

2. Project description

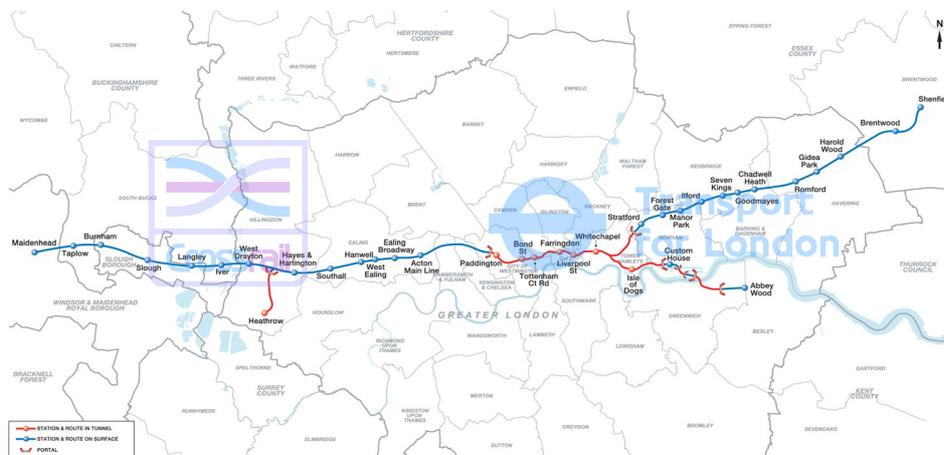
2.1 Introduction

- 2.1.1 This chapter provides a general introduction to Crossrail in terms of an overview of the permanent works that will be constructed as part of the project, information on the operation of Crossrail and a description of how the permanent works will be constructed.

2.2 Crossrail – a general introduction

- 2.2.1 Crossrail is a major new cross-London rail link project that has been developed to serve London and the southeast of England. Crossrail will support and maintain the status of London as a world city by providing a world class transport system. The project includes the construction of a twin-bore tunnel on an east-west alignment under central London and the upgrading of existing National Rail lines to the east and west of central London. The Crossrail route is shown in *Figure 2.1*.

FIGURE 2.1 OVERVIEW OF CROSSRAIL ROUTE



- 2.2.2 The project will enable the introduction of a range of new and improved rail journeys into and through London. It includes the construction of seven central area stations, providing interchange with London Underground, National Rail and London bus services, and the upgrading or renewal of existing stations outside central London. Crossrail will provide fast, efficient and convenient rail access to the West End and the City by linking existing routes from Shenfield and Abbey Wood in the east with Maidenhead and Heathrow in the west.
- 2.2.3 Crossrail will be a significant addition to the transport infrastructure of London and the southeast of England. It will

deliver improved services for rail users through the relief of crowding, faster journeys and the provision of a range of new direct journey opportunities. The project will also have wider social and economic benefits for London and the southeast of England.

2.3 Route overview

- 2.3.1 Crossrail's route has four distinct sections: a central section within central London and, outside central London, western, northeastern and southeastern sections.
- 2.3.2 In the west, Crossrail will use the Great Western Main Line between Maidenhead and Westbourne Park. The existing 25 kV overhead electrification between Paddington and Airport Junction will be extended to Maidenhead and bridge alterations will be undertaken as necessary. The main infrastructure changes are the construction of a flyover structure (the Stockley flyover) to allow Crossrail trains to access the existing tunnelled spur to Heathrow and the provision of a rail underpass (a dive-under) west of Acton Yard. A new line, within the existing railway corridor, will be provided between Langley and West Drayton. Enhancements will also be made to stations, with the most significant works being at Ealing Broadway, Southall, Hayes and Harlington, West Drayton, Slough and Maidenhead. New stabling sidings are also proposed at Old Oak Common, West Drayton and west of Maidenhead station.
- 2.3.3 The central route section will consist largely of a twin-bore tunnel beneath central London with portals at Royal Oak in the west, Pudding Mill Lane in the northeast and Victoria Dock Road in the southeast. The central route section extends from a point around 200m west of the A40 Westway to a point around 500m to the east of the portal at Pudding Mill Lane in the northeast and a point just to the east of Poplar Dock and the A1206 Prestons Road in the Isle of Dogs in the southeast. New stations and associated structures, such as ventilation shafts, will be provided along this part of the route.
- 2.3.4 On the northeast route section, Crossrail will use the existing Great Eastern Main Line between Pudding Mill Lane and Shenfield. The main infrastructure changes are a new train maintenance depot west of Romford station and the reinstatement of a track between Goodmayes and Chadwell Heath. Enhancements will also be made to stations, with the most significant works being proposed at Ilford and Romford. This route has existing 25kV overhead electrification. New stabling facilities will be provided at Gidea Park.
- 2.3.5 The southeast route section runs between a point to the east of the Isle of Dogs station and the eastern terminus at Abbey Wood,

where Crossrail will serve a reconstructed station. Crossrail will operate in a twin-bore tunnel to Victoria Dock portal where it will serve a reconstructed station at Custom House. The route will then follow the existing alignment currently used by the North London Line through the Connaught Tunnel to Silvertown. At North Woolwich, a new twin-bore tunnel to Plumstead, referred to as the Thames Tunnel, will pass beneath the River Thames. Two new tracks will be provided between Plumstead and a point east of Abbey Wood station to accommodate Crossrail services on the North Kent Line corridor. This route will be provided with 25kV overhead electrification on the Crossrail lines.

2.4 Permanent works

2.4.1 The permanent works required for the project are:

- twin-bore tunnels;
- stations;
- emergency intervention points, escape and ventilation shafts;
- train depot and stabling facilities;
- track works;
- traction power and signalling systems;
- communications systems; and
- a route control centre.

Twin-bore tunnels

2.4.2 Crossrail's twin-bore tunnels, which represent the largest scale engineering component of the project, will run through the central section and extend into the southeastern section of the route.

2.4.3 The twin-bore tunnels will run from Royal Oak, located to the west of Paddington, and will pass beneath Hyde Park, the West End, Holborn, Clerkenwell, Shoreditch and Stepney. At a point beneath Stepney Green, the route will fork. One set of tunnels will continue to the northeast before emerging at the surface at Pudding Mill Lane near Stratford, while the other set of tunnels will head southeastwards and emerge on Crossrail's southeastern section adjacent to Victoria Dock Road in the Royal Docks area. Twin-bore tunnels will be constructed between North Woolwich and Plumstead to take the southeastern section of the route under the River Thames. In total, 46 km of running tunnel will be constructed (equivalent to 23 km of twin-bore tunnel).

- 2.4.4 The tunnels will generally be constructed at approximately the same depth as London Underground's Central line, with the rail level being about 20 m to 25 m below street level, with low points at Hyde Park at 35 m and in the West End at 30 m. Through the City of London the tunnels would be constructed approximately 25 m to 35 m below street level, deepening to 40 m between Liverpool Street and Pudding Mill Lane and the Royal Docks with a low point of 50 m just east of Isle of Dogs.
- 2.4.5 The tunnels will be circular in cross-section. They will be larger than those of the existing deep-level London Underground lines. Crossrail tunnels will have an internal diameter of approximately 6 m compared with 4.35 m on the Jubilee line. This larger diameter is to accommodate the Crossrail main line rolling stock and overhead electrification equipment. At the location of the stations, the cross-section will be elliptical with a general width of 10 m.
- 2.4.6 The tunnels will include a walkway, approximately 1 m wide, for use by passengers in emergencies that necessitate the evacuation of trains between stations. A low-level walkway on the opposite side of the tunnel will be provided for maintenance and access by the emergency services.

Stations

- 2.4.7 Seven new stations will be located along the tunnelled section at Paddington, Bond Street, Tottenham Court Road, Farringdon, Liverpool Street, Whitechapel and the Isle of Dogs. Stations will include 210 m long platforms and a step-free access route between the street and Crossrail platforms. Each station will have two ticket halls, with the exception of those at Whitechapel and the Isle of Dogs. At each station, the platform tunnels will be constructed to allow for a future upgrade of platforms to 245 m for the operation of 240 m long 12-car trains, should demand for Crossrail services necessitate this.
- 2.4.8 The provision of two ticket halls will provide alternative means of egress during emergencies, sufficient capacity for anticipated passenger movements within the station and a widened local catchment area for the station. At each end of the stations there will be emergency intervention points and escape and ventilation facilities. At Whitechapel station there will be two escape and ventilation facilities, one at the Durward Street shaft, located at the western end of the station and one at Cambridge Heath Road at the eastern end. It will also be possible to provide a second ticket hall at Cambridge Heath Road should the need arise. At the Isle of Dogs station, a second escape and ventilation facility will be provided within the shaft at the eastern end of the station. There will also be passive provision for a second ticket hall at this location.

- 2.4.9 At existing stations outside the central area, platforms will be extended where necessary to accommodate the length of Crossrail's trains. Other works include expanded ticket halls and enhanced passenger facilities.

Over-site development

- 2.4.10 Where the project will require new facilities at the surface, such as station ticket halls and shaft structures, there will be opportunities to carry out subsequent developments on many of sites additional to those needed to construct or operate Crossrail. These are known as over-site developments. They will usually replace development that existed on the site prior to the construction of Crossrail. Development proposals for each site could include retail, office, residential or community space, or any combination of these.
- 2.4.11 Powers to construct future over-site developments are not included in the Bill. However, Crossrail operational structures will be constructed to provide physical support for the type of future over-site development that is likely to be proposed for these sites. Proposals for over-site development will require separate planning permission.

Emergency intervention, escape and ventilation shafts

- 2.4.12 Throughout the tunnelled section of the route, where distances between stations exceed 1 km, intermediate shafts independent from stations and the tunnel portals will be constructed in accordance with safety standards. These are sub-surface facilities with surface level access structures. The shafts provide one or more of the following features:
- emergency intervention points (EIPs), located at a maximum spacing of approximately 1 km, to be used by the emergency services to access the tunnels – the shafts include lifts or hoists and stairs, with a parking area provided at the surface for emergency services;
 - escape facilities, consisting of lifts and stairs to allow for passenger evacuation, with a place of safety provided at the surface; and
 - ventilation facilities, containing ventilation fans used to reduce temperatures in the tunnel and to provide forced ventilation for smoke control during emergencies.

- 2.4.13 The shafts and facilities provided are listed in *Table 2.1*.

TABLE 2.1 INTERMEDIATE SHAFT LOCATIONS AND KEY FEATURES

Location	EIP	Escape	Ventilation
Westbourne Bridge	✓		✓
Hyde Park	✓		✓
Park Lane	✓		✓
Fisher Street	✓		✓
Hanbury Street	✓		✓
Stepney Green	✓	✓	✓
Mile End Park	✓	✓	✓
Eleanor Street	✓		✓
Lowell Street	✓	✓	✓
Hertsmere Road	✓		
Blackwall Way	✓		
Limmo Peninsular	✓	✓	✓
Warren Lane	✓		✓
Arsenal Way	✓	✓	✓

2.4.14 EIP and escape facilities will also be provided at the Pudding Mill Lane, Victoria Dock, North Woolwich and Plumstead portals. Escape facilities will be provided at the Royal Oak portal.

Depots and stabling

2.4.15 Crossrail trains will be maintained at a new depot that will be located at the Railway Goods Yard and Gasworks site to the west of Romford station. Trains will also be stabled at other locations at the start and end of the day and between the peak periods, as listed in *Table 2.2*.

TABLE 2.2 MAINTENANCE AND STABLING FACILITIES

Location	Facilities	Capacity (number of trains)
Romford	New maintenance, train washing and stabling facility	15
Gidea Park	Existing stabling extended	8
Old Oak Common	Existing stabling modified, train washing	12
West Drayton	New stabling facility	22
Maidenhead	New stabling facility	6

2.4.16 In addition, sidings at Abbey Wood and Shenfield may be used for stabling during certain periods of the day.

Track works

2.4.17 New rail tracks will be provided in the Crossrail tunnels and at certain locations on the outer route sections, either to accommodate Crossrail services or to accommodate other

services and so free up capacity for Crossrail. These are described in detail in the relevant route windows.

- 2.4.18 On the western route section, a new line of about 1 km in length will be constructed within the existing railway corridor between Langley and West Drayton, which will link existing (but upgraded) freight lines to its east and west so providing increased track capacity. New track will be provided in connection with the new flyover at Stockley and the new rail underpass at Acton.
- 2.4.19 On the northeastern route section, a freight loop (a single rail line for freight trains) will be provided between Goodmayes and Chadwell Heath to replace an existing loop at Manor Park, which will be removed to accommodate Crossrail.
- 2.4.20 Two new tracks will be provided on the southeastern route section between White Hart Road in Plumstead and a point about 1,200 m east of Abbey Wood station, to accommodate Crossrail services on the North Kent Line corridor.
- 2.4.21 Track works will also take place in connection with new or remodelled sidings and stabling facilities.
- 2.4.22 The tunnel trackform will be designed to provide an appropriate level of resilience to mitigate the potential adverse impacts from vibration and groundborne noise. Where there are particularly sensitive receptors, such as theatres, above the route of the tunnels, increased resilience will be provided with floating slab track or similar technology. In addition, all new sections of track will be constructed of continuously welded rail.

Traction power and signalling

- 2.4.23 Traction power will be provided by an overhead line electrification system operating at 25 kV alternating current. Power will be fed to the overhead wires from feeder stations, which in turn take power from the National Grid.
- 2.4.24 New overhead line equipment will be provided on part of the western route section and along the southeastern route section. Overhead electrification equipment will comprise steel gantries with suspended catenary wires and contact wires which will deliver power to the trains. The gantries themselves will consist of portal frames spanning each side of the four-track rail corridor which will support the catenary. The gantries will be positioned every 50 m or so, although variations to this will be used in order to avoid structures such as bridges. The height of the gantries will be about 6 m above rail level and the contact wires will normally be positioned just over 4 m above the rail.
- 2.4.25 The signalling system on the new sections of line will be designed to provide Automatic Train Protection, which is a system that

supervises the driver's actions. It will check that the train stays within a braking trajectory when a caution signal has been passed, ensuring that the train will come to a stand at the stop signal. In the central tunnels and at points within the vicinity of the tunnel portals, Automatic Train Operation will automate the driver's function. It will control train stopping at stations, control speed between stations, ensure that only the doors on the correct side can be opened at each station, ensure trains stop in line with platform edge doors and initiate door closing. The tunnels will be bi-directionally signalled for use during disrupted operations (eg if a tunnel is blocked due to a train failure). On existing lines, the current signalling system will be used. Traction power and signalling in the central area will be controlled from a dedicated Crossrail Route Control Centre located to the west of Romford station.

- 2.4.26 The signalling and electrification works have been designed for staged installation to suit the commissioning of Crossrail services.

Communications

- 2.4.27 It is envisaged that by the time Crossrail begins operations, Network Rail will be equipped with the new 'Global Standards Mobile – Railways' system for voice and data communications on the railway network. It is intended that Crossrail will use this national system.
- 2.4.28 The tunnels in the central route section will be equipped with a cable (known as a 'leaky feeder' cable) running along the tunnels to act as a transmitter and receiver of signals. This system will permit continuous railway and emergency services communications.

Route control centre

- 2.4.29 The central section will be controlled by the Route Control Centre, which will be located on the depot site to the west of Romford station. The outer surface sections will be controlled from existing local control centres. The Route Control Centre will be capable of monitoring all Crossrail train movements, including those on the outer sections.

2.5 Crossrail operations

- 2.5.1 This section describes the normal operation of Crossrail and the services on existing lines that are assumed will change as a result of the introduction of Crossrail. The section includes a description of:

- interchanges;
- daily operations;
- changes to other services;
- predicted passenger numbers;
- rolling stock specification and performance;
- train servicing and stabling locations and activities;
- safety;
- employment; and
- operational waste.

Interchanges

2.5.2 Crossrail will interchange with other services across the network.

Daily operations

2.5.3 Crossrail services will call at all stations with a peak frequency between Whitechapel and Paddington of:

- 24 trains per hour (tph) from 07:45 to 09:15 and 16:45 to 18:15;
- 20 tph from 07:00 to 07:45, 09:15 to 10:00, 16:00 to 16:45 and 18:15 to 19:00; and
- 16 tph for much of the daytime, evening and weekend periods.

2.5.4 Services will operate at hours similar to the Underground, with the first trains due to arrive at Tottenham Court Road at 05:45 and the last trains at 00:30 Mondays to Saturdays. On Sundays, services will start later at 06:30, also finishing at 00:30.

2.5.5 During weekday peak hours, it has been assumed that Crossrail will operate 10 tph from the Great Western Line (four from Maidenhead, four from Heathrow and two from West Drayton) with 14 tph starting at Paddington, travelling east. To the east of central London, 12 tph will operate from Shenfield and 12 tph from Abbey Wood.

2.5.6 Dwell times (that is, the time allowed for passengers to alight and board trains) of 45 seconds are proposed at each station, with the exception of Paddington and Liverpool Street where the high number of interchange movements to and from national rail terminals will require 60 seconds.

Changes to other services

- 2.5.7 Where Crossrail services operate on the existing rail network, a number of existing services will be replaced or amended.
- 2.5.8 *Table 2.3* describes the changes to existing services during the peak periods assumed for the purposes of project appraisal. The precise changes made will be set by the relevant railway bodies in consultation with the train operating company responsible for operating Crossrail services.

TABLE 2.3 CHANGES TO EXISTING SERVICES RESULTING FROM THE INTRODUCTION OF CROSSRAIL

Branch	Key changes
Maidenhead (Great Western Main Line)	The majority of services that start at, or to the east of, Reading will be replaced by Crossrail. Some services that start west of Reading will be amended to operate fast between Reading and Paddington, with station calls at Maidenhead, Slough, Hayes & Ealing Broadway removed.
Shenfield (Great Eastern Main Line)	'Metro' services will be replaced by Crossrail, apart from the peak hours only service between Gidea Park and Liverpool Street. Additional services provided from the Lea Valley and/or London Stansted Airport.
North London Line	Custom House, Silvertown and North Woolwich services withdrawn.
Abbey Wood	No changes.

- 2.5.9 No changes are proposed to the Heathrow Express or longer distance services on the Great Western Main Line through Maidenhead to the West of England, Wales and the Cotswolds, or on the Great Eastern Main Line through Shenfield to destinations such as Norwich, Ipswich and Southend. On the North Kent Line, no changes will be made to existing services.

Disrupted operations

- 2.5.10 In the event of a section of one of the tunnels being closed for maintenance or other reasons, a limited Crossrail service can still operate using cross-overs that will be provided at Westbourne Park, to the east of Farringdon, to the west of the Isle of Dogs and on the tunnel approach at Pudding Mill Lane.

Predicted passenger numbers

- 2.5.11 Around 160,000 passengers are forecast to use Crossrail in 2016 during the three hour morning peak period between 07:00 and 10:00. Services will be most heavily used between Whitechapel and Liverpool Street (forecast to carry 55,000 passengers),

Liverpool Street and Farringdon (49,000 passengers), and Paddington and Bond Street (35,000 passengers).

Rolling stock specification and performance

- 2.5.12 The trains used for Crossrail will be 200 m long, formed from 10 cars of 20 m in length. The trains will be made up of two five-car units and will have a top speed of 160 km/h. The trains will draw power from overhead line systems. Their performance will be compatible with the project's requirement to operate 24 trains per hour (tph) through the central London stations.
- 2.5.13 The layout of each carriage will be designed to assist rapid boarding and alighting in the central area in order to minimise dwell times. Each carriage will have at least two sets of double doorways per side with wide set-backs and a combination of four abreast (as two plus two) and inward-facing seating. The trains will be air-conditioned.
- 2.5.14 The Crossrail peak service pattern requires 58 trains of 10 cars each formed from 116 five car units. This assumes 90% availability from an overall fleet size of 129 five-car units.

Train servicing and stabling locations and activities

- 2.5.15 Stabling will be undertaken at a number of locations across the Crossrail network as listed in *Table 2.2* previously in this chapter.

Safety

- 2.5.16 The project includes specific features for safe operation, including its signalling and communication systems, described above. It also includes features within the design of its tunnels, shafts and stations to aid efficient emergency access and escape, also described above. Like any new railway infrastructure, the project will be required to obtain approval of a safety case under the Railways (Safety Case) Regulations 2000. This will include approval of the design and management of the tunnel and station features that aid efficient emergency access and escape together with railway signalling and communications systems.

Employment

- 2.5.17 Approximately 1,360 full time equivalent jobs will be required to operate Crossrail in order to operate and maintain the trains, stations and tracks. It is estimated that approximately 990 of these full time positions will be new jobs, while the remainder will be taken up by staff transferring from existing rail operations. The range of skills employed will include train drivers, on-train revenue protection staff, station staff, head office functions and maintenance staff at the depot.

Operational waste

- 2.5.18 Crossrail will generate limited quantities of waste through station operation, maintenance, train washing and the disposal of litter collected from trains. This waste will be disposed of appropriately.

2.6 Project description – construction

- 2.6.1 This section describes the principles that will be adopted for the construction of Crossrail and the controls that will be implemented to avoid, reduce and, if possible, remedy the significant adverse environmental effects arising from the construction works. This section covers the following topics:

- construction strategy;
- mitigation measures;
- project programme;
- construction workforce;
- working hours;
- tunnelling strategy;
- station construction;
- rail services during construction;
- access arrangements;
- quantities of materials; and
- excavated material and waste management.

Construction strategy

- 2.6.2 A construction strategy has been developed with the following objectives:
- to meet the requirements of all relevant statutory legislation, codes of practice and standards;
 - to limit adverse impacts upon local communities and the environment so far as reasonably practicable;
 - to carry out the planning and delivery of the project in the most cost effective manner;

- to limit impacts on the operations of Network Rail, London Underground and other rail companies;
- to implement a community liaison plan including a complaints help-line and an independently appointed Complaints Commissioner;
- to remove, where reasonably practicable, excavated material by rail and water transport, and import construction materials by rail; and
- to implement a travel plan for construction workers.

Construction mitigation measures

- 2.6.3 The mitigation measures, as presented in *Appendix B1* of the ES, describe how the construction of the project will be managed to ensure that the impacts are controlled and mitigated. The mitigation measures represent a minimum level of mitigation that the project will be committed to providing. Physical mitigation measures that are integral to the project design are included in the scope of powers sought by the Bill.

Project programme

- 2.6.4 It is anticipated that the programme for the construction of Crossrail will start in 2007 and that the main construction works will take place over a six year period. It is intended that much of the main works will generally be completed within five years, followed by a period of testing, commissioning and preparation for operational readiness. The assessment assumes that the first train service is operational from 2013. Some work will be undertaken in advance of the start of the main construction period. This work will consist of the relocation of various facilities, the diversion of utility services and other minor works to facilitate the construction of Crossrail in a timely manner.

Construction workforce

- 2.6.5 The numbers and profile over time of workers have been assessed by examining the cash flow, determining the proportion of cost attributable to the labour element and then dividing by the average labour cost. Labour requirements for the construction of Crossrail are estimated at 87,000 employment-years.

Working hours

- 2.6.6 Normal working hours are assessed as being from 07:00 to 19:00 on weekdays and from 07:00 to 14:00 on Saturdays. Only non-disruptive preparatory work, repairs or maintenance will be carried out on Saturday afternoons or Sunday between 08:00 and 17:00. There are certain general exceptions to these hours, which

are described below. In addition, it may be necessary in exceptional cases of urgency to depart from these normal hours.

- 2.6.7 Tunnelling works together with directly associated activities (such as installation and maintenance of tunnelling equipment, construction of cross passages, installation of tunnel linings and transportation, storage and removal of excavated material) will normally be carried out on a 24 hour per day, seven days per week basis. Track laying and internal fit out works within the stations and tunnels may also be carried out on a 24 hour per day, seven days per week basis.
- 2.6.8 Where reasonably practicable, night time surface working will be kept to a minimum. However, certain works requiring temporary possession of roads and railways for safety or operational requirements, to limit disruption to the travelling public, and works in connection with utilities when demand is low will need to be undertaken outside normal working hours. This will include Saturday afternoon, night-time, Sunday and/or bank holiday working from time to time. Longer term possessions (in excess of one week) will be required for more major works.
- 2.6.9 Deliveries will be arranged to minimise impacts on the road system as far as reasonably practicable. Deliveries may extend beyond the normal working hours up to 22:00 from Monday to Friday. Abnormal loads may also be delivered or removed outside normal working hours subject to the requirements and approval of the relevant authorities.

Tunnelling strategy

- 2.6.10 The tunnelling will be carried out by tunnel boring machines (TBMs) in 16 separate driven lengths. There will be one additional tunnel built for construction purposes only. This tunnel will be 500 m long and will run between Hanbury Street and Pedley Street. Its purpose is to provide an underground route to move excavated material by conveyor to a railhead to reduce the need to use lorries.
- 2.6.11 The tunnels will lie in London Clay for two thirds of their length and the remainder will generally be within, or at, the interface with the Lambeth Group, which is essentially clay with sand layers. The Thames tunnel will be predominantly in chalk. The type of TBM that will be used will be suited to the ground conditions and the average rate of tunnel drive will be of the order of 65 to 75 m per week. The tunnelling operation will be undertaken on a 24 hour day, seven day per week basis and it is planned that up to 13 TBMs will be operating simultaneously.
- 2.6.12 The TBMs will be installed and removed through access shafts, which will become the permanent shafts used for emergency intervention/ escape/ventilation, or via temporary shafts

constructed at the portals. Pre-cast concrete segments will be erected from the TBM. The TBM will be propelled forwards by hydraulic jacks pushing on the previously erected tunnel lining ring. Gaps between the excavated tunnel wall and the tunnel lining will be filled with grout.

2.6.13 Excavated material from the tunnels will be removed by conveyor to handling facilities at worksites. The material will then be removed from the worksites by rail, river barge or road.

2.6.14 The station tunnels for five of the stations in the central area will be constructed using sprayed concrete lining, with spheroidal graphite iron and pre-cast concrete linings used in addition for certain escalator shafts, ventilation tunnels and adits. The stations at Paddington and the Isle of Dogs will be constructed from the surface as concrete boxes. Excavated material from the construction of the stations will be removed by road.

Construction of below ground stations

2.6.15 The construction of the below ground stations will consist of the following typical sequence of activities:

- works prior to the start of main construction, consisting of diversion of utility services and other preliminary works to enable construction;
- contractor mobilisation of labour and plant, followed by clearance of the site, including demolitions and setting up offices and welfare facilities;
- excavation and piled walls in concrete, reinforced concrete or steel;
- construction in reinforced concrete and sprayed concrete lining of shafts, underground tunnels and ticket halls;
- installation of mechanical and electrical equipment and distribution services, including ventilation and computer systems, together with installation of architectural finishes;
- completion of above ground station works;
- commissioning and testing of equipment and systems to provide a functioning facility; and
- a period of operational readiness to ensure that the trains and systems operate effectively prior to the start of the first revenue service.

Rail services during construction

2.6.16 The works will be planned to minimise disruption to the existing railway services during construction. It is intended that line closures will generally be restricted to over-night or weekend 'possessions' of the railway, allowing services to run as normal during weekdays. Some longer possessions may be required, but they will generally be planned so that they take place over public holiday or Christmas periods. Where possible, possessions will be linked with other works requiring rail lines to be closed. There will be a two week period where all mainline services into Paddington station will be stopped to allow the Crossrail works to take place, with a period of reduced services before and after this period.

Access arrangements

2.6.17 Access arrangements for the construction sites will be discussed and agreed with the relevant local authorities and other statutory bodies.

2.6.18 Traffic management plans will be developed which will include details of access arrangements, temporary and permanent closures and diversions, time restrictions on use and traffic signage.

Quantities of materials

2.6.19 The construction of Crossrail will require the use of many different materials. The principal items are detailed below:

- 1.1 million m³ of concrete;
- 140,000 tonnes of steel reinforcement; and
- 140 km of steel rails.

Excavated material and waste management

2.6.20 The construction of Crossrail is expected to generate approximately 8 million m³ of excavated materials and demolition and construction wastes. This figure represents the bulked volume of excavated material allowing for the increase in volume of material following excavation.

2.6.21 Where practicable, excavated material will be removed by rail and water transport. It is estimated that 30% of excavated material would be removed by train, 15% by barge and 55% by road.

2.6.22 The Secretary of State will take steps to ensure that any nominated undertaker's strategy will be to seek to dispose of

excavated materials and construction and demolition waste for beneficial re-use in preference to landfill disposal. However, it has been established, as a robust case, that there will be sufficient and available licensed landfill capacity within reasonable distance of Crossrail worksites to accept all of the excavated materials and wastes that will be generated, should the need arise. Suitable projects or other opportunities for re-use will be identified as the detailed construction planning is completed. A small proportion of the material will be contaminated and will need to be landfilled at licensed sites.

2.6.23 A hierarchical approach to waste management will be applied in accordance with the following principles:

- minimise generation of excavated materials and wastes;
- re-use and recycle excavated materials and waste within the Crossrail project;
- re-use and recycle excavated materials and waste through environmental beneficial use (eg at registered exempt sites or as landfill restoration cover); and
- dispose of surplus excavated materials and waste at licensed landfill sites.