



RIVER CROSSINGS: SILVERTOWN TUNNEL

SUPPORTING TECHNICAL DOCUMENTATION

SUMMARY AND COMPARISON OF TUNNEL OPTIONS

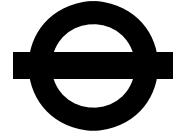
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December 2013

This report summarises the findings and outputs from the work to date, so that an objective comparison can be made between all Bored and Immersed tube options on the basis of costs, risks and impacts.

This report is part of a wider suite of documents which outline our approach to traffic, environmental, optioneering and engineering disciplines, amongst others. We would like to know if you have any comments on our approach to this work. To give us your views, please respond to our consultation at www.tfl.gov.uk/silvertown-tunnel

Please note that consultation on the Silvertown Tunnel is running from October – December 2014.



Programme River Crossings Programme
Project Silvertown Tunnel
Document reference tbc

Summary and Comparison of Tunnel Options – December 2013

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Document History

| Revision | Date | Summary of changes |
|----------|------------|---|
| V0 | 02/12/2013 | First draft |
| V1 | 06/12/2013 | Second draft inc. DF comments |
| V2 | 12/12/2013 | Incorporates corrections to cost estimates (Addendum v5). |
| | | |

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1 Background

1.1 Background Description

A new road-based crossing of the River Thames at Silvertown was identified as part of the East London River Crossings Programme in 2009. The principal drivers for a new crossing are the congestion and resilience problems at Blackwall Tunnel. In particular there are long delays at peak periods (over 20 minutes) and regular disruption caused by over 1,000 unplanned incidents a year, many related to overheight vehicles using the sub-standard northbound bore. Added to this the tunnel infrastructure is ageing and will require more regular maintenance in the future. With the lack of alternative river crossings in east London drivers face long delays and/or inconvenient and long diversions via river crossings towards central London. This situation is set to worsen as plans to develop the economy and grow the population in east London are rolled out. In this context the lack of reliable and resilient river crossings could become a significant constraint as essential movements such as road freight and servicing will be adversely affected.

Initially in 2009 a study was undertaken to investigate the feasibility of a wide range of crossing options from the Greenwich Peninsula on the south side of the river to the a variety of locations on the north side. The study reviewed previous work on river crossings and looked at the following options: a new vehicle ferry; a high-level fixed bridge; medium/low-level lifting bridges; an additional bore at Blackwall Tunnel; and new road tunnels. As a result of the study and other assessment work it was concluded that a new road tunnel from Greenwich Peninsula to Silvertown represented the best solution. Subsequent engineering feasibility and assessment work was focussed on the selection between bored and immersed tube tunnel options.

This report summarises the findings and outputs from the work to date so that an objective comparison can be made between all bored and immersed tube options on the basis of costs, risks and impacts.

2 Options Considered and Assessment Methodology

2.1 Bored and Immersed Tube Tunnel options

Based upon the work undertaken to date a total eight options have been identified for comparison on the basis that they are feasible in engineering terms but present contrasting impacts. The eight options break down into two groups – bored and immersed tube (four each) and include ‘full length’ and ‘short’ length variants.

The ‘full length’ tunnel options respect the agreed Greenwich Peninsula Masterplan layout with a southern tunnel portal to the west of Millenium Way such that there is physical separation between tunnel traffic and the areas of the Masterplan identified for residential and commercial developments.

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The 'short' tunnel options relocate the tunnel portal into the areas of the Masterplan identified for residential and commercial developments in a position dictated by maximum desirable tunnel gradient (of 4%) and the proposed road layout of the development. There is no opportunity to shorten the tunnel on the Silvertown side as the tunnel gradient is already at the maximum desirable gradient from the mid-river position to the northern portal.

The eight options are listed and described below:-

| Tunnel type | Option Name | Description |
|---------------|-------------|---|
| Immersed Tube | Base | Original full length option with on-site casting |
| Immersed Tube | A | Original full length option with off-site casting |
| Immersed Tube | B | Shortened option with on-site casting |
| Immersed Tube | A + B | Shortened option with off-site casting |
| Bored | Base | Original full length option with cross-passages at up to 350m spacing |
| Bored | C | Shortened option with cross-passages at up to 350m spacing |
| Bored | D | Shortened option with cross-passages at 100m spacing |
| Bored | E | Original full length option with cross-passages at 100m spacing |

The original 'full length' bored and immersed tube options were the subject of engineering feasibility, risk and cost assessment work set out in three reports:

- Mott MacDonald June 2012 Tunnel Engineering report
- East London River Crossings: Assessment of Options Report December 2012
- Mott MacDonald July 2013 Tunnel Engineering report.

The June 2012 report made mention of the potential opportunities to save cost by two means:-

- Use of an off-site casting facility for the immersed tube construction to save the cost of constructing an on-site casting yard and its eventual reinstatement.
- Potential to substantially shorten the tunnel on the Greenwich Peninsula side, reducing the length of border tunnel or cut & cover tunnel for the immersed tube option.

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In addition to the above opportunities to reduce costs a need was identified to evaluate the costs, risks and impacts of complying with the maximum 100m cross-passage spacing as required by Highways Agency standard BD78/99 for the bored tunnel options. This was undertaken in the July 2013 report which recommended a spacing up to 350 m as a result of a detailed Fire Life Safety assessment.

2.2 Assessment Methodology

In October 2013 it was decided that the above options should be assessed in a consistent manner to enable a direct comparison of their costs, risks and impacts. Three studies were commissioned to assess different aspects and led to the following reports:

- Tunnel Engineering Addendum Report October 2013 (Mott MacDonald) – investigated feasibility and layout of ‘short’ tunnel options, and produced cost estimates (including quantified risks) on a comparable basis.
- Silvertown Tunnel Development Impacts Study November 2013 (Atkins) – assessed the land-use and development planning impacts of the ‘full length’ and ‘short’ options for bored and immersed tube variants, and where possible quantified the impacts in cost and time terms.
- Silvertown Tunnel Options Study November 2013 (Hyder) – assessed the relative environmental impacts of the ‘full length’ and ‘short’ options for bored and immersed tube variants using a qualitative scale.

The above studies provide a high-level assessment of engineering feasibility and costs, land-use and environmental costs and impacts that is appropriate for the current Feasibility Stage. During the next stage of design development more detailed surveys, investigations and assessments will be undertaken to provide more detailed outputs on costs, risks and impacts.

In addition targeted engagement has been undertaken with key statutory stakeholders whose statutory functions are material to the assessment of options, as summarised below:-

- Royal Borough of Greenwich Planning Department – as the local planning authority responsible for the Greenwich Peninsula, TfL sought their informal views on the impacts of the ‘short’ tunnel options. Planners from RB Greenwich responded by e-mail on 27th November 2013 (see Appendix 1) and their views have influenced the assessment of planning risk for ‘short’ options.
- Port of London Authority – as the authority responsible for safeguarding, managing and promoting use of the River Thames (including associated port and wharf facilities), TfL sought their views on the bored and immersed tube options due to their contrasting construction impacts. Representatives from TfL met with the PLA,

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including the Head of Planning and the Harbour Master, on 22nd November 2013 and their preferences and views on the bored and immersed tube options were recorded in an agreed set of minutes (see Appendix 1). This has influenced the assessment of planning risks for the immersed tube options.

3 Comparison of Options

3.1 Comparison of study outputs and assessments

The section summarises the salient costs, risks and impacts for all options from the three reports to enable an objective comparison to be made between them. It is important to note that this is not a fully comprehensive assessment of all project costs and risks but focuses on areas, such as land-use and environmental impacts, where there are material differences between the options.

TfL have adopted the following process to compare the bored and immersed tunnel options and select a preferred option for recommendation.

Step 1 - Comparison of option costs, impacts and risks – sets out the base costs for each option, and summarises the qualitative land use and environmental impacts and risks (ref Table 3.1 below)

Step 2 – Conversion of land-use and environmental risks into additional time/delay to the planning process and evaluation of associated costs (ref. section 3.2)

Step 3 - Quantitative comparison – combines the base and the differential land costs from step 1 with the evaluations of additional planning stage delays derived from the land-use and environmental risks in Step 2

Step 4 – Based upon the quantitative comparison in Step 3 a set of conclusions are made to arrive at recommendation for a preferred option to proceed to concept design.

It is important to note that the comparison is not a fully comprehensive assessment of all project costs and risks but focuses on areas, such as land-use and environmental impacts, where there are material differences between the options.

Table 3.1 on the following page summarises the main findings and outputs from the three study reports and provides a qualitative comparison of land use and environmental impacts risks:-



| Table 3.1 – Comparison of study outputs and assessments | | | Cost estimates & QRA risks at Q1/2013 prices (ref. Tunnel Addendum Report Mott MacDonald) | | | Land-use impacts and risks at Greenwich Peninsula (ref. Development Impact Study – Atkins) | | | | Environmental Risks and Deliverability of Options (ref. Option Study – Hyder) | | | | | | | | | | Overall Env. Risk |
|---|-------------|---|---|--------------------------|---------------------------------|--|-----------------------------|-------------------------------|------------------------|---|------------------------------|-------------------|-------------------------------|---------------------------|-------------------|-----------|---------------------|----------------------|-------------------|-------------------|
| Tunnel type | Option Name | Description | Base Cost excl. All risks (£m) | QRA P50 (%) (see note 1) | Cost incl. QRA Risk at P50 (£m) | Land Take (sq m) | Land cost (£m) (see note 2) | Devaluation compensation (£m) | Land-use planning risk | Air Quality | Community and Private Assets | Cultural Heritage | Ecology / Nature Conservation | Effects on All Travellers | Geology and Soils | Materials | Noise and Vibration | Townscape and Visual | Water Environment | (see note 3) |
| Immersed Tube | Base | Original full length option with on-site casting | 469 | 14.2 | 535 | 2,272 | 3 | Nil | Low | 4 7 | 7 | 6 | 9 | 7 | 9 | 9 | 6 | 6 | 8 | 7.25 |
| Immersed Tube | A | Original full length option with off-site casting | 427 | 14.2 | 487 | 2,272 | 3 | Nil | Low | 4 7 | 7 | 6 | 9 | 7 | 9 | 9 | 6 | 6 | 8 | 7.25 |
| Immersed Tube | B | Shortened option with on-site casting | 434 | 14.2 | 495 | 14,768 | 18 | 44 | Med - High | 4 7 | 8 | 6 | 9 | 8 | 9 | 9 | 9 | 7 | 8 | 7.85 |
| Immersed Tube | A + B | Shortened option with off-site casting | 391 | 14.2 | 447 | 14,768 | 18 | 44 | Med - High | 4 7 | 8 | 6 | 9 | 8 | 9 | 9 | 9 | 7 | 8 | 7.85 |
| Bored | Base | Original full length option with cross-passages at up to 350m spacing | 423 | 13.8 | 482 | 4,024 | 5 | Nil | Low | 4 7 | 7 | 3 | 2 | 4 | 6 | 7 | 6 | 2 | 4 | 4.65 |
| Bored | C | Shortened option with cross-passages at up to 350m spacing | 412 | 13.8 | 468 | 14,768 | 18 | 44 | Med - High | 4 7 | 8 | 3 | 2 | 6 | 6 | 7 | 9 | 7 | 4 | 5.75 |
| Bored | D | Shortened option with cross-passages at 100m spacing | 422 | 13.8 | 481 | 14,768 | 18 | 44 | Med - High | 4 7 | 8 | 3 | 2 | 6 | 6 | 7 | 9 | 7 | 4 | 5.75 |
| Bored | E | Original full length option with cross-passages at 100m spacing | 437 | 13.8 | 497 | 4,024 | 5 | nil | Low | 4 7 | 7 | 3 | 2 | 4 | 6 | 7 | 6 | 2 | 4 | 4.65 |

Notes:

- 1 The QRA makes no allowance for environmental, land-use and planning risks but includes Contractor's risk.
- 2 TfL Property Team has advised that average land costs should be assumed at £5m per acre or 4,047sq m.
- 3 The 'Overall Environmental Risk' is derived from averaging the scores from the assessment against each of the 10 topics on the 9-point coloured scale (Lowest=1; Highest=9).

Key to 'Environmental Risks & Deliverability of Options' (ref. Table 4-3, Chapter 4 of Options Study – Hyder)



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3.2 Quantification of land-use & environmental risks and impacts

The land-use and environmental impacts and risks set out in Table 3.1 are largely derived from qualitative assessment. In order to assist the comparison between options and the selection of a preferred option it is desirable to convert these qualitative risks and impacts into quantitative measures.

The approach adopted to quantify these risks is to consider how the each risk may impact on the planning consents and approval process. The overall impact of the risks would be to either prolong or delay the planning process and as a direct result to delay the planning approval and the subsequent implementation stages. The costs of this delay to the programme can then be quantified in terms of prolongation costs (e.g. planning and preparation) and abortive costs (e.g. surveys, modelling etc) for the planning stage activities and inflation to the main implementation costs. These two main areas of cost associated with land-use and planning risks are explained below.

The time-related impacts of the main land-use planning and environmental risks are set out below with commentary:-

| Risk ID | Risk description | Additional time/Delay assessment | Comments |
|----------------|--|---|---|
| 1 | Revised planning application for Greenwich Masterplan to reflect 'short' tunnel options. | 12 months prolongation to prepare, submit & determine a revised application | This would effectively prolong the planning stage by 12 months with a consequential delay to planning approval. |
| 2 | Environmental and associated objections to river impacts related to immersed tube option | 12 months prolongation to resolve objections/negotiate with statutory stakeholders. | PLA have recently confirmed their preference for the bored tunnel option and their likely objection to the immersed tube option (ref. TfL/PLA meeting minutes at Appendix 1). |
| 3 | Risk of planning consent refusal | 12 months delay | This delay reflects the time it would take to prepare, consult on, submit and process a revised scheme. |

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The additional time/delay assessments shown above have been applied assigned to the land-use and planning risks in Table 3.2. The additional costs resulting from the time-related impacts comprise two elements as set out below:

Prolongation and abortive costs – additional cost of project team resources at planning stage and abortive costs for surveys, modelling and other time dependent studies is estimated at £3m per annum.

Inflation costs – estimated at 5% per annum of estimated tunnel option cost (design and construction) including QRA P50%.



| Table 3.2 – Comparison of quantified risks & costs | | | Cost estimates and QRA risks | | | Land costs – for acquisition and compensation on Greenwich Peninsula | | | Differential risks from land-use and environmental impacts | | | Quantification of differential risks | | |
|--|-------------|---|------------------------------|----------------|------------------------------------|--|----------------------------------|--------------------------------|--|--|-------------------------------------|---|--|---|
| Tunnel type | Option Name | Description | A. Cost excl. All risks (£m) | B. QRA P50 (%) | C. Cost incl. QRA Risk at P50 (£m) | D. Land cost (£m) | E. Devaluation compensation (£m) | F. Total land costs (D+E) (£m) | G. Revised planning application for Greenwich Masterplan to reflect short tunnel options | H. Env. and associated objections to river impacts related to immersed tube option | I. Risk of planning consent refusal | J. Maximum delay from risks materialising | K. Cost of the delay (£m) (see note 1) | L. Cost range inclusive of Land-use & risks (£m) (see note 2) |
| Immersed Tube | Base | Original full length option with on-site casting | 469 | 14.2 | 535 | 3 | Nil | 3 | ✗ | ✓ | ✓ | 2 years | 6 + 55 = 61 | 538 to 599 |
| Immersed Tube | A | Original full length option with off-site casting | 427 | 14.2 | 487 | 3 | Nil | 3 | ✗ | ✓ | ✓ | 2 years | 6 + 50 = 56 | 490 to 546 |
| Immersed Tube | B | Shortened option with on-site casting | 434 | 14.2 | 495 | 18 | 44 | 62 | ✓ | ✓ | ✓ | 2 years (G & H could be coincident) | 6 + 57 = 63 | 557 to 620 |
| Immersed Tube | A + B | Shortened option with off-site casting | 391 | 14.2 | 447 | 18 | 44 | 62 | ✓ | ✓ | ✓ | 2 years (G & H could be coincident) | 6 + 52 = 58 | 509 to 567 |
| Bored | Base | Original full length option with cross-passages at up to 350m spacing | 423 | 13.8 | 482 | 5 | Nil | 5 | ✗ | ✗ | ✗ | Nil | Nil | 487 |
| Bored | C | Shortened option with cross-passages at up to 350m spacing | 412 | 13.8 | 468 | 18 | 44 | 62 | ✓ | ✓ | ✗ | 2 years | 6 + 54 = 60 | 530 to 590 |
| Bored | D | Shortened option with cross-passages at 100m spacing | 422 | 13.8 | 481 | 18 | 44 | 62 | ✓ | ✓ | ✗ | 2 years | 6 + 56 = 62 | 543 to 605 |
| Bored | E | Original full length option with cross-passages at 100m spacing | 437 | 13.8 | 497 | 5 | Nil | 5 | ✗ | ✗ | ✗ | Nil | Nil | 502 |

Notes:

1 The estimated land-use and environmental planning costs are the sum of the 'Prolongations & abortive costs' calculated at £3m/year and the 'Inflation costs' at 5% per year applied to the Cost including QRA P50% plus 'Total Land costs'.

2 The lower end of the cost range is the 'Cost incl. QRA Risk at P50' plus 'Land costs' and the upper end adds the 'Land use and environmental planning costs' to the lower end.

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3.3 Conclusions and Recommendation

This report summarises and compares the main bored and immersed tube tunnel options to inform the selection of a preferred option to progress to Concept Design stage (as defined in TfL Pathway). The report draws on findings and outputs of three separate but related studies which quantify and assess different aspects of the tunnel options.

As the findings and outputs are presented in both quantitative and qualitative terms (ref. Table 3.1) it was not possible to make direct comparisons between options. To address this incompatibility the qualitative land-use and environmental elements have now been converted into quantifiable measures of time and cost. This has enabled an overall cost range to be derived for each option which summates estimated costs and quantified risks encompassing design, construction, land-use and environment (ref. Table 3.2).

The quantified comparison indicates that the 'short' tunnel options involve significant planning risks which are likely to result in a significant delay to the programme and therefore add to the outturn costs. On this basis the 'short' tunnel options have been de-selected leaving the 'full length' tunnel options.

Of the 'full length' tunnel options the lowest cost bored and immersed tube variants are as follows:

- Immersed Tube – Option A – cost range £490m to £546m.
- Bored – Option Base – cost £487m (cross-passages at up to 350m centres)

However in view of the potential safety related objections related to cross-passage spacing in bored tunnels then it would be prudent to allow for Option E (with 100m spacing) as a worst case. The eventual design solution may result in acceptable cross-passage spacing between 100m and 350m and so the lowest cost bored tunnel option should be in the range £487-502m.

Comparing the lowest cost options the 'full length' bored tunnel appears to be the best option as it avoids the planning risks and consequential costs of associated with significant construction impacts on the River Thames. This reflects the views of the Port of London Authority who have recently confirmed their preference for a bored tunnel and likely opposition to an immersed tube option. Furthermore the Environment Agency and other environmental and river user groups/interests are likely to take a similar stance which will constitute a significant challenge at the planning consent stage. The onus would be on TfL to demonstrate why an environmentally damaging option had been selected over a less impactful option and there is no compelling argument even on cost grounds.

In light of these conclusions it is recommended that the 'full length' bored tunnel option be progressed to Concept Design stage with a focus on mitigating and minimising risks safety and construction risks.

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4 Appendix 1

1. E-mail dated 27th November 2013 from Royal Borough of Greenwich planners confirming informal views on the 'short' tunnel options.
2. Minutes of meeting between TfL and the Port of London Authority on 22nd November 2013 to ascertain PLA views on the main bored and immersed tube tunnel options and to discuss availability of river data and permit to work arrangements.