



Rail Accident Investigation Branch

# Rail Accident Report



## **Penetration and obstruction of a tunnel between Old Street and Essex Road stations, London 8 March 2013**

Report 03/2014  
February 2014

This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

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Any enquiries about this publication should be sent to:

RAIB	Email: <a href="mailto:enquiries@raib.gov.uk">enquiries@raib.gov.uk</a>
The Wharf	Telephone: 01332 253300
Stores Road	Fax: 01332 253301
Derby UK	Website: <a href="http://www.raib.gov.uk">www.raib.gov.uk</a>
DE21 4BA	

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# Penetration and obstruction of a tunnel between Old Street and Essex Road stations, London

## 8 March 2013

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## Summary

During the morning of Friday 8 March 2013, a train driver reported that flood water was flowing from the roof of a railway tunnel north of Old Street station near central London. The driver of an out-of-service passenger train was asked to examine the tunnel at low speed and check for damage. The driver stopped short of the water flow and reported that two large drills (augers) had come through the tunnel wall and were fouling the line ahead of his train.

The augers were being used for boring piles from a construction site about 13 metres above the top of the tunnel. The operators of the piling rig involved were unaware that they were working above an operational railway tunnel. Its position was not shown on the site plan, or on any map available to either the developer or the local planning authority. As a consequence, Network Rail was not consulted during the planning application stage and was unaware of the construction activity.

The RAIB has determined that approximately half of the piles required for the new development would have intersected with the tunnel had they had been constructed. It has identified two learning points from this incident which are relevant to the construction industry: clients and design teams should be aware of the importance of information shown on land ownership records; and those carrying out investigations for proposed developments should be aware that not all railway tunnels are shown on Ordnance Survey mapping.

The RAIB has also made five recommendations: three are addressed to railway infrastructure managers, and relate to: the provision of information to organisations undertaking property-related searches; the provision of information on the location of railway tunnels and associated subterranean structures; and the identification of development work by third parties. One recommendation is made to the British Standards Institution relating to the enhancement of a British Standard, and one recommendation is addressed to the Department for Communities and Local Government relating to a recommendation made by the RAIB in 2007 which has not been implemented.

# Introduction

## Preface

- 1 The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability.
- 2 Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.
- 3 The RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of all other investigations, including those carried out by the safety authority, police or railway industry.

## Key definitions

- 4 All dimensions and speeds in this report are given in metric units, except speed and locations which are given in imperial units, in accordance with normal railway practice. Where appropriate the equivalent metric value is also given. Mileages on the Moorgate to Finsbury Park Junction line are measured from Moorgate.
- 5 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B.

## The incident

### Summary of the incident

- 6 At 10:09 hrs on Friday 8 March 2013, the driver of train 2V16, the 10:02 hrs First Capital Connect service from Moorgate to Welwyn Garden City, reported that water was flowing from the roof of the single line tunnel between Old Street and Essex Road stations on the Northern City line.
- 7 A train which was not carrying passengers was used to examine the line, the driver being accompanied by a Network Rail Mobile Operations Manager for this purpose. At 10:58 hrs, the driver reported that he had stopped short of the water flow in the tunnel and that two large drills had come through the tunnel wall and had fallen onto the track ahead of the train.
- 8 The drills were sections of a 0.35 metres diameter auger being used for boring piles from a construction site about 13 m above the crown of the tunnel on East Road, Hackney. The auger had penetrated the cast iron tunnel lining before falling onto the track. Each section of auger was 2 m long and weighed 120 kg.
- 9 Water entering through the hole was naturally occurring groundwater from a layer of gravel through which the auger had passed.
- 10 There were no injuries caused to staff or passengers, or damage to trains.

### Context

#### Location

- 11 Network Rail's Northern City line (Moorgate to Finsbury Park Junction) carries passenger rail services between a below-ground terminus at Moorgate in the City of London, and Welwyn Garden City, Letchworth and Hertford North. Between Moorgate and Drayton Park station the line is entirely below ground, the *Up* and *Down* Moorgate lines running within the adjacent single-bore Moorgate tunnels. Intermediate below-ground stations are located at Old Street, Essex Road, and Highbury & Islington (figure 2).
- 12 The auger penetrated the Down Moorgate line tunnel at 0 miles 66 chains<sup>1</sup> from Moorgate, and 420 m north of Old Street station.
- 13 The 2.7 mile (4.3 km) long Moorgate tunnels were built between 1898 and 1904 by the Great Northern and City Railway company to link Moorgate with Finsbury Park on the Great Northern main line. The tunnels were constructed with an internal diameter of approximately 4.88 m (16 feet) to accommodate main line rolling stock, making them significantly larger than London Underground's tube tunnels. The tunnels were lined with cast iron upper and brick lower sections. Between Moorgate and Drayton Park, the maximum line speed is 30 mph (48.3 km/h).

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<sup>1</sup> One chain is equal to 22 yards (approximately 20 metres).

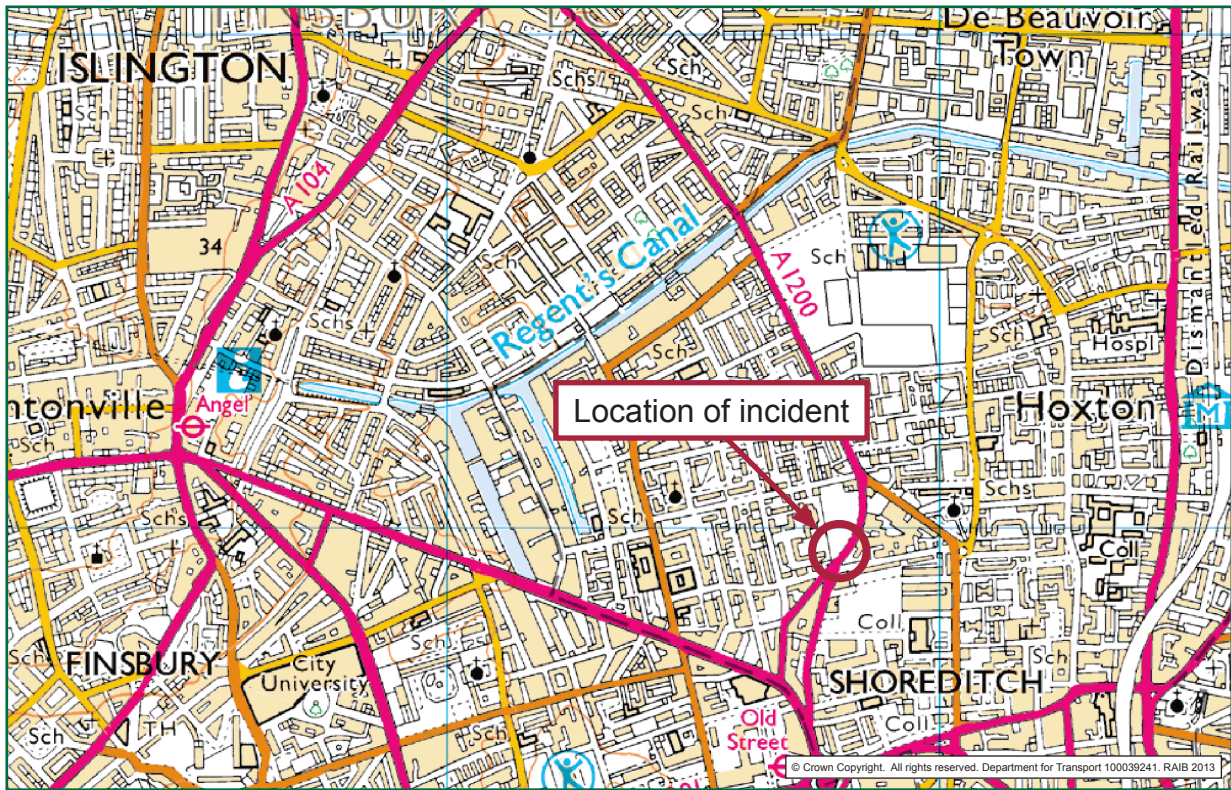


Figure 1: Extract from Ordnance Survey map showing the location of the incident

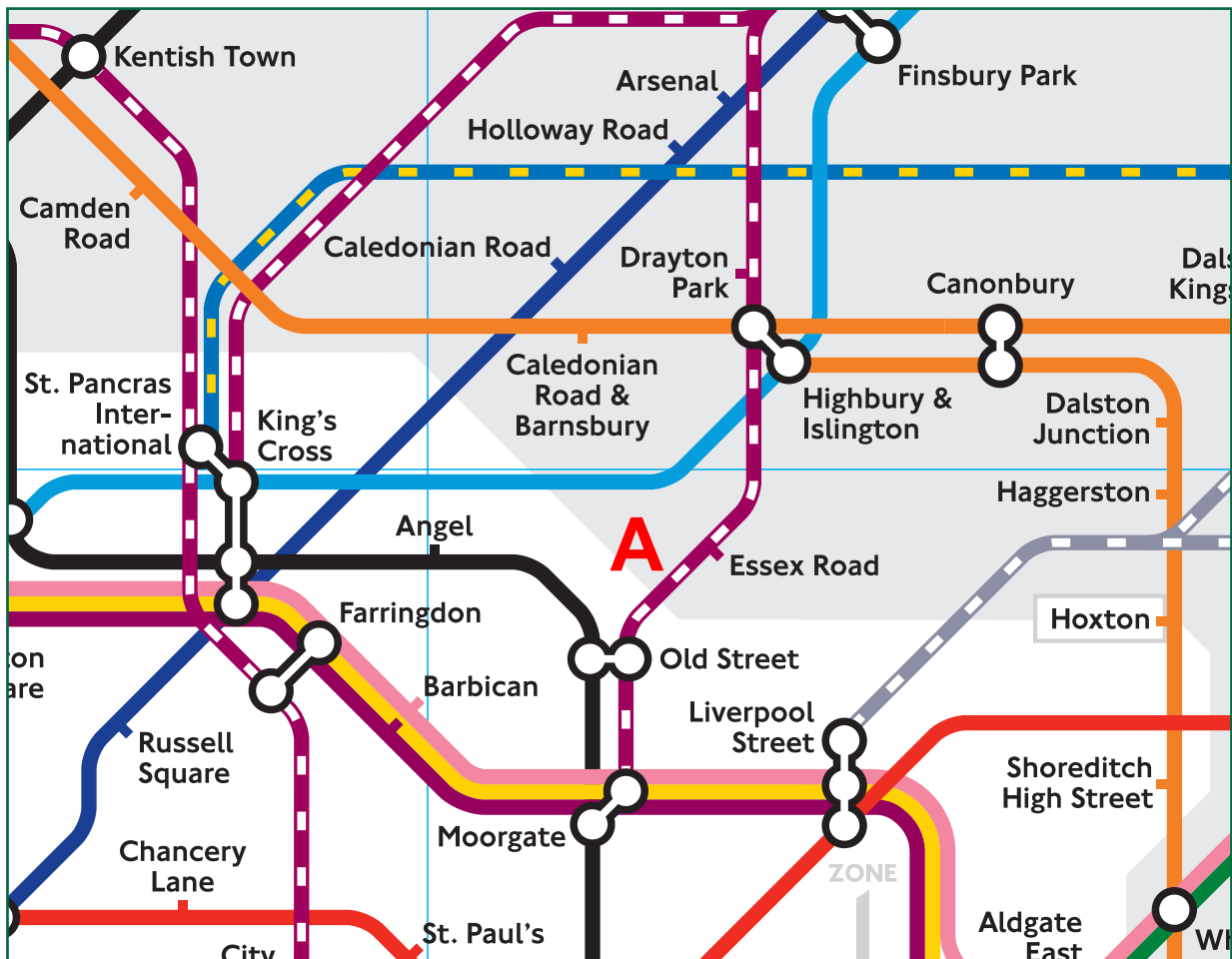


Figure 2: Extract from London Rail and Tube services map (Transport for London). The incident occurred at location marked 'A'.



- 14 The tunnels are equipped with a 750 V DC *third rail* electrification system to provide power for electric trains. A fourth rail, laid on the sleepers between the running rails, acts as a return conductor for traction power. North of Drayton Park, trains are powered by the 25 kV overhead electrification system.

### Organisations involved

- 15 Network Rail owns and manages the infrastructure. Prior to 1975, the Northern City line was owned by the London Transport Executive and formed part of the London Underground network (refer to appendix C).
- 16 First Capital Connect operated the passenger train services using Class 313 electrical multiple units.
- 17 The London Borough of Hackney was the *local planning authority* for the new development on East Road, and owned the site until 2002 when it was sold to Shoreditch Trust.
- 18 Protean Developments Ltd purchased the site from Shoreditch Trust in 2010 and was the owner at the time of the incident. Protean Developments acted as Client<sup>2</sup> for the construction works. Its design and construction team included the following parties:
- a. Charlotte Ambrose Architects - architect;
  - b. Elliott Wood Partnership - structural engineer (responsible for designing the foundation layout);
  - c. Site Analytical Services Ltd - site investigation contractor;
  - d. ATW Construction Ltd - principal contractor (responsible for building work); and
  - e. All Foundations Ltd - piling contractor (responsible for designing the piles).

### **Events preceding the incident**

- 19 Piling work for a proposed seven storey residential building commenced on 6 March 2013, two days before the incident (figures 3 and 4). During the boring of the fifth pile (out of 39), the piling rig's auger broke through the cast iron lining of the Down Moorgate line tunnel at a depth of approximately 13 m (43 feet) below the site. Two sections of auger became detached from the rig and fell onto the track, coming into contact with the electrified third rail. The piling contractor informed the RAIB that when drilling through hard ground or obstructions, the pins that join sections of auger can become dislodged and auger sections can become detached.
- 20 The piling team were unaware that they had penetrated a tunnel and attempted to locate the missing sections of auger by dropping metal bars down the hole. These bars also landed on the track (figures 5 and 6).

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<sup>2</sup> The duties and responsibilities of Clients, Designers and Contractors are defined in the Construction (Design & Management) Regulations 2007. These duties include providing information.



Figure 3: Piling rig on site at East Road

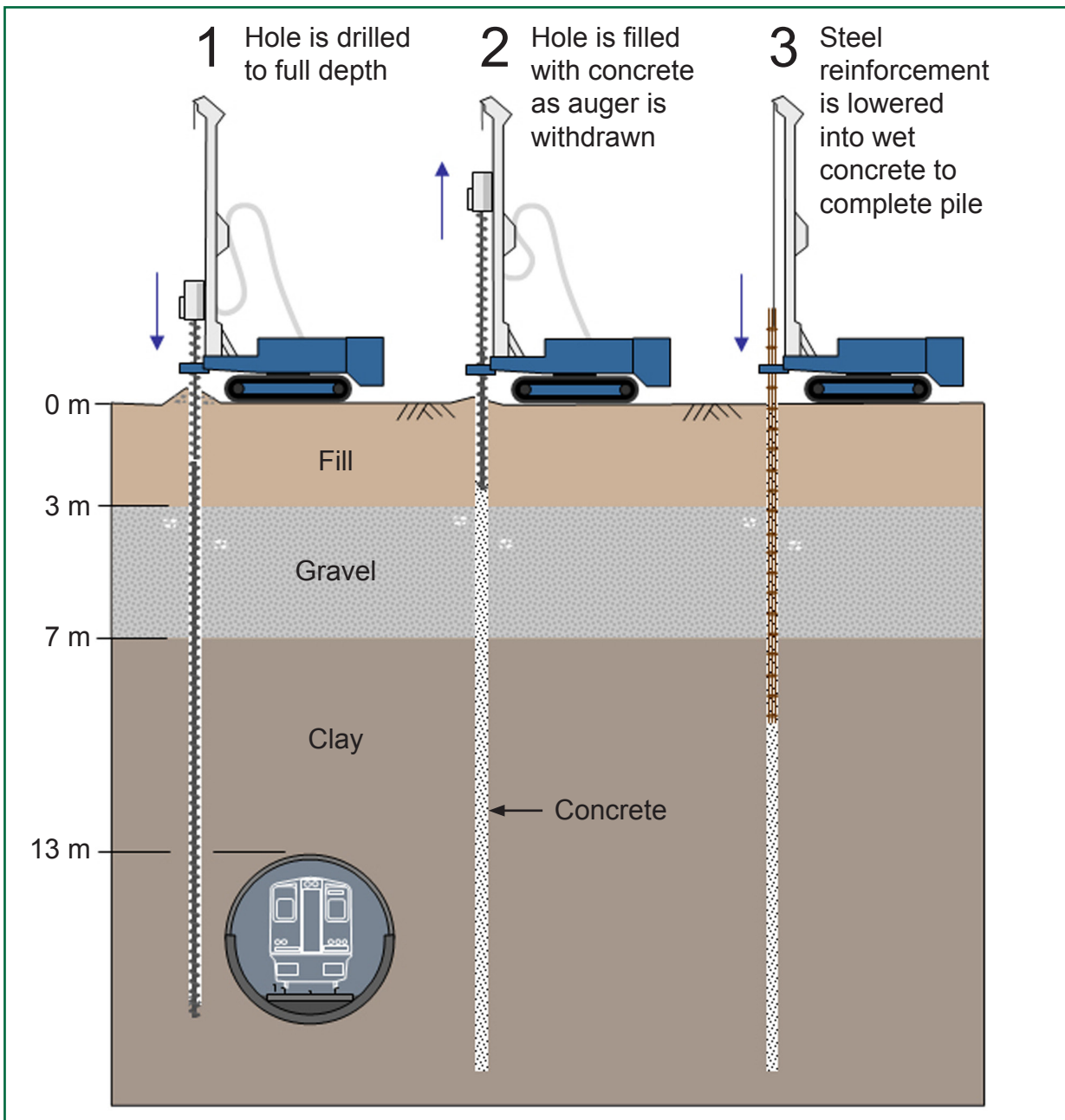


Figure 4: Diagram showing how a bored pile is constructed (tunnel level shown for comparison)



Figure 5: Penetration of tunnel lining and debris on track



Figure 6: Auger sections and debris on the track (photograph courtesy of Network Rail)

## Events following the incident

- 21 An entry in Network Rail's incident log stated that at 12:40 hrs, British Transport Police and Network Rail staff had located the construction site and were in attendance. The piling contractor had already stopped work following the loss of the auger sections. The works were suspended and the site made safe.

## Consequences of the incident

- 22 A derailment was avoided because a preceding train had reported water flowing from the tunnel roof. The driver of the following train, which was carrying no passengers and encountered the debris, had been cautioned to travel at low speed and be prepared to stop short of any obstruction.
- 23 Train services were suspended between Moorgate and Finsbury Park for the remainder of Friday 8 March. There was no scheduled passenger service on the following Saturday or Sunday, so during this period, Network Rail was able to repair the tunnel lining and remove the two sections of auger, the metal bars and 0.75 tonnes of soil which had fallen down the hole.
- 24 Train services recommenced on Monday 11 March. However, water and silt remaining within the tunnel caused persistent problems with the signalling system and First Capital Connect was unable to operate a full train service until Wednesday 13 March (5 days after the incident). Network Rail used overnight *possessions* to pump out water and silt, and to remove and replace contaminated ballast.

## The investigation

### Sources of evidence

25 The following sources of evidence were used:

- site photographs and measurements;
- land purchase and construction planning documents from the client;
- designs, drawings and pre-construction reports;
- local authority planning records and planning process documentation;
- Network Rail's conditions and requirements for engineering works in the vicinity of Network Rail tunnels;
- historical maps;
- London Underground infrastructure protection department's research into land ownership and related legal issues applicable to this site; and
- correspondence with affected parties.

## Key facts and analysis

### Background information

#### Proposed development

- 26 Protean Developments purchased the development site on East Road in November 2010 with planning permission for a residential tower obtained by the site's previous owner, Shoreditch Trust. Shoreditch Trust's architect had established the basic layout of the building, but without detailed knowledge of the ground conditions. The site had been vacant since the 1970s.
- 27 Protean Developments employed an architect and a structural engineer to develop the scheme as a mixed use building of the same overall shape and height as that established by Shoreditch Trust. The Protean development comprised a seven storey residential tower above a single storey commercial space (figures 7, 8 and 9). As the building did not include a basement, the structural engineer proposed that piled foundations, as opposed to a raft foundation, be used. A revised planning application was submitted to the local planning authority, the London Borough of Hackney, in February 2011, and planning permission was granted for the revised scheme in March 2012. Work to construct the piles for the residential tower commenced about a year later, two days prior to the incident.

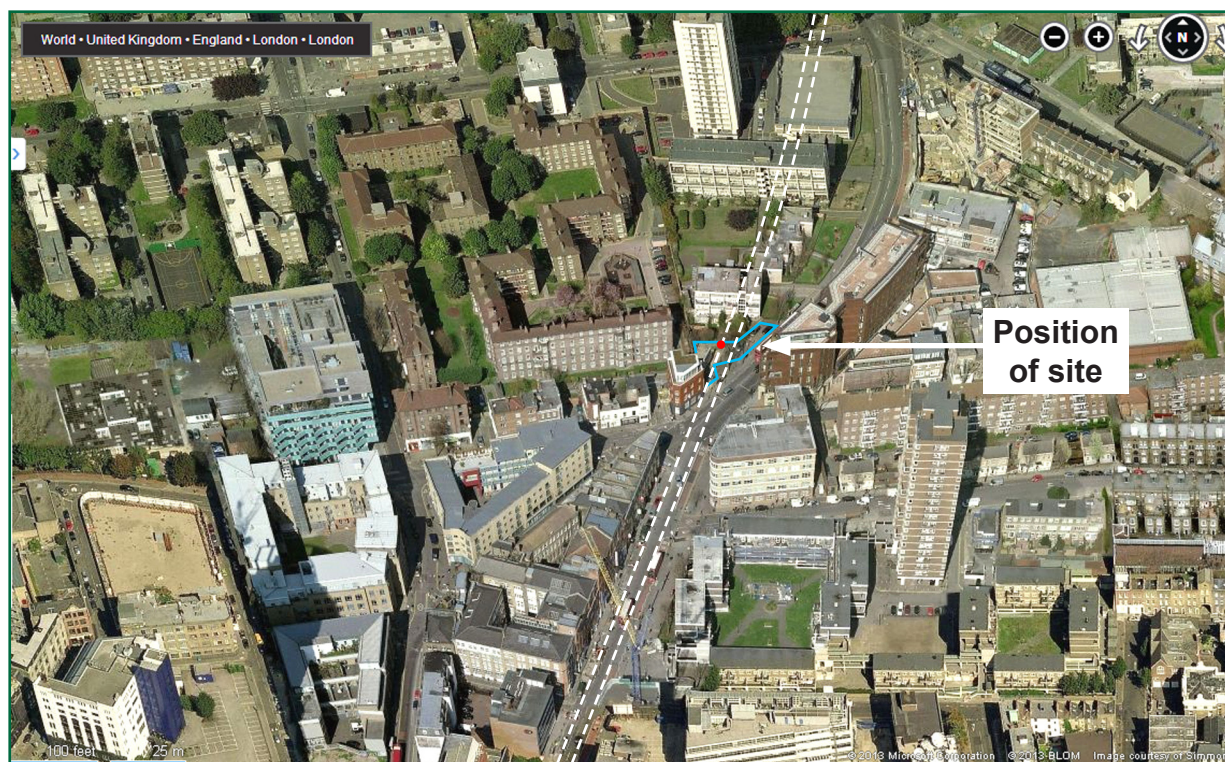


Figure 7: Aerial view of site, enhanced to show alignment of tunnels and site location (copyright Microsoft Corporation 2013)



Figure 8: Artist's impression of proposed development from 2011 planning application (looking north)

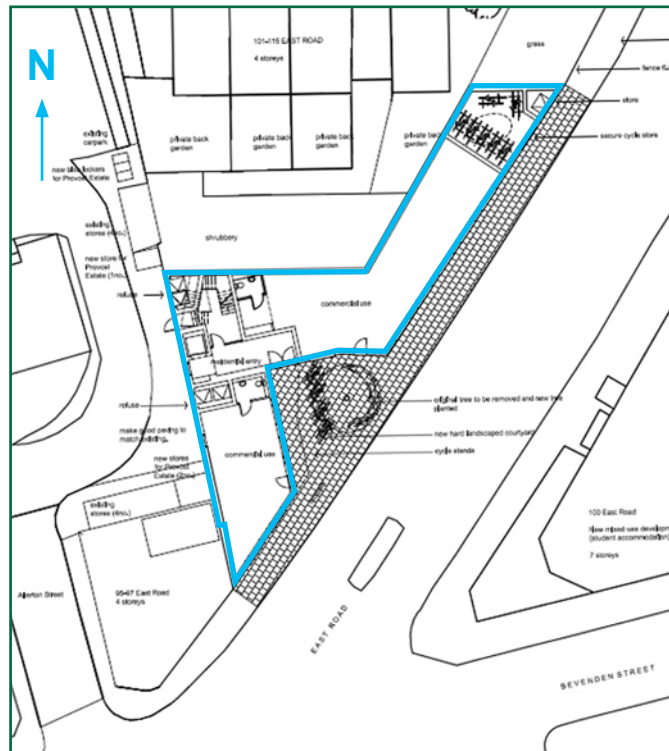


Figure 9: Extract from 2011 planning application enhanced to show outline of proposed building at ground level (blue)

Relationship between proposed piles and tunnel

28 Unknown to the designers, the planned position of 19 of the 39 piles intersected the Down Moorgate line tunnel (figure 10). The longest piles would have extended over 9 metres below rail level (figure 11).

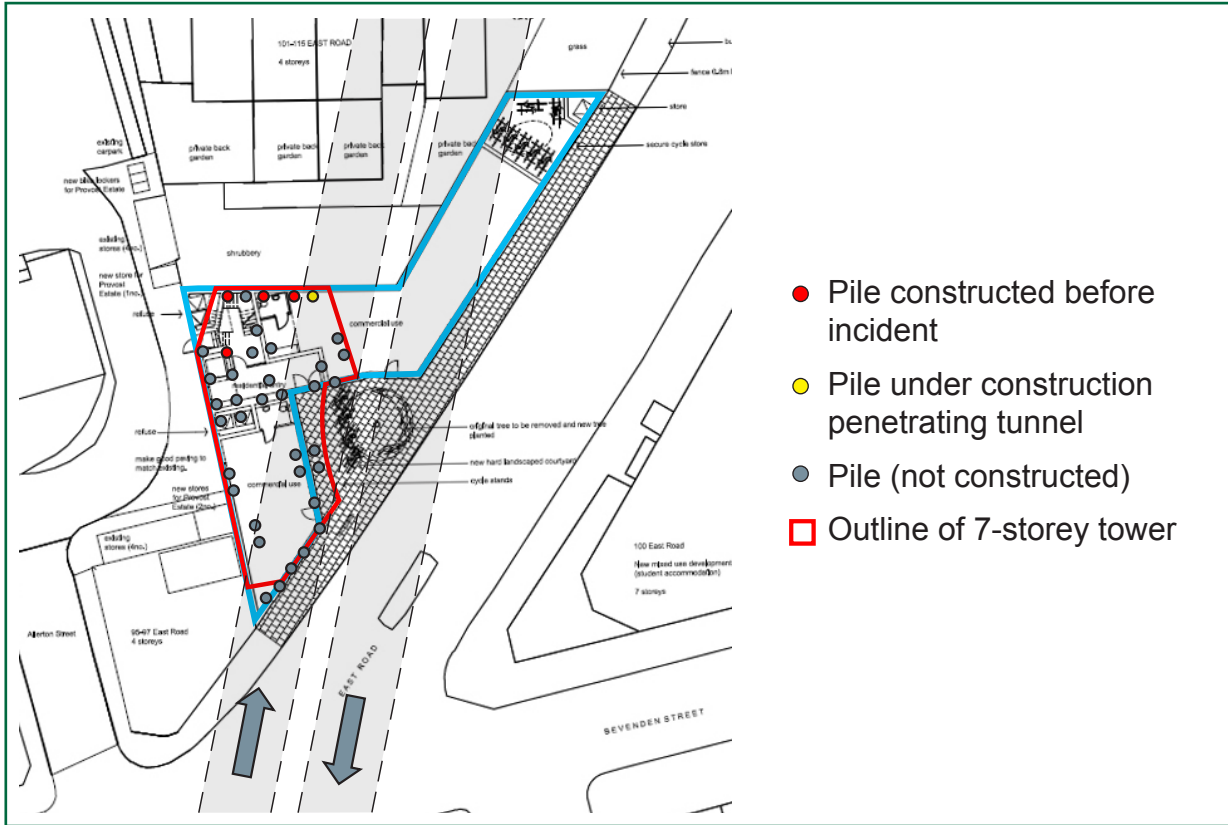


Figure 10: Extract from 2011 planning application enhanced to show location of piles and tunnels

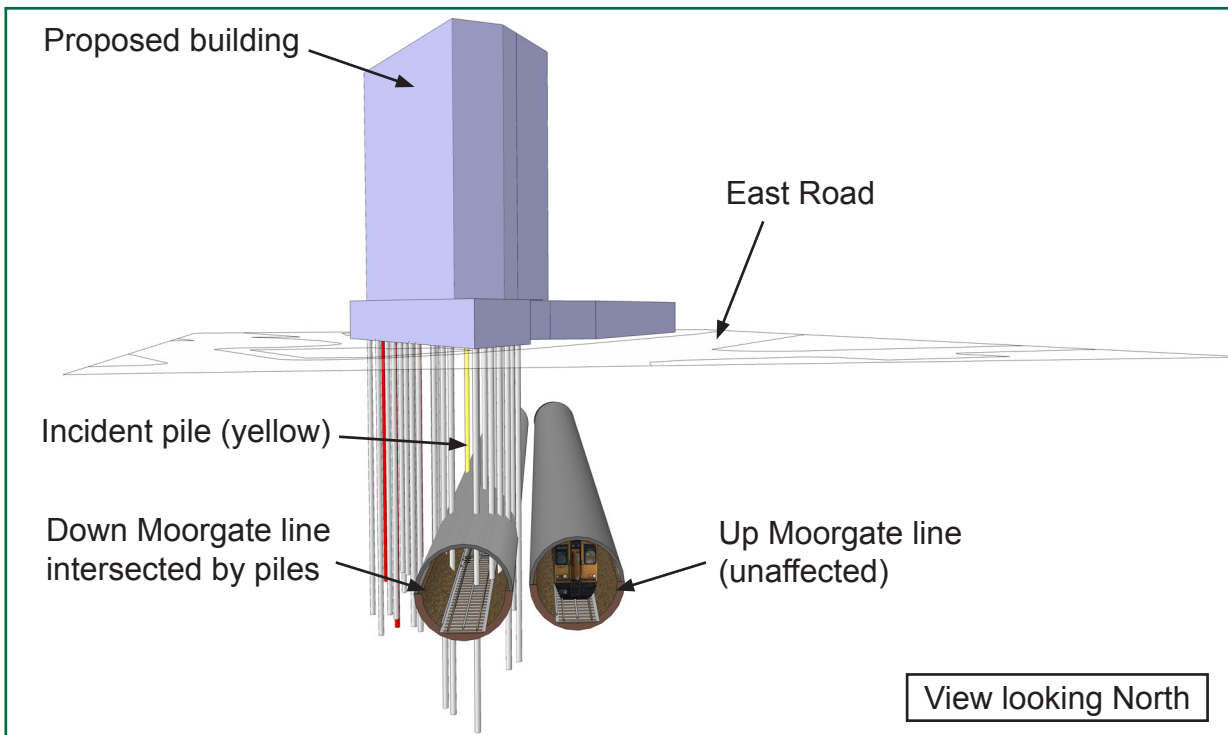


Figure 11: Scale diagram showing proposed foundation layout and extent of interaction with railway tunnel

## Identification of the immediate cause<sup>3</sup>

- 29 **The immediate cause of the incident was that piling operations conflicted with the railway tunnel.**
- 30 The planned position of 19 of the 39 piles for the proposed building intersected the existing Down Moorgate line tunnel. The first of these piles to be drilled therefore breached the tunnel.

## Identification of causal factors<sup>4</sup>

- 31 The RAIB has identified a number of causal factors:
- the Client did not appreciate the significance of an entry on the Land Registry Property Register (paragraph 32);
  - searches undertaken on behalf of the Client prior to it purchasing the site did not include Network Rail (paragraph 39);
  - a 1967 undertaking by the London Borough of Hackney, intended to give the tunnel owner the right to approve any proposed development, did not result in Network Rail being consulted before piling commenced (paragraph 43);
  - the structural engineer and contractors did not identify that an obstruction found in an exploratory borehole was part of a railway tunnel (paragraph 54);
  - pre-construction documentary searches did not detect the presence of the tunnels, or the need for additional searches (paragraph 68); and
  - the planning approval process did not recognise the tunnel risk (paragraph 75).
- Each of these factors is now considered in turn.

### Land Registry Property Register

#### 32 **The Client did not appreciate the significance of an entry on the Land Registry Property Register.**

- 33 In 1902, two years before the railway opened, a conveyance transferred the sub-soil required for tunnel construction to the Great Northern and City Railway (GN&CR) who were building the line. This transfer means that the current Land Registry register of title for the site on East Street includes the phrase:

*‘So much of the sub-soil as was vested in the Great Northern and City Railway is excluded from the registration.’*

- 34 The GN&CR tunnels generally followed public highways, but a bend in East Road required a 280 metre length of the tunnels to be constructed in part beneath private property, and in part beneath Fairbank Street (figures 12, 13 and 14). This is one of the few locations on London’s underground railway network where the early tube tunnels (designed and constructed between 1884 and 1907) passed for some substantial distance under private property.

<sup>3</sup> The condition, event or behaviour that directly resulted in the occurrence.

<sup>4</sup> Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.



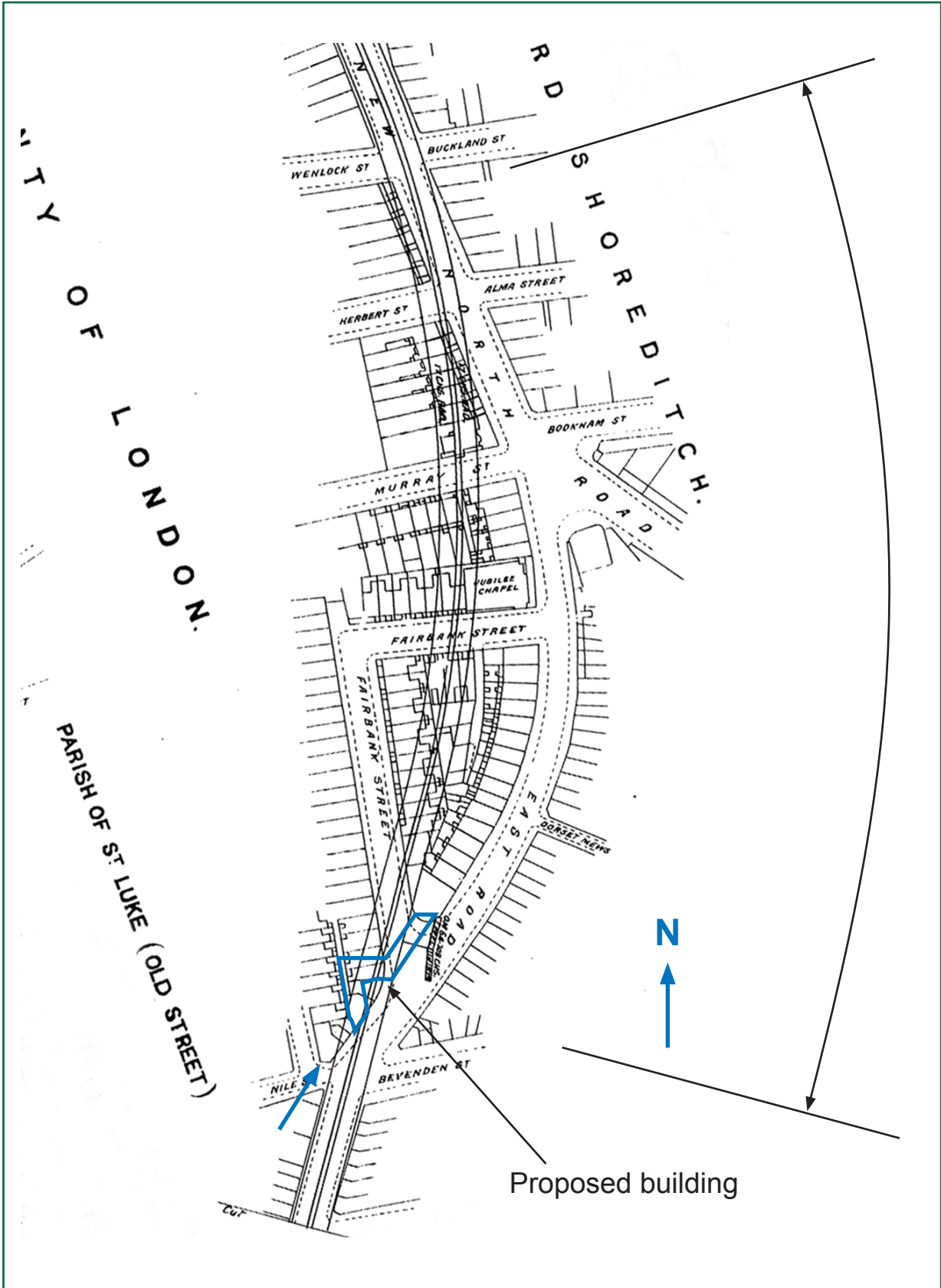
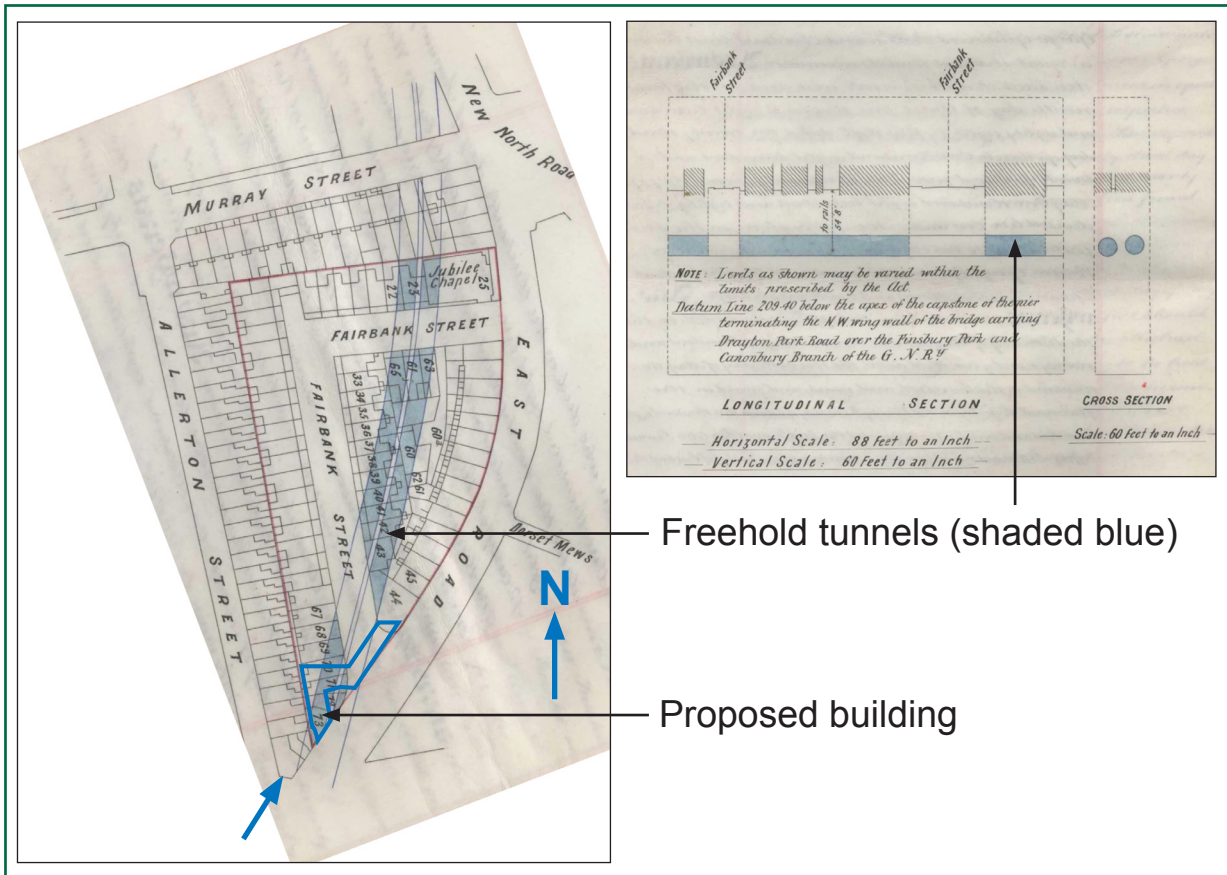


Figure 12: Extract from Great Northern and City Railway map showing route of tunnels beneath residential property, including Fairbank Street, and outline of proposed building (blue)



Figures 13 and 14: Extracted plan and sections from 1902 Conveyance of the freehold tunnels showing outline of proposed building (blue)

- 35 The conveyance meant that the railway company had no other property rights or interests relating to surrounding land. In particular, land ownership documentation for land above the tunnels included no requirement for land owners to consult the railway company before undertaking works.
- 36 When purchasing the site, Protean Developments asked the vendor's solicitor for information about the GN&CR entry in the Land Registry Property Register. The solicitors replied that they had no information about this. Protean Developments has stated that it received no information regarding buried services or obstructions from the previous owners of the site. The RAIB has confirmed that the GN&CR entry in the Land Registry Property Register was present at the time of the 2002 sale by the London Borough of Hackney (paragraph 17).
- 37 The RAIB has undertaken a Google search for 'Great Northern and City Railway' (paragraph 33), limited to web pages available on or before November 2010 when Protean Developments purchased the site. The first three pages listed all explain the linkage between GN&CR and modern train services to Hertford.
- 38 In the absence of an explanation for the reference to the Great Northern and City Railway, Protean Developments proceeded without appreciating that the entry was an indicator of a potential risk. Protean Developments did not give any information about the land registry entry to its design team and has stated to the RAIB that it was not its usual practice to discuss land registry matters with the design team.

## Searches

### **39 Searches undertaken on behalf of the Client prior to it purchasing the site did not include Network Rail.**

- 40 Protean Developments has stated that its conveyancing solicitor used a specialist conveyancing search provider to obtain searches required as part of the land purchase process. The provider offers standard searches which are selected by the user, and include London Underground and Crossrail, but not Network Rail. Protean Developments has stated that a London Underground search was requested in June 2010, but this gave no information about the tunnels. This is consistent with the tunnels being owned by Network Rail (refer to appendix C).
- 41 The search provider has stated that it did not offer a Network Rail search because it did not believe that Network Rail supplied a bespoke conveyancing search service to define rail infrastructure.
- 42 Network Rail has stated that, in June 2010, an external party could have contacted its asset protection team through the Network Rail external website ([www.networkrail.co.uk](http://www.networkrail.co.uk)), or by using its national telephone helpline number (08457-114141) listed on its website and on other directory services. This number is also listed in printed telephone directories (eg BT phone book).

## 1967 Undertaking

### **43 A 1967 undertaking by the London Borough of Hackney, intended to give the tunnel owner the right to approve any proposed development, did not result in Network Rail being consulted before piling commenced.**

- 44 In 1963, the London Borough of Hackney's predecessor (Shoreditch Metropolitan Borough Council) made a compulsory purchase order for properties surrounding Fairbank Street including the site on East Road. This was part of a local authority scheme to re-develop land west of East Road and replace existing properties with several blocks of flats. The redevelopment proposals included the 'stopping up' (permanent closure) of Fairbank Street.
- 45 The Moorgate tunnels which run under this land (figure 15), were at that time owned by the London Transport Board (refer to appendix C). As there was only limited legal protection for the tunnels (paragraph 35), the London Transport Board sought an undertaking to protect its asset from the proposed and any future demolition and re-development works which had the potential to adversely affect the safety of the railway. The London Transport Board objected to the stopping up of Fairbank Street until the undertaking was provided.
- 46 In February 1967, the London Borough of Hackney entered into an Undertaking with the London Transport Board to resolve this issue. The purpose of this undertaking was to:
- a. protect tunnels under Fairbank Street (not protected by land ownership); and
  - b. enhance protection of tunnels beneath properties either side of Fairbank Street (figures 13 and 14) where the London Transport Board already owned the subsoil around the tunnels.

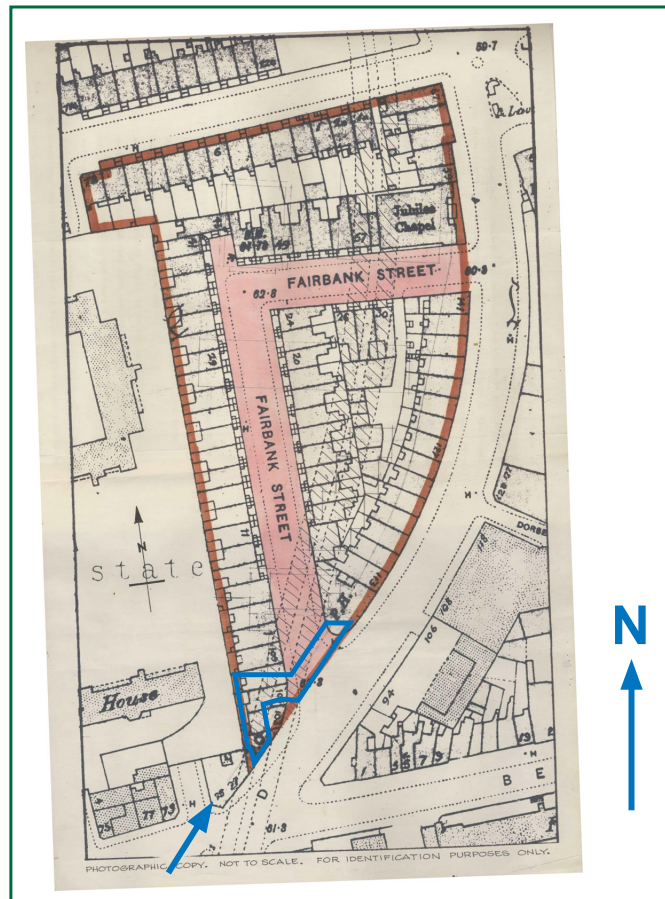


Figure 15: Extracted plan from the 1967 Undertaking showing protected area and outline of proposed building (blue)

- 47 The Undertaking, signed on 20 February 1967, committed the London Borough of Hackney to entering into a deed of covenant with the London Transport Board for the protection of the railway if the stopping up order came into effect. Protection was to be provided by requiring consultation with the London Transport Board and its agreement before any development took place in the area of land outlined on figures 15 and 16. This area includes the incident site and a larger area to the north which is now known as the Fairbank Estate. The undertaking also bound the London Borough of Hackney by the terms of the proposed deed of covenant until this became effective.
- 48 As is common with many covenants on land, the agreement was intended to create a process which would apply to the London Borough of Hackney and any successor owners of the land.
- 49 Fairbank Street was closed and the majority of the site was re-developed as the Fairbank Estate in the late 1960s and early 1970s. Properties on the site on East Road were demolished at this time but no new building work took place.
- 50 Protean Developments has stated that it was not made aware of the covenant intended to be created by the 1967 Undertaking. It is not recorded in the Land Registry entries for the site.

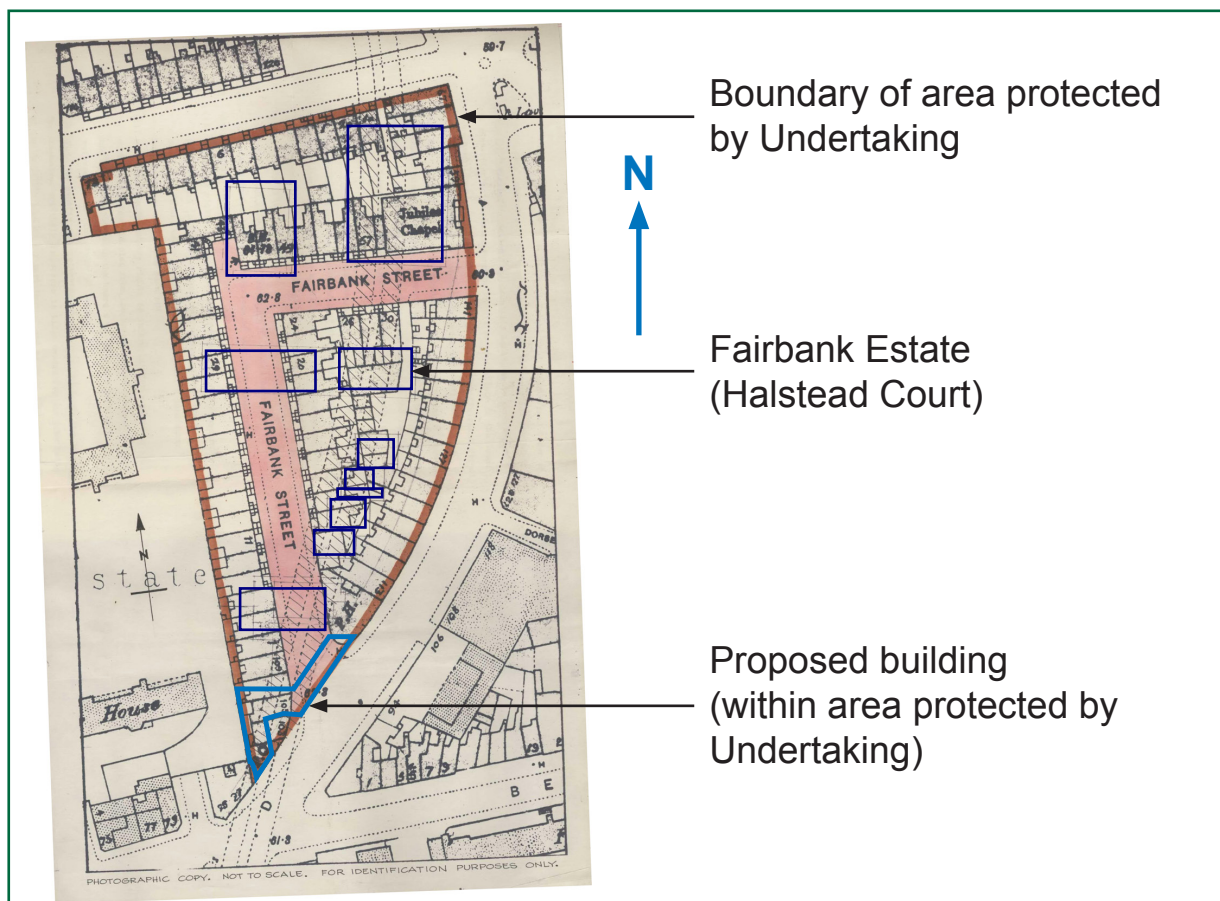


Figure 16: Extracted plan from the 1967 Undertaking, enhanced to show the outline of the post-1967 Fairbank Estate development (dark blue) and proposed building (blue)

- 51 It is uncertain whether the covenant was actually made between the London Borough of Hackney and the London Transport Board, and neither the London Borough of Hackney nor London Underground (as successors to the London Transport Board) has been able to locate a copy. It is also uncertain whether a covenant was created for the Fairbank Estate. The absence of a reference to a covenant in the Land Registry entries for the site on East Road may have been for one of the following reasons:
- a. the covenant was not drawn up;
  - b. an error in the records; or
  - c. the documents have been mislaid or inadvertently destroyed.
- 52 The consequence of the covenant not being enacted (or subsequently being mislaid) was that the protection for the tunnels sought by the London Transport Board was not achieved. Ownership of the Moorgate tunnels transferred to British Rail in 1975, and to Network Rail in 2002 (refer to appendix C).

- 53 London Underground's infrastructure protection team had an internal instruction requiring its staff to refer to Network Rail any person or organisation that approached them with a development proposal that affected Network Rail's infrastructure. This did not apply when a different part of the Transport for London organisation received a post-incident enquiry made on behalf of the developer. Its Operational Property division responded, correctly stating that neither London Underground Limited (LUL), nor Rail for London Limited (RFL), had any existing or proposed operational services beneath or close to the property. The response did not make specific reference to Network Rail, but advised the enquirer to 'make such further searches, enquiries inspections and surveys as are appropriate with respect to other rail service providers.'

#### Discovery of a possible man-made obstruction

#### **54 The structural engineer and contractors did not identify that an obstruction found in an exploratory borehole was part of a railway tunnel.**

- 55 Protean Developments instructed the structural engineer to arrange all surveys necessary for the design of the foundations. The structural engineer arranged for a site investigation contractor to carry out a *ground investigation* to establish the nature of the subsoil and provided it with a plan of the site.

#### Ground investigation

- 56 In November 2011, the site investigation contractor sank two 150 mm diameter boreholes using a shell and auger percussion rig. This type of rig forms a hole by repeatedly raising and dropping a heavy steel tube (shell) attached by a cable to a tripod standing over the hole. The shell cuts further into the ground each time it is dropped. An outer casing is used to support the sides of the hole when penetrating weak ground.
- 57 The boreholes were required to obtain soil samples and establish the strength of the ground at different depths and in different areas of the site. The boreholes were intended to be sunk to a depth of 20 m, but borehole 1, located towards the south end of the site, had to be terminated at a depth of 14 m because it encountered a hard object which the shell could not penetrate<sup>5</sup>. Borehole 2, located near the north end of the site, was sunk to the intended depth.
- 58 The RAIB has established, by mapping the ground investigation plan onto a map of the tunnels, that borehole 1 was located directly over the Down Moorgate line tunnel (figure 17). The depth of the obstruction corresponds to the depth of the tunnel roof at this location.
- 59 The site investigation contractor completed its ground investigation report in December 2011 and issued it to the structural engineer. The report recorded a 'possible man-made obstruction 14 m below ground level' at the base of borehole 1, and advised 'this is not thought to be associated with the tube network but may relate to the London sewer network.' It concluded, 'Further investigation into the structure will be required prior to any piling design.'

<sup>5</sup> The RAIB observes that the obstruction was only encountered by chance during the ground investigation survey as borehole 1 could have been positioned elsewhere on the site.

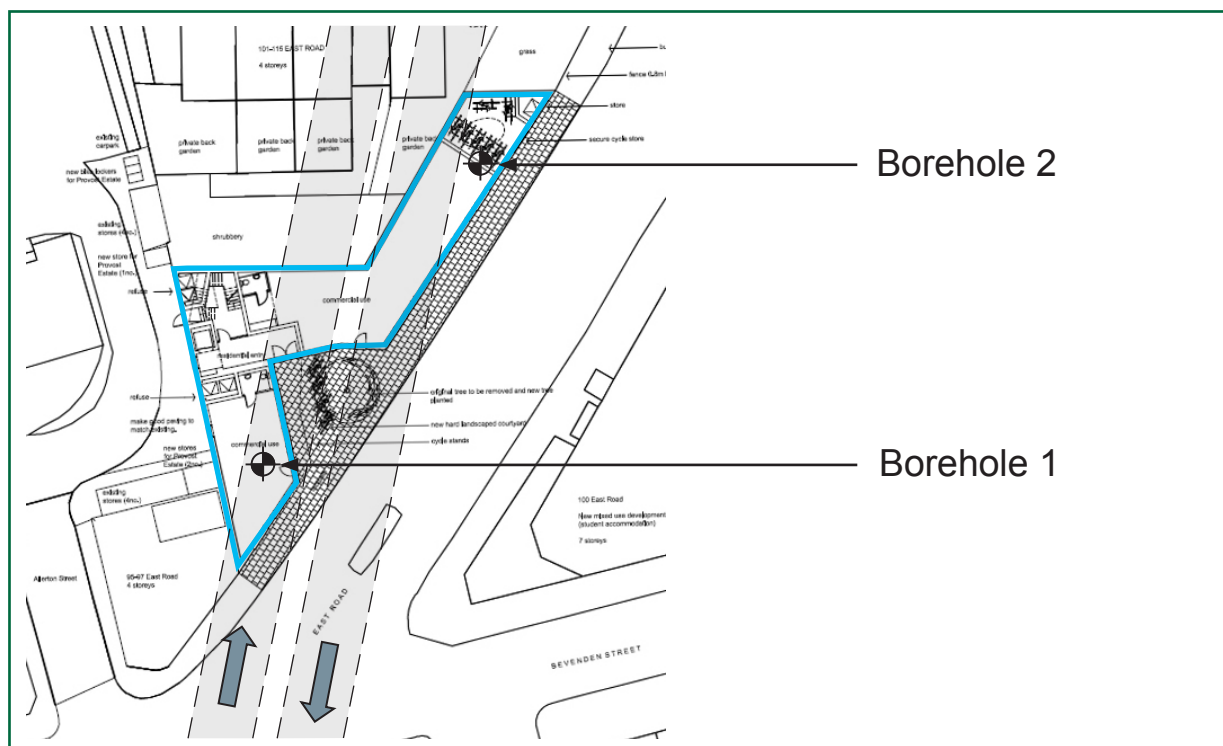
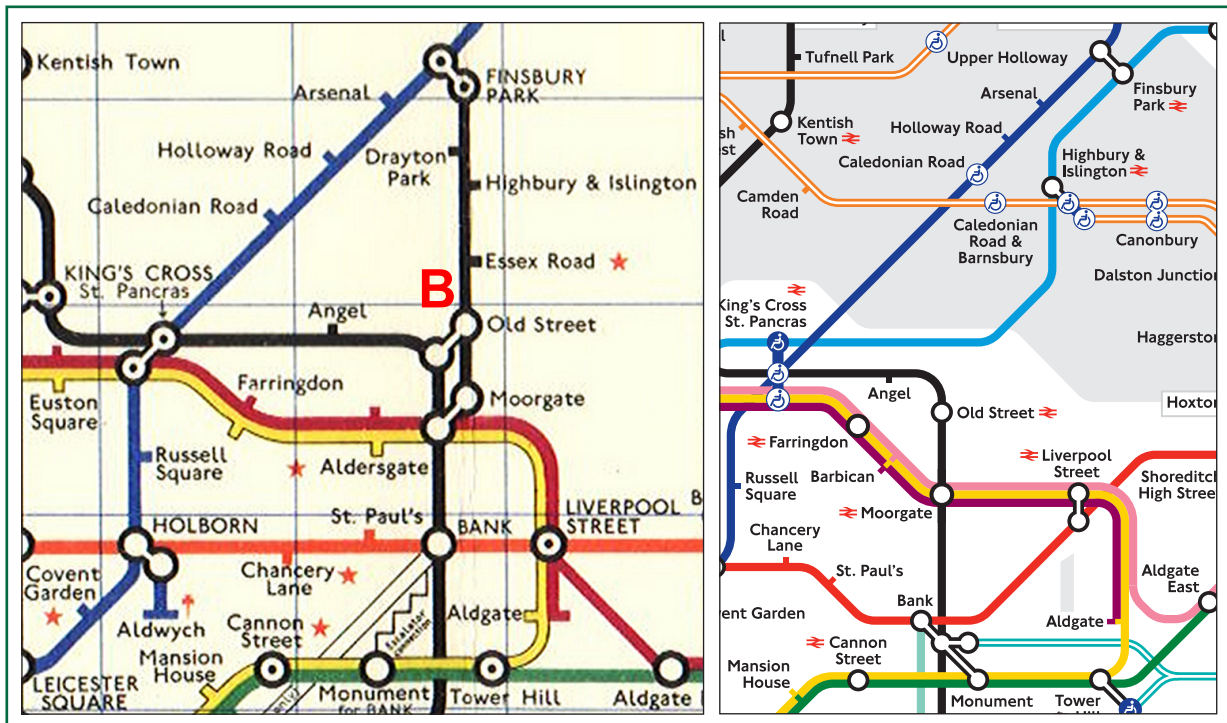


Figure 17: Extract from 2011 planning application enhanced to show location of boreholes and tunnels

- 60 The site investigation contractor has stated to the RAIB that its comment regarding the buried obstruction was based on a brief and preliminary study of London Underground *tube lines* in the vicinity of the site and discussions with the structural engineer. It envisaged that a comprehensive survey of the ground would occur prior to piling, and explicitly recommended further investigation of the obstruction in its report (paragraph 59).
- 61 The current London Underground map does not show the Northern City line as it is now part of the national rail network (figures 18 and 19). Mapping issues are discussed in paragraph 92 onwards.

### Foundation design

- 62 The structural engineer developed the design for the building's foundations. This used piles to support the seven storey residential tower and shallow foundations for the single-storey section of the building. The structural engineer subsequently issued a foundation plan (drawing) showing the positions of 39 piles, and the load each pile was required to support. Although the length and diameter of each pile was not specified on the foundation plan, the foundation layout appears to make no allowance for possible interaction between the piles and an obstruction (whose size and nature was still unknown).
- 63 The structural engineer states that it responded to the site investigation contractor's recommendation for further investigation of the possible man-made obstruction (paragraph 59). The investigations carried out by the structural engineer established that the obstruction was not associated with a disused sewer under another part of the site and not part of the London Underground network.



Figures 18 and 19: Extracts from London Underground maps from 1964 and 2013. The Northern City line is shown running between Moorgate and Finsbury Park on the 1964 map (position 'B').

- 64 The structural engineer issued the main (building) contractor with the ground investigation report, together with a specification for structural works. The specification described the duties of the principal contractor and included the following clauses:
- a. Site investigation: Confirm as adequate or propose further investigation as considered necessary.
  - b. Obstructions/ voids: As described in the [December 2011] ground investigation report.
  - c. Confirmation that installation of piles will not damage adjacent structures/ services.
- 65 The principal contractor did not propose further investigation of the obstruction, and subcontracted the design and installation of the piles to the piling contractor.
- 66 The piling contractor was also issued with a copy of the ground investigation report, and was responsible for the detailed design of each pile (eg its length and diameter) based on the structural engineer's foundation plan. It did not propose any further investigation as it considered its involvement was limited to providing piles capable of carrying the specified load, and had assumed that the designer had interrogated the reports commissioned, together with other service reports and historical records. The piling contractor's primary interest in the report was to establish the load-bearing capabilities of the soil, and borehole 2 provided the necessary information to a depth of 20 metres.
- 67 The piling contractor submitted its design to the structural engineer and principal contractor. The design required all 39 piles to be 350 mm in diameter, with individual pile lengths varying between 14.5 m and 23 m. The structural engineer responded 'We have no comments on the attached design.' The piling contractor states it received no response from the principal contractor.



## Pre-construction planning

### **68 Pre-construction documentary searches did not detect the presence of the tunnels or the need for additional searches.**

- 69 The structural engineer also commissioned the site investigation contractor to review environmental information and reports and undertake a risk assessment associated with potential contamination of the site. This requirement was in response to planning conditions imposed by the London Borough of Hackney. The site investigation contractor used current and historical Ordnance Survey maps, geological records and local data to produce an environmental report which it issued in October 2012. The study did not identify the tunnels.
- 70 The RAIB has examined current and historic Ordnance Survey mapping for the East Road area, including large scale maps (1:10,000 scale and Ordnance Survey MasterMap). It has found that the route of the Moorgate tunnels is not shown on any Ordnance Survey mapping despite other Network Rail tunnels being shown (refer to paragraph 92).
- 71 This omission may reflect the Northern City line's history as a former part of the London Underground network (refer to appendix C). Ordnance Survey distinguishes railway lines into two categories for the purposes of its mapping:
- a. Lines which are widely recognised as 'overground': (ie ground surface level communications routes, typically infrastructure owned by Network Rail or one of the preserved railway organisations). This includes lines that are part of an 'underground' network but operate at surface level.
  - b. Lines which are widely recognised as 'underground' communication networks focused on a particular urban area or conurbation.
- 72 In the case of tunnels on lines in category b, Ordnance Survey has stated that its policy is to show the approximate alignment of tunnel walls for the sub-surface Metropolitan and District Lines in London, as these routes are open to the ground surface in a number of places. Its mapping also shows some 'underground' tunnel entrances and interactions with overground lines, but excludes the route of most tunnels used by underground railway systems. Although there is no indication on Ordnance Survey maps that some underground railway system tunnels are omitted, information relating to the mapping specifications is provided within the User Guide Documentation available to users of digital information.
- 73 Ordnance Survey has stated that it has no record of being notified of the transfer in ownership of the Moorgate tunnels (in 1975), and therefore did not consider whether these tunnels should be shown on its mapping as part of the 'overground' railway network.
- 74 Utility searches commissioned by the client were undertaken by approaching each utility company separately. This process did not consider the possibility of railway tunnels.

## The planning process

### 75 The planning approval process did not recognise the tunnel risk.

- 76 The London Borough of Hackney was responsible for granting planning permission for the proposed development. As part of this process, the council was required to carry out a consultation exercise in accordance with the 'Town and Country Planning (Development Management Procedure) Order 2010 (as amended)'. The council's planning officers used this legislation, and the local 'Statement of Community Involvement' (required under the Planning and Compulsory Purchase Act 2004), to identify consultees appropriate for a development with a combination of commercial and residential use.
- 77 This process identified the following consultees who were allowed 21 days to respond:
- a. External consultees: neighbours and local residents, Invest in Hackney, National Health Service Primary Care Trust, Thames Water.
  - b. Internal consultees: waste management, pollution, conservation and design, transportation.
  - c. Additional consultees: landscape and tree officer, and Transport for London (for red route/bus route/Strategic Road Network).
- 78 Transport for London was identified as an additional consultee to verify the impact of the new development on the highway. However, for reasons the RAIB has not been able to establish, the consultation document was not received by the appropriate department within Transport for London, and consequently the council did not receive a response.
- 79 As part of the planning review process, the London Borough of Hackney's planning officers plotted applications onto digital maps which also held information on constraints affecting planning applications (eg location of listed buildings and floodplain areas). The council's digital maps did not show the railway tunnels under the site. The planning officers were therefore unaware of their presence and so did not consider it to be necessary to consult with either Network Rail or London Underground.
- 80 Both Network Rail and London Underground are not named on the list of statutory consultees. However, the planning officers have confirmed that either organisation could be consulted on a case-by-case basis if there was an obvious interface between an existing railway and a proposed scheme (eg as a neighbour).
- 81 Even if the council's planning officers had been aware of the tunnel, there was no requirement<sup>6</sup> for the local planning authority to consult with the operator of the railway as a statutory consultee. This is only required if a planning application relates to 'Development likely to result in a material increase in the volume or a material change in the character of traffic... using a level crossing over a railway' (see paragraph 101 for details of a previous RAIB recommendation linked to this issue).

<sup>6</sup> Article 16 of the Town and Country Planning (Development Management Procedure) Order 2010 (as amended).

- 82 Foundation type is not normally a material planning consideration unless a proposed development lies on a safeguarded route (ie on a route identified for future development, such as the proposed 'Crossrail 2' underground railway scheme). This development did not lie on such a route.

## Underlying factors<sup>7</sup>

### Protection of existing infrastructure

#### 83 Network Rail had no protection arrangements to identify risk due to proposed developments.

- 84 Network Rail had no proactive arrangements to identify developments which could affect the railway. It relied on it being notified of proposed works, either directly by a developer, or by a local planning authority after a planning application had been made, to protect its infrastructure. For this arrangement to work, it depended on third parties being aware of the presence of railway infrastructure including, as in this case, tunnels.
- 85 If Network Rail had been consulted, it would generally seek to prohibit the construction of piles within a five metre zone above and on either side of a tunnel (figure 20). This restriction is given in a Network Rail guidance document titled 'Conditions and requirements for engineering works in the vicinity of Network Rail tunnels', which states that no piles are to be driven or bored within this zone. Network Rail's asset protection department normally issues this document to developers when it receives enquiries about carrying out work adjacent to, or over, Network Rail's structures.

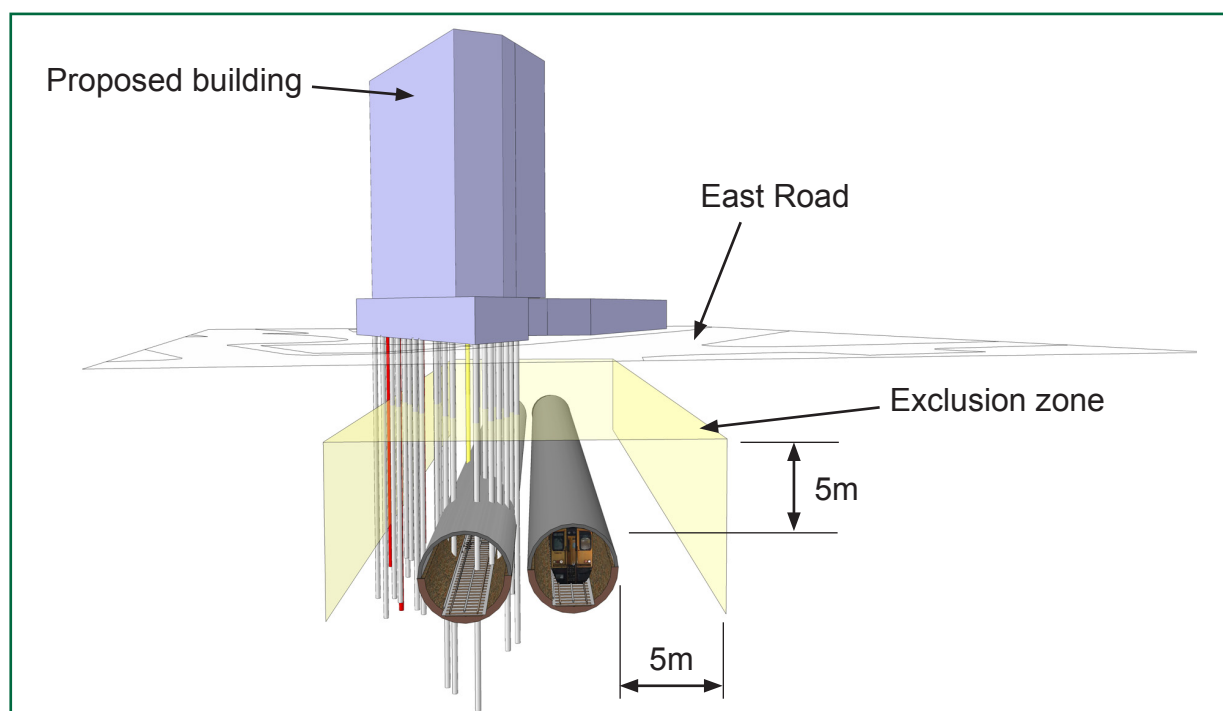


Figure 20: Scale diagram showing Network Rail's generic piling exclusion zone. Most of the proposed piles are located within this zone.

<sup>7</sup> Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

- 86 At the RAIB's request, Network Rail's asset protection team used the information provided in Protean Development's 2011 planning application to determine whether their checking processes would have revealed the proximity of the site to the tunnels. Network Rail has confirmed that it would have identified this if it had been consulted.
- 87 Network Rail's property department also used a digital mapping system (known as GI Portal). GI Portal uses Ordnance Survey mapping data and shows the line of most, but not all of Network Rail's tunnels. As the Moorgate tunnels were not shown on Ordnance Survey mapping (paragraph 70), they had been added to the GI Portal based on information from a detailed survey commissioned by Network Rail which was completed in 2006. The RAIB has verified that the position of the Down Moorgate tunnel relative to the site is shown in approximately the correct position on Network Rail's mapping by (figure 21) plotting the known position of the incident pile.

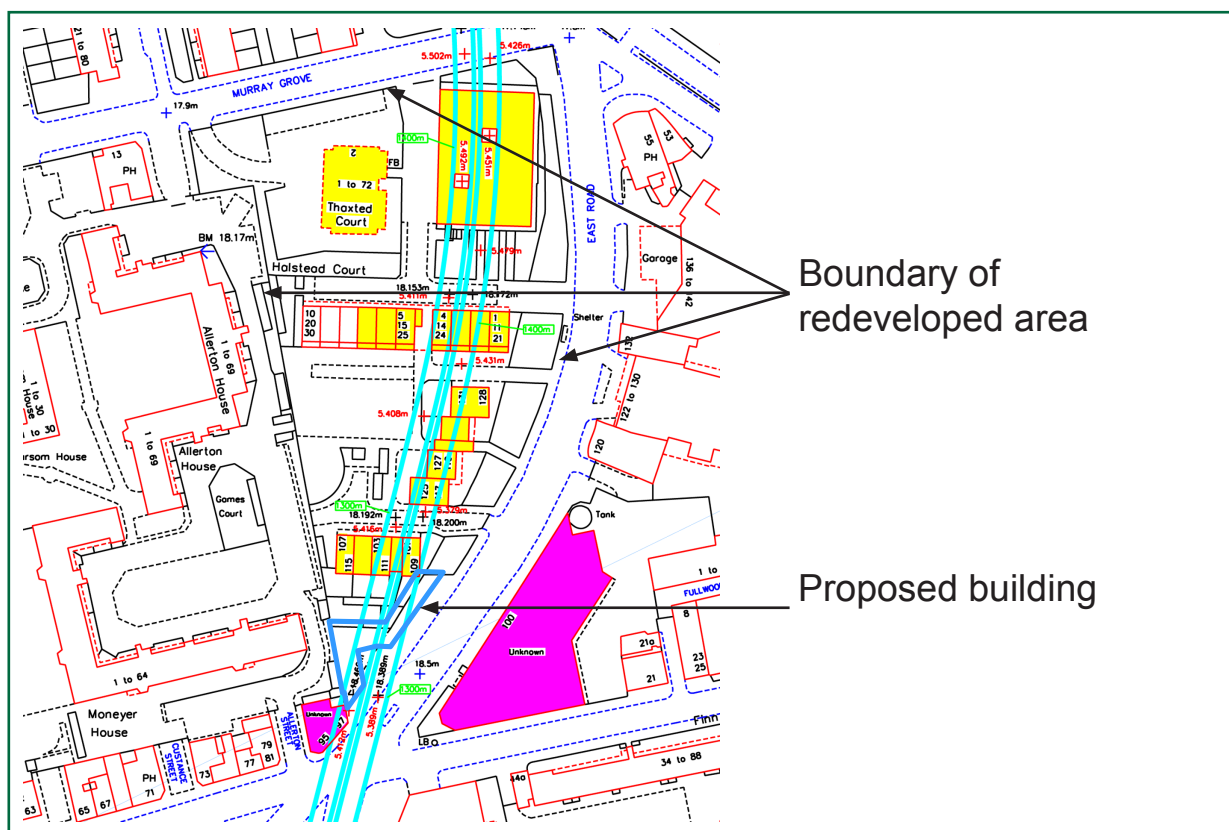


Figure 21: Extract from Network Rail's 2006 tunnel survey (post-1967 residential development shown in yellow)

- 88 Network Rail has stated that its asset protection process does not rely on covenants, and details of the 1967 undertaking (or covenant) are not noted on its land plan records. It has stated that it is unusual for its assets to be protected by a covenant applicable to a neighbouring landowner.

### London Underground's infrastructure protection arrangements

- 89 London Underground owns a significant number of tunnels which are not shown on Ordnance Survey mapping, and manages risk presented by nearby development using a dedicated infrastructure protection team. LUL stated that it manages risk by:
- providing local planning authorities, neighbours, developers and others with information on the location of surface and subsurface assets;
  - checking planning applications submitted to Local Planning Authorities, and where necessary, either objecting or seeking modification;
  - responding to enquiries from Local Planning Authorities;
  - reviewing third party design and working methods; and
  - examining notices from utility companies.
- 90 The infrastructure protection team has issued Local Planning Authorities (London Boroughs) with maps showing London Underground's area of interest, 25 m either side of the tunnel centrelines. It has asked the Local Planning Authorities to advise it of any planning applications within these areas.
- 91 London Underground staff also walk the routes of tunnels at street level to look for evidence of development work (eg demolition and site activity) which may not have been identified by other processes. The streets above subsurface tunnels (eg the Metropolitan, District and Circle Lines) are walked every four weeks, and above deep tube routes every eight weeks.

## Observations<sup>8</sup>

### Information on location of tunnels

- 92 Ordnance Survey's policy is to exclude the route of most tunnels used by underground railway systems on its mapping. However, there is no indication on Ordnance Survey maps, or in British Standard 5930:1999+A2:2010 (BS 5930) 'Code of practice for site investigations', that some railway tunnels are omitted (paragraph 72).
- 93 Accurate alignment information is not publicly available for underground railways in central London. In the absence of this information, some maps show an assumed alignment for the tunnels. For example, Google Maps (figure 22) shows a stylised alignment for the London Underground Northern Line which is significantly different from the actual alignment (figure 23). The lack of accurate information creates a risk of future development affecting existing tunnels due to misinterpretation of where the tunnels are located. For example, properties at locations A, B and C (figures 22 and 23) are much closer to existing tunnels than suggested by Google Maps.

<sup>8</sup> An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

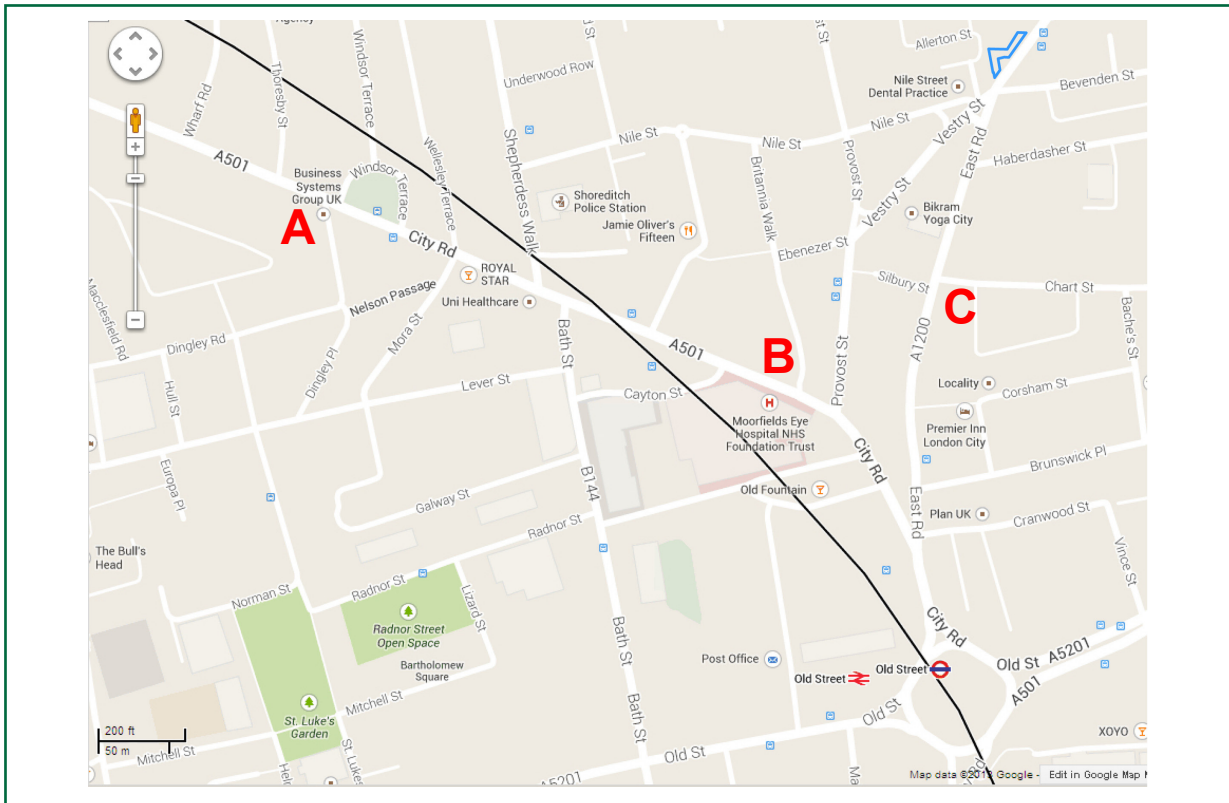


Figure 22: Screen capture of a Google Maps image of the area north-west of Old Street station. The black line represents the London Underground Northern Line. The Moorgate tunnels are not shown. Positions A, B, C and the East Road site refer to both figures 22 and 23.

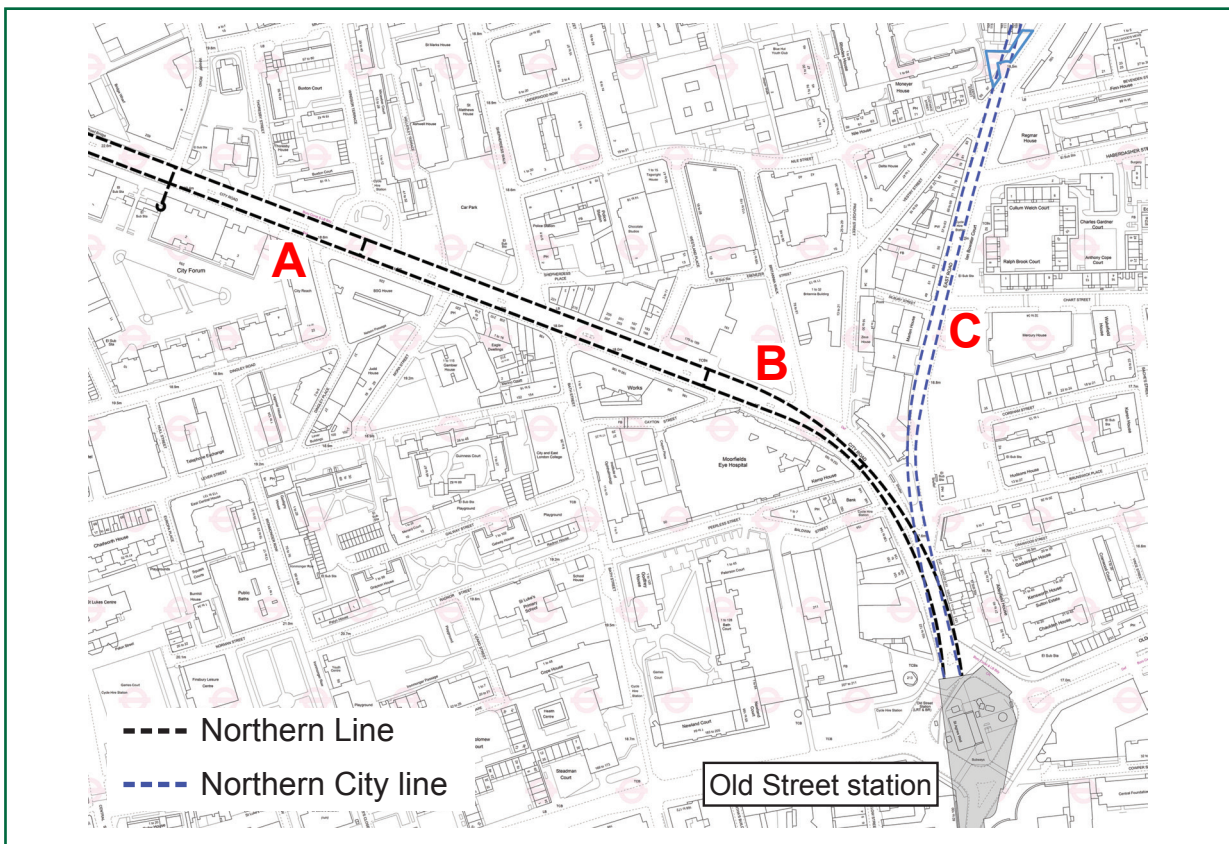


Figure 23: Plan showing the actual alignments of London Underground's Northern Line and Network Rail's Moorgate tunnels overlaid on Ordnance Survey mapping (alignment information courtesy of London Underground and Network Rail)

- 94 The RAIB has identified sections of the following UK rail systems which include tunnels that are not shown on Ordnance Survey maps; other railway tunnels may also be omitted:
- a. London Underground (controlled by Transport for London as *Railway Infrastructure Manager*);
  - b. Docklands Light Railway from near Tower Gateway to Bank (Transport for London);
  - c. Tyne and Wear Metro (Tyne and Wear Passenger Transport Executive); and
  - d. Glasgow Subway (Strathclyde Partnership for Transport).

### Previous occurrences of a similar character

- 95 The RAIB has identified two incidents where outcomes were similar to those at Old Street, both affecting London Underground tunnels. In at least one, if not both cases, the tunnels were known about, but an error was made in positioning investigation equipment at ground level:
- a. A 200 mm diameter drill penetrated the roof of a Central Line tunnel near Wanstead on 4 March 1986 when test borings were taking place for the M11 link road at Leytonstone Green Man roundabout. This incident caused damage to two trains and minor injuries to the driver of the first train.
  - b. A Northern Line tunnel was hit, but not penetrated, by ground investigation equipment working at Kennington on 20 November 2007. The tunnel was struck at a depth of 14 metres. Drilling was stopped and the incident reported. No delay or injuries resulted from the incident.

## Summary of conclusions

### Immediate cause

- 96 Piling operations penetrated the railway tunnel lining and obstructed the track (**paragraph 29**).

### Causal factors

- 97 The following causal factors have been identified:
- a. the Client did not appreciate the significance of an entry on the Land Registry Property Register (**paragraph 32, Learning point 1**);
  - b. searches undertaken on behalf of the Client prior to it purchasing the site did not include Network Rail (**paragraph 39, Recommendation 1**);
  - c. a 1967 undertaking by the London Borough of Hackney, intended to give the tunnel owner the right to approve any proposed development, did not result in Network Rail being consulted before piling commenced (**paragraph 43**);
  - d. the structural engineer and contractors did not identify that an obstruction found in an exploratory borehole was part of a railway tunnel (**paragraph 54**);
  - e. pre-construction documentary searches did not detect the presence of the tunnels, or the need for additional searches (**paragraph 68, Recommendation 2**); and
  - f. the planning approval process did not recognise the tunnel risk (**paragraph 75, Recommendations 2 and 5**).

### Underlying factors

- 98 Network Rail, unlike London Underground, did not have any pro-active arrangements to identify developments which could affect the railway (**paragraph 84, Recommendation 3**).

### Observations

- 99 Publicly available maps often omit underground railways in urban areas, or show the lines at incorrect positions. This could lead to misinterpretation of where tunnels are located and a potential risk to infrastructure (**paragraph 92, Learning point 2, Recommendation 1**).
- 100 BS 5930 does not make clear that some railway tunnels are not shown on Ordnance Survey mapping (**paragraph 92, Recommendation 4**).



## Previous RAIB recommendations relevant to this investigation

101 The following recommendation, which was made by the RAIB as a result of a previous investigation, has relevance to this investigation.

[Derailment near Moy, Inverness-shire on 26 November 2005. RAIB report number 22/2006 published 29 November 2006](#)

A passenger train travelling from Inverness to Edinburgh derailed after encountering a landslip at a cutting north of Moy in Inverness-shire. The immediate cause of the derailment was the train running into material deposited on the track as a result of the cutting landslip. The investigation found that Network Rail did not identify the drainage risks that were imported by the recent building of a parking area above the crest of the failed cutting slope.

### Recommendation 4

*The Scottish Executive and the Department for Communities and Local Government in England and Wales should ensure that Network Rail becomes a statutory consultee for planning applications for developments in the vicinity of the railway.*

In respect of England and Wales, the Department for Communities and Local Government accepted this recommendation in 2007. The Department informed the RAIB in July 2008 that it had had discussions with Network Rail about amending their statutory consultation requirements for planning applications on the basis that Network Rail was already a statutory consultee for developments affecting level crossings.

Following the incident described in this report, the Department for Communities and Local Government has stated that it is currently embarking on a fresh review of statutory consultation requirements, in particular the relationship between consultation requirements in the planning application process and works carried out below ground level by developers in the course of construction. The RAIB notes that this has not yet been brought to conclusion (**Recommendation 5**).

## Learning points<sup>9</sup>

102 The RAIB has identified the following learning points for the construction industry:

- 1 On this occasion, land ownership documentation provided the primary protection for the railway tunnels in the vicinity of the proposed piling works. There were no surface indications of the tunnel alignment. Clients and design teams should be aware of the importance of understanding and disseminating the significance of all information shown on land ownership records (paragraph 97a).
- 2 *Desk study* investigations should not assume that all railway tunnels are shown on Ordnance Survey mapping, and should always consider the need to approach rail infrastructure owners in urban areas with underground railway systems (paragraph 99).

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<sup>9</sup> Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when the RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where the RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

## Actions reported as already taken or in progress relevant to this report

- 103 Since this incident, Network Rail's Town & Country planning team has provided detailed tunnel survey data for the Moorgate tunnels to the Local Authorities which deal with planning applications which could affect the tunnels.
- 104 The RAIB has written to the Law Society and the Council for Licensed Conveyancers seeking their assistance in disseminating details of this incident to solicitors as an illustration of a dangerous occurrence which followed an organisation acquiring land without a full understanding of land ownership issues (appendix D).
- 105 The RAIB has written to the following organisations representing companies and individuals who regularly undertake desk studies asking that they advise their members that some railway tunnels in urban areas are not shown on current or historic Ordnance Survey maps, and to provide a case study illustrating the importance of understanding the significance of obstructions found in boreholes (appendix E):
- a. the Association of Geotechnical and Geoenvironmental Specialists (AGS);
  - b. the British Geotechnical Association (BGA);
  - c. the Engineering Group of the Geological Society; and
  - d. the Ground Forum as the 'umbrella' body for the ground engineering sector.

## Recommendations

106 The following recommendations are made<sup>10</sup>:

- 1 *The intent of this recommendation is to include Railway Infrastructure Managers in property-related searches, and to provide information for developers to reduce the risk presented to existing railway infrastructure where widely available mapping does not show tunnel alignments, or shows them incorrectly. Publication of accurate alignments is not required if implementers prefer alternative approaches (eg publishing maps showing bands of land encompassing tunnel alignments together with advice that the railway company should be contacted in respect of all proposed developments in these bands).*

Railway Infrastructure Managers with tunnels and associated subterranean structures which are under urban areas and not shown on Ordnance Survey mapping should implement a process to publish information concerning those areas of land that are in reasonable proximity to this infrastructure. They should then take all reasonable steps to publicise this information, and to ensure that it is available to those providing the legal and ground engineering professions with significant numbers of searches relating to property in Great Britain (paragraphs 97b and 99).

- 2 *The intent of this recommendation is to inform Local Planning Authorities so that the planning approval process can reduce the risk to railway tunnels due to construction activities in close proximity.*

Railway Infrastructure Managers with tunnels and associated subterranean structures which are under urban areas and not shown on Ordnance Survey mapping should provide Local Planning Authorities with the information needed for these authorities to identify when a planning application has the potential to affect this infrastructure (paragraphs 97e and 97f).

*continued*

<sup>10</sup> Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, Recommendations 1, 2, 3 and 4 are addressed to the Office of Rail Regulation and Recommendation 5 is addressed to the Department for Communities and Local Government. This is to enable them to carry out their duties under regulation 12(2) to:

- (a) ensure that recommendations are duly considered and where appropriate acted upon; and
- (b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 200 to 203) can be found on RAIB's website [www.raib.go.uk](http://www.raib.go.uk).

- 3 *The intent of this recommendation is to encourage Railway Infrastructure Managers to undertake pro-active measures to identify works which could affect the railway.*

Railway Infrastructure Managers should review, and where appropriate, revise existing arrangements for identifying infrastructure development which could affect tunnels and associated subterranean structures in urban areas. Where not already done, this should include pro-actively searching for planning applications and undertaking visual inspections of the ground surface above tunnels (paragraph 98).

- 4 *The intent of this recommendation is for the British Standards Institution to amend British Standard 5930:1999+A2:2010 to clarify that some railway tunnels are not shown on Ordnance Survey mapping.*

The British Standards Institution should amend British Standard 5930:1999+A2:2010 'Code of practice for site investigations' to make clear (paragraph 100):

- a. that tunnels used by underground railways and associated subterranean structures may not be shown on Ordnance Survey mapping; and
  - b. that rail infrastructure owners should be contacted during desk studies and utility searches where appropriate.
- 5 *The intent of this recommendation is to ensure that the planning approval process reduces the risk to railway infrastructure due to adjacent developments.*

The Department for Communities and Local Government should introduce a process to ensure that Railway Infrastructure Managers are made aware of all planning applications in the vicinity of railway infrastructure. This process should at least meet the intent of the statutory consultation process (paragraphs 97f and 101).

## Appendices

### Appendix A - Glossary of abbreviations and acronyms

GN&CR

Great Northern and City Railway

## Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (\*), have been taken from Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. [www.iainellis.com](http://www.iainellis.com).

Desk study	Stage 1 of a site investigation as defined by British Standard 5930:1999, which should be undertaken before the ground investigation begins. This should include a general land survey based on published maps and charts and consideration of obstructions below ground.
Down	A track on which the normal passage of trains is in the Down direction (ie away from London).*
Ground investigation	BS 5930:1999: For new works, the objectives of ground investigations are to obtain reliable information to produce an economic and safe design, to assess any hazards (physical or chemical) associated with the ground, and to meet tender and construction requirements.
Infrastructure Manager	In accordance with the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) an Infrastructure Manager is any person or organisation that: <ul style="list-style-type: none"> <li>● is responsible for developing and maintaining infrastructure (not including a station) or for managing and operating a station; and</li> <li>● manages and uses that infrastructure or station, or allows it to be used for operating a vehicle.</li> </ul>
Local planning authority	The public authority whose duty it is to carry out specific planning functions for a particular area.
Possession	A period of time during which one or more lines are blocked to trains to permit work to be safely carried out on or near the line.*
Third rail	A single conductor rail positioned on the sleeper ends.*
Tube line	Term used to differentiate underground tracks in bored tunnels from those above ground (surface lines) on London Underground lines.*
Up	A track on which the normal direction of trains is in the Up direction (ie towards London).*

## Appendix C - Short history of the Moorgate tunnels

- 1904 Great Northern and City Railway (GN&CR) opened between Moorgate and Finsbury Park (low level), including the tunnel section between Moorgate and Drayton Park (Moorgate tunnels).
- 1913 GN&CR purchased by Metropolitan Railway.
- 1933 Metropolitan Railway transferred into public ownership under the control of the London Passenger Transport Board. GN&CR renamed 'Northern City line'.
- 1937 The Northern City line became part of the Northern Line.
- 1967 Undertaking obtained by the London Transport Board (successor to London Passenger Transport Board) from London Borough of Hackney to protect tunnels from surface redevelopment.
- 1975 Transfer of tunnel ownership from the London Transport Executive (as successors to the London Transport Board) to British Railways. New surface connection built from Drayton Park to Finsbury Park (high level) to allow tunnels to be incorporated into British Rail's Great Northern suburban electrification network. This replaced the connection to Finsbury Park (low level) which had been lost in 1964 when the Victoria Line was built.
- 1976 British Rail services commence from Moorgate to Welwyn Garden City and Hertford North using dual voltage electrical multiple units.
- 1995 Transfer of tunnel ownership from British Railways Board to Railtrack.
- 2002 Transfer of tunnel ownership from Railtrack to Network Rail.
- 2002 London Borough of Hackney sold site to Shoreditch Trust.
- 2010 Shoreditch Trust sold site to Protean Developments.



## Appendix D - Text of letter to bodies representing legal professionals

(Paragraph 104)

I am writing to request that you disseminate to your members some important safety learning found during our investigation of an incident in which construction equipment bored into a railway tunnel used by trains operating between the below-ground terminus at Moorgate in the City of London and Welwyn Garden City, Letchworth and Hertford North. Fortunately, a train driver saw water flowing from the roof of the tunnel, and train services were stopped, shortly before heavy metal equipment fell onto the railway track (see attached illustrations).

Factors of particular relevance to your members and contributing to the developer and builder being unaware of the tunnel until the incident were:

- routine conveyancing searches did not include the tunnel owner, Network Rail, because this organisation was not included in the options offered by the specialist conveyancing search provider used when the development site was purchased in 2010;
- the tunnel, in common with some railway tunnels in urban areas, is omitted on most mapping, including all current and historic Ordnance Survey maps and plans. Although not relevant to the accident, maps showing underground railways often show a stylised, but incorrect, alignment; and
- the developer proceeded without understanding the significance of a Land Registry entry for the development site stating '*so much of the sub-soil as was vested in the Great Northern and City Railway is excluded from the registration*' (this railway company no longer exists but its assets, including the incident tunnel, have passed to other railway organisations).

The RAIB has established that it is Ordnance Survey's policy not to show railway tunnels considered to be part of an 'underground system' on its maps. Those commissioning searches for sites in inner London (including Docklands) should therefore ensure that search providers consider Network Rail and Transport for London. Searches in central Newcastle should include the Tyne and Wear Metro (Tyne and Wear Passenger Transport Executive), and in central Glasgow, the Glasgow Subway (Strathclyde Partnership for Transport).

Full details of the incident are given in our report on the 'Penetration and obstruction of a tunnel between Old Street and Essex Road stations, London, 8 March 2013', which will be published on 13 February 2014 and available at: [http://www.raib.gov.uk/publications/investigation\\_reports/reports\\_2014.cfm](http://www.raib.gov.uk/publications/investigation_reports/reports_2014.cfm). The report includes recommendations intending to make information about tunnels more readily available.

## Appendix E - Text of letter to bodies representing ground engineering professionals

(Paragraph 105)

I am writing to request that you disseminate to your members some important safety learning found during our investigation of an incident in which construction equipment bored into a railway tunnel used by trains operating between the below-ground terminus at Moorgate in the City of London and Welwyn Garden City, Letchworth and Hertford North. Fortunately, a train driver saw water flowing from the roof of the tunnel, and train services were stopped, shortly before a CFA piling auger penetrated the tunnel and obstructed the railway (see attached illustrations).

Factors of particular relevance to geotechnical specialists and contributing to the developer and builder being unaware of the tunnel until the incident were:

- the tunnel, in common with some railway tunnels in urban areas, is omitted on most mapping, including all current and historic Ordnance Survey maps and plans. Although not relevant to the accident, maps showing underground railways often show a stylised, but incorrect, alignment;
- routine conveyancing searches undertaken when the developer purchased the site did not include the tunnel owner, Network Rail, because this organisation was not included in the options offered by the specialist conveyancing search provider;
- the developer proceeded without understanding the significance of a Land Registry entry for the development site stating *'so much of the sub-soil as was vested in the Great Northern and City Railway is excluded from the registration'* (this railway company no longer exists but its assets, including the incident tunnel, have passed to other railway organisations); and
- the structural engineer and construction contractors did not identify that an obstruction found in an exploratory borehole was part of a railway tunnel.

The RAIB has established that it is Ordnance Survey's policy not to show railway tunnels considered to be part of an 'underground system' on its maps. Those commissioning searches for sites in inner London (including Docklands) should therefore ensure that search providers consider Network Rail and Transport for London. Searches in central Newcastle should include the Tyne and Wear Metro (Tyne and Wear Passenger Transport Executive) and in central Glasgow, the Glasgow Subway (Strathclyde Partnership for Transport).

The incident illustrates the importance of ensuring that designers are aware of relevant land ownership issues. Full details are given in our report on the 'Penetration and obstruction of a tunnel between Old Street and Essex Road stations, London, 8 March 2013', which is available at: [http://www.raib.gov.uk/publications/investigation\\_reports/reports\\_2014.cfm](http://www.raib.gov.uk/publications/investigation_reports/reports_2014.cfm). The report includes recommendations intending to make information about tunnels more readily available.

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Any enquiries about this publication should be sent to:

RAIB	Telephone: 01332 253300
The Wharf	Fax: 01332 253301
Stores Road	Email: <a href="mailto:enquiries@raib.gov.uk">enquiries@raib.gov.uk</a>
Derby UK	Website: <a href="http://www.raib.gov.uk">www.raib.gov.uk</a>
DE21 4BA	