Bakerloo line extension
Tunnelling Worksite Summary Report
October 2019
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1 Aims of the Tunnelling Worksite Summary Report

1.1.1. This report has been produced to provide more detail on the sites considered for the tunnelling worksites as part of our plans to extend the Bakerloo line. The report explains the worksite requirements, provides information on the options considered and summarises our assessment of those options.

1.1.2. We have produced factsheets and supporting information on individual topics which are available on our website.

1.1.3. To find out more

1.1.4. Visit tfl.gov.uk/bakerloo-extension where you can view and download a range of factsheets, maps, and other information about the scheme.

1.1.5. Alternatively, come along to one of our exhibitions where you will have the opportunity to view our proposals and speak to members of the Bakerloo line extension team. More details about the exhibitions are on the website at tfl.gov.uk/bakerloo-extension.

1.1.6. Please contact us to request a copy of our material in hard copy, Braille, large print, audio or another language, and a response form to provide feedback.

1.1.7. Contact us

- Website: tfl.gov.uk/Bakerloo-extension
- Email: ble@tfl.gov.uk
- Telephone: 0343 222 1155 (Note service and network details apply. Visit tfl.gov.uk/terms for details)
- Post: FREEPOST TFL CONSULTATIONS (BLE)
2. Introduction

2.1.1. An extension to Lewisham via Old Kent Road and New Cross Gate would provide new transport capacity to south east London and improve transport connections. This would help to enable development in south east London, support London’s growth and improve journeys for existing communities. We are also considering a potential extension beyond Lewisham to Hayes and Beckenham Junction. The proposal to Lewisham and potential extension beyond Lewisham are proposals in the Mayor’s Transport Strategy. A map of the proposal is shown in Figure 1.

![Figure 1: Bakerloo line extension proposal to Lewisham](image)

2.1.2. To deliver the extension we would require worksites along the route. These would be required to facilitate the construction and fit-out for both the site specific (e.g. stations) and line-wide (e.g. tunnels) infrastructure.

2.1.3. As part of the extension we have developed a tunnelled route for the Bakerloo line between Lambeth North and Lewisham via Elephant & Castle, Old Kent Road and New Cross Gate.

2.1.4. The tunnels required for the extension would be constructed using tunnel boring machines (TBM) in a similar manner to the tunnels recently constructed for the Northern Line Extension and Crossrail projects. There are different types of TBM and the choice of which to use would be dependent on the expected types of ground that would be encountered.
2.1.5. There would be more than one pair of TBM tunnelling drives to construct the required tunnels. This is due to the length of the extension, expected changes in ground type and to facilitate staged fit-out of the tunnels. The TBMs would require a tunnelling worksite at one end of each tunnel drive. This tunnelling worksite would service the TBMs and be the point at which tunnel lining segments are delivered and excavated material (spoil) is removed. More detail on tunnelling worksites can be found in Section 3.
3. **Tunnelling Works for the Bakerloo line extension**

3.1. *Background to Construction Phasing*

3.1.1. There are a series of stages required to construct the extension.

3.1.2. Once the proposals are funded and the powers to construct and operate the extension have been obtained, we would then clear the sites, undertake any required utility diversions and set up the services required to start construction. This would form part of the enabling works to allow construction of the new infrastructure to begin.

3.1.3. After the enabling works are complete we would start to construct the new tunnels, stations and the ventilation shaft.

3.1.4. Once the construction of these structures is largely complete we would start fitting out the structures, making them suitable for operational use. This phase also involves installation of the line-wide systems, such as signalling and power. The next stage would be to integrate the new extension with the existing line.

3.1.5. Finally, we would enter the final testing phases to ensure the extension can operate safely and reliably before opening the extension to passenger service.

3.2. *Worksites*

3.2.1. To build the infrastructure required for the extension, worksites both for tunnelling, and other infrastructure such as stations, are required along the route. The temporary land required to work on these sites would be larger than the permanent infrastructure (e.g. a station) that would remain after the construction concludes. This is to allow space to safely and efficiently undertake the construction and fit-out works.

3.2.2. Tunnelling worksites would be required at the start of the TBM tunnel drives. The worksites required to construct the tunnels would be larger than those required for the stations and shaft sites and could either be on the same site or be located separately from those sites.

3.2.3. The extension would require around 8.5km of new tunnelled route between Lambeth North and Lewisham, via Elephant & Castle, Old Kent Road and New Cross Gate. This would consist of two new train tunnels (or ‘running tunnels’) between these points, connecting into the existing Bakerloo line tunnels at Lambeth North.

3.2.4. The length of the TBM drives for the new tunnels is more than three times the length of those for the recent Northern Line Extension tunnels. There are advantages to not building these tunnels in one continuous drive. Dividing up the tunnelling drives would
allow more time for the critical line-wide fit out, testing and commissioning works and also reduce the programme risk around opening the extension on time.

3.2.5. A primary tunnelling worksite is one that can be used as the main tunnelling drive site.

3.2.6. A secondary tunnelling worksite can be used to allow for the earlier construction and fit out of a section of tunnels to shorten the programme.

3.3. Tunnels

3.3.1. The proposed route of the extension would require the construction of twin tunnels between Wearside Road Council depot, just south of Lewisham and Lambeth North station. The length of the new extension is around 8.5km, the total length of tunnels driven would be twice this distance as each running tunnel would provide one direction (northbound or southbound) for the future train service.

3.3.2. The majority of the tunnels would be constructed in more challenging ground conditions to those on most of the rest of the London Underground network. The ground conditions are also different to those recently encountered on the Northern Line Extension. Due to this we would likely use Slurry TBMs for the majority of the tunnel drives.

3.3.3. One key feature of Slurry TBMs is that the excavated soil (or spoil) is not taken away from the front of the TBM by conveyors, but in pipes mixed with slurry. Before the

Figure 2: A new running tunnel for the Northern Line Extension
spoil can be taken offsite the slurry and spoil must be separated in a slurry treatment plant at the main worksite. The slurry is then recirculated within the treatment plant and the separated spoil taken away. This type of TBM requires more worksite space than used to extend the Northern line, primarily to allow for the slurry treatment plant.

3.3.4. The majority of the new tunnels would be constructed in chalk, which suits Slurry TBMs. Between Old Kent Road I and Lambeth North, it is expected that the tunnels would begin to transition out of the chalk into the Lambeth Group (made up of gravels, sands, silts and clays) and then into the London Clay. For this section of tunnels we would expect to use Earth Pressure Balance (EPB) TBMs, which are the same type of TBM used on the Northern Line Extension.

3.3.5. The new tunnels would be larger than the existing Bakerloo line tunnels and would incorporate space for a walkway, similar to that shown in Figure 2.
4. Tunnelling Worksites Requirements

4.1.1. The principal functions of a primary tunnelling worksite are to set up and launch TBMs, supply the materials needed to support the tunnels e.g. tunnel lining segments, and handle excavated material for its onward transport off site. There are key requirements to be considered when determining the primary tunnelling worksite. These can be used to filter potential options down to a list from which the primary worksite can be determined. These requirements are summarised below.

4.1.2. A fully assembled TBM of the size required for the Bakerloo line extension is likely to be more than 100 metres in length and weigh around 1,000 tonnes. The TBM launch that would begin construction of the tunnels would use a portal, either at the end of a ramp or in an excavated box structure. This would be from a planned station on the route or a purpose-built structure. The launch portal would ensure the TBM could start tunnelling with sufficient level of ground above it.

4.1.3. A suitable area has to be made available at the main tunnelling site to facilitate the construction of the portal, as well as to stockpile the excavated material (spoil) prior to its removal from site.

4.1.4. When a tunnelling site has to stop work due to filling the spoil stockpile, this is called being ‘muckbound’. To avoid delays and stoppages in the tunnel construction space for a spoil stockpile has to be allowed for. This would allow continued progress in case of disruption to spoil removal.

Figure 3: TBM launch site for the Northern Line Extension
4.1.5. An area would also be required on the main tunnelling worksite to receive, store and dispatch tunnel segments to the TBM’s. These segments would be used to support the newly built tunnel. A stockpile of these segments must also be kept on site to allow for the tunnelling works to continue should there be disruption to the segment delivery.

4.1.6. To construct the extension sustainably, the primary tunnelling worksite must have access to the National Rail network and either contain, or have the ability to contain, rail sidings to enable the use of trains to unload materials and for the removal of excavated material (spoil) from the main tunnelling drives. We are proposing train lengths of circa 300 metres in length. We anticipate multiple train movements per day which would each remove the need for more than 60 lorries into and out of the site. The main tunnelling worksite needs to host at least two sidings (ideally more for resilience) off the National Rail network. The site options that we have identified would be capable of hosting rail freight facilities, either on purpose built or existing rail sidings, for the purpose of removing large volumes of material excavated during the tunnel construction. This would reduce the number of Heavy Goods Vehicles (HGVs) required to enter and leave the site.

4.1.7. A number of HGV movements would still be required to and from the tunnelling worksites as part of the works, as it would not be possible to move everything to and from the site by rail. The operation as a primary tunnelling worksite needs to consider how direct access from the main road network is and how the site can function day to day to support the tunnelling works, which would require a 24 hour operation.

4.1.8. We looked at the possibility of using the river for spoil removal and deliveries, however both the distance from the extension route and lack of access to suitable riverfront led us to prioritise rail options.

4.1.9. Within the primary tunnelling worksite, space must also be provided for welfare facilities, the storage of materials & equipment and to enable access into, out of and around the worksite.

4.1.10. Based on these requirements, the primary tunnelling worksite would require a minimum footprint of more than 24,000m². As this figure does not take into account site topography, access arrangements, changing requirements as we develop the scheme or the shape of the site available and the ease of using the space it provides, we anticipate that considering these and other factors, we would need at least 30,000m².

4.1.11. The impact on the environment and the local area is also a key consideration in determining the location of the primary worksite.
5. Tunnelling Strategy

5.1.1. There are different tunnelling strategies that we could use to construct the extension. These are dependent on the availability of suitable worksite(s), the length of tunnel to be driven and ground conditions (e.g. geology).

5.1.2. Given the length of tunnels to be driven, we anticipate the TBM drives would take up to 2.5 years to complete. We would however require the worksite for longer than this in order to build the launch portal, assemble the TBMs and complete the testing and commissioning of the line-wide systems.

5.1.3. As well as requiring the completion of the tunnel construction, the line cannot open until the installation, testing and commissioning of the various station and line-wide systems has taken place.

5.1.4. When tunnelling with TBMs it is not possible to undertake fit-out works at the same time. This is because there is no space due to the constant need to take tunnel lining to and spoil from the TBM to the tunnelling worksite.

5.1.5. Breaking up the tunnel construction into shorter sections would allow for the earlier installation of items such as track and signalling within the completed tunnels.

5.1.6. Three indicative tunnelling strategies are shown in Figure 5 below, as Scenarios A, B and C.

5.1.7. Scenario A shows a single continuous tunnel drive from one end of the extension to the other, this would be carried out by a pair of TBMs to create the required two running tunnels. In this Scenario the installation of elements within the tunnels,
station platforms and line-wide systems along with their testing and commissioning can only occur after completion of all of the tunnelling. This is a risk as the fit-out of the whole route would be delayed until after the completion of the tunnelling.

5.1.8. Scenario B, by contrast, shows two separate tunnel drives from a site along the route of the extension to either end. These could either be carried out in parallel or, as shown here, sequentially. In this instance, upon completion of tunnel drive 1, we could begin to install, test and commission infrastructure within the completed tunnels. This could occur independently of tunnel drive 2. The ability to break up the tunnel drives in this way and begin installation earlier reduces the programme risk around opening the extension.

5.1.9. Scenario C is a variant of Scenario A where there is not an available site to launch TBMs at the end of the line and therefore a site has to be found beyond the extension. This would therefore require additional tunnelling to reach the proposed route. As with Scenario A, the installation of elements within the tunnels, such as line-wide systems, along with their testing and commissioning, could only occur after completion of all of the tunnelling. This is a risk to the programme around opening the extension.

5.1.10. There are advantages to delivering the extension as shown in Scenario B, as opposed to Scenarios A and C given the length and complexity of the works.

Figure 5: Indicative tunnelling scenarios
6. Proposed Primary Tunnelling Worksite

6.1.1. We considered a number of different locations for the primary tunnelling worksite. We began by identifying options along the route of the proposed Bakerloo line extension and then those beyond the planned end of the operational extension at the council fleet depot site on Wearside Road in Lewisham. Based on the requirements set out in section 4, there were only three sites that we considered feasible for the primary tunnelling worksite.

6.1.2. The three options we shortlisted and considered further for the primary tunnelling worksite were:

1) New Cross Gate retail park
2) Hither Green railway sidings
3) Catford Hill Retail Park and Jubilee Grounds playing fields

6.1.3. Figure 6 below, shows the route of the proposed tunnelled extension between the tie-in with the existing Bakerloo line at Lambeth North and the Wearside Road Council depot just beyond Lewisham (in green), along with the location of the three primary tunnelling worksites considered for further study.

Figure 6: Route of the tunnelled extension showing the considered primary tunnelling worksites
6.1.4. The further assessment of these options considered worksite and environmental criteria in more detail (please see section 7 which sets out how the requirements were considered, and a description and assessment of the three options progressed). In addition to this, tunnelling scenarios were determined for the different options to gauge their programme implications (see section 8), which also fed into the option selection. As a result of this work, the New Cross Gate retail park is our proposed primary tunnelling worksite.
7. Primary tunnelling worksite option assessment

7.1.1. The table below is a summary of our assessment of each of the shortlisted sites by reference to our tunnelling worksite requirements.

Table 1: Primary tunnelling worksite assessment table

<table>
<thead>
<tr>
<th>Assessment Factors</th>
<th>New Cross Gate</th>
<th>Hither Green</th>
<th>Catford</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Size &gt; 30,000m²</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Access to Network Rail</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Opportunity to remove material by rail</td>
<td>Yes, several full length sidings possible.</td>
<td>Yes; two reduced length sidings possible. Requires use of additional land at Grove Park Sidings and larger number of train movements</td>
<td>Yes, several full length sidings possible.</td>
</tr>
<tr>
<td>Access – Trunk road connection, local roads</td>
<td>Direct access to and from the trunk road network via the A2 (New Cross Road)</td>
<td>Access to the trunk road network via local residential roads with traffic calming measures and risk of height restrictions</td>
<td>Direct access to and from the trunk road network via the A205 (South Circular Road)</td>
</tr>
<tr>
<td>On route of tunnel alignment</td>
<td>Yes</td>
<td>No – Approximately 1.6km (or ~19%) of additional twin tunnels required. 3.2km of extra tunnel in total</td>
<td>No – Approximately 1.7km (or ~20%) of additional twin tunnels required. 3.4km of extra tunnel in total</td>
</tr>
<tr>
<td>Uni or bi-directional TBM launch?</td>
<td>Bi-directional – tunnels can be driven in both directions on proposed route</td>
<td>Uni-directional – tunnels will be driven to and then along proposed route</td>
<td>Uni-directional – tunnels will be driven to then along proposed route</td>
</tr>
<tr>
<td>Synergy with other required works (Station, etc)</td>
<td>A proposed new station at New Cross Gate would already require use of this site, reducing overall disruption from</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Assessment Factors</th>
<th>New Cross Gate</th>
<th>Hither Green</th>
<th>Catford</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current land use</td>
<td>Retail and grocery, Network Rail lands comprising road access to site compound hosting portakabins and access to rail siding.</td>
<td>Network Rail land hosting rail sidings and maintenance plant. Local nature reserve.</td>
<td>Retail park, Network Rail substation. River Ravensbourne runs through site. St Dunstan’s College playing fields</td>
</tr>
<tr>
<td>Environmental and Planning Policy considerations</td>
<td>- Located within a District Town Centre</td>
<td>- Part of the site falls within an area designated as a Site of Importance for Nature Conservation and Green Corridor. The woodland area is known locally as Hither Green Triangle Nature Reserve and is improved by local community groups</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Railway sidings fall within Green Corridor and Site of Importance for Nature Conservation</td>
<td>- Loss of existing rail sidings/maintenance facility</td>
<td>- Located within Designated Urban Green Space and Metropolitan Open Land</td>
</tr>
<tr>
<td></td>
<td>- Part of the site falls within the Hatcham Conservation area</td>
<td>- Additional tunnelling beyond Lewisham required to reach the site resulting in large amount of waste and materials to tunnel and fit out</td>
<td>- Located within an Area of Archaeological Priority</td>
</tr>
<tr>
<td></td>
<td>- Located within an Area of Archaeological Priority Site allocation SA6 (mixed use housing, retail, community facilities and a new station access and public space)</td>
<td>- Rail logistics possible from the site</td>
<td>- Loss of Jubilee Grounds (St Dunstans School) Playing fields and associated sports facilities</td>
</tr>
<tr>
<td></td>
<td>- Loss of Sainsbury’s Supermarket and other retailers on the site would result in loss of jobs and this amenity for the community</td>
<td>- HGV access would be via a residential road</td>
<td>- Loss of Jubilee Nursery</td>
</tr>
<tr>
<td></td>
<td>- Rail logistics possible from the site</td>
<td></td>
<td>- Located within the Culverley Green Conservation Area</td>
</tr>
<tr>
<td></td>
<td>- Is located on strategic road network</td>
<td></td>
<td>- Located adjacent to River Pool Linear Park, a Green Open Space and Site of Importance for Nature Conservation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Loss of retail and light industrial businesses in the Catford Retail Park</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- River Ravensbourne culverted beneath the site</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Site falls within a Flood Risk area</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Waterlink Way link National Cycle Route located on the site</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>North end of St Dunstan’s</td>
</tr>
<tr>
<td>Assessment Factors</td>
<td>New Cross Gate</td>
<td>Hither Green</td>
<td>Catford</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Programme Risk</td>
<td>Low – enables route to be divided into discrete tunnel drives either side of New Cross Gate. This would enable staged fit-out of tunnels and line-wide systems, reducing programme risk.</td>
<td>High – requires continuous bored tunnel drive to Lambeth North. Fit-out and installation of line-wide systems occurs at more locations simultaneously.</td>
<td>High – requires continuous bored tunnel drive to Lambeth North. Fit-out and installation of line-wide systems occurs at more locations simultaneously.</td>
</tr>
<tr>
<td>(see section 5 for more detail on the tunnelling strategy, which is an important part of programme risk)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7.2. Primary tunnelling worksite at New Cross Gate

Figure 7: New Cross Gate Station and Primary Worksite

7.2.1. The site is located on the New Cross Gate retail park and on Network Rail land. It is on the route of the extension as it would be required for the construction of a new station and would require the shortest length of tunnel construction of the sites considered; equal to the length of the alignment. This would significantly reduce the volume of spoil that would be generated.
7.2.2. Tunnelling could occur in both directions from this location, as opposed to only one direction with the other options. Whilst there would be extra set up required for the second drive, this is outweighed by the benefits. As the tunnel drives from New Cross Gate would be shorter than those from either Hither Green or Catford, the first pair of drives would be completed earlier. The associated fit-out of these tunnels, installation of line-wide systems and testing could therefore begin earlier. Recent experience from similar rail projects has shown that this is valuable to reduce risk of delay.

7.2.3. In terms of environmental impact, part of the proposed site is located within an area designated as a Site of Importance for Nature Conservation as well as a Green Corridor. Part of the site lies within the Hatcham Conservation Area and within an Area of Archaeological Priority. The proposed worksite would mean the existing retail stores including Sainsbury’s would not be able to remain on the site during construction. The shorter length of tunnelling means there would be far less excavated material to dispose of, less material required to build and reduced fit-out required when compared with the other options.

7.2.4. This option has the lowest overall cost.

7.2.5. There is rail access adjacent to the site and suitable sidings could be built here to deliver and remove materials and spoil from the site. There is also a road connection straight onto the trunk road network via the A2 (New Cross Road), and the current site uses demonstrate that it can already accommodate a large number of vehicle movements. We anticipate that vehicle movements during our proposed works at the site could be lower than those currently generated by the retail park and supermarket.
7.3. **Primary tunnelling worksite at Hither Green**

![Figure 8: Potential Primary worksite at Hither Green](image)

7.3.1. The site is located on the Hither Green railway sidings. It is beyond the route of the extension and would require additional tunnel construction to get to the start of the route. This would significantly increase the volume of spoil generated compared to a worksite along the route as well as increasing the associated tunnel lining and fit-out required.

7.3.2. Tunnelling could only occur in one direction from this location which means the tunnelling would only require one set up. However, the tunnel drives from this site would be much longer than those from New Cross Gate and would therefore take longer. The associated fit-out of these tunnels, installation of line-wide systems and
testing would therefore begin later, which increases the programme risk around opening the extension on time.

7.3.3. In terms of environmental impact, part of the proposed site is located within an area designated as a Site of Importance for Nature Conservation as well as a Green Corridor. There is an area of woodland, known locally as Hither Green Triangle Nature Reserve, which would be impacted by the works. The proposed worksite would mean the existing rail sidings and maintenance facilities would not be able to remain on the site. The longer length of tunnelling would also mean that there would be more excavated material to dispose of and more material required to build and fit-out the tunnels.

7.3.4. This option has a higher overall cost than the use of a primary tunnelling worksite at New Cross Gate.

7.3.5. There is rail access at this site and existing sidings, however the sidings identified as most suitable for use on this site are relatively short and we would also need to use Grove Park sidings to receive longer trains. The need to undertake train movements at a higher frequency due to the shorter sidings, would be less efficient compared to the alternative sites.

7.3.6. Unlike the other sites considered, the road connection for this site requires access via a residential road with traffic calming measures. There would be an increase in the number of vehicles accessing and leaving this site as part of the works.
7.4. Primary tunnelling worksite at Catford

Figure 9: Potential Primary worksite at Catford

7.4.1. The site at Catford is located in the town centre on the Catford Hill Retail Park and Jubilee Grounds playing fields. It is beyond the route of the extension and would require additional tunnel construction to get to the start of the route. This would significantly increase the volume of spoil generated compared to a worksite along the route as well as increasing the associated tunnel lining and fit-out required.
7.4.2. Tunnelling could only occur in one direction from this location which means the tunnelling would only require one set up. However, the tunnel drive from this site would be much longer than those from New Cross Gate. The associated fit-out of these tunnels, installation of line-wide systems and testing would therefore also begin later, which increases the programme risk around opening the extension on time.

7.4.3. In terms of environmental impact, the site is located on a school playing field which is also designated Urban Green Space and Metropolitan Open Land. The retail park is within a flood risk area and located adjacent to the River Pool Linear Park. The river is in a culvert beneath the site which would have to be diverted. It also falls within the Culverley Green conservation Area and within an Area of Archaeological Priority. The current businesses on the site could not remain operational on these sites during construction. Additionally, the Waterway Link section of the National Cycle Route runs across the Catford Retail Park and would need to be diverted during the works. The longer length of tunnelling also means there would be more excavated material to dispose of and increased fit out required.

7.4.4. This option has a higher overall cost than the use of a primary worksite at New Cross Gate.

7.4.5. A new rail access would be required to provide sidings to remove spoil from the site. These would be built to the east of the existing railway line in the playing fields and would be removed at the end of the works.

7.4.6. The road connection is directly onto the trunk road network via the A205 (South Circular Road). There would be a significant increase in the number of vehicles accessing and leaving this site as part of the works compared to the current use as playing fields with a sports pavilion.
8. **Tunnelling Scenarios for Primary Tunnelling Worksites**

8.1.1. Three different tunnelling strategies (Scenarios A, B and C) that could be used to construct the tunnels required for the extension were set out in Section 5; see Figure 10 below. It also discussed the need to test and commission different systems before the extension could open. For the extension this would include ensuring the new systems integrate with the existing Bakerloo line.

8.1.2. The location of the primary tunnelling worksite relative to the proposed tunnels impacts on this strategy. The site at New Cross Gate would utilise Scenario B, whilst the sites at Hither Green and Catford would utilise Scenario C. There is no primary tunnelling worksite option at the end of the line reflecting Scenario A, as the Wearside Road Council depot site would not be large enough to accommodate a primary tunnelling worksite.

**Figure 10: Tunnelling scenarios from the proposed primary tunnelling worksites**

8.1.3. Scenario B would start with TBMs being launched towards the end of the line at Lewisham from a primary tunnelling worksite at New Cross Gate. Once this drive is complete, TBMs would then be launched from New Cross Gate towards Lambeth North. These could be the same TBMs recovered at Lewisham. Whilst the second drive is progressing, the completed first section of tunnel would be available for the installation of required infrastructure (e.g. track) and line-wide systems (e.g. signalling).

8.1.4. Scenario C with a primary worksite at either Hither Green or Catford, would involve TBMs being launched from beyond the end of the proposed line, progressing to the route of the extension at Lewisham and then along the alignment until they reach Lambeth North.
8.1.5. As well as having excess tunnelling not required for the extension, Scenario C options require a much longer TBM drive. Due to the nature of TBM tunnelling, installation within the tunnels cannot occur while the TBMs are being driven. This results in a longer wait for these tunnels to become available to fit-out, which increase the risk to the programme as the fit-out is pushed back until after the completion of all of the extended tunnelling.

8.1.6. As a result of the worksite assessment and the tunnelling strategy work, the New Cross Gate retail park is our proposed primary tunnelling worksite.
9. Secondary tunnelling worksite

9.1.1. The construction of the extension using a primary tunnelling worksite at New Cross Gate could be improved through the addition of a secondary tunnelling worksite closer to the tie-in location with the existing Bakerloo line at Lambeth North.

9.1.2. A secondary tunnelling worksite between New Cross Gate and Lambeth North would allow for the earlier completion of the tunnels and would reduce the programme risk. It would also allow earlier access to the point where the extension tunnels would be connected to the existing Bakerloo line tunnels. The use of a secondary worksite would reduce the length of the second tunnel drive from New Cross Gate towards Lambeth North. This would allow the second tunnel drive from New Cross Gate to begin fit-out earlier, reducing the overall programme length, meaning the extension could open sooner.

9.1.3. We are proposing to use the station site at Old Kent Road 1 for a secondary worksite, see Figure 11 below.

9.1.4. The site at Old Kent Road 1 has been proposed as a secondary worksite as it is on the route of the proposed extension and midway between New Cross Gate and the connection to the existing line at Lambeth North. This breaks up what would have been the longer second tunnel drive from New Cross Gate into two shorter tunnel drives.

9.1.5. We are proposing to build a station at Old Kent Road 1, which would be big enough to both launch TBMs towards Lambeth North and receive the TBMs coming from New Cross Gate.

9.1.6. The Old Kent Road 1 site has direct access to and from the trunk road network via the A2 (Old Kent Road) to allow for the delivery of tunnel segments and the removal of spoil. Given the current land use, it is expected that the total number of vehicle movements would reduce, however we acknowledge that the type of vehicle accessing the site would change.

9.1.7. The geology on the route between Old Kent Road 1 and Lambeth North changes from chalk to the Lambeth Group and then London Clay. This type of ground better suits the use of EPB TBMs, as discussed in section 3. We would therefore use this site to launch EPB TBMs towards Lambeth North.

9.1.8. Old Kent Road 1 has been preferred to Old Kent Road 2 as it is further from our proposed primary tunnelling worksite at New Cross Gate and therefore better balances the tunnel drives. Old Kent Road 1 is also a much larger site and therefore able to accommodate the tunnelling worksite requirements.
9.2. **Further Development of the tunnelling strategy**

9.2.1. In tunnelling Scenario B (as well as A and C) the TBMs arrive at Lambeth North right at the end of the tunnelling, which gives little room for recovery if there are delays.

9.2.2. The tie-in works to the existing line are a critical element of the extension works and would have to be undertaken during a closure of this part of the Bakerloo line. The use of Old Kent Road 1 as secondary tunnelling worksite, to launch TBMs towards Lambeth North earlier in the overall programme, would allow access to the tie-in location much earlier, thereby reducing the programme risk from this critical work.
9.2.3. The enhancement of Scenario B (a primary tunnelling worksite at New Cross Gate) with a secondary tunnelling worksite at Old Kent Road 1 is shown as Scenario D in Figure 12 below.

**Scenario D**

* This tunnel drive can occur at the same time as Tunnel Drive 1

9.2.4. Scenario D builds the running tunnels in three separate tunnel drives, which significantly reduces the length of each tunnel drive and allows access to the completed sections of tunnel for the fit-out works far earlier.

9.2.5. Scenario D allows for the earlier installation, testing and commissioning of the line-wide systems which is critical in terms of opening and operating the extension. The lessons learnt from installing these systems in the first section of tunnel could then be applied for the rest of the tunnels.

9.2.6. We therefore propose the use of Old Kent Road 1 as a secondary worksite, with tunnel drives towards Lambeth North.
10. Conclusions

10.1.1. We are proposing a primary tunnelling worksite at New Cross Gate as it is on the proposed route, is large enough to launch TBMs and has access to the railway for delivery of materials and removal of spoil. This site would be used to drive the tunnels to Wearside Road Council depot (just beyond Lewisham) where the TBMs could be recovered. These TBMs would then be brought back to New Cross Gate and relaunched towards Old Kent Road 1 station site where they would be recovered at the completion of these works.

10.1.2. We propose that Old Kent Road 1 station site be used as a secondary tunnelling worksite as it is large enough to support these works. Two TBMs would be launched from here towards the Bakerloo line tie-in location at Lambeth North. The TBMs launched from New Cross Gate would also be recovered from here. Using a secondary worksite in this location would reduce the programme risk to opening the extension.

10.1.3. We will use the public consultation responses to help us develop our proposals for the extension. We will analyse the feedback we receive and publish the results once the consultation has closed. Subject to the volume of responses and the issues that are raised, we plan to analyse and respond to the key issues raised during 2020.

10.1.4. There will be further opportunities to provide feedback on the Bakerloo line extension as the scheme develops.