Assessment of Lower Thames Crossing Capacity
The Counties of Kent and Essex share the lower reaches of the River Thames as a common boundary but have never accepted that it should be a barrier to communication, accessibility and movement. It was the two County Councils, as highway authorities, that first promoted the idea of a crossing of the River Thames between Essex and Kent as far back as 1929, with a pilot tunnel completed in 1938. The authorities jointly produced the first road tunnel in 1963 with a second bore opening in 1980.

During this time traffic levels rose from an opening year flow in 1963 of 7m vehicles per year, rising to 11m with the second tunnel in 1980 and 35m in 1992 with the Queen Elizabeth II Bridge. A peak flow of around 45m vehicles per year was recorded between 2004 and 2006, when the highest daily flow of just under 182k was recorded on 23 July 2004. Current average traffic levels are about 145k vehicles per day.

Although formal responsibility for the crossings at Dartford was handed over to a private operating company in 1988, the two county councils remain committed to maintaining and improving the quality of the communications between the two counties across the River Thames. Consequently, the significant increase in traffic volumes and the degradation of reliable journey times on the crossing, due to congestion and incidents, has become a considerable concern, especially because of the adverse impact on the local economies and the achievement of regeneration objectives.

With the opening of the QEIll Bridge, the use of the crossings as part of the M25, and the opening of the Channel Tunnel, the role of the crossing has shifted significantly from the original local and regional connection to a vital national and international network connection. This is particularly evident with the use of the crossing by Dover and Channel Tunnel HGV traffic heading north of London.

Essex and Kent County Councils have become increasingly concerned that their objectives are not now being fully met and that they fail to act as a coherent economic area. A new crossing of the Thames is also needed to bring together the proposed growth in employment and housing in the immediate area of the Thames Gateway, Europe’s largest economic development area, looking to create 225,000 new jobs and 110,000 new homes by 2016. It is vital to connect the key locations of Canary Wharf, Stratford, London Gateway and Ebbsfleet Valley and unlock the huge potential of these sites. For example, the London Gateway container port and logistics park could generate some 16,500 new jobs. Consequently, in recent years the counties have lobbied for a clear policy and programme of improvements to River Thames crossings.

The Dartford Crossing is a Government responsibility and it was not clear when it was going to investigate the capacity of the Dartford Crossing and possible improvements. As a result the counties of Essex and Kent joined forces again and commissioned this study to consider pragmatic solutions which would not only relieve the traffic pressure at the existing crossing but also achieve the growth aspirations of the Thames Gateway area.

Meanwhile the Department for Transport have instigated their own larger study which will report after this work is completed.

The purpose of this report is not to duplicate or challenge the DfT study but to enable the counties to develop an independent view based on their own objectives.
## Contents

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6. Summary
1. Introduction

Gifford, MVA Consultancy and Capita have been appointed on behalf of Essex County Council (ECC) and Kent County Council (KCC) to undertake a preliminary assessment of the likely impact of additional crossing capacity of the Lower Thames.

ECC and KCC are concerned about continuing congestion at the existing Dartford - Thurrock Crossing and its approach roads, and wish to understand the opportunities that additional crossing capacity might bring to economic regeneration and land use change on both sides of the estuary. The assessment also includes other issues such as engineering feasibility, sustainability, environmental impact and affordability.

This work takes place against the backdrop of wider economic, social and environmental regeneration of the Thames Gateway area which is one of the Government's priorities for growth in the country.

1.1 Earlier Work Undertaken by the Councils

ECC and KCC identified six potential improvements – the provision of additional capacity at the existing Dartford – Thurrock Crossing and five options showing approximately where a new crossing could be located. These options were reviewed by the Councils in the form of a high level SWOT analysis that concluded two of the options were preferable and should be developed further.

1.2 Scope of this Study

This study has been based on existing and freely available information in order to meet the time constraints of the two authorities. The analysis and assessments undertaken are therefore based only on this information combined with experience gained in a number of similar studies. Obviously for such a large and potentially complex scheme the due planning processes will involve the need for extensive data collection across the full range of disciplines and an extensive analysis and assessment process in line with current and expected guidance. This study is a small step along that path, designed to inform the two authorities of the likely benefits, disbenefits, problems and opportunities of a range of possible options.

The study is split into two main phases, plus an initial Phase 0 to agree the objectives of the study with ECC and KCC and to understand the work already undertaken by the two authorities. The broad tasks within each phase are illustrated in Figure 1.1.

Phase 1 was reported in the form of a presentation and discussions with KCC and ECC. A summary is provided in Section 2. The remainder of this report covers Phase 2 of the study and the complete document forms the final report of this commission.

The initial scope covered the six options analysed by ECC and KCC in their earlier work plus two private sector schemes – Metrotidal and Sir Terry Farrell’s proposals. Following completion of Phase 0 we recommended that an additional option, located just downstream of the existing Dartford - Thurrock Crossing, be included.
2. Phase 1 Summary
2. PHASE 1 SUMMARY

2.1 Introduction
Phase 1 was reported in a presentation to ECC and KCC project officers.

2.2 Objectives
The objectives of Phase 1 were to:
- Identify the need for intervention, in terms of problems, constraints and opportunities;
- Identify performance indicators in line with objectives against which options can be assessed;
- Evaluate each of the options using the performance indicators to identify preferred options;
- Discuss the results with ECC and KCC to confirm the options to be taken into Phase 2 of the study.
2.3 The Need for Intervention

The primary need for an intervention across the Thames at or downstream of the existing Dartford – Thurrock Crossing is two-fold. Firstly, there is the need to improve the level of reliability and dependability of journey times on the M25/A282 across the River Thames for European (TEN-T), national, regional and local traffic including freight. Secondly, there is the need to improve connectivity between the growth areas in North Kent and South Essex where aspirations for managed economic growth are high.

The capacity of the existing Dartford - Thurrock bridge and tunnel crossing that completes the M25 and is part of TENS, is significantly overloaded for considerable periods of the working day. In addition, as with all estuarial crossings, any incident in the tunnels or on the bridge has a significant impact on the operational capacity of the crossings often resulting in closure of some or all traffic lanes. The consequential impact on the road networks of London, Kent and Essex is considerable and extensive; affecting the reliability and dependability of journey times across a wide area.

These impacts exacerbate the poor accessibility already experienced in south Essex and north Kent as a result of their estuarial and coastal locations. In addition, within this environment, effective public transport provision (other than radial rail services to London) is difficult to provide either commercially or through tendered services as demand is low unless fully integrated with new development as with Fastrack.

Plans exist to regenerate the areas through a number of delivery agencies (e.g. Thames Partnerships). The plans identify the need for and benefits of an additional Thames Crossing in the area (as illustrated in Figure 2.1) but currently the plans are predicated only on the existing Dartford - Thurrock Crossing. Therefore, there is the potential to realise other possibly greater opportunities opened up by an additional crossing that will further help achieve national, regional and sub-regional planning and transport policies.

The traffic levels per average day on the existing Dartford - Thurrock bridge and tunnel crossings have increased in recent years but at a lower rate than other motorways in southern England which suggests that demand is constrained by the available capacity.

Figure 2.2 shows the recent four years data and the related trend projection in blue, and a higher level forecast from the Naomi model in red. The widening transport gap illustrates the potential impact on economic vitality should no further capacity be provided across the Lower Thames.
Even with planned improvements to A2 and A13 and with current traffic levels, most of the area's main road network is overloaded, often by a demand/capacity ratio of 2 or more. The existing crossing experiences queues for, on average, 4 hours per day.

The existing Dartford - Thurrock Crossing is crucial to the overall integrity of the motorway network as it provides the only tenable link east of London. The only other crossing is 19km upstream. The network is designed to carry long distance trips by both private and commercial (freight) vehicles. Long distance car trips on the UK motorway network only account for less than 5% of the total trips but this translates into 30-40% of traffic movements (vehicle kms). Alternative routings to avoid the crossing generate considerably longer journeys and greater traffic levels elsewhere on the network.

Road freight from Dover and the Channel Tunnel to the north, and from Harwich and Felixstowe to the south and south-east relies on this crossing (Figure 2.4). There are initiatives to achieve more rail freight in the Channel Tunnel, but they may only at best slow the rate of growth in HGV traffic. A new crossing of the Thames, downstream from Dartford, would increase the use of the A2/M2 corridor in Kent for freight traffic travelling between Dover, the M11 and Harwich/Felixstowe.

The Components of Need

Any intervention will need to facilitate the achievement of the planning objectives relating to the economic, environmental, social and employment needs of the area. As such the intervention options need to be tailored to local circumstances rather than a ‘predict and provide’ approach.

To meet these requirements and achieve the overall objectives the following components will be necessary:

- to reduce congestion and improve the reliability and dependability of journey times;
- to ease local traffic congestion and associated problems;
- to result in a safer and more efficient corridor;
- to cater for future planned growth;
- to assist in enabling future regeneration and economic growth;
- to support public transport and other sustainable modes.

Furthermore, interventions should facilitate other improvements and proposals that would benefit the wider community and reduce the effects of traffic on communities.
2. Phase 1 Summary

2.4 Options

There are a number of possible intervention types that could be considered:

- Management options, such as national road pricing and tolls;
- Non-road based options, such as public transport investment;
- Infrastructure interventions.

The study recognises that both management options and public transport investment would be a key consideration in any further justification and business case for a new crossing infrastructure.

Rail

Phase 1 investigated the potential for a heavy rail crossing as it would affect the engineering design of a crossing. In south Essex the radial network and services become increasingly congested approaching London and there is a similar situation in north Kent although the improvements with CTRL and HS services will provide improved accessibility to the Medway towns through to Margate (Figure 2.5). The conclusion was that although there would be local economy and sustainable travel benefits, the scale of development and therefore the size of the potential market for crossing movements would not be great enough to cover service provision costs. This conclusion is influenced by the distances involved between communities and took account of planned development as well as the potential for increased development with a new crossing.

Metrotidal has proposed a rail crossing linking together the Abbey Wood and Shenfield branches of Crossrail to create a new loop including a Thames rail crossing. However, the majority of the new links this would create would be between predominantly residential areas and therefore the volume of trips likely to be generated would be insufficient to justify the substantial infrastructure investment involved. In addition, HS1 between Stratford and Ebbsfleet will provide a more attractive journey option between East London/Essex and North Kent. This route also has the potential for freight usage, although at present there is a limited rail market for this. In addition, the Metrotidal proposal would be difficult to achieve due to complex engineering required around Ebbsfleet International. Therefore, we conclude that the rail link proposed by Metrotidal is unlikely to be feasible or deliver sufficient benefits to justify the level of investment involved.

Possible Locations of New Crossing

A total of 9 possible locations for new infrastructure have been assessed in Phase 1. The options are as follows:

- Wennington – Dartford: this option would connect the A13 to the A206.
- Existing Dartford – Thurrock Crossing: this would involve improvements (e.g. in terms of widening) to the existing crossing.
- West Thurrock – Swanscombe: this option would connect the A126 to the A206.
- Grays – Swanscombe: this option would connect the A1089 to the A2 (west of Gravesend). The option would include a proposed link back to the M25 at a new junction between North and South Ockendon.
- Chadwell – Gravesend: this option would connect the A1089 to the A2 (east of Gravesend). The option would include a proposed link back to the M25 at a new junction between North and South Ockendon.
- Stanford-le-Hope – Gravesend: this option would connect the A13 to the A2 (east of Gravesend). The option would include a proposed link back to the M25 at a new junction between North and South Ockendon.
- Canvey – Grain: this option would connect the A130 to the A228. The option would include a proposed link to London Gateway.
- Shoeburyness – Sheerness (Sir Terry Farrell): this is a private sector proposal consisting of a multi-modal tunnel together with a tidal power plant and new flood defenses for London. The option would include a proposed link to London Gateway.
- Canvey – Halstow (Metrotidal): this is a private sector proposal consisting of a multi-modal tunnel together with a tidal power plant and new flood defenses for London. A map of the Lower Thames area showing the locations mentioned above is shown in Figure 2.6 overpage.

Form of crossing

Phase 1 considered the feasibility of bridges (suspension, cable stayed, causeway) and tunnels (bored tunnel and immersed tube) at each of the above crossing locations.
Figure 2.6 The Lower Thames Area
2.5 Performance Indicators for the Appraisal Process

An appraisal framework was developed based on a number of key performance indicators against which each of the options were assessed. The indicators were developed from a set of key scheme objectives drawn from national, regional, sub-regional and local policies and the overarching recommendations of the Eddington and Stern reports.

The key drivers from national transport strategy are:

- Towards a Sustainable Transport Strategy (TaSTS);
- Economic performance remains a high priority;
- Proposals to widen the rest of M25 will affect demand.

From TaSTS the new goals of the transport agenda were identified:

- Climate change;
- Competitiveness and productivity;
- Equality of opportunity;
- Health, Safety and Security;
- Quality of Life and the Natural Environment.

The sub-regional strategies (including those of the Thames Gateway Partnerships) identify the Thames as a barrier to growth and state that a new crossing would provide a “further stimulus to growth and an increase in freight capacity”.

Local policy documents highlight concern about local crossing capacity as well as identifying the adverse impacts of freight traffic on strategic motorways and trunk roads, particularly from Dover and the Channel Tunnel.

After reviewing the current policy framework and with a particular emphasis on the consultative TaSTS, a set of key scheme objectives were established, shown in green in Figure 2.7 overleaf (in no particular order)

The final performance indicators, shown to the right in the figure, provided a wide appraisal framework that considered both scheme impacts and delivery, and acted as the basis for option testing. The appraisal framework supports the SWOT analysis and the definition of the need for an intervention as well as linking back to the stated national, regional and local policies and objectives as shown in the far right-hand boxes in the figure.

The option testing and assessment against the performance indicators has been a combination of quantitative, using data readily available, and research and analysis, achievable within the timescale, and qualitative, based on professional judgement and experience.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low impact or high benefits</td>
<td></td>
</tr>
<tr>
<td>Medium impact/ medium benefit</td>
<td></td>
</tr>
<tr>
<td>High impact/dis-benefit</td>
<td></td>
</tr>
<tr>
<td>No information/ no significant difference</td>
<td></td>
</tr>
</tbody>
</table>
2. Phase 1 Summary

Figure 2.7 performance Indicators and Appraisal Process

- National Policy
- Towards a Sustainable Transport System
- Regional Spatial Strategies
- Regional Transport Strategies
- Sub-Regional Strategies
- Local Transport Plans
- Funding Priorities
- Regional Funding Allocation - Refresh
- NATA
- Local Performance Indicators
- Scheme Objectives
  - CONGESTION RELIEF
  - ECONOMIC VITALITY
  - ENVIRONMENT
  - ENGINEERING
  - AFFORDABILITY
  - ENABLING DEVELOPMENT & REGENERATION
  - SUSTAINABLE TRAVEL
- Performance Indicators
  - Dartford Crossing and Approaches
  - Local Congestion
  - Area-Wide Traffic Mileage
  - Managing Networks Better
  - Peak Traffic Flows to Urban Centres
  - UK Competitiveness & Productivity
  - Improving Transport Reliability
  - Improving Freight Movements
  - Greenhouse gases
  - Biodiversity
  - Local Air Quality
  - Contamination
  - Landscape & Townscape
  - Noise
  - Heritage
  - Water Environment
  - Feasibility
  - Political Acceptability
  - Impact on existing networks
  - Capital Cost
  - Funding Sources
  - Long Term Economic Activity
  - Improving Mobility
  - Social Inclusion
  - Communities
  - Changing Travel Behaviour
  - Promoting Sustainable Modes
  - Improving Accessibility
  - Improving Safety
  - Reducing Demand for Travel
  - Share of Sustainable Modes

LTPs RTS TaSTS
2.6 Performance

Introduction
This section summarises the performance of the various options against each of the performance indicators:

- Congestion Relief;
- Economic Vitality;
- Environment;
- Engineering;
- Affordability;
- Enabling Development and Regeneration;
- Sustainable Travel.
### Congestion Relief

A local highway network model was constructed to provide indicative traffic flows and congestion delay during 2008 and 2021 morning peak periods. Forecasts were based on current planned developments and network improvements. Travel choices were restricted to route and destination choice – the latter being less certain and only part of any induced traffic expected with additional capacity provided some distance from the current crossing.

The total 2021 flows across both existing and new crossings is shown in Figure 2.8 where level of congestion relief on the existing crossing is indicated by the purple element of each column. The West Thurrock – Swanscombe, Grays – Swanscombe and Chadwell – Gravesend options have the highest combined traffic flows. These three options also achieve the highest flow across the new crossing itself (Figure 2.9) measured either using just re-routed traffic or with additional redistributed traffic.

Some main and local roads will have reduced traffic and others will have increases depending on the option. Measuring the length of the network affected by a +or- 20% change in traffic flow only the Wennington – Dartford option would actually achieve a reduction in this mileage and therefore a reduction in congestion overall. The Canvey – Grain and Canvey – Halstow options are expected to cause the biggest increase in local congestion, partly because these crossings would not generate much reduction in traffic on the existing network (based on the current disposition of planned development).

Whilst changes brought about by re-routing alone would produce reductions on some approach roads such as A127 and western sections of A2 and M20, the additional re-distribution changes (where the new crossing will open up alternative destinations for many types of trip) will result in additional traffic on the immediate approach roads (A13, A2, A229 and A228) that will displace other traffic onto other routes such as A127 in south Essex and in north Kent onto A249 and M20 (where it nearly counterbalances the rerouting benefits).

Partly because they attract the highest new crossing flows, the Grays – Swanscombe, Chadwell – Gravesend and Stanford-le-Hope – Gravesend options create greater than 5% increase in area-wide traffic (vehicle kms), as shown in Figure 2.10. Improved accessibility will encourage development and more travel to existing urban centres, impacting on flows to those urban centres. The options are aimed at improving accessibility and regeneration, and therefore would probably increase traffic flows into urban centres. At this stage we cannot determine whether any option will generate more or less urban centre traffic than another option.

Overall, the assessment indicates that the West Thurrock – Swanscombe option best meets the objectives for relieving congestion, followed by the Grays – Swanscombe, Chadwell – Gravesend and Wennington – Dartford options.

<table>
<thead>
<tr>
<th>Description</th>
<th>Total Vehicle Kilometres</th>
<th>% Change in Vehicle KMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>1,018,823</td>
<td></td>
</tr>
<tr>
<td>Wennington - Dartford</td>
<td>1,038,309</td>
<td>1.9%</td>
</tr>
<tr>
<td>Existing Dartford - Thurrock Crossing</td>
<td>1,065,890</td>
<td>4.6%</td>
</tr>
<tr>
<td>West Thurrock - Swanscombe</td>
<td>1,066,053</td>
<td>4.6%</td>
</tr>
<tr>
<td>Grays - Swanscombe</td>
<td>1,090,258</td>
<td>7.0%</td>
</tr>
<tr>
<td>Chadwell - Gravesend</td>
<td>1,106,495</td>
<td>8.6%</td>
</tr>
<tr>
<td>Stanford-le-Hope - Gravesend</td>
<td>1,077,131</td>
<td>5.7%</td>
</tr>
<tr>
<td>Canvey - Grain or Halstow</td>
<td>1,050,718</td>
<td>3.1%</td>
</tr>
<tr>
<td>Shoeburyness - Sheerness</td>
<td>1,048,571</td>
<td>2.9%</td>
</tr>
</tbody>
</table>
Economic Vitality

The existing Dartford - Thurrock Crossing is crucial to the overall integrity of the motorway network (European, national and regional) as it provides the only tenable link east of London. Note that this assessment excludes consideration of a Thames Gateway Bridge. On the UK motorway network long distance car trips only account for less than 5% of the total number of trips but this translates into 30-40% of traffic movements (vehicle kms). Alternative routings to avoid the crossing generate considerably longer journeys and greater traffic levels elsewhere in the network. Road freight from Dover and Channel Tunnel to the north, and from Harwich and Felixstowe to the south and south-east relies on this crossing. Figure 2.11 shows the volume (‘000s) of HGV movements per day.

The existing Dartford – Thurrock Crossing is one of the busiest sections of the M25 carrying nearly 150,000 vehicles on average every day, with up to 30% of traffic by period being goods vehicles. The existing crossing is part of the Trans-European Transport Network (TEN-T) and with M20 and A2 forms part of the Dover/Channel Tunnel road freight route to the majority of the UK. The existing Dartford - Thurrock Crossing currently suffers from poor journey time reliability with queues on the crossing experienced on average for 4 hours a day.

A reduction in congestion at the existing Dartford - Thurrock Crossing will bring about improved journey time reliability and dependability on the M25, the strategically important approach roads such as A2, M20 and A13, and their junctions. Options that provide the most traffic relief at the existing crossing by re-routing traffic would be preferable in terms of economic vitality. In response to the projected increase of cross-channel lorry traffic through Dover Port and the impacts on the A20 through the town, it is proposed that traffic using the Eastern Docks be routed along the M2/A2 and traffic using the Western Docks along the M20/A20. Therefore, a new crossing will also act as a catalyst for this bifurcation of strategic traffic to and from Dover.

The West Thurrock – Swanscombe, Grays – Swanscombe and Chadwell – Gravesend options produce the greatest reduction in traffic on the existing crossing with current planning proposals and so best meet the economic vitality objective.
Environment

The environmental performance of each of the options was evaluated in terms of a number of different aspects:

- Biodiversity;
- Heritage;
- Landscape;
- Hydrodynamics;
- Contaminated Land;
- Local Air Quality;
- Noise;
- Greenhouse Gases.

These can be divided into those disciplines that are affected by land take i.e. dependent on crossing type, and those where the impact is similar irrespective of the type of crossing.
The Thames Estuary and surrounding area is extremely sensitive in terms of nature conservation. Most importantly, a significant area of the land adjacent the estuary, to the north and south, is designated as a Special Protection Area (SPA) and a Ramsar site (International designations), as shown in Figure 2.12.

There is strict legislation and guidance in place in terms of protecting SPAs and Ramsar sites and significant planning constraints surrounding any direct impact on them. This constrains development in terms of the type of crossing that can be considered for the options further east along the estuary, i.e. Chadwell – Gravesend, Stanford-le-Hope - Gravesend, Canvey - Grain, Canvey - Halstow and Shoeburyness - Sheerness, especially on the Kent side of the estuary. This means that a bridge or immersed tube, which would involve a direct impact on the designated areas in terms of land take, are unlikely to be feasible; particularly in the case of Canvey – Grain, Canvey – Halstow and Shoeburyness – Sheerness options, where this would involve a large area of the SPA and Ramsar site being affected. The Chadwell – Gravesend and Stanford-le-Hope – Gravesend options would still have an impact on the Ramsar site in terms of a bridge or immersed tube option, but would affect a much smaller area.

In terms of the planning process, a Habitat Regulation Assessment will be required if there are likely significant impacts on the SPA or Ramsar site. This must demonstrate that in terms of the proposed crossing there is:

- No alternative;
- An imperative reason of overriding public interest;
- Appropriate compensation will be provided for the habitat lost.

Although the above designations are a constraint and must be acknowledged, this does not preclude development in this area, and a bored tunnel, which would run underneath the protected areas could be a feasible solution.

Another significant consideration is the potential heritage impact. The marshland in the area of the Thames estuary has been managed from prehistoric times and is known to contain prehistoric remains. Of particular consideration are Swanscombe Marshes, the prehistoric beaches at Blythe Sands and undisturbed marshland (the SPA area). Again, this does not preclude development, but avoidance or mitigation would be required. A bored tunnel option would reduce the impact on the more important beach and marshland areas nearer the estuary by tunneling underneath them.
Other aspects that are affected by land take include hydrodynamics, landscape and contamination. The hydrodynamic nature of the estuary increases towards the east, and has helped to shape the marshes and therefore designated areas (see Figure 2.13). A bored tunnel would avoid an impact on the hydrodynamics of the estuary. If structures are proposed to be placed in the channel, for example bridge piers, hydrodynamic modeling would be required to assess the likely impact of these.

There are a number of Metropolitan Green Belts in the area (shown in Figure 2.14) which affect the following options: Wennington – Dartford, Chadwell – Gravesend, Stanford-le-Hope – Gravesend, Canvey – Grain and Canvey - Halstow. There is also an Area of Outstanding Natural Beauty (AONB) in Kent which may be impacted by the Chadwell – Gravesend and Stanford-le-Hope – Gravesend options. Although a bored tunnel may reduce some of the impact, the approach roads or tunnel openings would impact the green belt areas, and potentially the AONB in the Chadwell – Gravesend and Stanford-le-Hope – Gravesend options, and would need consideration.

The risk of contamination is greater in the more industrialized areas, both current and historic. This will impact on design and cost, in terms of any mitigation (both during construction and operation) or remediation that is required. Any remediation that is undertaken would result in a beneficial impact in terms of the local environment.
In terms of air quality, noise and greenhouse gases, impacts are linked to the traffic generated by each option. Each of the options produce both adverse and beneficial impacts. Beneficial impacts are generated where congestion is relieved on the existing Dartford - Thurrock Crossing, and other related links, with corresponding improvements in Air Quality Management Areas (AQMA, shown shaded pink in Figure 2.15). However, adverse impacts are caused on the new crossing and its approach; and on links experiencing increased traffic as a result of re-routing and additional trips generated. Again, in terms of air quality, this is likely to cause a worsening of some AQMAs.

The options that tend to perform better in terms of congestion relief on the existing Dartford = Thurrock Crossing and economic vitality (West Thurrock – Swanscombe, Grays – Swanscombe and Chadwell - Gravesend) tend to perform worse in terms of air quality, noise and greenhouse gases, due to re-routing and the redistribution of journeys.

Overall, environmental considerations do not preclude development at any option location. However, they are extremely important in terms of determining constraints in certain locations, and for some options, the type of crossing that should be proposed, i.e. bridge or bored tunnel. Environmental considerations will need to be considered further and will be an important element of the planning process, in terms of undertaking an Environmental Impact Assessment and potentially a Habitat Regulation Assessment. They will also be very important in terms of design considerations and the incorporation of mitigation measures to reduce adverse impacts and the inclusion of enhancements where possible.

Consultation with statutory consultees is recommended in any further work, for example with Natural England, Environment Agency, English Heritage and the Port Authorities.
Table 2.2 Summary of Tunnel Requirements

<table>
<thead>
<tr>
<th>Option</th>
<th>Route length</th>
<th>River width</th>
<th>Tunnel length (below 35m ODN)</th>
<th>Estimated approach road/rail</th>
<th>Estimated total length road/air</th>
<th>PLA Headroom requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wennington - Dartford</td>
<td>5km</td>
<td>750m</td>
<td>3km/4km</td>
<td>3.5/4.5km</td>
<td>54m</td>
<td></td>
</tr>
<tr>
<td>Existing &amp; W. Thurrock - Swanscombe</td>
<td>4km</td>
<td>750m</td>
<td>3km/4km</td>
<td>3.5/4.5km</td>
<td>54m</td>
<td></td>
</tr>
<tr>
<td>Grays - Swanscombe</td>
<td>6.5km</td>
<td>1150m</td>
<td>700/1200m</td>
<td>5km/7km</td>
<td>76m</td>
<td></td>
</tr>
<tr>
<td>Chadwell – Gravesend</td>
<td>10km</td>
<td>1250m</td>
<td>750/1200m</td>
<td>6km/8km</td>
<td>90m</td>
<td></td>
</tr>
<tr>
<td>Stanford-le-Hope – Gravesend</td>
<td>12km</td>
<td>1250m</td>
<td>750/1200m</td>
<td>6km/8km</td>
<td>90m</td>
<td></td>
</tr>
<tr>
<td>Canvey - Grain</td>
<td>14km</td>
<td>2700m</td>
<td>1400/2240m</td>
<td>6km/8km</td>
<td>90m (assumed)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.1 Summary of Bridge Requirements

<table>
<thead>
<tr>
<th>Option</th>
<th>Route length</th>
<th>River width</th>
<th>Bridge span/length</th>
<th>Estimated approach road/air</th>
<th>Estimated total length road/air</th>
<th>PLA Headroom requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wennington - Dartford</td>
<td>5km</td>
<td>750m</td>
<td>450/720m</td>
<td>4km/5km</td>
<td>54m</td>
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<tr>
<td>Existing &amp; W. Thurrock - Swanscombe</td>
<td>4km</td>
<td>750m</td>
<td>450/720m</td>
<td>4km/5km</td>
<td>54m</td>
<td></td>
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<tr>
<td>Grays - Swanscombe</td>
<td>6.5km</td>
<td>1150m</td>
<td>700/1120m</td>
<td>5km/9km</td>
<td>5km/7km</td>
<td>76m</td>
</tr>
<tr>
<td>Chadwell – Gravesend</td>
<td>10km</td>
<td>1250m</td>
<td>750/1200m</td>
<td>6km/9km</td>
<td>90m</td>
<td></td>
</tr>
<tr>
<td>Stanford-le-Hope – Gravesend</td>
<td>12km</td>
<td>1250m</td>
<td>750/1200m</td>
<td>6km/9km</td>
<td>90m</td>
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<tr>
<td>Canvey - Grain</td>
<td>14km</td>
<td>2700m</td>
<td>1400/2240m</td>
<td>6km/8km</td>
<td>90m (assumed)</td>
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</tbody>
</table>

Engineering

Table 2.3 (over page) summarizes the feasibility of bridge and tunnel crossing types for each of the route options.

Widening of the existing Dartford - Thurrock Crossing, is considered difficult in engineering terms due to both the physical constraints surrounding the existing infrastructure and the challenges involved in either widening of the existing bridge or the accommodation of an adjacent structure. Also, there would be significant disruption to traffic during construction, which is likely to take two to three years. These constraints mean that a change to the existing Dartford – Thurrock Crossing is not considered to be a viable option.

One of the Port of London Authority’s (PLA) requirements is that any structure constructed within the riverbed should not interfere with the river flow. This would mean that the top of the immersed tube would need to be below the riverbed resulting in a dredging depth of approximately 13m. An initial assessment in Phase I has revealed that the cost of dredging to this depth together with the cost of creating stable slopes either side would be much greater than that for a corresponding bored tunnel. It was therefore decided that an immersed tunnel would not provide a cost effective solution and this crossing type was not pursued further.

Cable stayed bridge and bored tunnel construction are technically feasible for all of the options, although there are difficulties associated with the provision of rail, due to the gradients that would need to be achieved on the approach lines. There are also some challenges if a dual 3 road is required in terms of a bored tunnel, although these could be overcome with additional investment.

Table 2.1 and 2.2 summarise the key variables in terms of a cable stayed bridge and bored tunnel for various options. For the bridge option, this also includes the PLA’s headroom requirement, which increases from 54m at the Wennington - Dartford option to 90m for the following options: Chadwell – Gravesend, Stanford-le-Hope – Gravesend and Canvey - Grain. The length of bridge/tunnel increases from west to east due to the increasing width of the river.

The bored tunnel option offers particular opportunity to reduce the environmental impact on the more easterly alignments as it can be lengthened to underpass the environmentally protected areas. A bridge crossing, however, would be sizable and could present an opportunity to provide a landmark which could serve to add significant identity to the area and provide a focal point for its future development and regeneration. Its form would need to be developed to harmonize with the surrounding environment.

All of the route options have a relatively similar combination of ground conditions. The planning, design and construction within the alluvial deposits will form a significant challenge in each case. The selection of the option will also need to consider the impact of construction on the river flood defences. The design of any tunnel portals will need to provide sufficient protection against flooding of the tunnel following extreme flood events from the River Thames, taking due account of rising sea levels and the impact of climate change.

Affordability

The capital costs are considered in Phase 2, however, in general terms, the majority of the cost will be in the construction of the crossing, rather than the approach roads. The options will get increasingly more expensive the further east you locate it along the estuary due to the width of river that needs to be spanned/tunnelled under.
## 2. Phase 1 Summary

### Table 2.3 Feasibility of Bridge and Tunnel Crossing for Different Route Options

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**Legend:**
- **Y** Feasible
- **D** Difficult

Table 2.3 Feasibility of Bridge and Tunnel Crossing for Different Route Options
Enabling Development and Regeneration

Overall the Thames Gateway region has an expanding economy, but there are major pockets of social and economic deprivation particularly in:

- Grays/Tilbury;
- South Ockendon;
- Southend on Sea;
- Basildon;
- Chatham;
- Gravesend;
- Sheerness and Leysdown on Sea.

Accessibility modelling has been undertaken to assess the change in accessible jobs using an average commuting time of 20 minutes. Access to jobs within the 2021 Thames Gateway Development Plans, which includes the planned London Gateway development, has been modelled for Basildon, Rochester / Chatham / Gillingham, Southend on Sea, and Tilbury. Across the four towns, the Chadwell – Gravesend, Stanford-le-Hope – Gravesend and Canvey – Grain or Halstow options would allow 90% more jobs to be accessible to residents within average commuting times. The 20 minute commutable area from Rochester/Chatham/Gillingham is shown in pink in Figure 2.16 for the existing crossing and Figure 2.17 for the additional crossing at either Chadwell or Stanford-le-Hope - Gravesend, illustrating that areas of south Essex including London Gateway would come within commutable range for these areas of north Kent.

Looking at car ownership levels and indices of multiple deprivation for the Kent and Essex Thames Gateway regions (see Figure 2.18), we have identified areas of existing deprivation and low car ownership, such as Tilbury and the Isle of Sheppey, that would benefit from a new crossing by improving mobility and increase social inclusion. Linking areas of low car ownership presents the opportunity for new public transport services to be introduced and integrated with a new crossing and with new development.

The Wennington – Dartford, Existing Dartford – Thurrock Crossing, Grays – Swanscombe and Chadwell – Gravesend options are directly connecting deprived areas that are already developed, thus improving connectivity, although the Shoeburyness – Sheerness option does as well but with a much longer new connection that is also providing access to associated high income developments.

Overall the Chadwell – Gravesend option best meets the objective of enabling development and regeneration, followed by the Grays – Swanscombe and Shoeburyness – Sheerness options.

The above analysis is based on the current plans to regenerate the area through a number of delivery agencies (e.g. Thames Partnerships). The plans identify the need for and benefits of an additional Thames crossing in the area but currently the plans are predicated only on the existing Thurrock – Dartford Crossing. Therefore, the potential to realise other possibly greater opportunities by an additional crossing needs further examination. Given the extent of current development, The Chadwell or Stanford-le-Hope - Gravesend options and the Canvey - Grain or Halstow options provide opportunities for additional development and/or new communities, subject to the usual planning restrictions, adjacent to the new infrastructure in both north Kent and south Essex.
2. Phase 1 Summary

Increased Access to Jobs

Measuring the increased opportunities provided by an additional crossing, and accessibility analysis shows that for the Chadwell–Gravesend option (Figure 2.19) an additional 200,000 people and about 100,000 jobs would be within a 20 minute journey time of the two crossing points. For the Canvey – Grain option (Figure 2.20) the improved 20 minute journey time accessibility would affect 350,000 people and about 150,000 jobs. This assessment includes estimates of 16,500 jobs being provided at the London Gateway port by 2021.

The more easterly options of Chadwell – Gravesend, Stanford-le-Hope - Gravesend and Canvey - Grain would provide significant benefits in terms of access to jobs at London Gateway, not just for those in the immediate area but also by providing a link between the site and labour markets in north Kent.

Sustainable Travel

Any new cross river link will need to be part of an integrated strategy that includes the provision of public transport services across the river that connect well with the communities either side.

Local rail passenger demand across the river is unlikely to be large enough to generate enough revenue for the provision of a viable service. However, there are good opportunities to provide high quality bus or light rail systems across the river. Kent has the existing Fastrack quality guided bus network and there are similar aspirations for the South Essex Rapid Transit (SERT) system. Linkages between the two are easily possible in the short term with extensions into adjacent towns and developments such as London Gateway (see Figure 2.21). Ultimately the network can be upgraded to a light rail system. The widening of the existing Dartford - Thurrock Crossing and the Grays – Swanscombe options provide the greatest opportunity for linking Fastrack and SERT services. The Chadwell or Stanford-le-Hope - Gravesend options link well in Essex but easy connection at Gravesend may be difficult.

Results from the accessibility analysis suggest that the Chadwell or Stanford-le-Hope - Gravesend options (Figure 2.21) with new crossing with new crossing between Chadwell and Gravesend and the Canvey - Grain or Halstow options would improve accessibility across the estuary between target communities. The impacts of the Wennington – Dartford, widening of existing Dartford - Thurrock Crossing, the Grays – Swanscombe option and the West Thurrock – Swanscombe options on increased accessibility is only marginal due to their close proximity to the existing Dartford - Thurrock crossing.

Improving safety is an important objective and one that will require more detailed analysis than has been possible in this study. Therefore it is left unmarked as there is no indication at this stage whether any option would perform better than any other.

One of the main planning objectives for south Essex and north Kent is to enable development in order to regenerate the areas. A new crossing can help achieve these objectives and indeed can also open up new areas thought inaccessible for new development. However, the net outcome will be increased demand for travel in total within the area, but many opportunities exist to offset this with an increase in the share of travel on sustainable modes. New high quality bus networks can be incorporated into an integrated strategy including a new crossing to link together the public transport networks on both sides of the river. Generally those options in the west (Wennington – Dartford, existing Dartford - Thurrock Crossing, West Thurrock – Swanscombe, Grays – Swanscombe, Chadwell – Gravesend and Stanford-le-Hope - Gravesend) will have a better chance of meeting this objective, given current public transport networks.

In summary, improving the existing Dartford - Thurrock Crossing, or the Grays or West Thurrock – Swanscombe options present the best opportunities for improving sustainable modes on the crossings by linking into existing or proposed quality bus routes. The Chadwell or Stanford-le-Hope - Gravesend, Canvey - Grain or Halstow and Shoeburyness – Sheerness options improve accessibility significantly across the estuary.
## 2. Phase 1 Summary

### 2.7 Conclusions

The Wennington – Dartford option, improvements to the existing Dartford - Thurrock Crossing and the West Thurrock – Swanscombe options are likely to have less significant environmental impacts in terms of biodiversity as they would be constructed in an existing built environment. The Wennington – Dartford option, however, would only connect with local roads and it would not relieve congestion on the existing crossing or its wider network. The option to improve the existing Dartford – Thurrock Crossing would increase capacity at the existing crossing but presents significant design and construction difficulties.

The West Thurrock – Swanscombe option along with the Grays – Swanscombe and Chadwell – Gravesend options would attract re-routed and re-distributed traffic to generate a significant reduction in flow, and therefore also congestion, on the existing crossing. The levels of flow on the new crossing warrant a dual 2 lane carriageway. For these reasons and their good connectivity to the A13 and A2, The West Thurrock or Grays – Swanscombe and Chadwell – Gravesend option would be the best meet the economic vitality objective and enable development and regeneration (with the proviso that for the latter the West Thurrock or Grays – Swanscombe options do not directly link with target areas on both sides of the river). The Grays – Swanscombe option would have a more significant vehicle emissions impact resulting from the greater level of re-routed traffic.

The Stanford-le-Hope option is a contrasting variant of the Chadwell – Gravesend option, with an eastern-routed connection to the A13 and as such would be less attractive to crossing traffic and less directed towards the regeneration areas, although it would improve the connections to London Gateway. In addition to significant vehicle emission issues, both the Chadwell – Gravesend and the Stanford-le-Hope options would affect an Internationally designated site (Ramsar) if constructed as a bridge crossing. A bored tunnel construction is likely to overcome this issue. The Canvey - Grain or Halstow and the Shoeburyness - Sheerness options would have significant environmental impacts if they are implemented as a bridge crossing, predominantly in terms of their direct impact on a significant area of the SPA and Ramsar site. They would also not achieve the improvements in local congestion and sustainable travel. Other than the Canvey - Grain or Halstow options improving connections to London Gateway they, and the Shoeburyness - Sheerness option, would not meet the economic vitality objective based on the location of new development in the current plans.

However, these development plans for the area are not predicated on there being a new river crossing (at any location). Significant opportunities would open up with the Canvey - Grain or Halstow and Shoeburyness - Sheerness options for different and/or additional development areas to be pursued. To ensure accessibility to existing and new communities and employment opportunities either side of the river, the Canvey - Grain or Halstow options would offer more scope.
A cable stayed bridge or bored tunnel option is feasible in engineering terms at each of the option locations, although environmental constraints dictate a bored tunnel where the SPA and Ramsar are impacted. The engineering feasibility, including the form of junctions and costs are reported in more detail in Phase 2.

Overall, against the performance indicators and using current development plans and locations, the Grays – Swanscombe and Chadwell – Gravesend options show the greatest potential to meet the required objectives. This answers the question: given current development plans where would it be best to pursue an additional crossing of the Thames that addressed the need and met the necessary policy objectives?

The next question is: where else could an additional crossing of the Thames be located to open up new development opportunities that could provide greater benefits in addressing the need and meeting the policy objectives? The assessment indicates that the Canvey - Grain option in bored tunnel form (to reduce the impact on the SPA and Ramsar) would provide that opportunity.

Consequently the Grays – Swanscombe, Chadwell – Gravesend and Canvey – Grain options have been taken forward to Phase 2 of the study. In addition, a variation of the Stanford-le-Hope – Gravesend option, aligning towards the west, rather than east towards Stanford-le-Hope on the Essex side, is considered worthy of further investigation and has been taken forward into Phase 2.
3. Phase 2 Options
3. PHASE 2 OPTIONS

3.1 Introduction

As summarised in Section 2, the following options were taken forward into Phase 2:

- Grays – Swanscombe;
- Chadwell – Gravesend;
- Stanford-le-Hope – Gravesend (variant - aligning west on Essex side);
- Canvey – Grain.

The Grays – Swanscombe, Chadwell – Gravesend and Stanford-le-Hope – Gravesend (variant) options passed through Phase 1 using current and planned development and current policy framework. The Canvey – Grain option was included in Phase 2 to demonstrate the regeneration opportunities that may exist should the planning and policy background change in light of a new crossing.

Due to environmental constraints identified in Phase 1, the following types of crossing were considered in Phase 2 for the above options:

- Grays - Swanscombe – bridge or bored tunnel;
- Chadwell/Stanford-le-Hope - Gravesend - bridge or bored tunnel;
- Canvey - Grain – bored tunnel.

Phase 2 specifically addressed the following for the above:

- Engineering - form of crossing and full scheme cost;
- Funding sources and opportunities.
4. Engineering Feasibility
4. ENGINEERING FEASIBILITY

4.1 Introduction

Within Phase 1 of the study structural options for crossing the river were considered and discussed, and contemplation given to both bridge and tunnel structures.

In terms of capacity requirements, it was concluded in Phase 1 that a dual 2 crossing would be sufficient based on current known and planned development and the current policy framework. This section therefore assumes a dual 2 crossing. If further capacity is thought to be required in the future (e.g. dual 3) a bridge could be designed to be future proofed for widening. This would be more difficult for a bored tunnel. Evaluation would need to undertaken to balance any initial investment against the likelihood of the need to widen.

For bridge structures the main span required would be technically feasible in either suspension bridge or cable stayed bridge form for the Grays – Swanscombe, Chadwell – Gravesend and Stanford-le-Hope – Gravesend options. However the span would be at the lower end of modern suspension bridge construction and such an approach would incur significant cost and risk issues potentially influencing deliverability. As a consequence it was concluded for the route options under consideration that a cable stayed bridge would be most appropriate.

The largest span cable stayed bridge in the world is Sutong in China with a main span of 1088 metres, greater than that envisaged as being necessary for a new Lower Thames Crossing.

Bored tunnels were also identified as appropriate engineering solutions, particularly for Canvey - Grain, where environmental constraints dictate that a bored tunnel would be required to tunnel under internationally designated sites.

Consideration of the above in terms of structural form and cost follows.
Bridge Structure Option

Based upon the span and navigational requirements identified within the Phase 1 study, the most appropriate and economic form of bridge construction over the river, for the Grays – Swanscombe, Chadwell – Gravesend and Stanford-le-Hope – Gravesend options, is considered to be a combination of a cable stayed bridge and multi-span approach viaducts. The cable stayed bridge would likely consist of a main span, and two side spans with length of approximately 30% to 50% of the main span. The cable stayed bridge would most likely be structurally independent of the approach viaducts.

The construction of a cable stayed bridge typically uses a cantilever approach broadly as follows:

- Construct foundations;
- Construct pylons and end supports;
- Erect cantilever segments progressively and in balance around each pylon gaining support from each pair of cables;
- Connect at midspan;
- Install finishes.

Alternatively, the side spans could be built first with the back stays installed prior to constructing the main span. In either case, there would be no need for temporary supports over the river to obstruct the navigational span during the construction. The prefabrication of deck segments would also help to reduce the risk of contaminating the river during the works.

Since all the load from the deck is brought back to the two main towers, the construction of these elements would significantly influence the overall economics of the structure. Different structural forms can be considered for the towers to fulfil the required aesthetics and functionality, e.g. ‘A’, ‘H’, inverted ‘Y’, diamond shape, or hollow vertical masts. The stay cables could be arranged in one plane, or in two parallel or inclined planes. The geometric pattern of the stay cables would need to be carefully studied to satisfy both structural efficiency and aesthetics of the bridge. In addition to the two main towers, 2 to 4 piers would be required under each side span to act as anchors to the back stays.

Caissons are considered likely to be the most appropriate form of foundation for the main towers and would require to be designed to resist vessel collision loads. Caissons could be cast in a dry dock, floated, transported, sunk and subsequently filled with concrete to form the base for the main towers. The smaller foundations for the side span piers within the river can be constructed by means of cofferdams made of sheet piles, and where necessary plugged with concrete placed under water. They would also need to be designed for vessel collision load albeit with a much smaller magnitude compared with that applied to the caissons. Piled foundations could also be considered and would be appropriate for the inland back span piers.
The main span could be formed in either steel or concrete but in order to reduce weight a steel deck is considered likely to be the most appropriate. This could be made of prefabricated torsionally stiff steel segments using orthotropic steel plates or alternatively reinforced concrete slab as part of a steel composite structure as was used on the Second Severn Crossing as illustrated above. The deck segments can be lifted up from the ground or river, put in place and bolted together. If found necessary and in order to mitigate the adverse wind effect and increase bridge stability, the deck can be made of two separate box girders connected by vertical diaphragms placed at equal intervals. The side spans can be constructed of either steel or prestressed concrete box segments. The latter has the advantage of providing a more efficient anchor for the stay cables. It also results in a better fatigue performance of the stays and could enhance the aerodynamic stability of the deck.

Each approach viaduct could be formed in either posttensioned concrete or as steel composite construction.

As a concrete structure this would be composed of a number of independent continuous multi-span prestressed concrete bridges with similar span lengths in the range of 80m to 120m. The actual span lengths will be determined by ground features and overall economics depending on the pier height and foundation cost. An appropriate form of construction for the approach viaducts would be the balanced cantilever method. In this method, the deck segments are added at each end of opposing cantilevers by maintaining the whole structure in balance and avoiding instability. The segments would generally consist of concrete boxes constructed either in situ within a travelling false work system established at the tip of each cantilever, or are precast at a remote location and brought to their final position for joining with its predecessor.

Due to the relatively long length of the approach viaducts, the use of travelling gantry to place the precast segments is considered to be cost effective. The deck could be supported on hollow concrete piers via pier heads and bearings. The foundations for the piers are anticipated to consist of pile caps supported on end bearing piles.
Bored Tunnel Option

Bored tunnels constructed using a Tunnel Boring Machine (TBM) is a well established construction technique and is adaptable to working in a range of different ground conditions. Based on an initial assessment it has been concluded it is an appropriate form of construction for the ground conditions likely to be encountered for the Grays – Swanscombe, Chadwell – Gravesend, Stanford-le-Hope – Gravesend and Canvey – Grain options.

This method has the advantage of minimising the disturbance to surrounding soil, thus, making it particularly suitable for use in built-up areas or for passing beneath environmentally sensitive areas. It also produces a smooth tunnel surface, thus reducing the cost of lining the tunnel and minimising the overdig and overbreaks. The construction of bored tunnel by TBM is most efficient where a homogeneous ground is present. In this study the crown of bored tunnel is assumed to be approximately 15m below the riverbed where the tunnel would be mostly bored through the Upper Chalk or London Clay.

Within this form of construction the cutting of the tunnel is performed using either cutters or scrapers and discs in an enclosed inside shield heading. The shield is pushed forward by means of jacks thrusting against the launching shaft at the beginning of the tunnel boring process and, subsequently, against already installed linings. The steering of the shield is controlled by applying different pressures to the jacks installed along shield's perimeter. After each stroke the hydraulic pistons of the jacks are retracted in such a way that an additional slice of lining is added under the protection of shield tail. During the subsequent advance stroke, the tail gap is filled with grout. Typical advance rates are 0.5m to 2m per hour. It is anticipated that the chalk will be water bearing so that the TBM will have to operate in a closed mode, using either “Earth Pressure Balance” or “Slurry Balance” to secure face stability. It is envisaged that the segmental linings would need to be watertight.
For a dual 2 lane highway, two separate tunnels would be required, one for each traffic direction. The tunnel would therefore be a twin-bore tunnel with a bore diameter of 13m required to accommodate the carriageway width, ventilation and safety requirements. This diameter is well within the range of existing technology and comparable to recently constructed tunnels such as, the Dublin Port Tunnel or that on the Zurich Bypass.

The bores would have circular cross-sections and it is likely the cross passages between the tunnels would need to be considered in the design to ensure safe operation of the tunnel. These passages are typically sealed and in the event of an emergency pressurised to prevent the inflow of smoke or noxious gasses. Typically, an incident in one tunnel would necessitate traffic being stopped in the other to enable this corridor to be used in order to evacuate and provide access for the emergency services. Construction of cross passages could require specialist ground treatment.

A bored tunnel option is likely to be shorter than the corresponding bridge structure on the same alignment (not taking into account environmental constraints), although an appropriate site would need to be available for the disposal of excavated material.

**Approach Cut and Cover Tunnels**

At either end of the bored tunnel where the depth of soil cover becomes too shallow for TBM operation (typically less than the diameter of the tunnel), the tunnel is constructed by cut and cover. Generally, two methods can be considered for constructing the cut and cover structure. In the first method a trench is excavated and supported as necessary, and the tunnel is constructed within the trench. The tunnel could be constructed using in situ or precast concrete and is subsequently backfilled. In the second method ground support walls and capping beams are constructed from ground level, using secant, diaphragm contiguous bored piling. A shallow excavation is then made to allow the tunnel roof slab to be constructed using precast beams or in situ concrete allowing for access openings for lowering excavator machinery. The soil excavation below the roof slab is subsequently carried out followed by constructing the base slab.
4.2 Grays – Swanscombe Option

This route option is approximately 6.5km long and connects the A1089 to the A2. Junctions will need consideration in terms of connecting to the existing highway network. The width of the Thames in this area is approximately 1150m. It is envisaged that both bridge and bored tunnel crossings would be technically feasible for this option.

Structure Consideration

Bridge Structure Option

From consultation with the PLA the navigational headroom required in this area is 76m. In addition the PLA’s initial advice was to provide a navigation width equal to that between existing piers and jetties on the river, thus giving a required clear span of 700m for a bridge crossing. An economical form of construction would be a combination of a cable stayed bridge and two approach viaducts. The overall length of the cable stayed bridge would be 1120m consisting of a main span of 700m and two 210m long side spans. Assuming a maximum gradient of 4%, each approach viaduct would be approximately 950m long resulting in total bridge structure length of approximately 5km.

The approach viaduct on the north bank would be placed such as to minimize clashing with any existing buildings and planned housing developments. With a required navigational headroom of 76m, the north approach would conveniently span over many existing obstacles such as existing roads and railway lines.

On the south bank the approach viaduct would also span over many existing obstacles such as existing transmission lines, roads and railway lines. Significant constraints may need to be overcome such as any proposed development in the area.
Grays - Swanscombe Layout

4. Engineering Feasibility

BRIDGE OPTION

BORED TUNNEL OPTION

2km

1.1km

2km

3.5km (Tunnel Length)
Bored Tunnel Option

This crossing option can alternatively be procured by constructing twin tunnels under the River Thames using Tunnel Boring Machines (TBM). Assuming that the crown of tunnels is approximately 15m below the riverbed and considering a maximum gradient of 4%, the tunnels would be approximately 3.7km long. At the maximum depth of 35m below ODN the tunnel would be mainly bored through a chalk layer. Tunnelling would enable the avoidance of structures such as railway lines, roads and power lines.
Geotechnical Consideration

There is one significant marsh on the south side of the river (Swanscombe Marshes) and extensive presence of alluvial deposits on the north side. The presence of this marsh indicates wet and soft surface ground conditions, and the geological map shows alluvial deposits on both sides of the river. The geological map also shows made ground, on the north side of the river probably related to the docks construction and very extensive on the south side. Drift deposits in this area also include River Terrace Deposits, Taplow Gravel on the north bank and Boyn Hill Gravel on the south bank, and Head Deposits. Isolated spots of Brickearth (Ilford Silt) are also defined on the north side. The solid geology consists of Thanet Sands and Upper Chalk, although the Thanet Sands may be more limited on the north side. The soils form a major water supply aquifer for the south-east of England and as such are protected by the Environment Agency (EA).

It is unlikely that the alluvial deposits will be able to support foundations or significant additional load and the possible extensive thickness of the alluvium would make shallow foundations on river terrace deposits unfeasible. Any surface earthworks will need to be designed to allow for substantial amounts of settlement and would need to be built on piled or treated soil foundations. The River Terrace Deposits may prove reliable as founding stratum for piled foundations, although this will be dependant on thickness of stratum. The Thanet Beds and Upper Chalk will form reliable founding soils for piled or other form of deep foundation. Tunnelling through the Thanet Beds would be feasible but this material is generally found to be saturated fine dense sand so an open face tunnelling technique would not be suitable. Forming tunnels in the underlying Upper Chalk is likely to be more straightforward depending upon the depth of weathering at the top of the chalk and the occurrence of inclusions such as flint bands.
4. Engineering Feasibility

4.3 Chadwell – Gravesend Option

This route is approximately 10km long and connects the A1089 to the A2. Junctions will need consideration in terms of connecting to the existing highway network. The River Thames in this area is approximately 1250m wide. It is envisaged that both bridge and bored tunnel crossings would be feasible for this route option.

Structure Consideration

Bridge Structure Type

From consultation the navigational headroom required in this area is 90m. Additionally, with regard to navigation width, consideration of the existing jetty on the south bank adjacent to the alignment of this route option, and providing a distance of 150m from the main span pier to the north bank (as in QEI1 Bridge), a clear span of 750m is required for the bridge crossing. As identified earlier the most appropriate form of construction for this crossing would be a combination of a cable stayed bridge and two approach viaducts. The cable stayed bridge would be 1200m long consisting of a main span of 750m and two 225m long side spans. Assuming a maximum gradient of 4%, each approach viaduct would be approximately 950m long resulting in the total bridge structure length of approximately 6km.

The required navigational headroom of 90m would provide sufficient height for the approach viaducts to clear any existing obstacles such as transmission lines, roads and railways on both banks of the river. However, other constraints would need to overcome such as the internationally protected Ramsar site. Approximately 1km of the south approach viaduct may pass through the Ramsar site.

Bored Tunnel

This route option can alternatively be accommodated within twin tunnels under River Thames probably most appropriately constructed using Tunnel Boring Machines (TBM). Assuming that the crown of tunnels is approximately 15m below the riverbed and considering a maximum gradient of 4%, the tunnels would be approximately 3.7km long. At the maximum depth of 35m below ODN the tunnel would be mainly bored through a chalk layer. Above surface constraints would need to be considered in terms of tunnelling under them to minimise disturbance, and consideration of where the tunnel approach and portal would be located and its impacts. A bored tunnel option enables the environmentally sensitive Ramsar site to be tunnelled under.
Geotechnical Consideration

On the north side of the river, there is one significant marsh in the area, West Tilbury Marsh. Its presence indicates wet and soft surface ground conditions. There is also presence of made ground. It is likely that solid deposits underneath the alluvium comprise Upper Chalk. The soils form a major water supply aquifer for the south-east of England and as such are protected by the Environment Agency. This set of ground conditions indicate the earthworks associated with the works would probably have to be piled or deep foundations into the Upper Chalk. Tunnelling through the Upper Chalk is also possible as stated above.

On the south side of the river, the geological map shows alluvial deposits and made ground in the area, probably acting as flood defences. The presence of these deposits indicates wet and soft ground conditions. The marsh extends approximately 1km from the southern river bank where the alluvium is fringed by a deposit of Kempton park gravel at the surface. The solid geology beneath the alluvium and gravels comprises upper Chalk. Further south the surface geology consists of upper chalk with localised deposits of the Thanet Beds. This change in surface geology is associated with a general rise in ground level as the route proceeds southwards. The soils form a major water supply aquifer for the south-east of England and as such are protected by the Environment Agency. Any construction into these materials will require the approval of the EA and other associated bodies.
Chadwell - Gravesend Layout

4. Engineering Feasibility

BRIDGE OPTION

1.9km  1.2km  2.4km

BORED TUNNEL OPTION

3.8km (Tunnel Length)
4.4 Stanford-le-Hope – Gravesend Option

This route is approximately 12km long and connects the A13 to the A2. Junctions will need consideration in terms of connecting to the existing highway network. The River Thames in this area is approximately 1250m wide. It is envisaged that both bridge and bored tunnel crossings would be feasible for this route option.

Structure Consideration

**Bridge Structure Type**

As for the Chadwell to Gravesend option, from consultation the navigational headroom required in this area is 90m. Additionally with regard to navigation width, consideration of the existing jetty on the south bank adjacent to the alignment of this route option and providing a distance of 150m from the main span pier to the north bank (as in QEII Bridge) a clear span of 750m is required for the bridge crossing. As identified earlier the most appropriate form of construction for this crossing would be a combination of a cable stayed bridge and two approach viaducts. The cable stayed bridge would be 1200m long consisting of a main span of 750m and two 225m long side spans. Assuming a maximum gradient of 4%, each approach viaduct would be approximately 950m long resulting in the total bridge structure length of approximately 6km.

The required navigational headroom of 90m would provide sufficient height for the approach viaducts to clear any existing obstacles such as transmission lines, roads and railways on both banks of the river. However, other constraints would need to overcome such as the internationally protected Ramsar site. Approximately 1km of the south approach viaduct may pass through the Ramsar site.

**Bored Tunnel Structure Type**

This route option can alternatively be procured by constructing twin tunnels under the River Thames using Tunnel Boring Machines (TBM). Assuming that the crown of tunnels is approximately 15m below the riverbed and considering a maximum gradient of 4%, the tunnels would be approximately 3.7km long. At the maximum depth of 35m below ODN the tunnel would be mainly bored through a chalk layer. Above surface constraints would need to be considered in terms of tunnelling under them to minimise disturbance, and consideration of where the tunnel approach and portal would be located and its impacts. A bored tunnel option enables the environmentally sensitive Ramsar site to be tunnelled under.
4. Engineering Feasibility

Chadwell - Gravesend and Stanford-le-Hope - Gravesend Options Indicative Bridge Layout
4. Engineering Feasibility

Artist's Impression of Indicative Bridge Structure
4. Engineering Feasibility

Artist's Impression of Indicative Bridge Structure
Geotechnical Consideration

On the north side of the river, East Tilbury Marshes and Alluvial Deposits indicate wet and soft surface conditions. Some made ground is also present. Drift deposits on this area also include River Terrace Deposits comprising Taplow Gravel and Lynch Hill Gravel, and Head Deposits. Solid geology is recorded as Thanet Sands. The soils form a major water supply aquifer for the south-east of England and as such are protected by the Environment Agency.

It is unlikely that the alluvial deposits will be able to support foundations or significant additional load. Any surface earthworks will need to be designed to allow for substantial amounts of settlement and would need to be built on piled or treated soil foundations. The River Terrace Deposits may prove reliable as founding stratum for piled foundations, although this will be dependant on thickness of stratum. The Thanet Beds will form reliable founding soils for piled or other form of deep foundation. Tunnelling through the Thanet Beds will be feasible but this material is generally found to be a saturated fine dense sand so an open face tunnelling technique would not be suitable.

On the south side of the river, the geological map shows alluvial deposits and made ground in the area, probably acting as flood defences. The presence of these deposits indicates wet and soft ground conditions. The marsh extends approximately 1km from the southern river bank where the alluvium is fringed by a deposit of Kempton Park gravel at the surface. The solid geology beneath the alluvium and gravels comprises upper Chalk. Further south the surface geology consists of upper chalk with localised deposits of the Thanet Beds. This change in surface geology is associated with a general rise in ground level as the route proceeds southwards. The soils form a major water supply aquifer for the south-east of England and as such are protected by the Environment Agency.
Stanford-le-Hope – Gravesend Option Layout

4. Engineering Feasibility
4.6 Canvey – Grain Option

This route option is approximately 14km long and connects the A130 (Canvey Way) to the A228 (Ratcliffe Hwy). Junctions will need consideration in terms of connecting to the existing highway network. The river width is approximately 2.7km in this area, including the Blyth sands. A bridge crossing in this area was discounted in Phase I of the study as a result of the significant impacts on environmentally protected areas. Similarly, an immersed tube tunnel with cut and cover type approaches was discounted for the same reason. A deeper tunnel option passing beneath the protected areas is considered to be the most appropriate physical solution.

Bored Tunnel Structure Type

Construction of the twin bore tunnel carrying the dual two lane carriageway would best be made using Tunnel Boring Machines (TBM). Assuming that the crown of the tunnels is approximately 15m below the riverbed and considering a maximum gradient of 4%, the tunnels would have a total length of approximately 5.5km including 1km length under the designated environmentally protected area. At the maximum depth of 35m below ODN the tunnel would be mainly bored through London Clay.

Geotechnical Considerations

On the north site, there are predominantly undifferentiated alluvium clays in the area, whereas on the south side are Halstow Marshes and alluvial deposits. These features indicate the ground conditions to be wet and soft in the top few metres below ground level. The solid geology underneath the alluvial deposits is shown to be London Clay over Lambeth Group (Woolwich and Reading beds, mainly sands and clays) and Thanet Beds. The depth of the London clay is not known, although the geological map indicates a maximum thickness of 137 metres.

It is unlikely that the alluvial deposits will be able to support foundations or significant additional load. Any surface earthworks will need to be designed to allow for substantial amounts of settlement, the need for any piled or treated soil foundations will depend upon the thickness of alluvium encountered. Shallow or piled foundations can be formed on London Clay, the Thanet Beds will form reliable founding soils for deep or piled foundations. Bored tunnelling will be possible within the solid geology encountered along this route.
4. Engineering Feasibility

Canvey – Grain Option Layout

Bored Tunnel Option

5.4km (Tunnel Length)
4.7 Scheme Cost

Indicative construction costs for each of the Phase 2 options were estimated. These estimated construction costs include a 60% optimism bias for both the bridge and tunnel options consistent with DfT guidance. The costs are summarised below (rounded to the nearest 10 million).

<table>
<thead>
<tr>
<th></th>
<th>Grays - Swanscombe*</th>
<th>Chadwell - Gravesend*</th>
<th>Stanford-le-Hope - Gravesend*</th>
<th>Canvey - Grain**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bridge</td>
<td>Tunnel</td>
<td>Bridge</td>
<td>Tunnel</td>
</tr>
<tr>
<td>Cost</td>
<td>580</td>
<td>610</td>
<td>630</td>
<td>660</td>
</tr>
<tr>
<td>60% Optimism Bias (OB)</td>
<td>348</td>
<td>366</td>
<td>378</td>
<td>396</td>
</tr>
<tr>
<td>Total cost (including OB)</td>
<td>930</td>
<td>980</td>
<td>1010</td>
<td>1060</td>
</tr>
<tr>
<td></td>
<td>Bridge</td>
<td>Tunnel</td>
<td>Bridge</td>
<td>Tunnel</td>
</tr>
<tr>
<td>Total cost (including OB)</td>
<td></td>
<td>1280</td>
<td>1280</td>
<td>1380</td>
</tr>
</tbody>
</table>

* Includes estimated cost of M25 link and junction allowance.
** Includes estimated cost of junction and easterly link to London Gateway.
# If tunnel length is extended under SPA and Ramsar site.

It should be noted that for cost comparison between different route options a rigorous whole life costing of the schemes should be carried out taking due account of not only the cost of construction but also the cost of operation and maintenance of the scheme over its service life.
4.8 Conclusion

Cable stayed bridge and bored tunnel construction are technically feasible for all of the Phase 2 route options. The tunnel option offers particular opportunity to reduce the environmental impact on the more easterly alignments as it can be lengthened to underpass the environmentally protected areas. A bridge crossing, however could present an opportunity to procure a landmark which could serve to add significant identity to the area and provide a focal point for its future development and regeneration. Its form could be developed to harmonize with the surrounding environment. A bridge form may also present reduced operational costs when compared to a tunnel.

All the routes have a relatively similar combination of ground conditions. The planning, design and construction within the alluvial deposits will form a significant challenge in each case. It is likely that these deposits will be at their thickest for the western option: Grays - Swanscombe. The selection of the route will also need to consider the impact of construction on the river flood defences. The design of any tunnel portals will need to provide sufficient protection against flooding of the tunnel following extreme flood events from the River Thames, taking due account of rising sea levels and the impact of climate change.

The following concluding remarks can be made on individual options:

- **Grays - Swanscombe**: Bridge and tunnel construction are equally feasible in engineering terms for this option. However, this location is likely to provide significant obstacles in terms of developments, both existing and proposed. Constraints are likely to cause the most significant problems on the south side of the river where there are known proposed developments, including a major new settlement at Ebbsfleet Valley around the new international station. A crossing in this area is likely to significantly impact on this development and it is therefore deemed not a viable option.

- **Chadwell - Gravesend**: Bridge and tunnel construction would be feasible for this option. Approximately 1km of the approach viaduct for the bridge option is likely to encroach into an environmentally protected area (Ramsar and SSSI) on the south bank. The bored tunnel construction has the advantage of passing under this area and therefore minimising the environmental impacts on these designated sites.

- **Stanford-le-Hope - Gravesend**: Bridge and tunnel construction would be feasible for this option. Approximately 1km of the approach viaduct for the bridge crossing is likely to encroach into an environmentally protected area (Ramsar and SSSI) on the south bank. The bored tunnel construction has the advantage of passing under this area and therefore minimising the environmental impacts on these designated sites.

- **Canvey - Grain**: This option is considered to be the most expensive scheme. Tunnel construction provides the only feasible solution as it is capable of passing under the relatively large designated area (Ramsar and SPA) on the south bank.
5 FUNDING

5.1 Introduction

Major transport schemes are assessed separately from other Local Transport Plan funding. Individual bids have to be prepared, requiring extensive preparatory work. All major schemes in England are assessed against one another by the Department for Transport. This section of the report aims to review the currently available funding sources for the capital costs associated with the following options: Chadwell – Gravesend, Stanford-le-Hope – Gravesend and Canvey - Grain. The Grays – Swanscombe option has not been taken forward at this stage due to the likely impact of this option on major new developments rendering it unfeasible (as explained in section 4.8).

It is envisaged that the funding agreement between the Councils and the Government will be financed by a combination of toll revenue and public sector investment. The Councils then have the option of entering a concession agreement with a private sector concessionaire for the elements that comprise this new Thames Crossing Project.

A combination of toll revenues and public and private sector funding will meet the financing, operational and maintenance costs during the concession term.

This section will build up a funding envelope for each option and will assess any shortfall between predicted funding streams and those funding elements that at this early stage remain targeted elements of this project.

5.2 Capital and Operation and Maintenance Costs

The table below summarises the capital and running costs associated with each of the preferred options. This information will be used to compare against the funding sources.

<table>
<thead>
<tr>
<th></th>
<th>Chadwell - Gravesend*</th>
<th>Stanford-le-Hope - Gravesend*</th>
<th>Canvey - Grain**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bridge</td>
<td>Tunnel**</td>
<td>Bridge</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>£1,010M</td>
<td>£1,280M</td>
<td>£1,010M</td>
</tr>
<tr>
<td>Annual Operation and</td>
<td>£7.6M</td>
<td>£12.8M</td>
<td>£7.6M</td>
</tr>
<tr>
<td>maintenance costs*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Based on 0.75% of capital cost for a bridge crossing and 1.0% of capital costs for a tunnel
** Costs assume that tunnel under SPA and Ramsar site
5.3 Predicted Funding Streams

Traffic Flow

Traffic flow models for 2021 have predicted a level of usage based on peak hour flow rates. This information has been used to calculate a predicted income for the year based on the charging structure currently used at the existing Dartford - Thurrock Crossing. Allowance has been made for an annual RPI uplift (based on 2008 figures) for toll charges.

<table>
<thead>
<tr>
<th></th>
<th>Chadwell - Gravesend*</th>
<th>Stanford-le-Hope - Gravesend*</th>
<th>Canvey - Grain**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bridge</td>
<td>Tunnel</td>
<td>Tunnel</td>
</tr>
<tr>
<td>Annual Traffic Flows (number of crossings)</td>
<td>30,700,000</td>
<td>30,700,000</td>
<td>13,800,000</td>
</tr>
<tr>
<td>Annual Toll Income*</td>
<td>£61.2M</td>
<td>£61.2M</td>
<td>£27.6M</td>
</tr>
<tr>
<td>Less: profit at 15%</td>
<td>£9.1M</td>
<td>£9.1M</td>
<td>£4.1M</td>
</tr>
<tr>
<td>Amount available for maintenance, operation and financing</td>
<td>£52.1M</td>
<td>£52.1M</td>
<td>£23.5M</td>
</tr>
<tr>
<td>Risk adjustment factor – 25%</td>
<td>£14M</td>
<td>£14M</td>
<td>£5.9M</td>
</tr>
<tr>
<td>Risk adjusted income to support maintenance, operation and financing</td>
<td>£38.1M</td>
<td>£38.1M</td>
<td>£17.6M</td>
</tr>
<tr>
<td>Amounts available to support borrowing costs</td>
<td>£30.5M</td>
<td>£25.3M</td>
<td>£10.0M</td>
</tr>
</tbody>
</table>

* Annual Toll income based on following assumptions:
  - Annual Average Daily Traffic figures have been uplifted by a factor of 350
  - Current Dartford Crossing Tolls have been uplifted by 3% pa up to 2021
  - 65:35 split between peak and off peak traffic flow
  - HGV and Coaches account for 15% of all traffic flow over the crossing

** Canvey - Grain option traffic flows have been uplifted by 20% to account for additional development potential and associated traffic flow

Assumed a operational and maintenance costs for a tunnel for all options to apply consistently.
The traffic flow modelling does not include any allowance for induced traffic flow as a result of future development that may arise as a result of a new crossing. It is assumed that the level of development will correlate with the amount of land available for development. The Chadwell – Gravesend and Stanford-le-Hope - Gravesend options have a small amount of development potential due to the intensive nature of land use in the area. However, the Canvey - Grain option is relatively undeveloped and therefore additional development is liable to increase traffic flow.

Further studies would be necessary to quantify this increase in traffic flow. For the purposes of this report an uplift factor of 20% has been used to quantify this potential additional traffic flow for the Canvey – Grain option.

Based on this analysis the total amount of available resource to support prudential borrowing has been calculated. We would encourage a concession whereby the Councils are able to access prudential borrowing as a funding source rather than have a reliance on private sector funding. Public sector borrowing can be accessed at rates considerably lower, often as much as 2.0%, than the private sector.

The risk adjusted figures represent a prudent assessment of the income from tolls associated with each crossing option. The adjustments to this total figure gives us the resource envelope available to support borrowing to fund the capital costs. This level will have to be risk adjusted to account for the interest rate fluctuations that may occur between now and the point of borrowing.

<table>
<thead>
<tr>
<th>Crossing Option</th>
<th>Bridge Resource Available</th>
<th>Tunnel Resource Available</th>
<th>Bridge Total level of prudential borrowing</th>
<th>Tunnel Total level of prudential borrowing</th>
<th>Risk adjusted level of borrowing available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chadwell - Gravesend*</td>
<td>£30.5M</td>
<td>£25.3M</td>
<td>£390M</td>
<td>£370M</td>
<td>£320M</td>
</tr>
<tr>
<td>Stanford-le-Hope - Gravesend*</td>
<td>£10.0M</td>
<td>£4.5M</td>
<td>£110M</td>
<td>£80M</td>
<td>£170M</td>
</tr>
<tr>
<td>Canvey - Grain**</td>
<td>£10.0M</td>
<td>£4.5M</td>
<td>£100M</td>
<td>£80M</td>
<td>£170M</td>
</tr>
</tbody>
</table>

* Based on Council PWLB borrowing at 4.40% over 50 year period (correct as at 19 September 2008) and risk factor of 20%
5.4 Targeted Funding Streams

Targeted funding are sources of funding that are generally available for projects similar to the Thames Crossing. However, applications for this funding must be made based on specific criteria. We would encourage that all funding sources are reviewed and the project path is aligned to maximise its ability to access this funding.

European Union (EU) Funding

In certain circumstances national transport and infrastructure programmes can attract significant levels of EU funding. Below are a few examples of funding streams that the Councils may wish to consider when financing the crossing. The Trans-European Transport Networks (TEN-T) Funding is available for transport projects that contribute to the implementation and development of the Internal Market, as well as reinforcing economic and social cohesion of the EU. The TEN-T is seen as a major element in economic competitiveness and a balanced sustainable development of the EU.

In order for any new Thames Crossing to be considered for EU TEN-T funding it must first be adopted as an official route. It could be argued that any new crossing would fall within the boundaries defined by the TEN-T priority axes and could be used to link the existing network in the UK to priority axis 13 (as defined by the EU’s Axes and priority projects).

Funding levels associated with this Network can be as high as 50% of the total capital costs.

Research and Technological Development Funding (FP7)

A grant pool of €53 BN is available up to 2013 to support and develop safer, greener and smarter pan-European transport systems that will benefit all citizens, respect the environment and increase the competitiveness of European Industries in the global market. Funding has been set aside for sustainable surface transport aims such as:

- inter-modal regional and national transport links; and
- infrastructure constructions and maintenance, integrative architectures.
Central Government – Direct Funding

The Government is committed to major transport investment to support the growth of the Thames Gateway region. The Department for Transport (DfT) with Communities and Local Government (CLG) have been working closely to ensure that all development within the area is integrated. In 2007 the Government committed significant funding to ensure the planned £2.2BN of transport development necessary over the next 3 years was progressed.

In 2007 the Secretary for State for Transport commissioned a study examining options for tackling long term demand for the crossing. This may indicate an intention within government to fund a Thames Crossing scheme and any option put forward by the Council could apply for this funding in the usual manner.

Central Government – PFI Credits

The Councils could apply for PFI arrangements to be put in place to fund the construction works. The finance costs will be met over time by toll revenue and PFI Credits payments. The combination of toll revenue and the annual PFI Credit would also be expected to cover the requirements to meet all operational costs and maintenance costs during the concession term.

Application for PFI Credits would be considered as part of the national picture and be based on the level of funding available from the sponsoring Central Government Department.

Central Government – Regional Grant Funding

There are currently a number of government funding streams available to local government to help fund the cost of transport schemes. For instance Transport Innovation Funding, (TIF) for road pricing schemes, Growth Area Funding (GAF) and Regional Funding Allocation, (RFA). Elements of these funding streams may be available to support the cost of the new Thames Crossing but this will depend on the structure of the funding agreement and the involvement of the private sector.
Community Infrastructure Levy (CIL)

The CIL is currently under consultation, so the exact details are not yet known. The key point for infrastructure projects such as this however, is that the CIL will break the direct link between the use of sums raised and the development which generates them.

Currently under s106 legislation there must be a direct link between the development and the infrastructure that is being funded. This will cease under the CIL. Furthermore, it is the intention that any infrastructure will be considered at a sub-regional level. The new crossing will therefore be able to attract funds from any authority where it is believed there will be a demand placed upon the crossing by new developments.

The Government has committed to the development of at least 160,000 homes in the Thames Gateway by 2016. Under, pilot CIL models this development alone could secure approximately £1.6bn in infrastructure funding for the region, to be spent on all infrastructure projects. An element of this funding may be available to contribute to the Thames Crossing Project. The anticipated additional development that would occur as a result of the Canvey - Grain option being pursued may result in an overall increase of CIL sums for both Kent and Essex. Should this be the case then it would strengthen the argument for a larger drawdown of this funding stream when compared to the other options for the Crossing.

By looking to place a new Thames Crossing away from the already congested areas of Dartford and the other London crossings, the Canvey - Grain option offers the opportunity to spread and enhance the overall national strategic road network.

The Canvey – Grain option could be assessed by simply looking at existing planned development. However, this does not take account of the opportunities that will arise from the crossing at this location. The crossing will create a more vibrant sub-region bringing with it greater commercial opportunities, increasing the economic benefits. Better connectivity will improve development potential. This “vision” for the sub-region and the routes of transit it opens can create a clear justification for the crossing as well as identify a strong set of benefits that could be assessed.

The link between the M2 up through Essex creates a connection to the A14 that offers a route for traffic from the East, Midlands and North of England that avoids the congested areas around the London orbital route. Routing traffic in this way gives benefits over the other options in that it provides a different journey and completely avoids the London area.

In addition, the position of the crossing unlocks the development potential of the Medway Towns and Kent area. For Essex and the East of England the current route to the channel crossing is restricted and the Canvey - Grain option could see the towns of Basildon and Rayleigh benefit form any additional economic activity.

The proximity of this route to the London Gateway Port Development could also benefit the Essex side of the crossing through creation of a transportation and economic hub.
Funding of London’s Crossrail Project

The funding of the Crossrail Project remains vague, despite receiving parliamentary consent. The Department for Transport has confirmed its commitment to provide £5.1bn towards the cost and set out the following sources of funding to meet the £16bn costs:

- £3.5bn through the raising of a special 2p in the pound supplementary business rate on all businesses with a rateable value above £50,000;
- £2.3bn to be securitised (borrowed against future income) from the access charges paid by train operators;
- £2.7bn from Transport for London Land sales
- Section 106 contributions

We have discussed the viability of a number of these items as a possible funding source for the new crossing.

Supplementary Business Rates

Potentially, if a similar business rate levy scheme was adopted in the Kent and Essex area as in London, this could raise significant sums for the project. With the expectation that the Thames Gateway will provide 180,000 new jobs by 2017 a similar system could be used to access this growth and development. Additional business rates secured by pursuing Canvey - Grain could also provide additional resources over and above the other options being considered.

Capital Receipts

The Council’s could review their asset portfolio to release value from surplus properties. However, this is unlikely to generate significant resources.

Cross Subsidy from the existing Dartford – Thurrock Crossing

Depending on the current contract in place with the Dartford Crossing Company there may be scope to divert toll revenues to help support the new Thames Crossing, especially as the concession on this crossing has come to an end. This proposal has been suggested for number of similar projects both in the UK and globally.

The public body created after the concession period would have to take a view of whether this cross subsidy is a viable option. Currently, the existing Dartford – Thurrock Crossing has Net Proceeds for the Year of £47.2M.

Based on current PWLB borrowing rates, any additional income received from the Dartford - Thurrock Crossing could be used to support prudential borrowing and provide the following additional funding for the new crossing as follows (over page).
For the purposes of this model we have assumed an contribution from the existing Dartford – Thurrock Crossing of £20M per annum.

Investment Funds

Investment funds, sponsored by global investment banks, private equity firms, and institutional money managers, are looking to place money from pension funds, insurance company general accounts, and high-net-worth clients into infrastructure investments. During the mid-1990s Australian investment firms established the first of these funds looking for new assets to invest in after “tapping out” on local real estate, stocks, and bonds. In 2007, more than $30 billion of Australian infrastructure assets was held in publicly traded or listed entities.

Various new global infrastructure funds have raised about $100 billion to invest in infrastructure assets with an initial focus on Europe, where public/private partnerships have been well established in many countries whose governments have sought alternative financing sources.

Fund marketers tout infrastructure as a “new asset class” offering secure, long-term cash flows, inflation protection, and opportunities for reducing overall portfolio volatility and risk. Funds tend to be highly diversified—“a broad basket of things” investing in economic infrastructure like toll roads, parking provision, power plants, water treatment facilities, and airports as well as social infrastructure, including hospitals, schools, and affordable housing. Portfolio managers may balance the known and predictable cash flows of existing infrastructure investments with investments in higher-risk/ higher-return greenfield construction projects.

The use of these investment funds would require a more complex arrangement between the Public Sector and the Private Sector. These arrangement do offer the opportunity to access significant levels of funding. However, it must be noted that this could potentially be an expensive method of funding as it would be necessary for any investment to make a return and the costs of borrowing would be significantly higher than those accessed by the public sector.

<table>
<thead>
<tr>
<th>Income from the Dartford - Thurrock Crossing</th>
<th>Additional borrowing secured</th>
</tr>
</thead>
<tbody>
<tr>
<td>£1M</td>
<td>£22M</td>
</tr>
<tr>
<td>£5M</td>
<td>£113M</td>
</tr>
<tr>
<td>£10M</td>
<td>£226M</td>
</tr>
<tr>
<td>£15M</td>
<td>£339M</td>
</tr>
<tr>
<td>£20M</td>
<td>£426M</td>
</tr>
</tbody>
</table>
### 5.5 Summary

These numbers represent the estimated capital costs of the options as well as the potential funding sources. It should be noted that scheme benefits have not been wholly quantified at this stage and that additional costs would need to be allowed for items such as land acquisition and associated compensation, scheme development, maintenance and operation etc.

Our analysis is based on information currently available and has looked at additional income streams associated with a road crossing. We have not reviewed the possibility of accessing rail freight concessions that may be available if a tunnel solution was pursued.

There is some debate that a new crossing could attract additional revenues from a new airport development in the Lower Thames area or as a result of the new Crossing facilitating new Thames flood defences in the area. These have been omitted from this analysis but should be considered as part of the overall solution should it be deemed appropriate.

In the first instance, Supplementary Business Rates and the CIL have been assumed as equal across each option. In the absence of additional information, an estimated allowance has been made for any additional development over and above that already included, that may result from the pursuance of the Canvey – Grain option.

At this stage of the project all amounts are indicative and have been risk adjusted to represent the current progress of this project. All figures would require additional and more detailed research with associated business cases as the project progresses.

The delivery of this project will not stand alone. It will form part of a portfolio of projects being delivered by Kent and Essex County Councils. It is possible that the schemes can be delivered under procurement solutions that combine or package schemes on a way to generate better value for money, improving affordability and easing access to funding. Those efficiencies have not been factored into the numbers but can assist in addressing the level of commitment required from central and local government.

<table>
<thead>
<tr>
<th></th>
<th>Chadwell - Gravesend</th>
<th>Stanford-le-Hope - Gravesend</th>
<th>Canvey - Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital Cost</strong></td>
<td>Bridge £M</td>
<td>Tunnel £M</td>
<td>Bridge £M</td>
</tr>
<tr>
<td></td>
<td>1,010</td>
<td>1,280</td>
<td>1,010</td>
</tr>
<tr>
<td><strong>EU Grant Funding</strong></td>
<td>(130)</td>
<td>(160)</td>
<td>(130)</td>
</tr>
<tr>
<td><strong>Central Government funding</strong></td>
<td>(100)</td>
<td>(100)</td>
<td>(100)</td>
</tr>
<tr>
<td><strong>Community Infrastructure Levy</strong></td>
<td>(50)</td>
<td>(50)</td>
<td>(50)</td>
</tr>
<tr>
<td><strong>Additional CIL as a result of additional development from Canvey – Grain option</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Supplementary Business Rates</strong></td>
<td>(10)</td>
<td>(10)</td>
<td>(10)</td>
</tr>
<tr>
<td><strong>Additional Business Rates as a result of additional development from Canvey – Grain option</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Securitised future tolls based on current prudential borrowing rates</strong></td>
<td>(520)</td>
<td>(430)</td>
<td>(170)</td>
</tr>
<tr>
<td><strong>Addition borrowing from Dartford Crossing contribution – based on £20M contribution or to cover costs</strong></td>
<td>(200)</td>
<td>(400)</td>
<td>(400)</td>
</tr>
<tr>
<td><strong>Potential deficit to be provided by additional grant or Council contributions</strong></td>
<td>0</td>
<td>(120)</td>
<td>(150)</td>
</tr>
</tbody>
</table>

*Excludes costs such as: land acquisition, compensation, scheme development etc.*
6. Summary
6.1 Introduction

ECC and KCC are concerned about continuing congestion at the existing Dartford - Thurrock Crossing and its approach roads, and wish to understand the opportunities that additional crossing capacity might bring to economic regeneration and land use change on both sides of the estuary.

The study is an initial step in the due planning processes needed for a major infrastructure scheme that is designed to inform the two authorities of the likely benefits, disbenefits, problems and opportunities of a range of possible options. The study is based on existing information and is split into two main phases, plus an initial Phase 0 to agree the objectives of the study with ECC and KCC and to understand the work already undertaken.

Phase 1 covered nine options and identified that four of these should be assessed further in Phase 2. This was reported in a presentation and discussions with KCC and ECC.

Phase 2 investigated the four options in more detail and included scheme costs and funding.

Both Phases of the study have used a set of performance indicators within an appraisal framework that has been developed from the DfT’s consultative Towards a Sustainable Transport System (TaSTS) and the Regional Transport Strategies and Local Transport Plans (including those for the Thames Gateway Partnerships).
6.2 The Need for Intervention

The primary need for an intervention across the Thames at or below the existing Dartford – Thurrock Crossing is two-fold. Firstly, there is the need to improve the level of reliability and dependability of journey times on the M25 across the River Thames for European, national, regional and local traffic including freight. Secondly, there is the need to use any additional capacity to improve the urban environment, assist in maintaining a sustainable level of growth and enable regeneration and the achievement of social objectives (as defined in the current national transport policy).
Need to improve the level of reliability and dependability of journey times

The M25 is significantly overloaded (150k vehicles on average per day) for considerable periods of the working day and any incident in the tunnels or on the bridge has a significant impact on the operational capacity across a wide area of the road network (on average queues for 4hrs per day). Operational capacity is also affected by maintenance operations and whether there is a greater requirement in the tunnels going into the future. South Essex and north Kent bear the brunt of any incident or closure as it adversely affects all their accessibility.

Commercially, the dependability of journey times is crucial and adding in slack time to achieve it is inefficient and economically damaging. Considerable volumes of road freight from Dover and the Channel Tunnel need to use the existing Dartford – Thurrock crossing to access north London and the rest of the UK using the M11 and M1. Movements from Felixstowe/Harwich to the south are similarly affected. Although more may transfer to rail there will be increasing reliance on the single crossing point for the vital flow of goods by road into and out of the UK.

Therefore for day-to-day and planned operational reasons alone, the continued reliance on the single crossing point has disbenefits and could be viewed as a high risk strategy. The benefits of a second crossing located some distance from the existing crossing would reduce the risk of disruption caused by a single incident and improve network resilience over a wide area.

The efficiency of the crossing is also affected by the connecting approach roads. Immediately either side of the current crossing the local network junctions reduce the available capacity. In the future, the upgrading of the M25, A2 and A13 will add to the pressure, and there is the problem of implementing both the widening of M25 and A13 at the complex J30. Clearly a way around that problem or a way of reducing the demand at that junction could be strategically beneficial.
Need to improve the urban environment, assist sustainable growth and enable regeneration

The Thames Partnerships plans identify the need for and benefits of an additional Thames Crossing in the area but currently assume only the existing Dartford – Thurrock Crossing. This is an important point as different levels and distributions of development could be achieved with an additional crossing – especially one located a distance downstream from Dartford.

Even so there are regeneration and sustainability issues that the current crossing at Dartford is not addressing, partly because of the highly developed and constrained nature of the surrounding area and road network. Crucially the Thames Partnership plans do not improve accessibility and connectivity between south Essex and north Kent and place further reliance on the Dartford – Thurrock Crossing approach roads even for London traffic.

The economic vitality of the areas either side of the Thames are already affected by their coastal locations and would benefit from greater cross-Thames capacity and journey reliability. Increasing sustainable travel across the Thames is extremely difficult at present and will continue to be in the future with only a single crossing.
6.3 Performance of the Options

The options were assessed against the appraisal framework using performance indicators. Options that dealt well with both the cross-river traffic (by relieving the current crossing and attracting redistributed trips) and the regeneration and sustainability issues performed the best. The performance of the options against transport and economic objectives is strongly influenced by the amount of traffic attracted to the new crossing and this favours those that both link the A2/M20 with M25 and link existing and currently planned developments either side of the Thames. However, levels of existing development around the bridgeheads or tunnel portals, for options around Dartford, introduce significant construction impacts. There are also many environmental constraints along both sides of the Thames and some affect the type of crossing at a particular location.

Increasing capacity at the existing Dartford - Thurrock Crossing does not increase the total crossing traffic by as much as other options as there is minimal re-routing to the improved crossing and no redistribution as the journey time reductions are small. The option also does not meet the regeneration objectives as the local area is already heavily developed with little opportunity for expansion in the future, especially given the congested approach roads. The engineering and construction difficulties also ruled it out.
Chadwell - Gravesend and Stanford-le-Hope - Gravesend

These two options can be considered variants of one route as they both start on the A2 and cross the river east of Gravesend, with one option linking to the A1089 and the other to the A13. Both options include a link road to the M25 between South and North Ockendon. The crossing could be either a tunnel or bridge, although there are implications regarding the Ramsar site with a bridge crossing, which could be overcome with a bored tunnel.

These options best meet the main objectives of need and the other performance indicators, particularly sustainable travel, in the appraisal framework.

Importantly, this assessment is based on existing and currently planned development. The options also open up opportunities for development east of Tilbury and improve substantially the accessibility from the disadvantaged areas in Kent Thameside to London Gateway – both for employment and the road freight movements. An additional 200,000 people and about 100,000 jobs would be within a 20 minute journey time of the two crossing points with these route options.
Canvey - Grain

This route would link the A130 to the A228 and includes a link to London Gateway. Importantly, because of the environmental constraints, principally on the south bank, this option has to be in a twin bore tunnel.

The option performs less well against the traffic and economic objectives because these are influenced by the location of the existing and planned development. The option provides the opportunity to consider wider issues. Firstly it presents the opportunity to link the A2 Dover road with A130 through to A120 and M11 thus achieving relief at Dartford and the north east section of M25, and improving the accessibility to the whole of south Essex. Secondly, related to accessibility, it addresses the regeneration issues in Southend on Sea, Canvey and Basildon (generally better than other options). It also provides an easy link to London Gateway for freight and access to employment from north Kent. In total, an additional 350,000 people and about 150,000 jobs would be within a 20 minute journey time of the two crossings with Canvey - Grain.
6.4 Scheme Costs and Funding

The adjacent table shows the estimated capital costs of the options as well as the potential funding sources available based on information currently available. At this stage of the project all amounts are indicative and have been risk adjusted to represent the current progress of this project. All figures would require additional and more detailed research with associated business cases as the project progresses.

### 6.5 Conclusion

The study has identified the feasibility of three potential route options. Each has their own challenges in terms of deliverability; each would also provide for different opportunities. Development of the options beyond this point would require a more in-depth analysis to confirm the conclusions to date leading to the identification of a preferred option for progression through planning procedures.