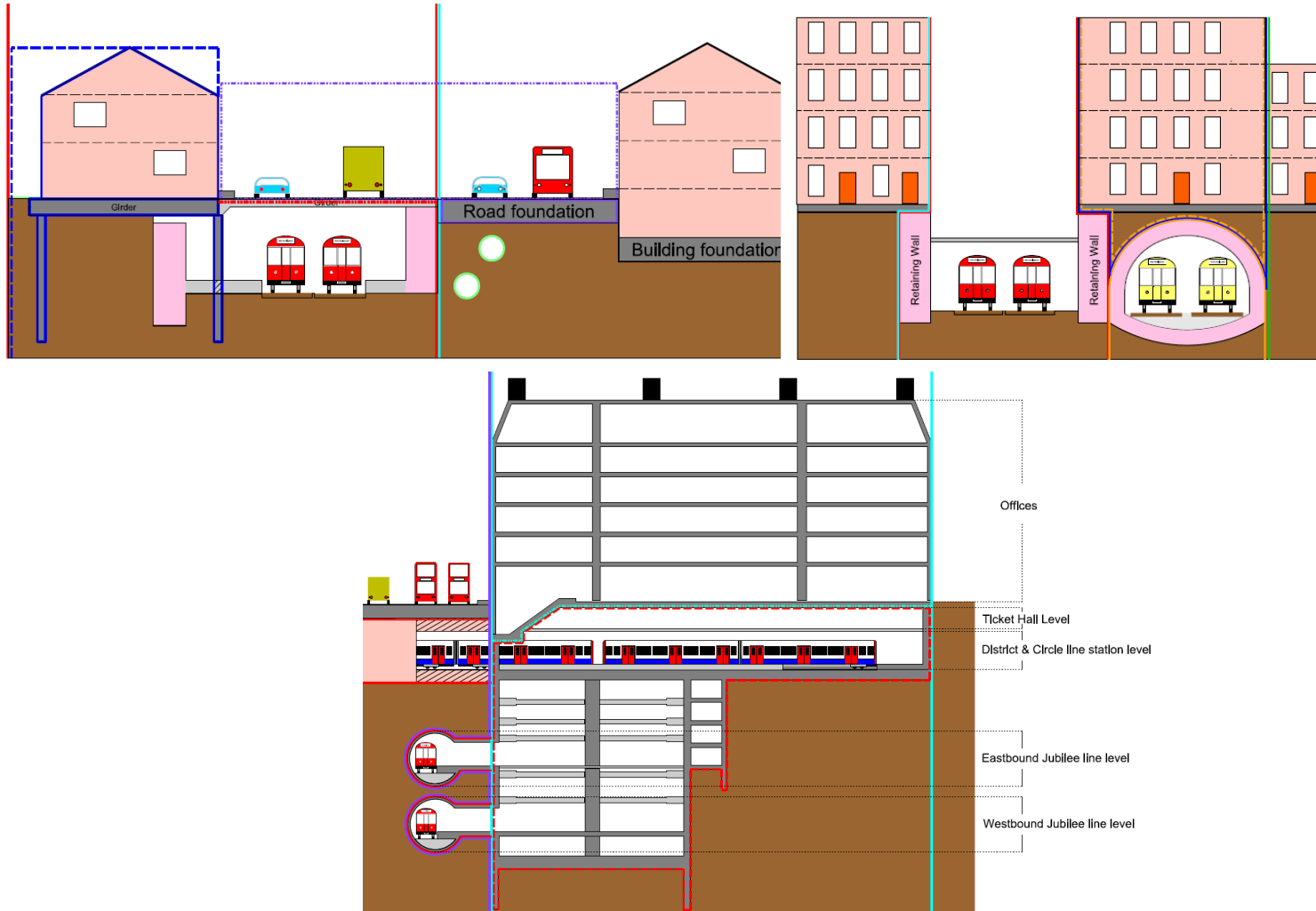


Example depth of tunnel crown
-15m below ground level



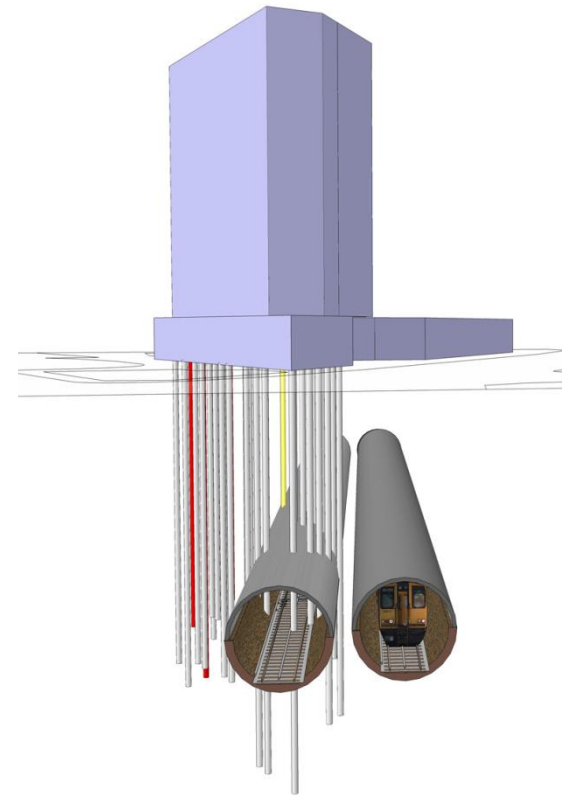
PROTECTING METRO INFRASTRUCTURE

....which can be complicated...



PROTECTING METRO INFRASTRUCTURE

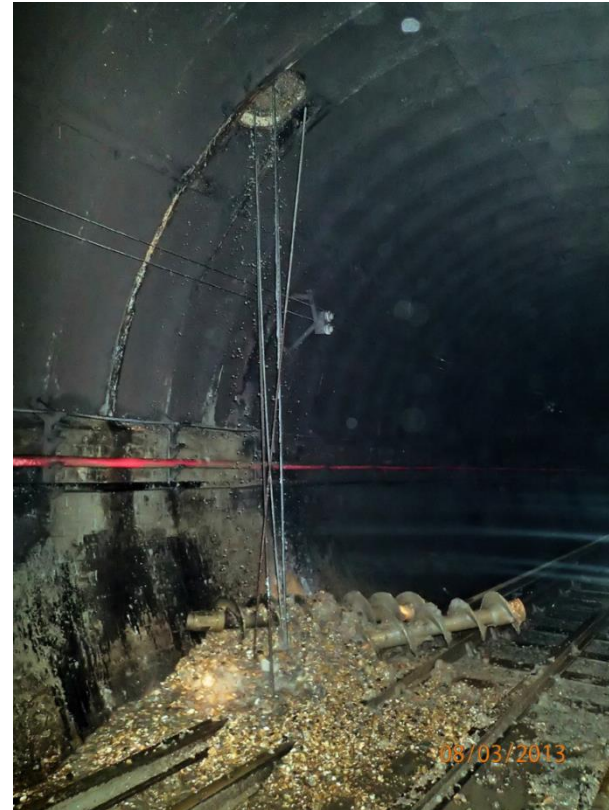
...and must be *protected*.



Source: Railway Accident Investigation Branch, 2014. Penetration and obstruction of a tunnel between Old Street and Essex Road stations, London, 8 March 2013. [pdf] Derby: Railway Accident Investigation Branch. Available at: <http://www.raib.gov.uk/cms_resources.cfm?file=/140213_R032014_Old_Street.pdf> [Accessed 30 July 2014].

PROTECTING METRO INFRASTRUCTURE

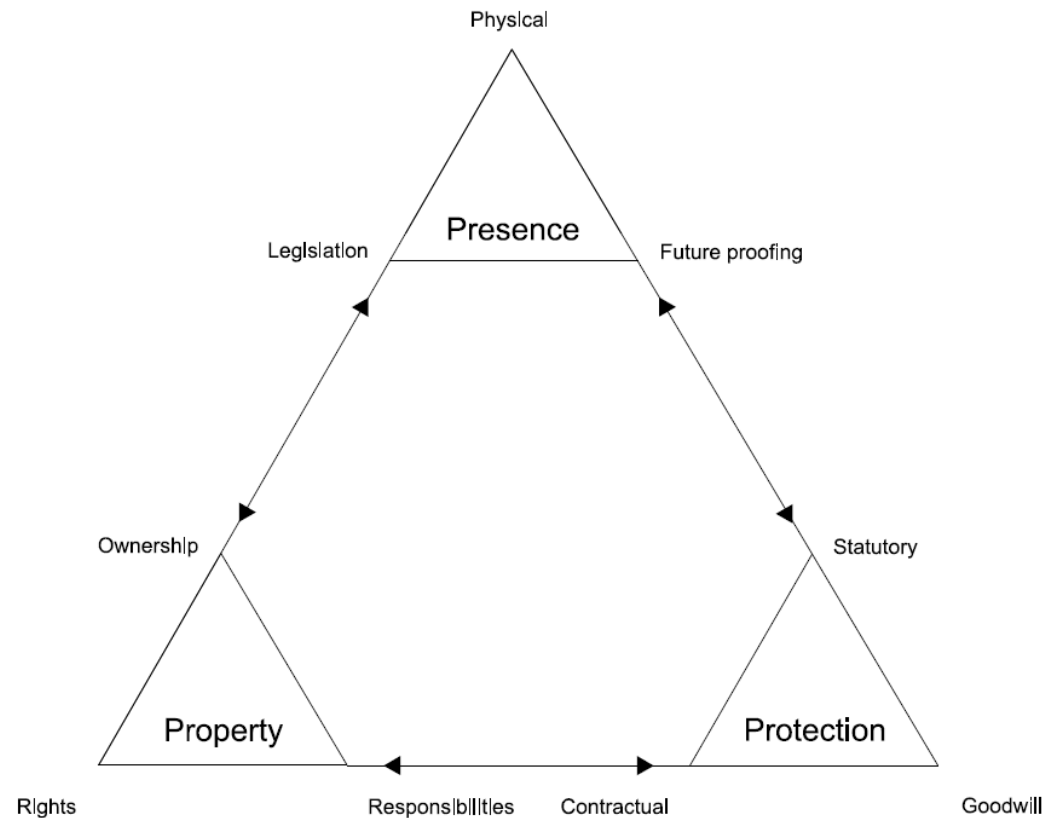
To *minimise* risk to infrastructure, services, passengers and staff...



Source: Railway Accident Investigation Branch, 2014. Penetration and obstruction of a tunnel between Old Street and Essex Road stations, London, 8 March 2013. [pdf] Derby: Railway Accident Investigation Branch. Available at: <http://www.raib.gov.uk/cms_resources.cfm?file=/140213_R032014_Old_Street.pdf> [Accessed 30 July 2014].

PROTECTING METRO INFRASTRUCTURE

...we must clearly understand these interfaces.



A conceptual framework to identify the interfaces between metro infrastructure and its environment

PROTECTING METRO INFRASTRUCTURE

Kingsgate House development, London, SW1E 6SQ

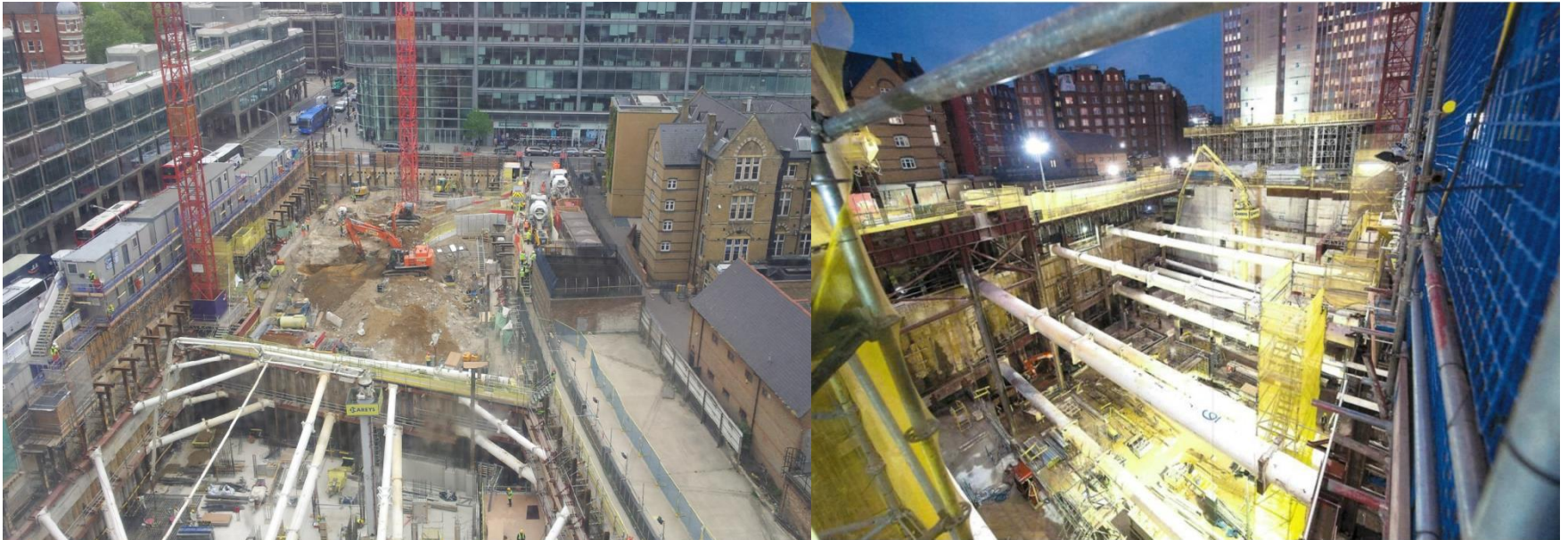
- located on Victoria Street, Westminster
- directly adjacent to the District and Circle lines

The original building was demolished...



PROTECTING METRO INFRASTRUCTURE

...foundations were formed and basement levels excavated...

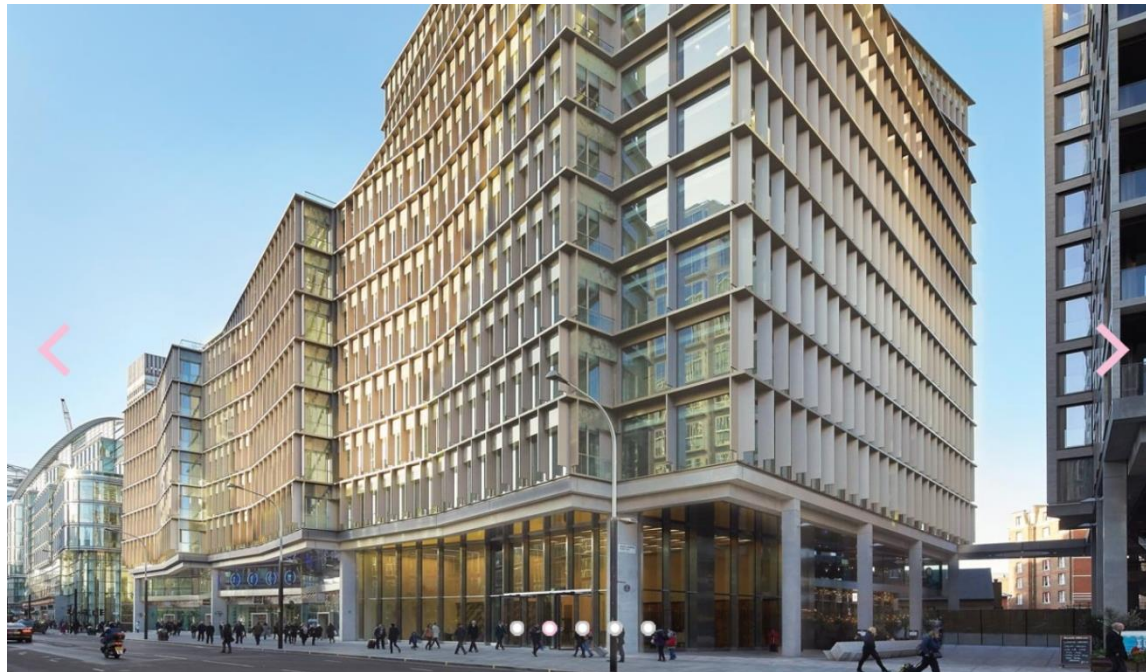


PROTECTING METRO INFRASTRUCTURE

...and buildings with:

- 8 storeys below ground level (at their lowest point)
- and up to 14 storeys above ground level (22 storeys in total)

...were constructed, all with an operational railway directly adjacent.



PROTECTING METRO INFRASTRUCTURE

If London Underground and the developers engineers, did not understand these interfaces:

- the risks to the presence of the engineered assets forming the railway would be high
- there would be a serious risk to the safe operation of the railway
- passengers and staff would be put at risk
- there would be severe disruption to or suspension of railway services.

SUMMARY

- Changes in technology have had an effect on London's underground and surface railways, their design, location, their environment and vice versa
- On one day in 2015, London Underground carried nearly 5 million people
- This will soon be the norm, whilst seeing further changes to and densification of its urban environment
- The relationship between *any* metro and its urban environment from physical, property and protective perspectives must be clearly understood at design, construction, *and* ongoing presence (life cycle) stages
- This enables the ongoing use and benefits of that metro/railway system to continue effectively in to the future
- Not only in central areas, but also suburban areas where the metro/railway is on or above the surface

THANK YOU

If you would like to know more, please see
the suggested bibliography or contact me:

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Tel: 0203 054 2411

SUGGESTED BIBLIOGRAPHY

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<http://www.raib.gov.uk/cms_resources.cfm?file=/140213_R032014_Old_Street.pdf>
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TfL Visual Services, 2016. LU Infrastructure Protection. [online] Available at:
<<https://www.youtube.com/watch?v=0hGoJMTBOEg&feature=youtu.be>> [Accessed: May 2017].