# Crossrail Baseline Evaluation
# May 2022

## Construction Impacts

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Executive summary

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# Executive Summary

Arup and Volterra were contracted by Transport for London (TfL) and the Department for Transport (DfT) to carry out a Crossrail Baseline Evaluation Study. This report assesses the capital expenditure, employment, environmental and social impacts of the construction of the Elizabeth line using information until the end of 2021. It is part of a suite of documents that additionally address wider economy, planning and regeneration aspects, the transport baseline, the construction impacts, case study interviews, and the pre-opening property impacts.

The key findings of this workstream are:

- Stations and other contracts (mainly tunnels and shafts) were the most significant cost components, at 26% and 34% respectively. Crossrail Ltd had a total available funding envelope of £18.8bn, split between £15.9bn Anticipated Final Cost (AFC) for integrated Crossrail costs and £2.9bn for Network Rail Own Network Works.
- Crossrail created 75,000 job opportunities for businesses, generating the equivalent of 55,000 full time jobs for the duration of the construction. 62% of Tier 1 direct suppliers and 76% of Tier 2 suppliers (suppliers of direct suppliers) were small and mid-size enterprises (SMEs).
- Crossrail employed and upskilled workers across the UK, especially in and around London. 96% of contracts by volume were awarded to companies within the UK, and 62% of businesses in Crossrail's supply chain were based outside of London. At the same time, 65% of people directly employed by Crossrail lived in London (62% of supply chain employees lived in the capital); 14% of Crossrail Ltd employees, and 13% of the supply chain workforce were based in the remainder of the South East.
- The value of Crossrail Ltd wages were less focussed on London. Out of the total wage bill, 41% was earned by employees living outside London. 18% was earned by employees living in the South East, and 14% by employees living in the East of England.
- Almost two-fifths, or 37% of Crossrail Integrated Team (Crossrail Ltd, Programme Delivery Partners and the Project Representative) employees identified as women, and over one-quarter, or 28% of its employees were Black, Asian and minority ethnic. Crossrail and its contractors performed better than industry average regarding diversity among their workforce.
- Crossrail has been performing well on its employment targets, which have all been met or exceeded. Crossrail exceeded its targets on Strategic Labour Needs and Training, underground construction and engineering skills, opportunities for apprentices (710 against initial target of 400), and work experience placements. From 2011, the Tunnelling and Underground Construction Academy (TUCA) trained over 20,000 students, against a target of 8,000.
- Crossrail provided more than 5,000 job starts by local or previously unemployed people. This constitutes about 9% of the total number of jobs supported by Crossrail across the UK.

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# Executive Summary

- Crossrail reached all its sustainability targets and mitigated its environmental impact. Environmental targets have been achieved or exceeded including those for recycled content by value, waste reduction, air quality impacts and carbon emissions. As a result, a 18.6% reduction in carbon footprint against the 2010 baseline was expected at project completion, exceeding the initial stretch target of 8%.
- Crossrail's construction resulted in the emission of estimated 1.7 million tonnes of CO2. New line operation is expected to annually save between 70,000 and 225,000 tonnes of CO2, "payback" period therefore being between 7 and 26 years after opening, beyond which there will be net savings in CO2.
- The project met CEEQUAL and BREEAM (both of which are international sustainability standards) assessment ratings. Crossrail was one of the UK's first major construction projects to closely monitor environmental outcomes.
- The project caused biodiversity losses around work operations, but these have been mitigated by the habitat creation project at Wallasea Island in Essex.
- Noise and vibration were the main area of concern in terms of environmental complaints during construction.
- Crossrail's health & safety management improved significantly during the construction. Accident Frequency Rates and Lost Time Cases, the two main indicators monitored for accidents, have been decreasing through years of construction, exceeding the reduction targets set in the preceding years and reflecting actions carried out for improvement.

Throughout this report, 'Elizabeth line' will be used when referring to the future operational railway, and Crossrail will be used when referring to the construction project as a whole.

# 1. Introduction and approach

# 1. Introduction and approach

## Introduction

In 2016, Arup and Volterra were contracted by Transport for London (TfL) and the Department for Transport (DfT) to carry out a Crossrail Baseline Evaluation study. The study aims to quantify the impact of Crossrail in six areas: construction, transport, the property market, direct employment, carbon, and the wider economy. The purpose of the construction study is to assess the outturn capital costs, as well as the direct impacts of Crossrail construction activities, especially on employment, skills, safety, transport and environment.

The primary emphasis of an evaluation of a major project is naturally on the impacts it has during its operation. However, the construction impacts of major projects can also be significant. The construction of Crossrail, one of the largest capital programmes in Europe, had major economic, environmental, social and transport effects which need to be quantified and evaluated in order to understand the project's lifecycle impacts.

There are also indirect impacts from the supply chain of Crossrail construction, where capital expenditure and employment opportunities are created outside the impact zone of Crossrail. The employees in the Crossrail supply chain spend their income in their local areas, bringing indirect and induced impacts of Crossrail across the UK.

Since early 2020, Covid-19 has disrupted many of the indicators of the baseline analysis of Crossrail. However, Covid-19 is likely to have had little impact on the data examined within this report, as it focuses primarily on the construction phase and also most of the work was already completed before the pandemic.

Aerial view of Canary Wharf station


*Source: Crossrail*

# 1. Introduction and approach

## Approach

Crossrail's construction impacts arise from the construction of:

- Railway infrastructure
- Stations
- Rolling stock and depots

For most indicators, we have measured scheme or project-wide impacts, but we have also analysed costs and contractual relationships of elements of the scheme, such as the delivery of Woolwich and Canary Wharf stations and the rolling stock and depot contract with Bombardier.

Our general approach to measuring the construction-related impacts of Crossrail is to:

- Disaggregate all costs, benefits and disbenefits arising from the construction of Crossrail from the costs, benefits and disbenefits due to Crossrail's operation;
- Present outturn figures, for the entire Crossrail construction programme from initial works to pre-opening costs;
- Collect, review, summarise and present existing secondary research (including information and data produced and provided by Crossrail Ltd and TfL, specifically the Crossrail Delivery Strategy, Crossrail Sustainability Reports, TfL annual reports, Semi-Annual Construction Reports), rather than conducting significant primary research;
- Follow a monitoring and measurement approach, rather than an 'evaluation' approach for most indicators (no quantitative attempt has been made to define a counterfactual for the purposes of attributing causality), as data and research has been routinely collected by Crossrail Ltd and reported annually, enabling us to put the data together to understand the overall impacts across years; and
- Collect employment-related data for Crossrail Ltd and supply chain companies and analyse the geographical distribution of the benefits of Crossrail investment across local areas.

This report draws on indicators from four categories of impact, listed below as well as on the previous page:

- Financial and economic impacts;
- Employment and skills impacts;
- Environmental impacts; and
- Health and safety impacts.

Details of these categories and indicators can be found overleaf.

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# 1. Introduction and approach

## Approach (cont.)

| Expected construction impacts | Detail | Indicators |
|---|---|---|
| **Financial and economic impacts** | The capital expenditure for construction will be spent through the delivery of the programme, by delivery parties and across sectors. Through the supply chain, construction has impacts on suppliers across the UK which took part in the Crossrail project. | • Capital expenditure<br>• Supply chain (including skills and employment)<br>• Operating costs |
| **Employment and skills impacts** | The construction of Crossrail is expected to have impacts on the labour force through employment, training, skills and learning, as well as health and safety issues. | • Construction-related employment<br>• Diversity of the Crossrail workforce<br>• Proportion of Crossrail project employees paid the London Living Wage and above<br>• Number of jobs occupied by local and previously unemployed people<br>• Number of apprentices, work experiences and volunteer placements created by the project<br>• Strategic Labour Needs and Training targets – skills and employment created<br>• Young Crossrail programme audience reach |
| **Environmental impacts** | The process of the construction of Crossrail has impacts on the environment within and adjacent to the sites, as well as in areas affected by the transportation of construction and waste materials. The environmental design of the Crossrail will also have longer term environmental impacts during operation. | • Environmental assessment ratings<br>• Resource use (recycled content)<br>• Recycling and reuse of waste<br>• Carbon footprint of construction<br>• Environmental complaints<br>• Air quality controls<br>• Water use<br>• Biodiversity impacts |
| **Health and safety impacts** | The construction might have health and safety impacts. | • Accident rates of construction<br>• Incidents relating to construction employee or vehicles |

# 2. Financial and economic impacts

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## 2. Financial and economic impacts

### Overview of programme governance

The capital expenditure of Crossrail needs to be viewed together with the delivery structure for Crossrail. It is important to note that on 1 October 2020, the responsibility for the Crossrail project moved to sit directly with Transport for London to streamline decision making during the final stages of the programme. The Crossrail programme was delivered through the governance structure outlined below and illustrated opposite:

**1) Two Sponsors:**

- **Department for Transport (DfT):** reports to the Secretary of State for Transport; and
- **Transport for London**: reports to the Greater London Authority

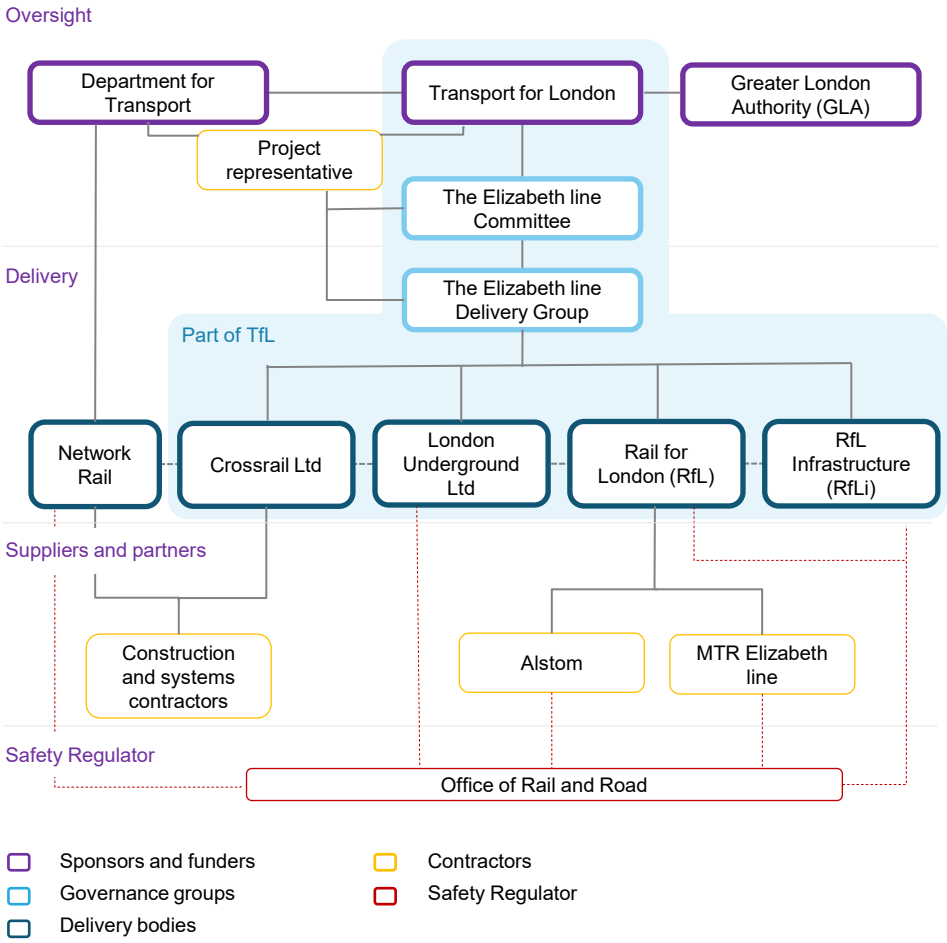
The Sponsor organisations are the clients for the programme and make strategic decisions through the Elizabeth line Committee appointed by the TfL Board. The Elizabeth line Delivery Group oversees the implementation of the Committee and supervises the delivery partners. The Project Representative provides oversight support to the Sponsors; this role was awarded to Jacobs Engineering UK Ltd.

**2) Crossrail Ltd:** the Delivery Agent for the programme, previously a full subsidiary and now a management unit of TfL.

**3) Delivery Partners:** appointed by the Elizabeth line Delivery Group:

- **Executive team:** chaired by the Transport Commissioner and including Crossrail Ltd executives and TfL executives
- **Project Partners (PP):** support the overall delivery of the route-wide programme. These include: Network Rail (supervised by DfT), Crossrail Ltd, London Underground, RfL, RfL Infrastructure, as well as contractors.

Figure 1: Programme's governance




Source: own chart based on National Audit Office -'Crossrail – a progress update', 2021

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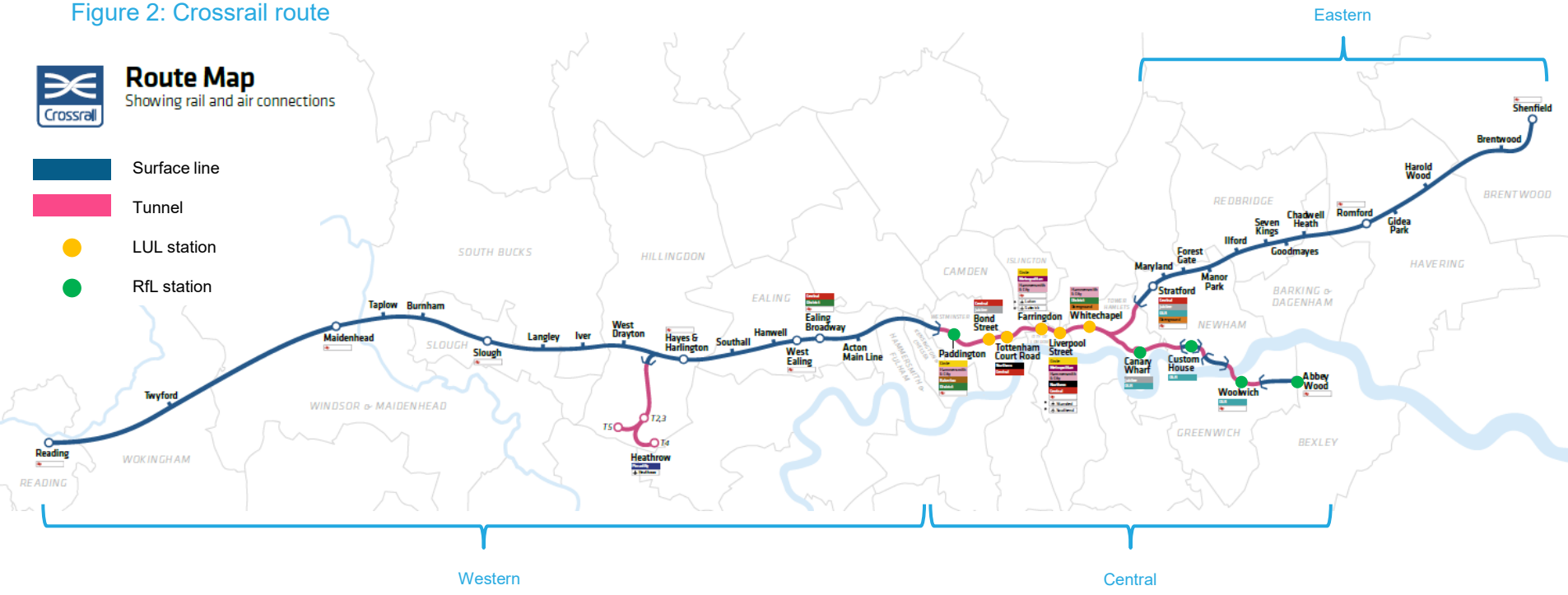
## 2. Financial and economic impacts

### Breakdown of programme delivery by area

The east to west Crossrail route, including its three main sections and new stations, is illustrated in the map below. From a construction perspective, the route was divided into key programme delivery components. These are detailed on the following page.

Figure 2: Crossrail route




Source: Crossrail Regional Route Map

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# 2. Financial and economic impacts

## Programme delivery by component

| Programme components | Delivery components | Delivery Agents | Funding/Financing Mechanism | Value |
|---|---|---|---|---|
| 1 – Central Section Works | Tunnelling, shafts and portals, as well as works associated with new stations, and route-wide civil engineering and systems. | Crossrail Limited central section delivery team, interfacing with Network Rail, London Underground, Rail for London Infrastructure (RfLi) MTR Elizabeth line, utility partners, power supply | Sponsors Funding Account to Crossrail | £18.8 billion (Combined with Crossrail on-network works) |
| 2 - Crossrail on-network works | Infrastructure modifications and enhancements, station modifications and upgrades, track, signalling and electrification works on the Great Western main line, between Paddington, Reading and Heathrow Airport, on the Great Eastern main line between Shenfield and Liverpool Street, as well from Abbey Wood to Plumstead | Network Rail;<br>Crossrail Ltd as the programme manager and systems integrator | Sponsors Funding Account (from Network Rail) to Crossrail | £18.8 billion (Combined with Crossrail Section Works) |
| 3 - New depot and rolling stock | New rolling stock fleet and depot, including stabling, maintenance facilities and accommodation. | Alstom (formerly Bombardier Transportation) - contract awarded by TfL in February 2014 | Financed on TfL balance sheet | £1.1 billion |
| 4 - London Underground congestion relief works | Congestion relief works across stations, station upgrade works including ticket hall upgrade and step-free access. | London Underground | Funded by London Underground | - |

Source: NAO (2019) Completing Crossrail and NAO (2021) Crossrail – a progress update.

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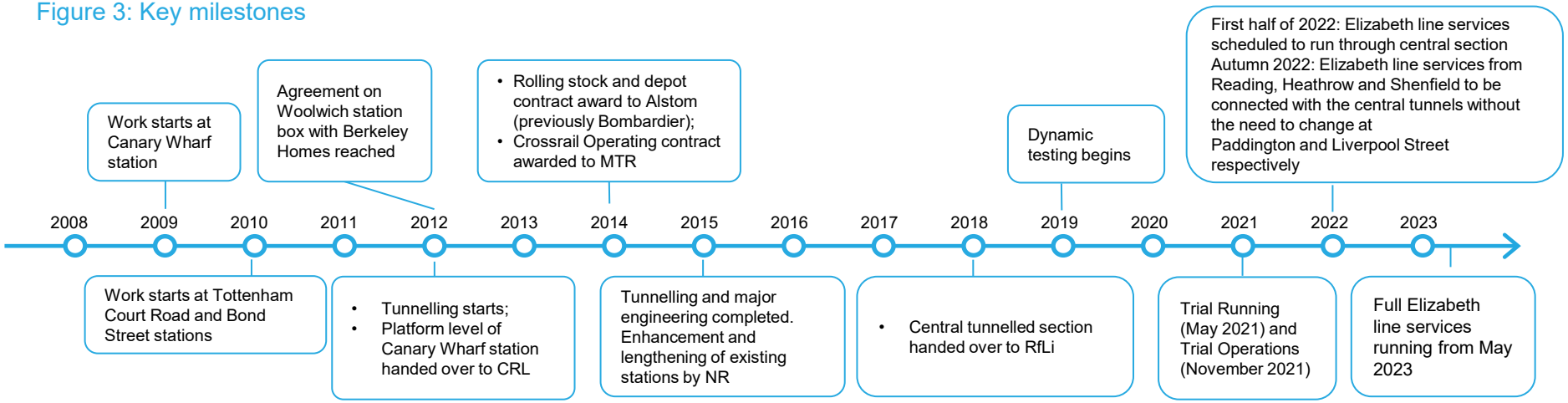
## 2. Financial and economic impacts

### Programme delivery timeline and costs

Figure 3: Key milestones




*Source: NAO (2019) Completing Crossrail and NAO (2021) Crossrail – a progress update.*

# 2. Financial and economic impacts

## Crossrail funding sources and risk mitigation

Crossrail Ltd (CRL) secured £15.9 billion of funding in 2007 (in 2007 prices), which was set at the P95 (contingency level, risk probability of 95% of costs not exceeding stated amount) value of the risk assessment in 2008. In July 2021, following delays and a revision to the scheduling of the project, the funding was revised to £18.8 billion overall.

Crossrail Ltd (CRL) developed the Crossrail Investment Model (CIM), initially as a high-level tool to inform funding discussions as part of the Comprehensive Spending Review (CSR) in February 2007. It was then developed further to support project agreements, and used as a reporting tool and to monitor Anticipated Final Cost (AFC) and Anticipated Final Crossrail Direct Cost (AFCDC) at different levels of risk exposure (P50, P80, P95) against agreed Sponsor intervention points.* From the financial year 2019/2020, the CIM was replaced by periodical Elizabeth line Delivery Group (ELDG) reports, the key metrics of AFCDC, AFC, COWD (Cost Of Work Done) remaining the same.

Intervention Points were established as a mechanism for the sponsors to control project costs, along with intervention rights based on different contingency levels.

Analysis on capital expenditure includes data sourced from the Crossrail Investment Model as well as from ELDG reports. The figures shown on this report are those modelled in the P50 scenario.

The initial P95 level of AFCDC was established at £12,500m. As of November 2021, the AFCDC for the project was £15,910m.

Figure 4: Sponsor Intervention Points

| | |
|---|---|
| **IP0** risk | If the AFCDC exceeds the P50 level, set at the original assessment, CRL needs to create a remedial plan to be presented to the sponsors. |
| **IP1** | If the AFCDC exceeds the P80 level, this is considered a 'TfL Remedy Trigger Event' and TfL has the right to step in and take their own actions to remedy the situation. |
| **IP2** | If the AFCDC exceeds the P95 level, this is considered a 'TfL Significant Remedy Trigger Event' and the sponsors may consider the option to transfer CRL into DfT's ownership. |

*CRL (2011) Description of the Investment Model; P50, P80 and P95 are contingency levels; AFCDC is the sum of the sector-level AFCs and an AFC of indirect costs, land and property costs and programme and board level risk.
*"The purpose of the CIM is to support the provisions of the PDA, and provide CRL with a means of estimating the Anticipated Final Crossrail Direct Cost (AFCDC), Anticipated Final Cost (AFC) and Intervention Points (IPs)."*

Source: KPMG Independent Review of Crossrail 2019, Elizabeth line Delivery Group report P08 2021-2022.

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## 2. Financial and economic impacts

### Crossrail funding sources and risk mitigation (cont.)

The DfT and TfL agreed a total funding amount of £18.8 billion to deliver the project. Funding for Crossrail has come from a variety of sources, both public and private. These sources include TfL (including funding from the GLA, Corporation of London and funding from local businesses in London), the DfT, as well as funding from industry partners of Crossrail Ltd, as seen in the figure on the following page.

Raising funds from and collaborating with the private sector was key to securing funding for Crossrail. Both TfL and DfT raised significant amounts of funding from private sector organisations through different mechanisms.

Crossrail Ltd has a number of industry partners, including: Network Rail, Heathrow Airport Limited, London Underground, Canary Wharf Group, Berkeley Homes, Docklands Light Railway. It also has other less formal arrangements with utility providers, which are managed through a Utilities Steering Group.

Note that the £1.1 billion contract between RfL and Alstom (previously Bombardier Transportation) for the supply, delivery and maintenance of the rolling stock, and the construction of the Old Oak Common depot, is not included in the £18.8 billion total costs. However, the enabling and surface works at Old Oak Common are included. The contract initially awarded in February 2014 was extended in March 2018 by an estimated £73 million to include 5 further trains, bringing the Elizabeth line fleet to 70 trains (Crossrail, 2021c).

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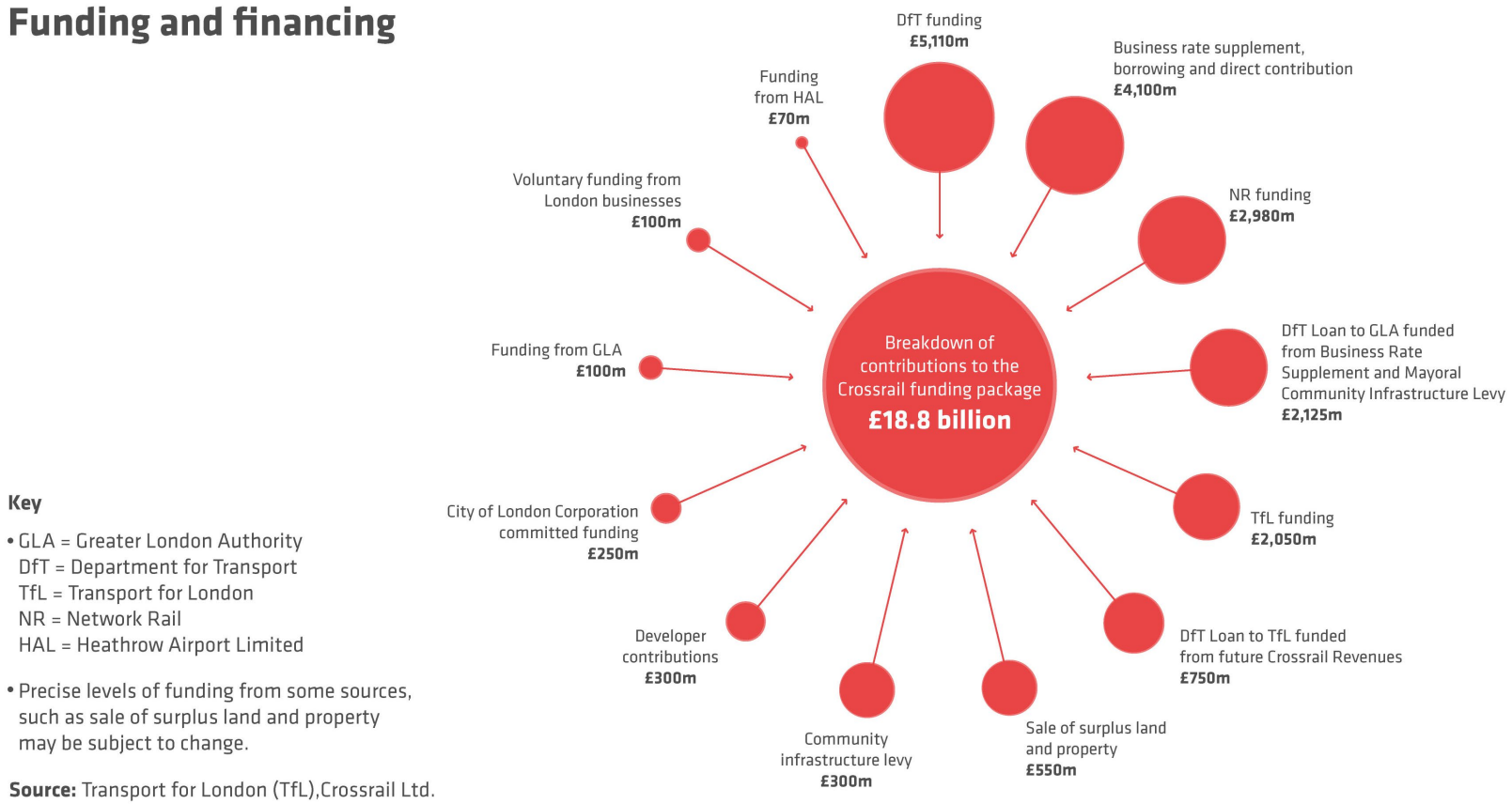
## 2. Financial and economic impacts

Crossrail funding sources and risk mitigation (cont.)

### Figure 5: Crossrail sources of funding



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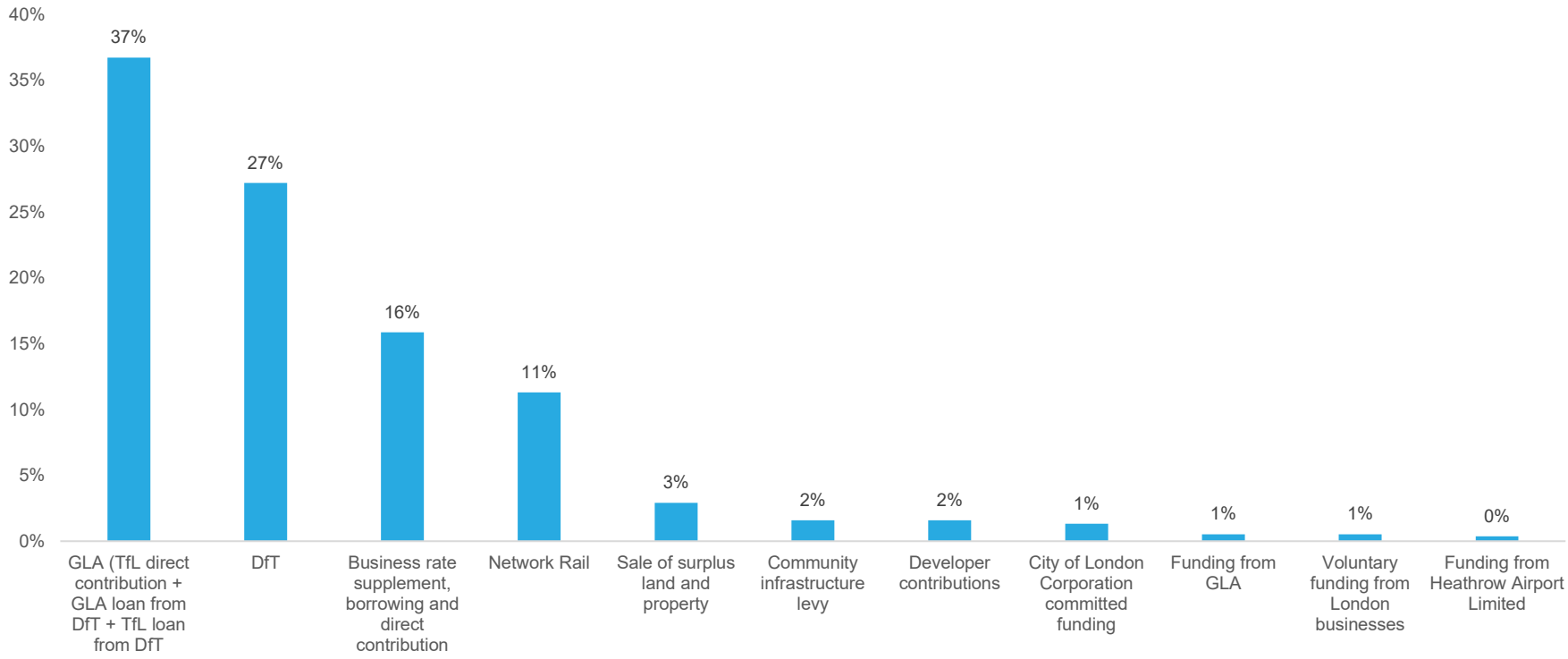
## 2. Financial and economic impacts

Crossrail funding sources and risk mitigation (cont.)

### Figure 6: Proportion of funding contribution




Source: Crossrail (2021) Funding

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# 2. Financial and economic impacts

## Overview of industry partners and key funders

| Industry partners / key funders | Roles | Funding | Incl. in £18.8 billion? |
|---|---|---|---|
| **London Underground (LUL)** (Industry partner) | • Works affecting the Underground;<br>• The protection of LU's assets from CRL works;<br>• The transfer of responsibility for five stations to LU as Infrastructure Manager: Bond Street, Tottenham Court Road, Farringdon, Liverpool Street and Whitechapel. | N/A | Excluded |
| **Network Rail (NR)** (Industry partner) | • To undertake the on-network works (ONW);<br>• To undertake works directly for CRL at the interfaces between the ONW Section and the Central Section Works;<br>• To act as Operator and Infrastructure Manager for both the ONW Section and the railway systems in the Central Section Works. | £2,980 million financed by NR | Included |
| **Docklands Light Rail Limited (DLRL)** (Industry partner) | To modify DLR's existing infrastructure to enable the development and operation of the Elizabeth line alongside the DLR, particularly at Pudding Mill Lane and Custom House, but also other locations. | N/A | Included |
| **Canary Wharf Group (CWG)** (Industry partner) | Financing, design and construction of the Canary Wharf Elizabeth line station in the North Dock at Canary Wharf. | CRL funds £350 million, CWG funds balance to actual cost (estimated £500 million). | Included |
| **Berkeley Homes (BH)** (Industry partner) | To develop and part fund the Woolwich station box. CRL will be responsible for managing the works and related interfaces at a Programme level. | N/A | Included |
| **Rail for London (RfL)** (Key Funder) | • The Infrastructure Manager and Operator of Paddington, Canary Wharf (Elizabeth line), Custom House and Woolwich stations;<br>• The owner of the operating cost model and procurer of the Train Operating Company (TOC) to operate Elizabeth line services. | N/A | Excluded |
| **Heathrow Airport Holdings Ltd (HAHL; formerly the British Airport Authority)** (Key Funder) | HAHL owns the Heathrow Spur from Airport Junction on the Great Western mainline, and operates the Heathrow Express between Heathrow and Paddington through its subsidiary, Heathrow Express Operating Company. | Direct contribution of £70 million to DfT | Included |
| **Corporation of London (CoL)** (Key Funder) | A group of organisations from within the City of London Corporation pledged £250 million to the project. | £250 million | Included |

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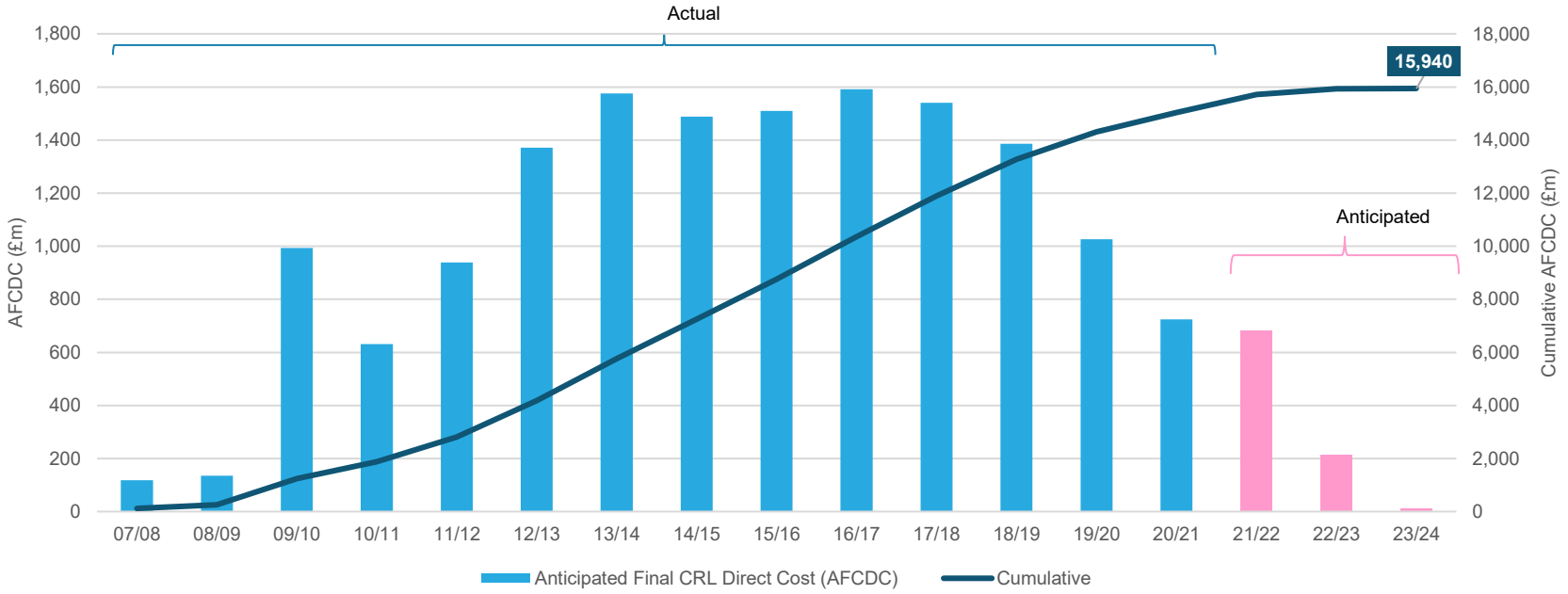
## 2. Financial and economic impacts

### Programme delivery costs over time

Figure 7: Actual and Anticipated programme delivery costs




Source: Crossrail Investment Model SACR 23, ELDG report - P07 2021-2022, * Nominal prices

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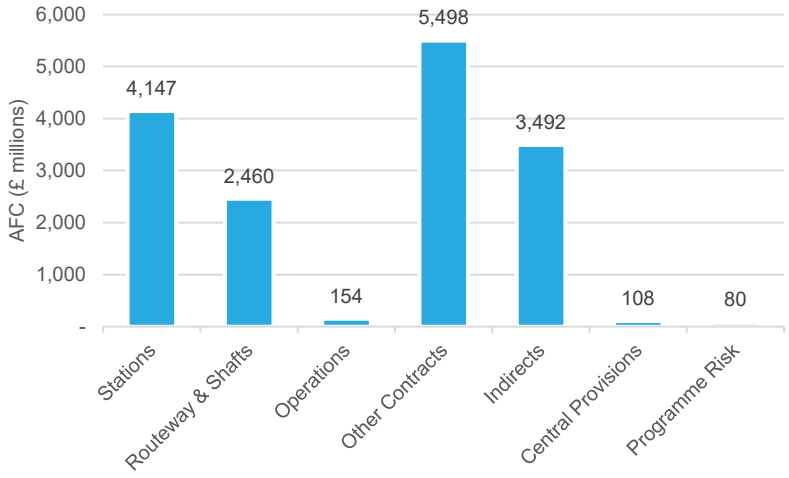
## 2. Financial and economic impacts

### Nominal construction costs by component

- Some 96% of total Anticipated Final Cost (AFC) – excluding On Network Works (ONW) financed by NR – were incurred during the period up to September 2021, with the Actual Cost of Work Performed (ACWP) rising to £15,380 million.
- 'Other contracts' and stations are the most costly components, followed by routeway and shafts and indirect costs.
- Elements in the 'Other contracts' category include the construction of tunnels and early shafts, the Canary Wharf station main works and a variety of costs including PAD or Technical Design.
- 'Routeway & Shafts' include signalling systems, tunnelling, communication and control systems, power, mechanical systems and platform screen doors.
- 'Indirects' includes costs related to the programme delivery, Land and Property and NR financing
- The main remaining Costs To Go (CTG) come from expected central provisions (CEO/COO management reserve and Scope Gaps), indirect costs and routeway and shafts (mainly signals, comms and controls and tunnelling costs).

| Component | ACWP (£ millions) | Total CTG (£ millions) | AFC (£ millions) | Risk (£ millions) | Total (£ millions) | *% of total spent* |
|---|---|---|---|---|---|---|
| Stations | 4,067 | 62 | 4,129 | 18 | 4,147 | *98%* |
| Routeway & Shafts | 2,370 | 79 | 2,449 | 11 | 2,460 | *96%* |
| Operations | 119 | 28 | 147 | 7 | 154 | *77%* |
| Other Contracts | 5,439 | 57 | 5,497 | 1 | 5,498 | *99%* |
| Indirects | 3,385 | 107 | 3,492 | 0 | 3,492 | *97%* |
| Central Provisions | 0 | 108 | 108 | 0 | 108 | *0%* |
| Programme Risk | 0 | 0 | 0 | 80 | 80 | *0%* |
| **Total (£ millions)** | **15,380** | **441** | **15,821** | **118** | **15,940** | ***96%*** |

Figure 8: Total anticipated costs by component




Source: Elizabeth line Delivery Group – Crossrail programme progress, Period 07, 2021/22

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## 2. Financial and economic impacts

### Nominal construction costs for Network Rail

The table opposite and graph overleaf, based on the Crossrail On Network Works by National Rail Delivery Report issued in November 2021, break down construction expenditure by project types:

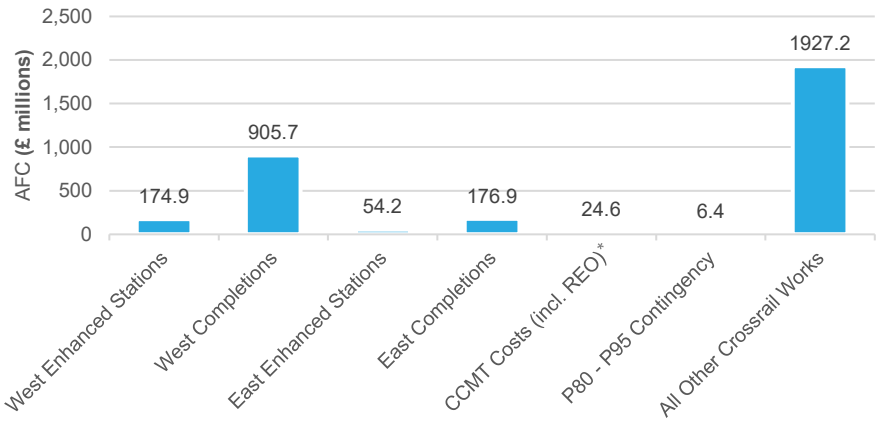
- Stations: completions of West (28%) and East Stations (5%) are the most significant costs to date.
- They are followed closely by West Enhanced Stations.
- All other Crossrail Works that are not stations (new overhead electrification equipment, 70km of upgraded tracks and upgrade to signals) account for the major part of the On Network Works with 59% of the total AFC.

Many Network Rail stations have undergone improvements as passenger numbers are expected to rise following the opening of the Elizabeth line.

- For example, Abbey Wood Station is one of the new stations delivered by Network Rail. It will provide better connections to bus services, reduce journey times to other London destinations, while also changing the civic spaces surrounding the station (Crossrail, 2021a).
- In addition to station improvements, Network Rail is implementing new efficiency measures. These include (Network Rail, 2018):
  - Continuing the roll out and implementation of analysis techniques to identify opportunities to improve;
  - Utilisation of enhanced analytics to understand rates of degradation and asset health;
  - Application of techniques from other industries such as aerospace and automotive industries in the use of Design for Reliability;
  - Increased use of intelligent infrastructure which replaces visual inspections to support the existing train-borne ultrasonic testing.

| Project Name | Total Budget (£ millions) | Total AFC (£ millions) | Total COWD (£ millions) | % of AFC spent |
|---|---|---|---|---|
| West Enhanced Stations | 174.9 | 174.9 | 169.5 | *97%* |
| West Completions | 905.7 | 905.7 | 880.7 | *97%* |
| East Enhanced Stations | 54.2 | 54.2 | 48.5 | *89%* |
| East Completions | 176.9 | 176.9 | 164.0 | *93%* |
| CCMT Costs (incl. REO) | 24.8 | 24.6 | 17.8 | *72%* |
| P80 - P95 Contingency | 6.4 | 6.4 | 0.0 | *0%* |
| **Subtotal** | **1,342.9** | **1,342.7** | **1,280.5** | ***95%*** |
| All Other Crossrail Works | 1,927.0 | 1,927.2 | 1,927.2 | *100%* |
| **TOTAL** | **3,269.9** | **3,269.9** | **3,207.7** | ***98%*** |
| Other Funding | -289.9 | -289.9 | -289.9 | *100%* |
| **TOTAL ONW WORKS (£ millions)** | **2,980.0** | **2,980.0** | **2,917.8** | ***98%*** |

Figure 9: Network Rail ONW Total anticipated costs by component




* Climate Change Mitigation Technologies

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# 2. Financial and economic impacts

## Wider impacts of capital expenditure programme

The delivery of Crossrail's capital programme has had positive knock-on effects on other parts of London's transport network. The Elizabeth line has a total of 41 stations, of which ten are new stations. This has:

- Catalysed or brought forward improvements on other parts of London Underground, DLR and Network Rail, as well as urban realm improvements.
- Leveraged the private sector in the delivery of infrastructure – including Canary Wharf and Woolwich stations.

**DLR improvements**

- Crossrail is also complementary to the new DLR rolling stock with 43 new full-length trains, which will begin service in 2022. This will increase the network capacity by around 30%, which will help to serve passengers using the Elizabeth line at Canary Wharf, West India Quay, Stratford and Custom House.

**Urban realm improvements**

- In addition to adding substantial capacity across the London Underground network, significant public realm improvements are being delivered as part of the construction of Crossrail. Crossrail has been working closely with local councils and Transport for London to transform the areas around the stations, bringing additional benefits to local residents and visitors.
- There has also been a focus on spreading urban realm and regeneration impacts outside of stations through the commission of urban realm 'masterplans' (Crossrail Learning Legacy, 2016).
- An example is Tottenham Court Road station, which has pedestrian links towards Soho and has a new public plaza (Crossrail, 2021b).

**Canary Wharf station**

- The Elizabeth line Canary Wharf station is considered to be a good example of private and public sector working together to deliver infrastructure. The station was partly funded by Canary Wharf Group, who contributed £150m towards the station and also took ownership of the design and build of the new station.
- This station was delivered ahead of the opening of the Elizabeth line for commercial purposes and ahead of schedule. The upper 3 floors of the 115,000 sq ft retail provision opened in May 2015, over 3 years ahead of the original planned opening of the Elizabeth line, offering a mix of leisure activities and restaurants.

It is important to mention that due to the delay in opening the line, some of the benefits are also delayed. This potentially decreases both the Crossrail project's short and long-term benefits.

3. Direct Impacts:
Employment and skills

# 3. Employment and skills impacts

## 3.1 Introduction

This section of the report assesses the direct employment and skills impacts of the construction of the Elizabeth line.

In order to do so, employment data from Crossrail Ltd and key contractors across its supply chain were used. Employment data on all directly employed by Crossrail Ltd since 1 January 2007 (with the exception of non-executive directors) was obtained along with wage band and home location (represented by the first half of their postcode) directly from Crossrail Ltd's HR directorate. Data from contractors was gathered through direct requests to them on a set of employee characteristics. More information on the methodology and challenges regarding this data collection can be found in the following pages and in Appendix II and III of this report.

The data show that between January 2007 and December 2021, Crossrail Ltd directly employed 1,612 people. The analysis of the Crossrail Ltd workforce in this section is based on this sample size.

It is estimated that close to 55,000 new jobs have been generated as a result of the construction (NAO, 2021). Given only a proportion of these would be within Crossrail Ltd itself, it was important that information on the wider project workforce was obtained. In order to do this, we contacted Tier 1 contractors (based on contracts worth at least £50 million), and key delivery partners to request anonymised employee data. For the purpose of this report, the data from each contractor and from CRL Ltd were aggregated. This approach is complementary to the analysis undertaken in the Economy, Planning and Regeneration report where employment data from future Crossrail operators was analysed.

In addition to employment data, we also requested information regarding Tier 2 sub-contractors.

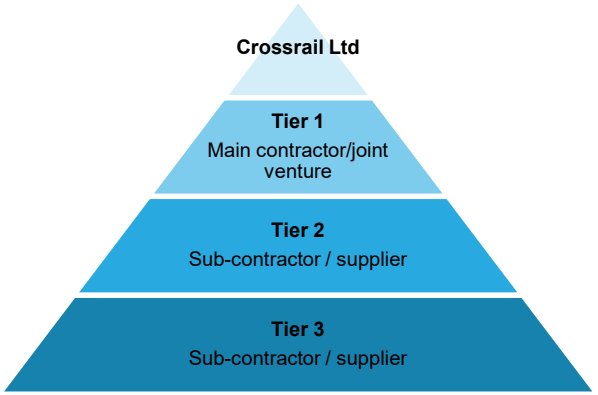
We have also included findings from the Crossrail Sustainability Reports (2012-2018) for employment sustainability impacts.

In this section we analyse the following:

- Geographical distribution of the workforce, both Crossrail Ltd and contractors;
- Tier 2 sub-contractor analysis (including proportion of contract delivery and location);
- Breakdown of wages, both Crossrail Ltd and Tier 1 contractors;
- Geographical distribution of Crossrail Ltd employees by wage;
- Employment diversity, both Crossrail Ltd and contractors;
- The London Living Wage;
- Number of jobs occupied by local and previously unemployed people;
- Apprenticeships, work-experience and work placements;
- Strategic Labour Needs and Training;
- Crossrail's Skills and Employment Strategy.

The final part of this section presents 'Lessons Learned' from the data collection of the supply chain workforce, as well as recommendations for future infrastructure projects of similar scale.

Figure 10: The hierarchy of the Crossrail project supply chain



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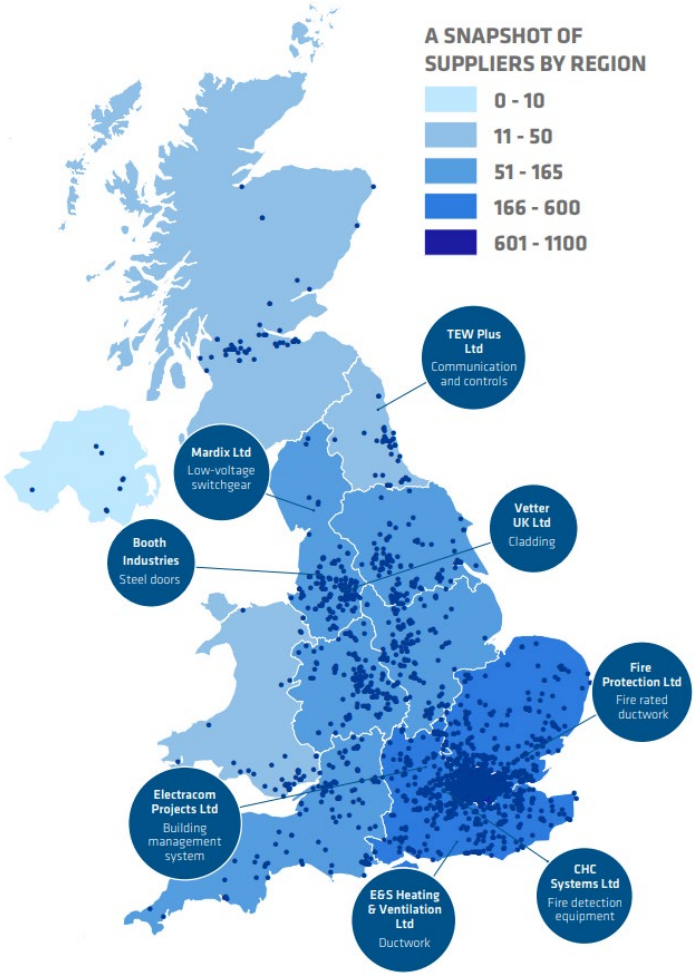
## 3. Employment and skills impacts

### Crossrail supply chain overview

The construction of the Elizabeth line, which began in 2009 and is due to complete in 2022, has been delivered by contractors across the country.

Key facts based on publicly available information* on the supply chain include (Crossrail, 2018):

- 62% of businesses in Crossrail's supply chain are based outside of London
- 96% of contracts awarded to companies within the UK
- 62% of Tier 1 suppliers are SMEs
- 76% of Tier 2 suppliers are SMEs
- 75,000 job opportunities for businesses supporting the equivalent of 55,000 full time jobs are expected




Source: Crossrail Sustainability Summary Report, 2018

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# 3. Employment and skills impacts

## Supply chain data collected

To assess the supply chain employment impacts from the construction of the Elizabeth line, the contractors delivering the largest contracts (contracts worth at least £50 million) were contacted to provide data.

The data requested from the Tier 1 organisations included:

- The geographical distribution of employees (by home region) who have worked on Crossrail;
- The workforce diversity of employees who have worked on the specific Crossrail contract (including the proportion of female, Black, Asian and minority ethnic, under 25s, disabled, and living wage workers);
- The number of employees by wage band (<£25,000, £25,000-50,000, £51,000-100,000, £100,000 +) based on their most recent wage, as well as wage band by employees' home region if available;
- The number of apprenticeships established;
- The proportion of contracts which was undertaken in-house and the proportion which was sub-contracted; and
- For their top-three direct sub-contractors, the addresses of head-offices.

The data in this section is based on answered received in 2018. In some cases, companies returned data for just some of these questions, and others returned all, as well as data of Tier 2 and 3 employees. For a more complete explanation of the data gathering issues encountered, refer to the 'Lessons Learned' section in the Appendix section.

Note that not all companies who were contacted returned data. The list on this page shows the companies that did. For a full list of all Tier 1 companies and delivery partners, please see Appendix I.

Figure 11: List of Tier 1 contractors and Crossrail delivery partners who provided workforce data for this study report.

| Contract | Reference | Supplier(s) |
|---|---|---|
| Whitechapel and Liverpool Street Station Tunnels | C510 | Alpine-BeMo JV / Balfour Beatty Civil Engineering Ltd / Morgan Sindall (Infrastructure) Plc / VINCI Construction Grands Projets |
| Main Works Tunnel Fit-out | C610 | Alstom Transport / TSO / Costain Ltd |
| Whitechapel Station | C512 | Balfour Beatty Civil Engineering Ltd/ Morgan Sindall Group Plc/ VINCI Construction Grands Projets |
| Woolwich East and West Boxes | C530 | Balfour Beatty Group Limited |
| Western Running Tunnels | C300/ C410 | BAM Nuttall Ltd / Ferrovial Agroman (UK) Ltd / Kier Construction Ltd |
| Farringdon Station | C435 | BAM Nuttall Ltd / Ferrovial Agroman (UK) Ltd / Kier Construction Ltd |
| Paddington Station | C405 | Costain Limited / Skanska Construction UK Limited |
| Bond Street Advance Works | C411 | Costain Limited / Skanska Construction UK Limited |
| Bond Street Station | C412 | Costain Limited / Skanska Construction UK Limited |
| Eastern Running Tunnels | C305 | Dragados S.A. / John Sisk & Son (Holdings) Ltd |
| Liverpool Street Station | C502 | Laing O'Rourke Construction Ltd |
| Delivery Partner | N/A | Canary Wharf Group |
| Delivery Partner | N/A | Nichols Group |

Source: List compiled based on the Crossrail Supplier and Contract Opportunities Directory.

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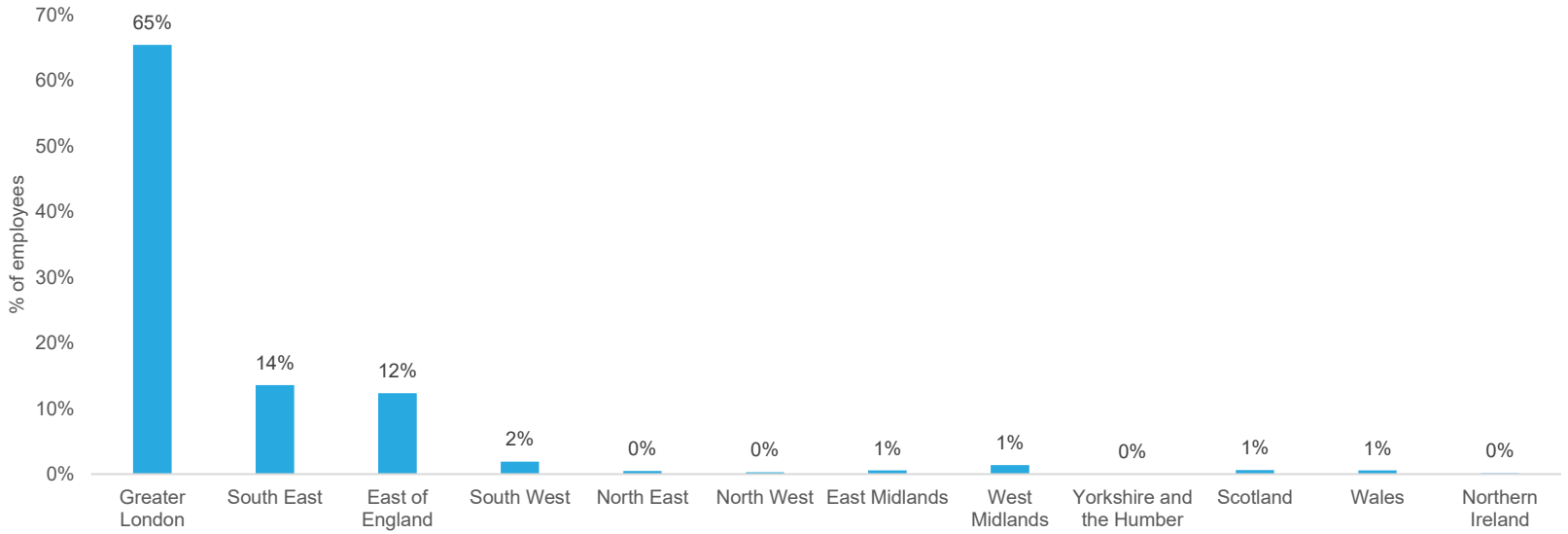
# 3. Employment and skills impacts

## Geographical distribution of Crossrail Ltd workforce

Based on information from Crossrail Ltd on the employees directly employed by Crossrail Ltd throughout the project's lifetime, we found that:

- The majority of staff, 65%, lived in Greater London, and a further 14% in the South East;
- After Greater London, the next largest group of staff lived in the South East (219 people) closely followed by the East of England (199 people);
- Some 8% of staff were based outside London, the East and the South East of England; and
- Only 1% of Crossrail Ltd staff listed their address as outside England.

Figure 12: Geographical distribution of Crossrail Ltd workforce by home address (2021)




Source: Crossrail Ltd employment data – December 2021

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# 3. Employment and skills impacts

## Geographical distribution of supply chain workforce

The majority of the supply chain workforce, based on the sample of 10,334 employees, were based in Greater London, followed by the South East and then the East of England.

The graph below shows the results for the home address of supply chain workforce, indicating that 75% of the sample, or 7,743 employees, lived in London or the South East. 287 people listed their home address as outside England.

The data presented here should be treated with some caution, as companies that provided data had reported in different ways, some asking home address, and some asking for current address. One Tier 1 contractor collected employees' home address as well as their address whilst working on Crossrail, which was sometimes different, common for contractors who work away from home for periods of time. The issue of inconsistent reporting will be discussed more in the Lessons Learned section on page 67. It is to be noted that the latest available data was from 2018.

Figure 13: Geographical distribution of supply chain workforce by home address (2018)


Source: Tier 1 respondents

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# 3. Employment and skills impacts

## Subcontractor analysis

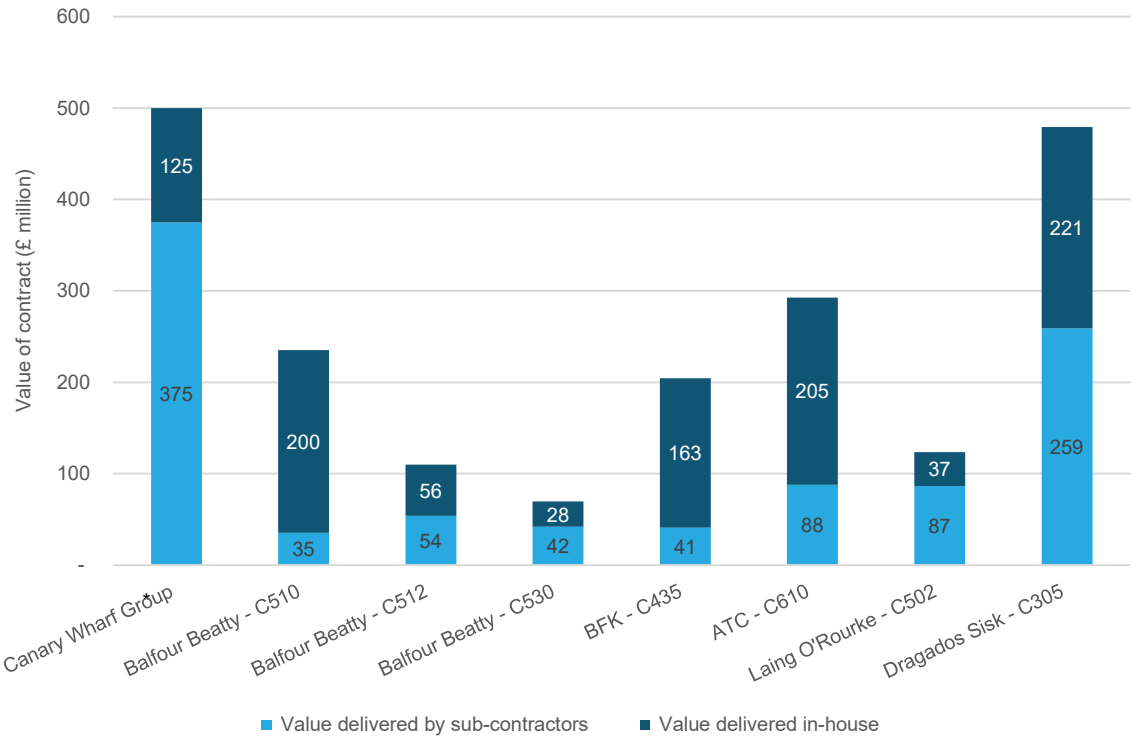
Along with workforce data, Tier 1 contractors were asked what proportion of their work (by value) was carried out in-house, and what proportion was subcontracted.

This information has been analysed alongside the values of the total contract, published following a Freedom of Information request.

The results are presented opposite. There is no apparent relationship between contract value and the proportion sub-contracted.

*The Canary Wharf Group (CWG) contract (£500 million), is not strictly a Tier 1 contract as CWG are a Delivery Partner.
Source: Crossrail 2008

Figure 14: Value of work sub-contracted, by Tier 1 contractor (2018)




Source: Tier 1 respondents, Canary Wharf Group, Construction News) (BFK: BAM, Ferrovial, Kier Joint Venture; ATC: Alstom, TSO, Costain Joint Venture

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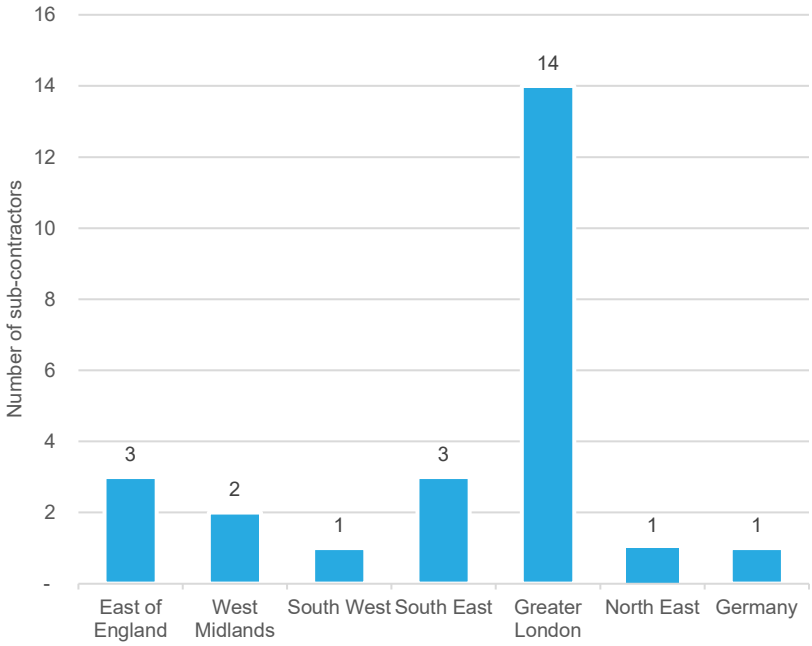
# 3. Employment and skills impacts

## Subcontractor analysis (cont.)

In addition to the value of the contracts carried out by sub-contractors, another aim of the study was to gather data on the location of sub-contractors (headquarters). The top three by value, were provided for eight contracts (one Tier 1 contractor provided the top four), resulting in a sample size of 25 sub-contractors.

The results show, that 56% of the sub-contractors in this sample had headquarters in London, and an additional 12% were based in the South East. This is a higher proportion than the estimated 57% confirmed by Crossrail Ltd in 2013, but given the small sample, this figure should be treated with caution.

Figure 15: Number of sub-contractors in the sample, by UK region or country (2018)




Source: Tier 1 respondents

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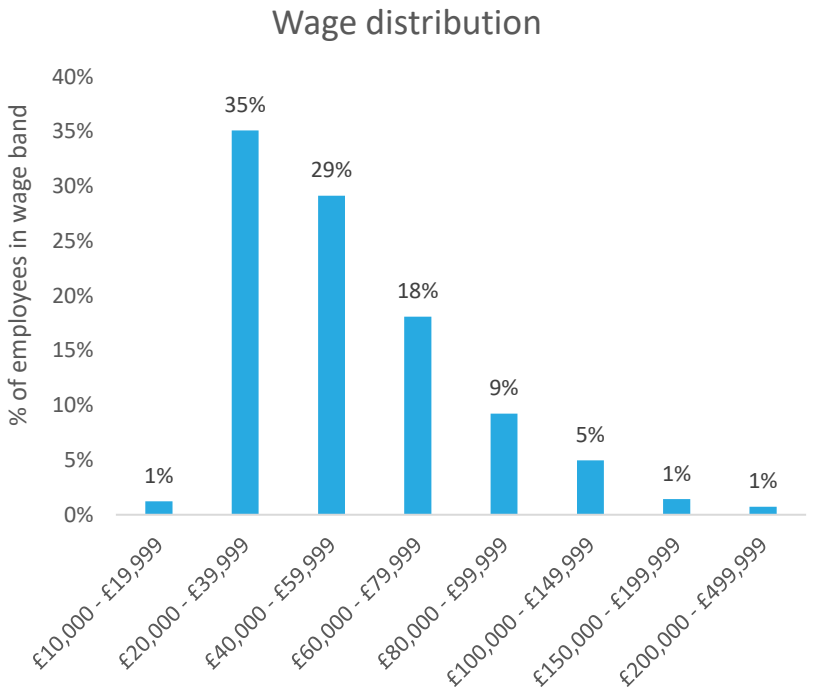
# 3. Employment and skills impacts

## Breakdown of Crossrail Ltd wages

Some 35% (566 people) of Crossrail Ltd employees are within the £20,000-39,999 wage band (the mode of the distribution) and 29% (470) are within the £40,000-59,999 band.

- The median wage of Crossrail Ltd employees is around £49,000, and the weighted average wage is around £57,000. Crossrail Ltd however as a client organization did not employ construction workers.
- In 2021, the average annual earnings in London for a job in the construction industry was £52,500, with a national average of £42,500*.
- 7% of Crossrail Ltd employees in the sample, 115 people, earn more than £100,000 annually.

Figure 16: Wage distribution of Crossrail Ltd, by value (2021)




Source: Crossrail Ltd employment data

*Source: TotalJob, UK construction industry, December 2021 – based on a sample of around 15 000 jobs*

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# 3. Employment and skills impacts

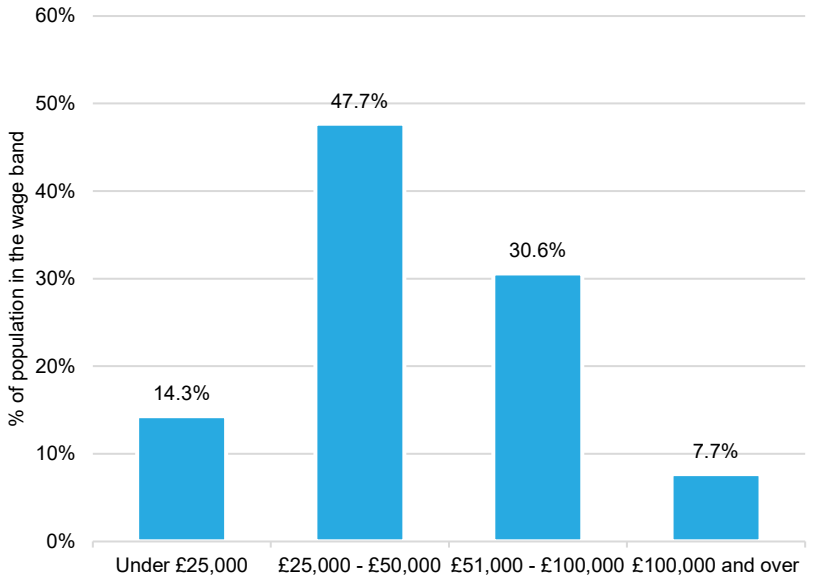
## Breakdown of supply chain wages

Among Tier 1 contractors, just under half (310) of the sample population of 650 employees earned between £25,000 and £50,000 annually, representing the largest group.

- This is broadly in line with the national average construction industry wage of £42,500 (*op.cit.*).
- 8% of the supply chain in this population earned over £100,000 per year, compared to 7% of the Crossrail Ltd sample shown on the previous page.

For this specific focus on wage distribution, Tier 1 respondents were not all able to provide us with their employees' wages. This results in a smaller sample available for the analysis (only 650 employees) as opposed to other sections of the study (above 10,000 employees). Therefore, the results presented should be taken with caution as they might not be fully representative of all the workforce involved in Crossrail's construction.

Figure 17: Wage distribution of supply chain workforce (2018)




Source: Tier 1 respondents

(Sample size: 650)

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## 3. Employment and skills impacts

### Geographical distribution of Crossrail Ltd wages (cont.)

Based on the data provided to the study by Crossrail Ltd, the map opposite shows the indicative total wages, by region, based on the mid-point of the wage bands provided (i.e. we have taken the mid point of a wage of £20,000-39,999 to be £30,000).

Of the total £91,350,000 total aggregated wage paid for all the 1,612 employees of Crossrail Ltd (based on the mid-point of the wage bands), 59% has been earned by employees whose home address is listed as London, and a further 18% has been earned by employees whose home address is listed as within the South East and 14% has been earned by employees whose home address is listed as within the East of England.

Just 10%, or £8,685,000, has been earned by employees with home addresses listed outside of these three regions.

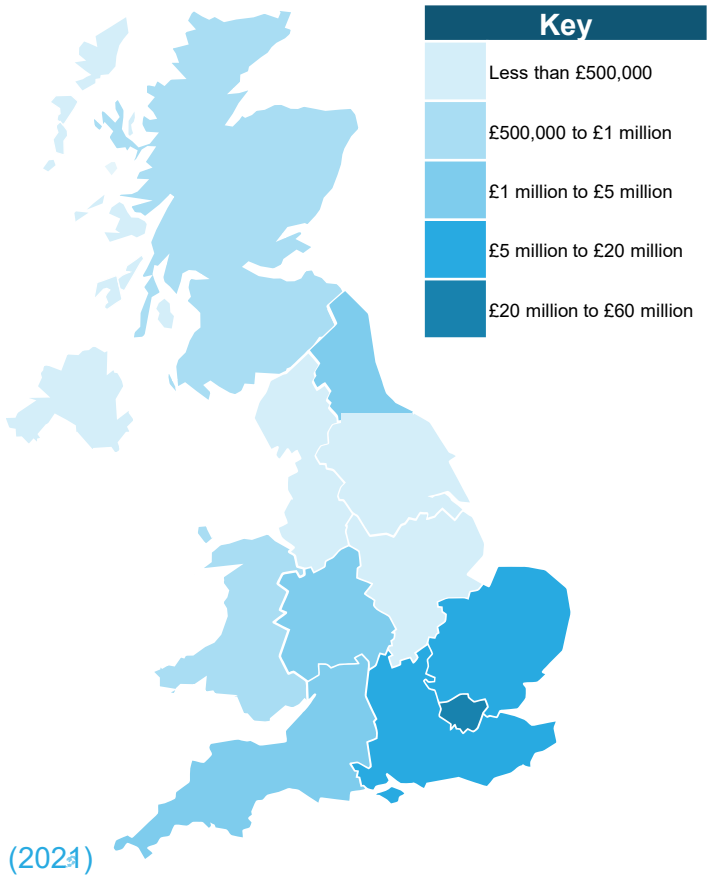


Figure 18: Indicative wages by region, based on the mid-point of the wage bands (2021)

| Greater London | South East | East of England | South West | North East | North West | East Midlands | West Midlands | Yorkshire and the Humber | Scotland | Wales | Northern Ireland | Outside the UK or unknown |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| £54,025,000 | £16,005,000 | £12,635,000 | £2,085,000 | £1,050,000 | £305,000 | £555,000 | £1,360,000 | £25,000 | £540,000 | £675,000 | £110,000 | £1,980,000 |

Source: Crossrail Ltd employment data, in 2018 prices

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# 3. Employment and skills impacts

## Characteristics of the Crossrail Ltd and supply chain workforce

Crossrail aimed to promote diversity and equality throughout the project. Its key objectives were:

- Creating opportunities for all;
- Empowering change;
- Embedding equality throughout all steps of construction and across all supply chain;
- Supporting local action;
- Celebrating diversity; and
- Leaving a long lasting a legacy

Key actions undertaken involved:

- Developing a strategic partnership with "Women into Construction" an independent not-for-profit organisation that promotes gender equality in construction
- Engaging with schools to inspire future talents
- Creating a Tunnelling and Underground Construction Academy (TUCA)
- Requiring Crossrail contractors to follow a “Responsible Procurement” policy, in which diversity was advocated

**As a result,**

- **Over 1,000 apprentices** were given opportunities on the Crossrail Project (among which 13% were women)
- **More than 44,000** parents, teachers and young people engaged in the Young Crossrail programme
- **43% of students** completing the Young Crossrail Work Experience Programme **were girls**
- **15% of people** commencing the Crossrail Graduate Programme **were women**

At the Crossrail Diversity Conference held in May 2013, three priority themes were identified:

- Raise the profile of construction to women;
- Inspire future talent; and
- Raise awareness of disability and the workforce.

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# 3. Employment and skills impacts

## Characteristics of the Crossrail Ltd and supply chain workforce (cont.)

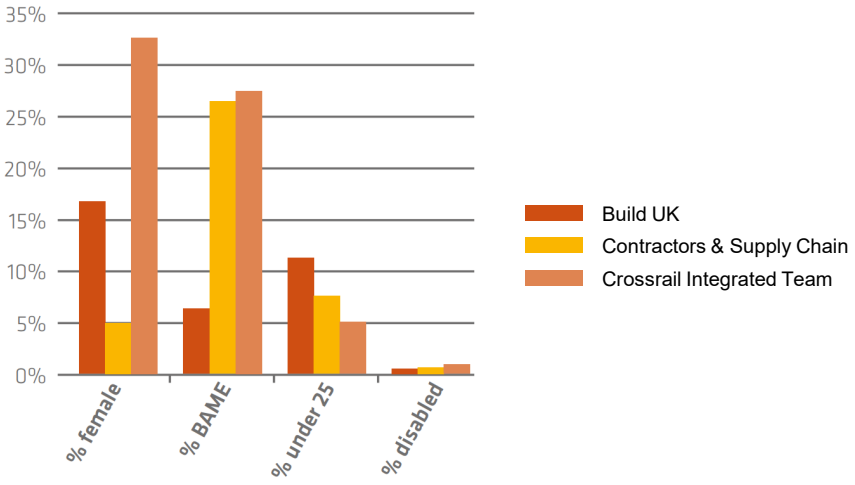
In the Crossrail Sustainability Reports, the Crossrail project's diversity performance was benchmarked against the Build UK* averages for the year 2016.

- Based on three of the four measures (proportion of female employees, proportion of employees under 25 and proportion of disabled employees), the Crossrail Integrated Team** performed better than the Build UK average.
- However, the percentage of those under 25 in Crossrail Integrated Team was lower than the Build UK average. This could be because there were relatively more senior staff working on Crossrail than the Build UK average, though efforts such as Young Crossrail (see pages 42-43) sought to address this, particularly the Crossrail Corporate Work Experience Scheme.
- When comparing Build UK averages directly to Crossrail Ltd averages, Crossrail Ltd was likely employing a higher proportion of office-based staff than the proportion represented by the Build UK figures, given that the construction work was carried out by Tier 1 contractors as opposed to Crossrail Ltd itself.
- It should also be acknowledged that Crossrail Ltd structurally benefits from a stronger ethnic diversity within its workforce as a London-based project, when compared to national average, although this should not undermine efforts made in favour of diversity throughout the project.

*Build UK, formed in 2015 after a merged between the UK Contractors Group and National Specialist Contractors Council, is a leading organisation, endorsed by the Government, which represents 27 of the largest main contractors, and 40 trade associations who in turn represent 11,500 specialist contractors.

**The Crossrail Integrated Team consists of Crossrail Ltd, the Programme Delivery Partners and the Project Representative (Jacobs Engineering Ltd UK team appointed to work on Crossrail)

Figure 19: Crossrail diversity indicators, benchmarked against Build UK (2015/16)




Source: Crossrail 2016 Sustainability Report

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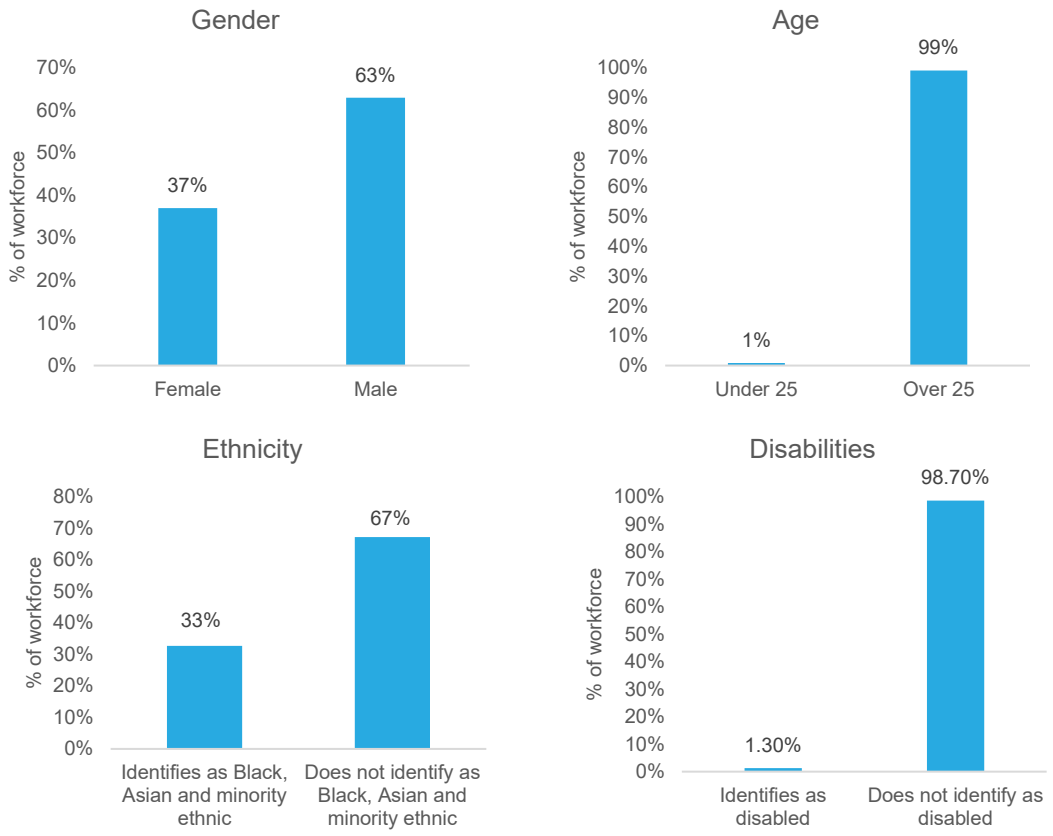
# 3. Employment and skills impacts

## Characteristics of Crossrail Ltd workforce

- Compared to the graph presented on page 37 for Crossrail Ltd and supply chain employees, the data provided by Crossrail Ltd in 2021 shows the most up to date figures of the workforce's structure for the project.
- The graphs opposite represent the characteristics of Crossrail Ltd's workforce, based on a sample study population of at least 1,612 employed during the project.
- Analysis shows that both gender and ethnic diversity has increased since the Sustainability report 2016, with women representing 37% of all employed (previously 32%) and 28% of the workforce identifying as Black, Asian and minority ethnic (27% before).
- However, the age indicator shows that just 1% (14 people) of all employed by Crossrail were aged under 25 in 2021; this figure is lower than in 2016. This result can be parlty explained by the fact that the workforce was smaller in 2021, with different delivery priorities focused on systems integrations and assurance as well as commissioning. In addition, graduate and apprentice schemes had concluded, thus automatically reducing the share of young people employed.

Figure 20: Crossrail Ltd workforce diversity indicators




Source: Data from Crossrail Limited and Crossrail Pay Gap report 2021

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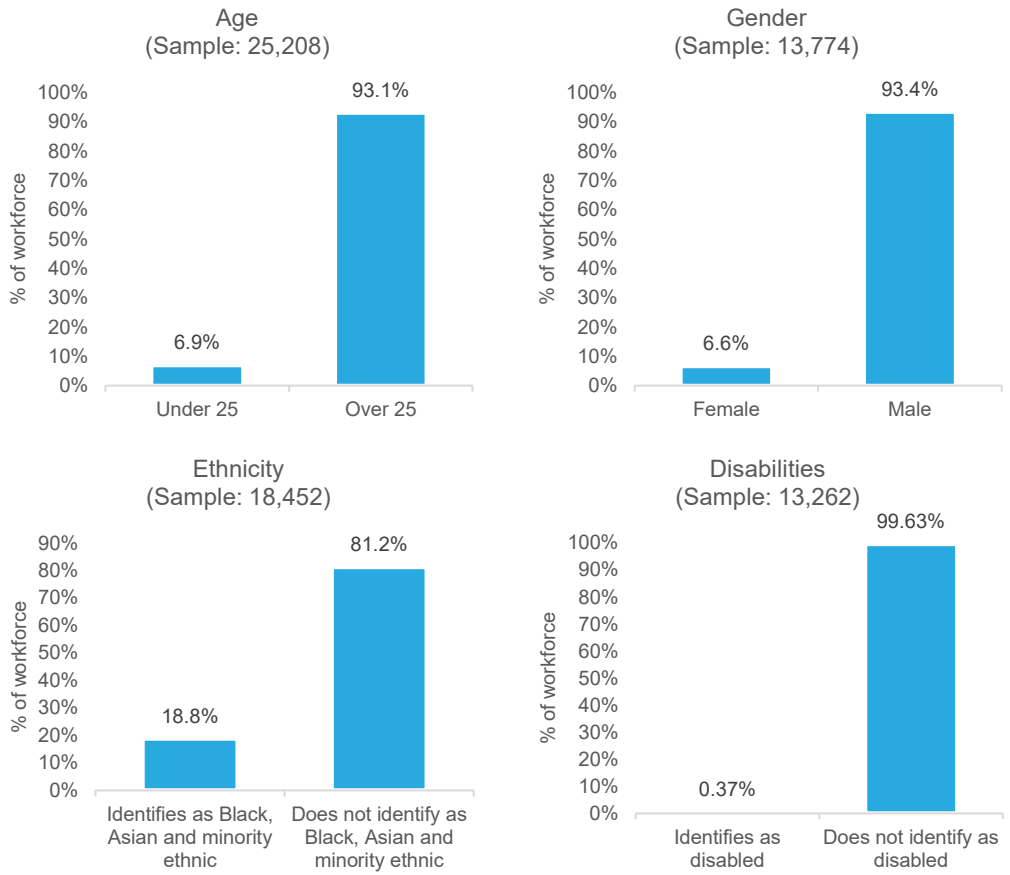
# 3. Employment and skills impacts

## Characteristics of the supply chain workforce

- Compared to the graph presented on page 37 for Crossrail Ltd and supply chain employees, the data provided by a sample of Tier 1 contractors and their subcontractors shows broadly similar results.
- The graphs opposite represent the characteristics of the supply chain, based on a sample study population of at least 13,000 (see page 27 for the list of contractors who provided data to us). This includes both Tier 1 employees and their subcontractors' workforces.
- Crossrail Ltd estimated that the construction of the new route would generate the equivalent of 55,000 full time jobs – this would indicate that, assuming no duplication of records (see p. 66), the results on this page cover at least a quarter of the workforce created by the project.
- There are some differences in employee characteristics between data gathered from Tier 1 respondents and the data in the Crossrail Sustainability Report - with the greatest differences observed for ethnic background. Some 19% of the workforce identified as Black, Asian and minority ethnic in our sample of supply chain contractors, compared to around 28% in the Crossrail Sustainability Report.
- Whilst contractors agreed to follow Crossrail's Responsible Procurement policy, no specific targets were set to increase diversity among workforce.
- When comparing ethnic and gender characteristics, Crossrail Ltd workforce shows higher diversity than its supply chain which can be partly explained by the location and nature of jobs performed within Crossrail Ltd.

Figure 21: Crossrail supply chain diversity indicators (2018)




Source: Tier 1 respondents

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# 3. Employment and skills impacts

## The London Living Wage

Crossrail Ltd made it a contractual requirement to adopt the London Living Wage as a minimum. This entails that contractors and supply chains are required to pay their London-based employees at least the London Living Wage, and payroll audits have shown a high level of compliance.

- The London Living Wage (LLW) is £10.85 per hour and covers all boroughs in Greater London. The national living wage is £9.50 per hour (Living Wage, 2021).
- Crossrail has imposed numerous contractual agreements to ensure compliance, and there is a process for monitoring and enforcing LLW compliance. Contractors are expected to undertake regular payroll audits of subcontractors of their London-based employees. Labour-only contractors, security, cleaning and catering companies are considered as priority for the audits (Crossrail Learning Legacy, 2016b).
- For the most part, contractors complied with the LLW rules set out by Crossrail Ltd; in one instance of non-compliance (a cleaning company in 2012), the contractors were required to meet minimum standards. Crossrail Ltd have stated that non compliance was an oversight and not deliberate, highlighting the value of audits.
- The London Living Wage does not normally apply to apprentices. However, Crossrail has encouraged contractors to pay above national apprentice rates (ibid).

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## 3. Employment and skills impacts

### Number of jobs occupied by local and previously unemployed people

- The number of jobs at Crossrail Ltd and in its supply chain occupied by local and/or previously unemployed people can act as a measure of the (incremental) benefits of Crossrail construction on areas in close proximity to construction works.
- According to the 2020 Gender Pay Gap Report, there have been more than 5,000 job starts by local and/or previously unemployed people, about 9% of the total number of jobs being supported by Crossrail across the UK, which is at least 55,000.
- Crossrail Ltd has worked on the implementation of a partnership between Crossrail contractors and Jobcentre Plus in order to foster local employment. As a result, all new jobs had to be advertised through the Jobcentre Plus platform (the government-funded employment agency and social security office whose aim is to help people of working age find employment in the UK) 48 hours before general advertising.
- In addition, Crossrail worked with all the London boroughs and some councils outside London, whose job brokerage services prepared the candidates for job interviews.

Figure 22: Job starts by local and/or previously unemployed people (cumulative)

| Social Indicator | 2012 | 2013 | 2014 | 2015 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|
| Job starts (cumulative) | N/A | Number not reported; 62% of new jobs were taken by previously unemployed people, 86% by local people | 2,800 | 4,115 | 4,544 | 4,706 | 5000 + |

*Source: Crossrail Sustainability Reports 2013 to 2016 and 2018, Gender Pay Gap Report 2020*

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# 3. Employment and skills impacts

## Apprenticeships, work experience and work placements

- To support the legacy of the project, Crossrail Ltd and contractors across the supply chain have promoted opportunities for apprentices, work experience and work placements for young people.
- Targets were set by Crossrail Ltd both at a project level and at a contract level. In the last 2018 Sustainability Summary Report, it was announced that more than 1,000 apprenticeships had been created by Crossrail, Network Rail, Alstom (previously Bombardier), MTR Crossrail, and across the wider the supply chain.
- Alstom, Network Rail and MTR* have also created 297 apprenticeships as part of the on-network works, and the manufacture and operation of the new Elizabeth line trains.
- In total, 710 apprenticeships were created during the construction of the new route and stations, which is much higher than the original target of 400.
- Based on the data we gathered from the supply chain, 305 apprenticeships were created by respondents, indicating that a substantial proportion of the apprenticeships created were in the supply chain.
- As seen to the right, more than 44,000 young people participated in Crossrail activities between 2012 and 2016 (ibid).

*MTR Crossrail will operate the Elizabeth line on TfL's behalf, under the name 'TfL Rail'.

Figure 23: Young Crossrail programme indicators, 2012 - 2016

| Social Indicator | Overall Target | 2012 | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|---|---|
| **Young Crossrail programme** Young Crossrail ambassadors (annually) | N/A | 26 | 80 | 171 | 250 | 280 | 807 |
| **Young Crossrail programme** Work experience placements (annually) | 350 | 224 | 48 | 95 | 97 | 75 | 539 |
| **Young Crossrail programme** Apprenticeships (cumulative) | 400 | 64 | 198 | 283 | 426 | 657 | 657 |
| **Audience reach** Students, teachers and parents engaged (annually - estimates) | N/A | N/A | N/A | 10,000+ | 13,000 | 15,800 | 44,000+ |
| **Audience reach** Schools engaged (annually - estimates) | N/A | N/A | N/A | 100+ | 70 | 150 | 300+ |

*Source: Crossrail Sustainability Reports 2013 – 2016 and Crossrail Press Release 31.03.17*

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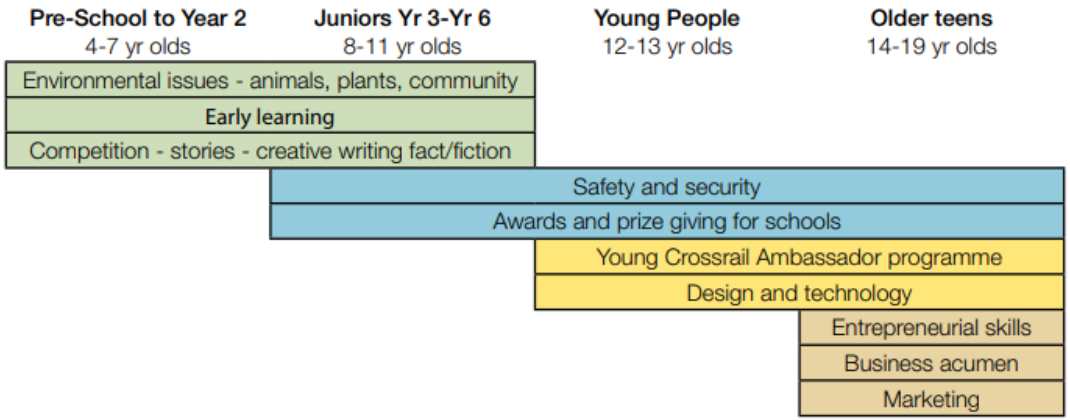
## 3. Employment and skills impacts

### Apprenticeships, work experience and work placements (cont.)

- A large number of placements, apprenticeships and ambassador opportunities were provided through the Young Crossrail programme.
- Young Crossrail was created in 2005 and is a science, technology, engineering, and mathematics (STEM) schools engagement programme, run by Crossrail Ltd.
- Crossrail Ltd has also worked with schools to raise awareness of the project amongst students and young people, especially those who live close to the route, through activities in schools, work place visits, events and the introduction of the Young Crossrail ambassadors programme (volunteers from across the project who worked to support the Young Crossrail activities).
- The Young Crossrail programme transferred to TfL in 2016 to be part of their Schools and Young People Programme.

Figure 24: Young Crossrail themes across age groups




Source: Crossrail Skills and Employment Strategy

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# 3. Employment and skills impacts

## Strategic Labour Needs and Training

- In order to support the legacy of Crossrail construction and improve the skills and future employability of the people employed for the Crossrail project, Crossrail Ltd set Strategic Labour Needs and Training (SLNT) targets for contractors, to deliver specific skills and employment outcomes. Crossrail Ltd reviewed the SLNT progress of its contractors every quarter and worked with them to help achieve the targets.
- Many initiatives were brought to an end in 2017 as the project was expected to be nearing completion. Data on SLNT compliance was gathered from 2016 onwards. However, the figures opposite demonstrate that, for the most part, amongst Tier 1 contractors, SLNT targets were either met or exceeded between 2013 and 2016. Even though data is not available for 2012, the 2012 Sustainability Report states that the apprenticeship target within the SLNT target was exceeded by 21%.
- Crossrail contractors agreed to achieving one SLNT result every £3m in contract value. SLNT results can be achieved among others by providing developing skills for existing workforce or providing new work opportunities including apprenticeships, job starts or graduate training positions. Figure 26 shows that most SLNT targets were met by enhancing workforce skills (between 53% and 66% for the period), followed by job starts (consistently second highest). This means that most of the SLNT objectives were met through skills training for full time employees and new job starts. These were not reported in detail after 2015.

### Figure 25: SLNT Compliance by Tier 1 contractors, 2013-2016

| Social Indicator | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| SLNT Compliance by Tier 1 contractors | N/A | 95% achieved more than 80% of SLNT targets; 55% achieved full SLNT targets | All T1 contractors on track to meet or exceeded SLNT targets | All T1 contractors on track to meet or exceeded SLNT targets | All but one T1 contractors on track to meet or exceeded SLNT targets |

*Source: Crossrail Sustainability Reports*

### Figure 26: Breakdown of SLNT beneficial impacts, 2012-2015

| SLNT commitment | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| **Improve workforce skills** | **57%** | **55%** | **53%** | **66%** |
| **Job starts** | **19%** | **25%** | **42%** | **24%** |
| Work experience | 12% | 9% | 5% | 4% |
| Apprenticeships | 6% | 4% | 4% | 2% |
| Graduate training | 4% | 3% | 3% | 2% |
| Work placements | 3% | 4% | 3% | 2% |

*Source: Crossrail Sustainability Reports*

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# 3. Employment and skills impacts

## Crossrail's Skills and Employment Strategy

According to Crossrail Ltd's 'Skills and Employment Strategy' report published in 2010 and the associated micro-report published in 2016, there have been increasing skills gaps within the construction and engineering industry over the last few decades. Skills gaps include engineering, project management, site supervision and trade skills. Significantly for the project, it was reported that if nothing were done to address this, underground construction skills, such as tunnelling, would be insufficient to support the delivery of Crossrail.

To help address these shortfalls, the Tunnelling and Underground Construction Academy (TUCA) was established in 2011. Its aim was to cater for skills development and training needs of Crossrail and the wider underground construction sector. It was created in conjunction with other programmes, such as the Young Crossrail Programme, apprenticeship programme, and the partnership with JobCentre Plus.

- The TUCA also forms a key element of the legacy of the Crossrail project. It was was established by Crossrail Limited in 2011 at a cost of £13m with a £5m contribution provided by the Skills Funding Agency.
- While an initial target was set for 8,000 learners, over 20,000 people have been trained at the TUCA since 2011 (Crossrail, 2018).
- TUCA is still evolving and will include training opportunities for rail operation and maintenance; additionally, it is now home to a mock station to train staff in customer service (Crossrail, 2016).
- The TUCA will become one of the DfT's 'Centres of Excellence', a network of facilities providing training in the transport sector to improve quality of training and efficiency in the industry. In March 2017, the TUCA was transferred to TfL in order to support future infrastructure and tunnelling projects such as HS2 and Thames Tideway.
- A partnership was set with PROCAT a national college serving the engineering, aviation, rail and construction industries providing apprenticeships and workforce development for some of the UK's leading companies.

### The Tunnelling and Underground Construction Academy

Source: Crossrail

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# 3. Employment and skills impacts

## Crossrail's skills and Employment Strategy (cont.)

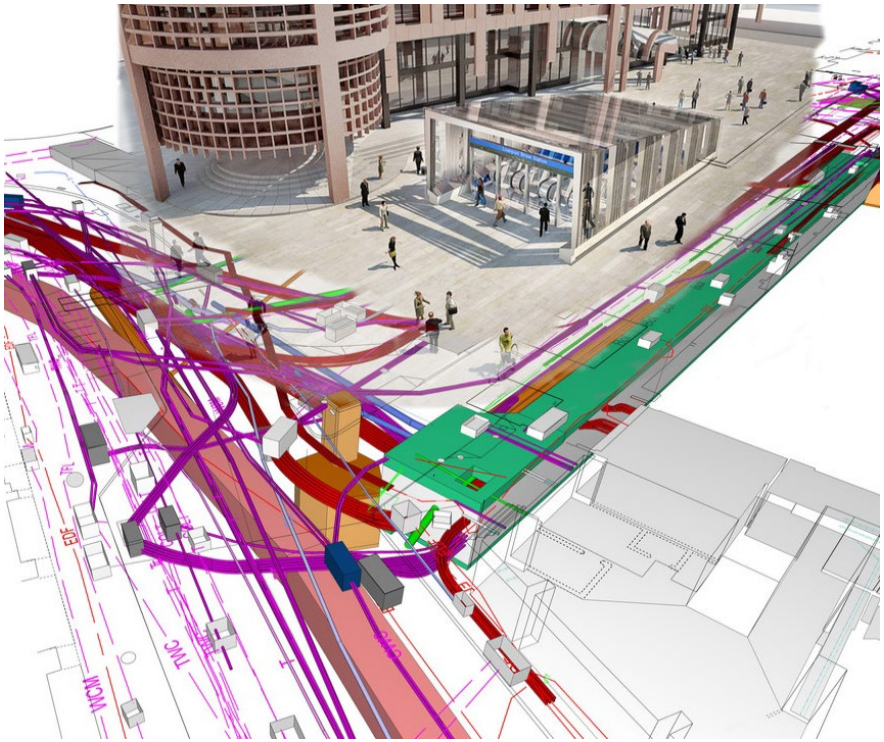
Crossrail Ltd also established other training schemes:

- The 2010 Skills and Employment Strategy report outlined the need for logistics training for the delivery of materials to station sites and removal of the excavated material and other waste. This training requirement aligned with Crossrail Ltd's 'Target Zero' health and safety strategy described in more detail on page 60.
    - Some 9,794 drivers employed on Crossrail have attended lorry training and road safety course. Each frequent lorry driver has completed a custom-made training course, which was co-designed with cycling safety groups and the police. The programme won the Safer Vehicles award at the 2013 Brake Fleet Safety Forum.

- The Crossrail Bentley Information Academy was established as a partnership between Crossrail Ltd and Bentley Systems* to drive building information modelling (BIM) best practice across the supply chain. BIM is a key part in the Government's Construction Strategy and the academy has created a lasting legacy in this technology.

*Bentley Systems is a technology company who develops software for the architecture, engineering and operation of infrastructure.

BIM model of the utility corridor beneath Liverpool Street station



*Source: Crossrail*

# 4. Environmental impacts

# 4. Environmental impacts

## Introduction

Crossrail Ltd has set a series of environmental sustainability performance indicators and targets, in two themes: the physical environment (natural resource protection and environmental enhancement) and addressing climate change and energy.

Crossrail is one of the first major infrastructure projects where environmental indicators have been monitored and reported transparently.

Environmental performance data are collected and monitored by Crossrail Ltd with performance against the targets reported in the Crossrail Sustainability Reports annually from 2012 to 2016. In 2017, an Environment Report was published that focuses on environmental impacts and indicators. In 2018, a Sustainability Summary report was published that looks at Crossrail's overall sustainability performance.

Data on the following environmental indicators are collected from the Crossrail Sustainability Reports and presented in this section:

- Environmental design
- Carbon footprint and environmental assessment ratings
- Recycled content by value
- Recycling and reuse of waste material
- Air quality controls
- Water use
- Biodiversity
- Environmental complaints

The study will also benchmark the performance of Crossrail against other projects, where information is available.

Wallasea Island post-sea wall breach in July 2015

Source: Crossrail

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# 4. Environmental impacts

## Environmental design

Industry standards and innovative designs are applied in the design of Crossrail.

The standards applied for the environmental design include:

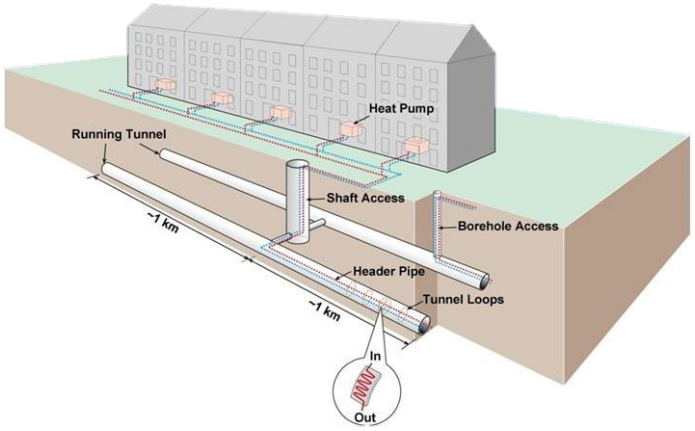
- **CEEQUAL** is an internationally-recognised sustainability assessment, rating and award scheme for civil engineering and infrastructure projects. The assessment scheme has been applied for new tunnels, portals and shafts in the central section and outer surface sections.
- **BREEAM** is another sustainability assessment methodology for infrastructure, masterplanning and buildings which looks at the whole built-environment lifecycle form construction through to refurbishment. The use of BREEAM for underground stations was pioneered on Crossrail.

Various innovative methods to reduce environmental impact were also modelled:

- **Thermal Tunnel Energy Segments**: a thermal 'tunnel energy segment' (TES) system was designed for use on the tunnelled sections of the Elizabeth line, though not implemented. The system uses a closed-loop, water-filled pipework within the tunnel to extract the heat generated by the braking, and accelerating of trains, which can be used to cool the tunnels and provide heat to nearby buildings. *(Institution of Civil Engineers)*
- **Repurposing of Grout Shafts*:** There are 13 grout shafts in central London associated with Crossrail. The shafts and their expansive grout pipes networks (for compensation grouting) could be repurposed to provide the basic infrastructure for ground source heat collection, as they have significant contact with the earth. Trials undertaken at Whitechapel have demonstrated that viable heat can be extracted from these networks. The Crossrail Innovate18 Programme has facilitated investigating other potential end uses for grout shafts, such as cycle storage, waste consolidation, heat extraction, water storage, and even commercial and social uses such as automatic parcel collectors, car parks, bars, studios etc.

**Grout shafts ensure that buildings are protected from any potential ground movement during Crossrail works by allowing engineers to pump grout (a cement-like substance) deep into the ground*

A schematic diagram of the tunnel energy segment system, from the paper published on ICE: The design of thermal tunnel energy segments for Crossrail, UK,




Source: Crossrail Sustainability Reports, Crossrail Learning Legacy, ICE paper: The design of thermal tunnel energy segments for Crossrail, UK, Repurposing of Grout Shafts

# 4. Environmental impacts

## Carbon footprint and environmental assessment ratings

**Crossrail is on target to exceed an 8% reduction in construction related carbon emissions** (set against the 2010 baseline). Total emissions of carbon dioxide from the construction phase of the project are estimated to be in the order of 1.7 million tonnes of CO2. Once the railway is operational, there will be annual savings in the order of 70,000 to 225,000 tonnes of CO2, largely due to the displacement of car journeys and replacement of diesel trains on the existing network. The 'payback' period is therefore between 7 and 26 years after opening, beyond which there will be net savings in CO2.

From 2014, Crossrail Ltd signed up to the Green Infrastructure Board's (GIB) Infrastructure Carbon Review, providing an annual report of Crossrail's performance regarding carbon emissions. A spreadsheet-based tool was also developed to measure the overall carbon footprint through Scope 1,2,3 in construction and also over 120 years of operation*. This model provides a benchmark for future rail projects and basis for post-opening evaluation.

Meanwhile, Crossrail has reduced its expected carbon footprint by reducing energy consumption throughout construction and across the operational railway, as well as the embodied carbon in construction materials.

- A 18.6% reduction in carbon footprint against the 2010 baseline is expected, exceeding the stretch target of 8%**.
- In certain sites the use of concrete in place of cement has increased by up to 72%, contributing to a carbon reduction.
- The rolling stock for the Elizabeth line has been made to be highly energy efficient, with a passenger only contributing to approximately 32g of carbon emissions per km.
- The business case for introducing carbon-reducing initiatives during the construction identified a £2 million cost saving through efficient fuel and electricity usage.

**On target for Environment Assessment Ratings with CEEQUAL and BREAM.**

CEEQUAL (Civil Engineering Environmental Quality) and BREEAM (Building Research Establishment Environmental Assessment Methodology) are the two environmental assessment ratings applied for Crossrail construction, for tunnels and new stations respectively.

**The CEEQUAL target is that all structures achieve 'Excellent' ratings** (the definition of a 'structure' here include a tunnel, a shaft, a structure, a portal, a section of track infrastructure, stations).

Over time, there have been improvements from 'very good' to 'excellent' on certain Crossrail projects. **All structures have achieved 'Excellent' or "On target" in the post-construction rating**.

**BREEAM has been adopted for new Crossrail stations, and the target is for all stations to achieve a 'Very Good' rating.**

Crossrail Ltd worked with BRE to develop a tailored set of criteria to facilitate the environmental assessment, measurement and benchmarking of Crossrail's underground stations at the design and post construction stages of assessment.

All Crossrail stations, depots, and manitenance sites have achieved 'Very Good' in the design stage rating.

For a full list of CEEQUAL and BREEAM results to date, please see Appendix III.

* Crossrail Construction Carbon Model

**The 2017 Environmental Report states that this strong result is partly due to a revalidation exercise undertaken.

# 4. Environmental impacts

## Resource use and recycled content

### Target exceeded for recycled content by value

Recycled content by value* is the standard industry metric developed by the Waste Resources Action Programme (WRAP) for the measurement of recycled content within construction products.

- The minimum requirement set by WRAP is 10%, but Crossrail Ltd set a target of 15% across the programme with a 'stretch' target of 20%.
- By 2017, 34% of the resource use were recycled (by value), significantly exceeding the stretch target.
- The 34% figure remained consistent with previous years because similar construction materials have been used.

*According to WRAP, "*the material value of reused materials is either the purchase price, or if materials are not purchased (e.g. are reused onsite) is taken as the value of an equivalent new product if procured on the open market.*" (Source: Setting a requirement for recycled content in building projects, p.11)*

Figure 27: Recycled content indicator by value

| Environmental Indicator | Target | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|
| Resource use (recycled content) | 15% across the programme, 20% stretch target | - | 32% | 32% | 34% | 34% | 34% | 39% |

*Source: Crossrail Sustainability Reports 2013-2015 and Crossrail Environmental Report 2017 and Crossrail Sustainability Summary 2018*

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# 4. Environmental impacts

## Recycling and reuse of waste

### Target achieved for excavated and construction material recycling and reuse

- Over the life of the project, more than 8 million tonnes of material were excavated, and 99.7% of that were beneficially reused.
- More than 539,499 tonnes of construction and demolition waste were produced, 99.6% of which were diverted from landfill.
- Excavated materials were mainly soil and aggregate, and were reused to create new areas of agricultural or industrial land, nature reserves and recreational facilities.
- Crossrail is in partnership with the Royal Society for the Protection of Birds (RSPB) to create the Wallasea Island in Essex for nature reserve habitat. This is the main destination of reused excavated waste, accommodating over 3 million tonnes of material. Some 80% of the transportation of Crossrail waste to Wallasea Island was by rail or river transport, thereby reducing the traffic impact on London's roads.
- The rest of the waste was transported to other sites, where the material was used to create agricultural land, nature reserves and recreational facilities.
- 80% (per tonne km) of the excavated material was transported by rail or water, minimising the impact on road traffic and air pollution from vehicles.

### Figure 28: Waste recycling and reuse indicators

| **Environmental Indicator:** Waste recycling and reuse rate | **Target** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
|---|---|---|---|---|---|---|---|---|
| Excavated material | Target 95%, stretch target 100% | 97% | 99.7% | 99.7% | 98% | 98% | 97% | **99.7%** |
| Construction material | Target 90%, stretch target 95% | 95% | 99.5% | 99.5% | 96.5% | 97% | 97% | **99.6%** |

Source: Crossrail Sustainability and Environmental Reports

### Figure 29: Waste volumes

| **Environmental Indicator:** Waste by volume (tonnes) | **2009-2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **Total** |
|---|---|---|---|---|---|---|---|
| Excavated material | 1,134,000 | 1,083,114 | 1,900,000 | 1,500,000 | 389,068 | 146,000 | **6,152,182** |
| Construction material | 193,800* | 66,196 | 42,000 | 80,721 | 67,280 | 67,000 | **323,197** |

Source: Crossrail Sustainability and Environmental Reports

*Source: Crossrail Sustainability and Environmental Reports*

** Includes 68,000 tonnes from construction and 125,800 tonnes from demolition of buildings*

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# 4. Environmental impacts

## Air quality controls

**There was a significant improvement in air quality controls over the construction programme**

- Crossrail Ltd was committed to reducing particulate emissions from construction machinery as part of the environmental minimum requirements standards that it is required to meet.
- Crossrail was the first UK infrastructure project to set out requirements for emissions control on construction machinery (in the central section) to bring about environmental benefits (as opposed to only occupational health benefits in an underground setting).
- Air quality control was measured by the percentage of equipment (NRMM Non-Road Mobile Machinery) fitted with diesel particulate filters or cleaner Euro Stage IIIB engines. The air quality control for Crossrail has been improving over time, from around 40% to over 80% during 2012 to 2018.
- Crossrail was the first project in the UK to have achieved over 80% of its non-road mobile machinery fitted with diesel particulate filters or Euro Stage IIIB engines.

Figure 30: Equipment fitted with emission controls - diesel particulate filters or cleaner Euro Stage IIIB engines

| Environmental Indicator | Target | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|
| Air quality controls compliance rate | 80% | 40% | 57% | 72% | 86% | 84% | 88% | **83%** |

Source: Crossrail Sustainability and Environmental Reports

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# 4. Environmental impacts

## Water use

**Rainwater harvesting and groundwater remediation were implemented where possible.**

- Water usage data were only available from the years 2015-2017.
- There was a reduction of 75,000m$^3$ in water usage from 2015 to 2016, due to the cessation of tunnelling and other heavy civil engineering work, though the volume rose to around 300,000m$^3$ in 2017.
- Tunnelling accounted for 85% of water usage.
- Measures implemented for water sustainability:
  - Smart meters
    - Paddington site: the Costain Skanska Joint Venture installed smart meters to review and benchmark water use across stations
  - Groundwater remediation
    - Pudding Mill Lane, Stratford: remediate the groundwater that is contaminated from historical industrial uses.
  - Low volume flush and leak detection systems for stations and portal washroom facilities
  - Old Oak Common: rainwater will be harvested to wash the new trains
  - Whitechapel station: rainwater will be harvested and stored to irrigate its green roof

Figure 31: Volume and sources of water use through time (*no set target*)

| Water usage breakdown | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| Volume (m$^3$) | N/A | N/A | N/A | 275,000 | 200,000 | c.300,000 |
| **Tunnelling** | **N/A** | **N/A** | **N/A** | **85%** | **85%** | **15%** |
| Sytemwide | | | | - | - | 56% |
| Main station/large concrete structures | N/A | N/A | N/A | 6% | 9% | 9% |
| Surface works | | | | - | - | 17% |
| Piling/portal walls | N/A | N/A | N/A | 5% | 1% | - |
| Demolition/utilities | N/A | N/A | N/A | 3% | - | - |
| Other (groundworks) | N/A | N/A | N/A | 1% | - | - |
| Light construction | N/A | N/A | N/A | - | 2% | - |
| Depots | N/A | N/A | N/A | - | 2% | 1% |
| Shipping | N/A | N/A | N/A | - | 1% | - |

Source: Crossrail Sustainability and Environmental Reports

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# 4. Environmental impacts

## Biodiversity

### Network Rail set a 'no net loss' biodiversity target during construction

- The Department for Environment, Food & Rural Affairs (DEFRA) developed the accounting methodology for biodiversity values. Crossrail Ltd and Network Rail used this biodiversity accounting methodology to determine the value of habitats lost and created from the Crossrail development.
- Results from a 2018 study undertaken by Crossrail Ltd show that the project has had net biodiversity benefits (see more explanation on next page).
- Crossrail Ltd also identified opportunities for increasing biodiversity value across different sites to minimise the biodiversity loss or increase biodiversity in areas where a reduction was identified.
- Crossrail's largest biodiversity project was shipping 3 millions tonnes of excavated earth to create the 1,500 acre wildlife habitat at Wallasea Island — a collaboration between Crossrail Ltd and the RSPB.

- Other actions taken to preserve and/or enhance biodiversity during the construction:
- Whitechapel station, Paddington Integrated Project, Westbourne Park: using suitable floral species for land restoration
  - Mile End, Eleanor Street and Limmo Peninsula shafts, Paddington Integrated Project and Whitechapel station: delivering green roofs
  - Pudding Mill Lane, Royal Oak portal, Custom House and Victoria Dock portal: New landscapes
  - Surface sections of the route: biodiversity along the rail corridor, such as planting 85 new trees across around ten new stations. The South East section, Woolwich to Abbey Wood (see page 13), received a Green Apple Environment Award for tree planting in November 2014.

*Source: Crossrail Sustainability Reports, DEFRA Biodiversity offsetting in England Green paper*

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# 4. Environmental impacts

## Biodiversity (cont.)

Crossrail Ltd undertook a study in 2018 to assess Crossrail's impact on biodiversity

- The report overall shows that although several sites experience a biodiversity gain, more sites exhibit biodiversity losses. The overall biodiversity value balance was negative of 116.75 biodiversity units.
- However, the Crossrail Ltd and RSPB partnership that has created the Wallasea Island in Essex, is a habitat creation project. This project has significant biodiversity benefits and it is estimated that the biodiversity units can be as high as 775.714, overall contributing to a net gain of 413.7 biodiversity units.

Figure 32: Biodiversity gains and losses (in biodiversity units)

| Sites | Biodiversity units |
|---|---|
| Mile End Shaft | 0.41 |
| Eleanor Street Shaft | 1.58 |
| Old Oak Common | -16.92 |
| Paddington Integrated Project (PIP) | 0.83 |
| Plumstead Portal | -17.00 |
| Pudding Mill Lane and Ham & Wick | -4.03 |
| Westbourne Park and Royal Oak Portal | -24.92 |
| Whitechapel Station | 2.36 |
| Limmo Peninsula Shaft | -28.91 |
| Liverpool Street Station | -2.53 |
| Ilford Yard | 0.34 |
| Connaught Tunnel | -4.05 |
| Woolwich Station | 1.20 |
| Custom House and Victoria Dock | -7.04 |
| North Woolwich Portal | -19.41 |
| Stepney Green | 1.29 |
| Urban Realm | 0.07 |
| **Total** | **-116.73** |
| **Wallasea Island** | **413.7** |

Source: Crossrail Biodiversity Accounting Report Central Section 2018

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# 4. Environmental impacts

## Environment complaints

### Noise and vibration are the main concerns raised in environmental complaints

- The latest data on environmental complaints is from 2017, when most of the sustainability initiatives were finalised.
- However, over 90% of environmental complaints were related to noise and vibration, and the main locations were areas where residential properties are close to the works.
- Other concerns in the complaints records included ecology and nature conservation, site lighting and air quality, excavated material, waste management, recycling, contaminated land, water resources.
- There were more complaints related to the outer surface sections, as opposed to central section. This is due to the changing nature of construction works, from heavy civil construction to railway fit-out across the central sections.
- However, Crossrail Ltd made commitments to reduce noise and vibration impacts and this was an important consideration throughout planning, design, and construction. Examples include the provision of a noise insulation package and a temporary re-housing scheme to eligible properties that were in close proximity to the construction works (Crossrail, 2007).
- The Construction Industry Research and Information Association (CIRIA) has quoted the Crossrail programme as ‘world class noise management’.

### Figure 33: Number and main concerns of environmental complaints

| Environmental complaints | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| **Number of complaints** | 320 | 444 | 731 | 785 | 725 | 575 |
| **Main concerns** | noise and vibration | noise and vibration | noise and vibration | noise and vibration | noise and vibration | noise and vibration |
| **Percentage of main concerns** | N/A | N/A | 93% | 90% | 94% | 94% |
| **Complaints on the outer surface sections** | N/A | N/A | 127 | 167 | 363 | N/A |
| **Percentage of outer surface sections complaints** | N/A | N/A | 17% | 21% | 50% | Over half |
| **Location with highest number of complaints** | Central section | Whitechapel, Bond Street, Paddington | Whitechapel | Whitechapel, Bond Street | Whitechapel, Bond Street, Farringdon | Maidenhead, Abbey Wood, Shenfield, Brentwood, Whitechapel, Liverpool Street, and Ilford stabling yard |

Source: Crossrail Sustainability and Environmental Reports

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# 4. Environmental impacts

## Benchmarking and summary of environmental sustainability targets

From the start, Crossrail Ltd aimed to achieve environmental best practice with their targets, monitoring and performance reporting; it was the first major infrastructure project in the UK to report environmental performance so transparently.

We benchmarked Crossrail targets to two infrastructure projects, the East London Line and the Olympic Park, as well as the Waste & Resource Action Programme (WRAP).

This benchmarking demonstrated that the targets set for Crossrail are the same or greater than those set for the other projects we compared Crossrail against, and the WRAP standard targets. This indicates a strong willingness by the Crossrail project team to engage with environmental strategies, as well as setting a high standard for future large-scale infrastructure projects to follow.

| | Crossrail | East London Line | Olympic Park | WRAP |
|---|---|---|---|---|
| **Waste** | Recycled content used by value: target 15% across the programme, 20% stretch target | Maximising the use of existing and decommissioned railway to minimised the land take | – | Recommend setting 10-15% recycled content by value as a minimum. |
| | Waste recycling and reuse rate (100% stretch target for excavated and 95% stretch target for construction material) | – | ODA aimed to achieve 90% re-use and recycling of construction waste, achieved 99% re-use & recycling of waste | Zero waste to landfill |
| **Air Quality** | Air quality controls compliance target rate (% of equipment fitted with emission controls), 80% | – | – | – |
| **Water** | Monitored the water use volume (300,000 $m^3$ in 2016/17) | – | The Olympics Delivery Agency targeted 40% reduction in the demand for potable water, 90% re-use and recycling of water | – |
| **Biodiversity** | Target at 'no net loss' | Strategic documents for the management of impacts on ecology, drainage, landscape and archaeology. | Largest new urban park to be built in over a century. | Snaresbrook embankment stabilisation project – project delayed for 6 months because of two nesting birds. |
| **Environmental Design** | CEEQUAL, BREEAM for underground stations, Thermal Tunnel Energy Segments, Repurposing of Grout Shafts. | Environmental Management System compliant with ISO 14001, Environmental good practice within the preliminary design, for example operational noise and vibration requirements, rain water harvesting and seeded substrate beds | BREEAM, CEEQUAL | – |

# 5. Health and safety impacts

# 5. Health and safety impacts

## Health and safety objectives

Crossrail Ltd set ambitious health and safety management targets. Crossrail's Corporate Health and Safety objectives were to:

- Strive for excellence in industry health and safety performance
- Continue to drive the Frontline Leadership programme
- Drive down accident rates

Target Zero was the core of Crossrail Ltd's approach to promoting health and safety, underpinned by six pillars (see opposite). It comprised three core principles which, taken together, provided its workforce with a clear message on health and safety:

- We all have the right to go home unharmed everyday
- We believe that all harm is preventable
- We must all work together to achieve this

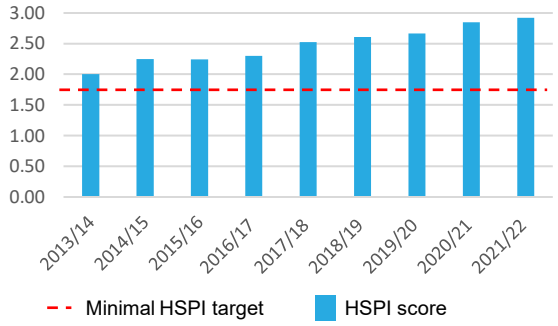
Crossrail Ltd instigated a number of initiatives across the supply chain to help achieve their Target Zero objectives. This included the Health and Safety Performance Index (HSPI) based on measures within the six pillar model. Scoring ranges from zero ('Does not meet basic contractual expectations') to three ('Demonstrates excellence').

Crossrail consistently achieved its target of all contracts achieving a score of at least two ('Exceeds contractual expectations') throughout the period despite the introduction of more challenging indicators in 2016.

Stepping Up Week was another programme which took place at each of the live sites, with site-specific, bespoke schedules of activities geared toward engaging the workforce in health and safety issues.

Crossrail Ltd demanded the highest standards of health and safety across the project and worked closely with their principal contractors in support of making sure this is the case. Despite all these intiatives, Crossrail's construction saw incidents which resulted in injury by construction workers. Since construction work begun on the project in 2009, there was one construction fatality within the supply chain workforce. This incident took place on 7 March 2014 at the site in Fisher Street. There have also been four fatal collisions involving HGVs or lorries working for sub-contractors on the Crossrail project - three cyclists and one pedestrian - the last occurred on 19 February 2015.

Figure 34: Crossrail Overall HSPI




Source: Crossrail Health and Safety Report 2016 and data from DfT


Source: Crossrail Health and Safety Report 2016

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# 5. Health and safety impacts

## Accidents and road incidents

Driving down accident rates was one of Crossrail LTD's Corporate Health and Safety objectives as part of their Target Zero initiative. There are two indicators for accident rates, which were reported in the Crossrail Sustainability Report, and Annual Health and Safety reports:

- RIDDOR* Accident Frequency Rates (AFR): measured over a rolling year and normalised per 100,000 hours worked.
- Lost Time Case (LTC) AFR: the rate per 100,000 hours worked where an accident results in one or more days absence.
- Both RIDDOR AFR and LTC AFR have decreased between 2012 and 2021, showing improvement in performance, as well as reflecting the change in the types of work being carried out.
- The steep decrease observed for the period 2012 to 2016 reflects actions carried out for improvement such as the implementation of a bi-annual Stepping Up Week which has received overwhelmingly positive feedback from staff, or the Frontline Leadership Programme providing coaching and mentoring, for those fulfilling supervisory roles on the programme.
- Incident numbers were collected through the incident monitoring data held by Crossrail Ltd. The data was then used to organise incidents learning reviews and investigations that were communicated to other sites.

*Reporting of Injuries, Diseases and Dangerous Occurrences Regulations

Figure 35: RIDDOR AFR

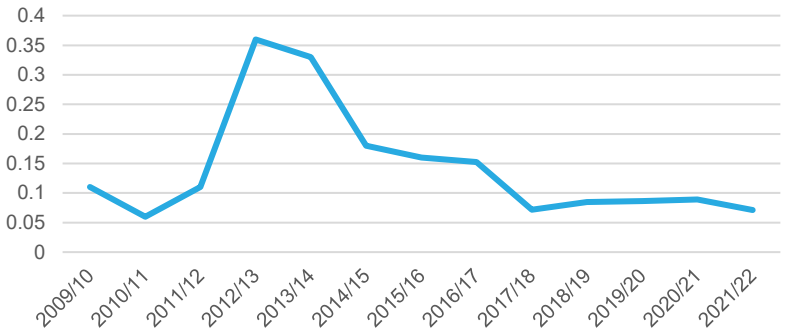
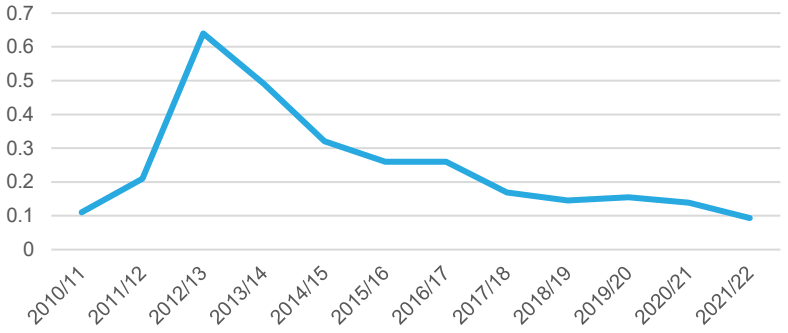



Figure 36: LTC AFR




Source: Crossrail Health and Safety Report 2016, Crossrail Sustainability Reports and data from DfT

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# 5. Health and safety impacts

## Injuries and harm free days

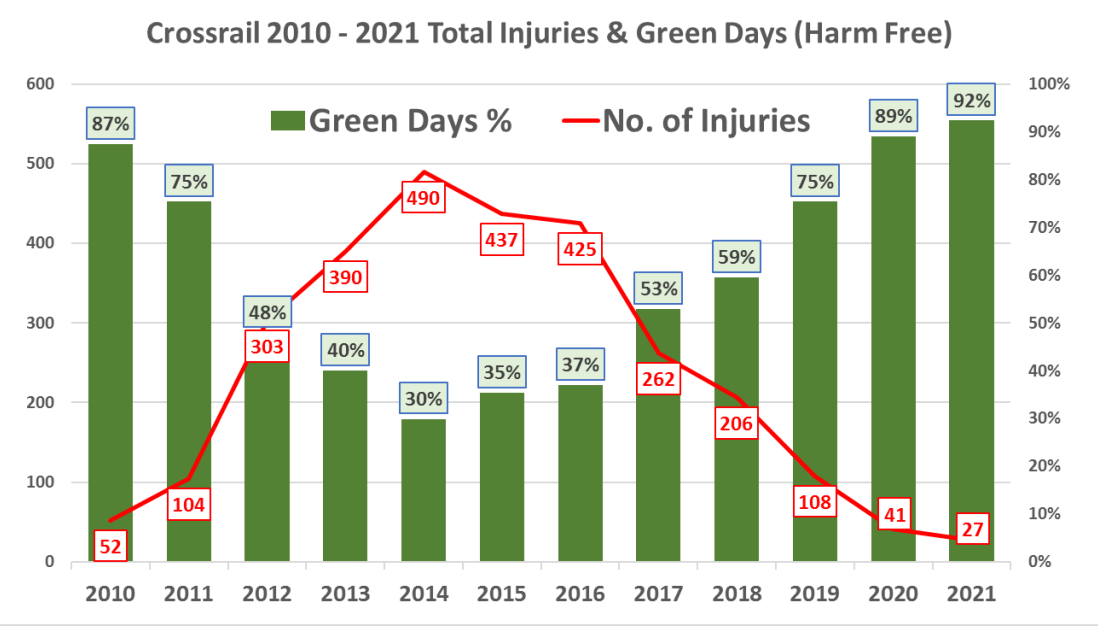
The graph to the right shows the impact behaviours based golden rules had when they came in in 2015. Before that they were activity based golden rules (task specific activities), whereas the new rules focused more on ensuring the evolving workforce had a consistent understanding of the what was expected from them and the behaviours they had to adopt.

At the same time, Nine High Risk activities were also agreed and incorporated into the Target Zero messaging. This updated messaging and clarified expectation were integrated into the programme-wide induction and all health and safety related messaging and initiatives.

On the presented figure, green shows the % of harm free days for the year and how these gradually increased following that change in 2015.

The 2021 figures were an all time low for the programme with 27 injuries in 2021 (January to November) and 92% of days being harm free.

Figure 37: Total injury and harm free days 2010-2021




Source: Data from DfT and ELDG report 2021

Appendices

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# Abbreviations

RfL – Rail for London

GLA – Greater London Authority

DfT – Department for Transport

TfL – Transport for London

RIDDOR – Reporting of Injuries, Deseases and Dangerous Occurrences Regulations

HSPI – Health and Safety Performance Index

LTC – Lost Tme Case

AFR – Accident Frequency Rate

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# Appendix I
## List of contracts worth £50m

This schedule represents all of the contracts worth at least £50 million, based on information provided by Crossrail's Team.

| Contract Ref | Contract Name [and Scope] | Contractor/JV Long Name |
|---|---|---|
| C121 | Sprayed Concrete Linings (SCL) Design | Mott MacDonald |
| C122 | Bored Tunnels Design | Arup |
| C272 | Paddington Integration - Main Works (incl M&E) | Carillion |
| C300 | Western Running Tunnels and Bond St / TCR (early access shafts & SCL works) | Bam Nuttall, Ferrovial, Kier JV |
| C305 | Eastern Running Tunnels | Dragados John Sisk JV |
| C310 | Drive H (Thames Tunnel) Incl North Woolwich and Plumstead Portals | Hochtief Murphy JV |
| C315 | Connaught Tunnel Refurbishment & Surface Rail Works | Vinci |
| C336 | Paddington New Yard Project | Costain |
| C340 | Victoria Dock Portal (Civil Works) | Vinci |
| C350 | Pudding Mill Lane Portal (Miain Civils Works) | Morgan Sindall |
| C360 | Intermediate Shafts | Costain / Skanska JV |
| C405 | Paddington Station (Main Station Works, Fit Out + M&E) | Costain / Skanska JV |
| C411 | Bond Street Station (Piling & Dwall) | Costain / Skanska JV |
| C412 | Bond Street Station (Main Station Works, Fit Out + M&E) | Costain / Skanska JV |
| C422 | Tottenham Court Road (Main Station Works, Fit Out + M&E) | Laing O'Rourke |
| C435 | Farringdon Station (Main Station Works, Tunnels, Fit Out + M&E) | Bam Nuttall, Ferrovial, Kier JV |
| C501 | Liverpool Street Station (Pilling & Dwall) | Bam Nuttall, Kier JV |
| C502 | Liverpool Street Station (Main Station Works, Fit Out + M&E) | Laing O'Rourke |
| C503 | Liverpool Street Station (Civils Advance Works Package 1) | Vinci |
| C510 | Liverpool St and Whitechapel Station (Early Access Shafts & SCL Works) | Balfour Beatty, Bemo, Morgan Est, Vinci |
| C512 | Whitechapel Station (Main Station Works, Fit Out + M&E) | Balfour Beatty, Morgan Est, Vinc |
| C520 | Custom House (Main Station Works) | Laing O'Rourke |
| C530 | Plumstead and Woolwich Fit Outs | Balfour Beatty |
| C610 | Track, OHLE & Logistics | Alstom, TSO, Costain JV |
| C620 | Railway Signalling & Control (Central Operating Section) | Siemens |
| C631 | Platform Screen Doors | Knorr Bremse |
| C660 | Communications and Controls Systems | Siemens |
| C695 | Plumstead Maintenance Facility | Alstom, TSO, Costain JV |
| C807 | Marine Transportation | Bam Nuttall, Van Oord JV |
| C828 | Ilford Yard Stabling Sidings | VolkerFitzpatrick |

*Source: Crossrail Contracts Commercial Management Team*

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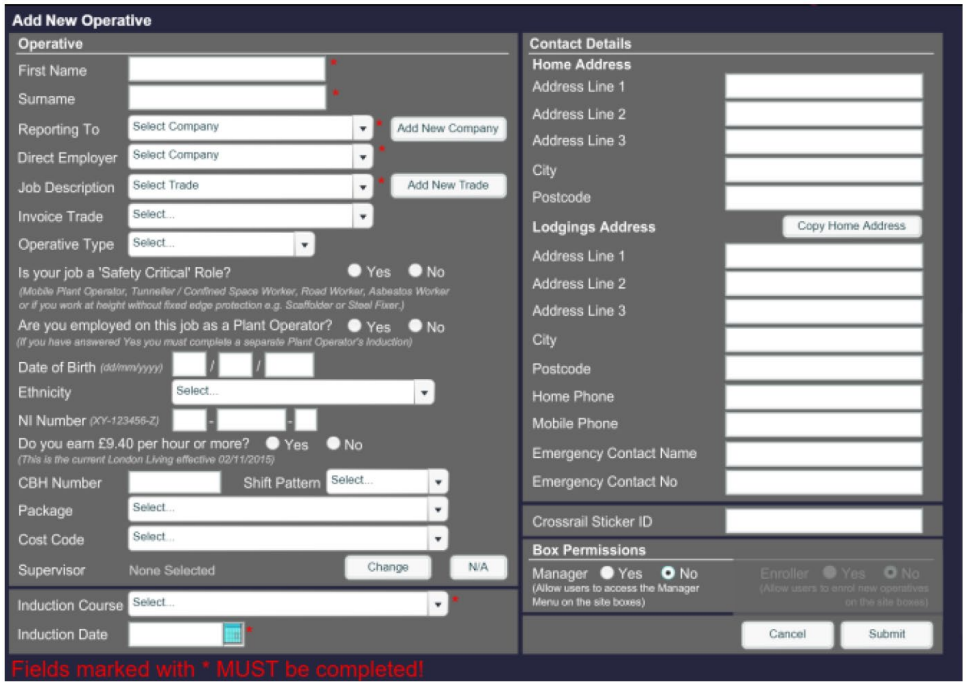
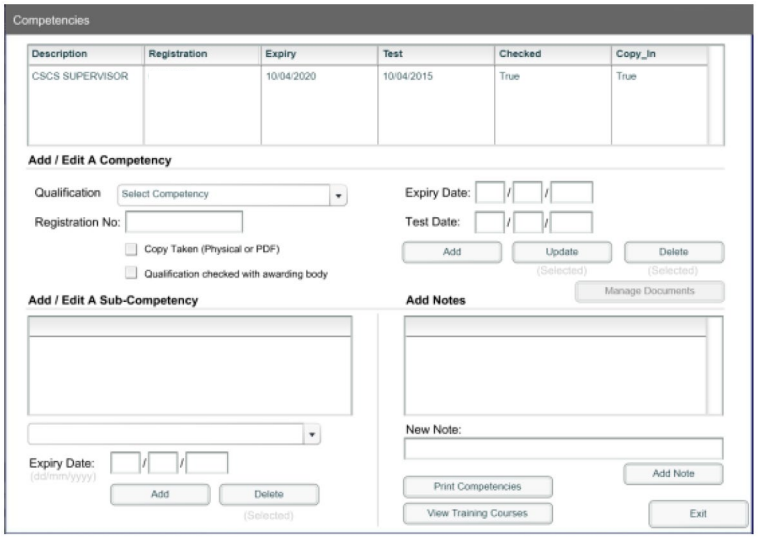
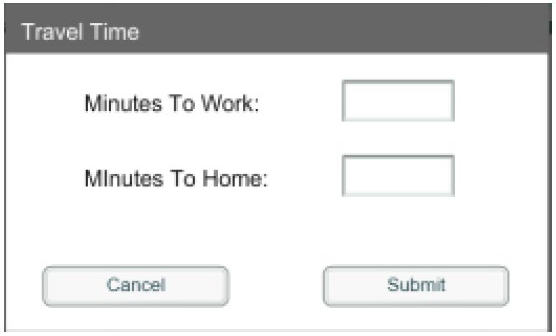
# Appendix II
## Questionnaires

Screenshots of the induction questions for the Alstom/TSO/Costain workforce using the DataScope software.

The operative would have completed a hard copy of the questionnaire to a certain standard, and then the data is uploaded into the database by an ATC administrator.



# Appendix III

## Lessons learned from supply chain data analysis

During the process of gathering workforce data from the Tier 1 contractors, a number of challenges regarding the data collection arose. This meant that some companies were not able to provide us with necessary data or that records provided were incomplete. The data collection process was challenging.

One of the challenges was the discrepancies in the data collection and record-keeping between each organisation, and even within joint venture partnerships. This highlights the need for a more consistent approach to gathering workforce data in future large-scale infrastructure projects.

This section presents a few of these issues, describes the challenges in gathering the data as relayed to us by the contractors, and identifies ideas to address these in future projects of this scale.

**Crossrail Responsible Procurement**

Crossrail Ltd engaged their contractors in a responsible procurement policy which emphasised the importance of:

- Encouraging a diverse base of suppliers;
- Promoting fair employment practices;
- Promoting workforce welfare;
- Meeting strategic labour needs and enabling training opportunities;
- Community benefits;
- Ethical sourcing practices; and
- Promoting greater environmental sustainability.

Contractors were required to gather information on the make-up of their workforce and report findings to Crossrail Ltd periodically. The implication of this was that the companies that were contacted already had the records required for the analysis stored somewhere on their systems and that Crossrail was able to monitor key diversity and employment statistics. The findings from this data collection have been reported annually in Crossrail Sustainability reports.

However, some companies only held records for their own employees working on a particular contract, whilst other companies held records for all the employees working on that contract including subcontractors' employees.

**Issues with data collection**

Many Tier 1 contractors explained that data were gathered at each worksite as part of site induction. Each person working on-site would need to be enrolled, and were required to complete a questionnaire which included questions on their age, ethnicity, disability status, and sometimes their home address. Biometric data was also obtained at this stage to support time tracking.

This type of data gathering has a number of implications:

- Records are not complete as many questions were not compulsory for privacy reasons (such as ethnicity);
- The template for recording information changed over time. This was seen in the data provided by some contractors.
- Induction surveys were sometimes completed by hand, and then entered into a database at a later stage, increasing the likelihood for human error;

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# Appendix III

## Lessons learned from supply chain data analysis (cont.)

- Answers were sometimes collected in 'free text' boxes, as opposed to pre-populated drop-down menus, which produced inconsistencies in spelling and structure (e.g. 'south east' versus 'south-east') making data analysis more complex;
- People were often employed on multiple sites, and by different contractors, meaning that they were required to complete more than one induction survey. One contractor we spoke to explained:

  *"There is a very good chance of people working on multiple sites. I, for example, have been inducted on four different sites for two different companies. Many of the subcontractors will be working across multiple sites simultaneously too. Crossrail employees are often inducted on numerous projects to make it easier for them to move around sites."*

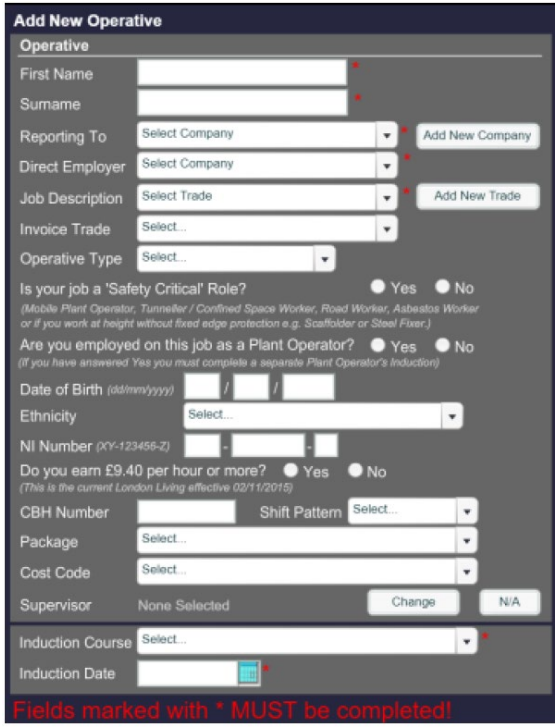
  This in turn means duplicate records and less chance for accurate reporting.
- Wage data was not recorded, as this was not a contractual requirement. It was therefore difficult and time consuming for contractors to pull key statistics on employees by wage band. Only a few contractors were able to provide wage data.

In addition to these issues, and despite the fact that these companies were required to collect most of this data as part of the Responsible Procurement Policy, it was not always straightforward for some of the supply chain contractors to provide this data. They explained that it would require time to collect and analyse, which was beyond the scope of their contract. This was particularly the case for wage data, which contractors were not required to collect throughout the project.

**Data collection companies**

Many of the Tier 1 contractors employed specialist access control and door entry firms to gather attendance data, and/or gather biometric and induction data. These firms included DataScope, Ganetime International, and Access Control Technology (ACT; now part of Vanderbilt Industries).

An example of the types of data being gathered at inductions by these access control companies is shown opposite (taken from DataScope's software provided to the Alstom/TSO/Costain JV). See Appendix II for further details.



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# Appendix III

## Lessons learned from supply chain data analysis (cont.)

The fact that different companies employed different data collection companies and systems contributed to the overall inconsistency and reduced accuracy of supply chain employment data.

**Recommendations**

Given these difficulties in collecting complete and consistent data records on the supply chain employment, we recommend that for future infrastructure projects:

- A unique identifying number per employee is created to avoid double reporting of employees;
- A consistent format of data collection is implemented across contractors and over time; and
- Wage data is collected throughout the project and combined with diversity data to enable an evaluation of the spatial distribution of employees across the UK and beyond.

We would also recommend that providing aggregated data for all construction years for evaluation purposes to the Department for Transport (if the project receives funding from DfT) becomes a contractual requirement for future large infrastructure projects.

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# Appendix IV

## Crossrail structures and their current CEEQUAL rating

Crossrail structures and their current CEEQUAL rating.

| CEEQUAL | Target Rating | Client and interim design rating | Construction rating |
|---|---|---|---|
| Western tunnels | Excellent | Excellent | Excellent achieved |
| Eastern tunnels | Excellent | Excellent | Excellent achieved |
| Thames tunnel | Excellent | Excellent | Excellent achieved |
| Sprayed concrete lining structures | Excellent | Excellent | Excellent achieved |
| Paddington Integrated Project | Excellent | Excellent | Excellent achieved |
| Eleanor Street/Mile End shafts and headhouses | Excellent | Excellent | Excellent achieved |
| Victoria Dock portal | Excellent | Excellent | Excellent achieved |
| Pudding Mill Lane portal | Excellent | Excellent | Excellent achieved |
| Royal Oak portal | Excellent | Excellent | Excellent achieved |
| Connaught tunnel | Excellent | Excellent | Excellent achieved |
| Stockley flyover | Excellent | Excellent | Excellent achieved |
| Acton dive under | Excellent | Excellent | Excellent achieved |
| Western outer track infrastructure | Excellent | Excellent | Excellent achieved |
| Western outer track electrification | Excellent | Excellent | Excellent achieved |
| Old Oak Common Paddington approaches | Excellent | Excellent | Excellent achieved |
| West stations | Excellent | Excellent | On target |
| Northeast section | Excellent | Excellent | Excellent achieved |
| Southeast section | Excellent | Excellent | Excellent achieved |

*Source: Table provided by Elizabeth line Sponsor Team*

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# Appendix IV

## Crossrail buildings and their current BREEAM rating

Crossrail buildings and their current BREEAM rating.

| BREEAM | Target Rating | Design stage rating | Post-construction rating |
|---|---|---|---|
| Tunnelling and Underground Construction Academy | Very Good | Achieved | Excellent achieved |
| Paddington Station | Very Good | Achieved | Very good achieved |
| Bond Street station | Very Good | Achieved | On Target |
| Tottenham Court Road station | Very good | Achieved | Excellent achieved |
| Farringdon Station | Very Good | Achieved | Excellent achieved |
| Liverpool Street station | Very Good | Achieved | Excellent achieved |
| Whitechapel station | Very Good | Achieved | On Target |
| Custom House station | Very Good | Achieved | Very Good achieved |
| Abbey Wood Station | Very Good | Achieved | On Target |
| Woolwich Station | Very Good | Achieved | Very good achieved |
| Ilford logistics and stores | Very Good | Achieved | Very good achieved |
| Ilford operations and welfare | Very Good | Achieved | Very good achieved |
| Plumstead Maintenance Building | Very Good | Achieved | On Target |
| Plumstead Accommodation Building | Very Good | Achieved | On Target |
| Old Oak Common Depot | Very Good | Achieved | Very good achieved |

*Source: Table provided by Elizabeth line Sponsor Team*