8  Environmental Baseline and Assessment of Impacts – South East Route Section

8.1 Overview of Route Section

This chapter describes the southeast route section of Crossrail, which runs from the east of the Isle of Dogs station to the eastern terminus at Abbey Wood. The figure below shows the route alignment.

Figure 8.1: South East Route Section

Specifically the chapter describes the permanent and temporary works which would be undertaken along the route section, the environmental baseline and the significant environmental impacts that would arise from the construction and operation of the scheme.

Many of the impacts that would potentially occur during construction would be similar to those associated with other rail projects. Experience gained from these projects has assisted in the identification of appropriate measures to mitigate or reduce impacts during Crossrail’s construction. The measures that would be used are described in Appendix B1. Implementation of these measures has been assumed (A.SE.1) in the assessment.

For part of the southeast route section, Crossrail would use existing main line railway alignment. Crossrail would operate in tunnel to the west of Victoria Dock portal and would serve a reconstructed surface station at Custom House. The route would then follow the existing alignment currently used by the NLL through a refurbished Connaught Tunnel to Silvertown. Crossrail would then descend a ramp to the North Woolwich portal where a new twin-bore tunnel would be constructed that would surface at Plumstead portal, located
between the existing Plumstead and Abbey Wood stations. Abbey Wood station would be reconstructed to allow twelve Crossrail trains per hour to terminate.

It is assumed that the NLL, south of Stratford, is closed by the DLR extension to Stratford International line from Canning Town, which would include closure of Silvertown and North Woolwich stations and the withdrawal of services through the Connaught Tunnel.

The scale of the works along the route varies. Table 8.1 summarises the main works (excluding enabling works) that would take place in the southeast section. Those route windows containing the more substantial works are highlighted with shading.

The level of detail that is reported in subsequent sections for route windows SE1 to SE8 is commensurate with the extent of works that is proposed in each of these route windows.

Table 8.1: Main Elements of the Scheme within the South East Route Section (Route windows with major works are highlighted)

<table>
<thead>
<tr>
<th>Route Window</th>
<th>Major Project Works</th>
<th>Local Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE 1 Blackwall Way &amp; Limmo Peninsula shafts Blackwall Way to Tarling Road.</td>
<td>Blackwall Way shaft Limmo Peninsula shaft</td>
<td>LB Tower Hamlets LB Newham</td>
</tr>
<tr>
<td>SE2 Custom House Station Tarling Road to Prince Regent Footbridge.</td>
<td>Victoria Dock portal Reconstruction of Custom House station; modifications to DLR platform Realignment of DLR tracks OHLE New station entrance and footbridge</td>
<td>LB Newham</td>
</tr>
<tr>
<td>SE3 Connaught Tunnel Prince Regent Footbridge to Lord Street.</td>
<td>Refurbishment of Connaught Tunnel Demolition of Silvertown station OHLE</td>
<td>LB Newham</td>
</tr>
<tr>
<td>SE4 North Woolwich Portal &amp; Thames Tunnel Lord Street to 80 Beresford Street.</td>
<td>North Woolwich portal New twin-bore tunnel (Thames Tunnel) Warren Lane shaft OHLE</td>
<td>LB Newham LB Greenwich</td>
</tr>
<tr>
<td>SE5 Arsenal Way Shaft 80 Beresford Street to Ann Street bridge.</td>
<td>New twin-bore tunnel (Thames Tunnel) Arsenal Way shaft</td>
<td>LB Greenwich</td>
</tr>
<tr>
<td>SE6 Plumstead Portal Ann Street bridge to Marmadon Road</td>
<td>Plumstead portal Replacement of White Hart Road bridge Two new tracks and track realignment OHLE</td>
<td>LB Greenwich</td>
</tr>
</tbody>
</table>

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Chapter 8 - South East Sectionrev103.doc
Sections 8.2 to 8.4 outline sources of data, baseline conditions and impacts at a route section level. Sections 8.5 onwards discuss baseline conditions and impacts relevant to each individual route window.

### 8.2 Sources of Information

Data on the baseline conditions has been obtained from various sources, including the Environment Agency, Thames Water Utilities Ltd, English Nature and various London Boroughs and District Councils. Table 8.2 contains information about the data obtained and used in the assessment.

#### Table 8.2: Sources of Data – South East Route Section

<table>
<thead>
<tr>
<th>Subject</th>
<th>Data</th>
<th>Source</th>
<th>Date received</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>Groundwater quality records</td>
<td>Environment Agency</td>
<td>November 2002</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Groundwater abstraction licenses</td>
<td>Environment Agency</td>
<td>November 2002</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Groundwater abstraction licenses</td>
<td>Environment Agency</td>
<td>December 2002</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Section 32 consents</td>
<td>Environment Agency</td>
<td>October 2003</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Abstractions in determination</td>
<td>Thames Water</td>
<td>October 2003</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Protected Groundwater Rights</td>
<td>Personal contact with London Boroughs and District Councils</td>
<td>November 2002</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Source Protection Zones</td>
<td>Environment Agency</td>
<td>November 2002</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Source Protection Zones</td>
<td>Environment Agency</td>
<td>December 2002</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Water Levels 2003-2004</td>
<td>Crossrail GI data</td>
<td>Periodic</td>
</tr>
</tbody>
</table>
8.3 Baseline Information – South East Route Section

8.3.1 Introduction

The route window descriptions of baseline conditions include a summary of the baseline data, relevant for the window. Baseline data are assessed according to the scope and methodology described in Chapter 3; the environmental receptor in question may be outside the route window. This is noted wherever it applies.

Maps have been produced showing the following baseline data: groundwater abstractions, 2003 Chalk water levels, area affected by saline intrusion, groundwater protection zones, surface water abstractions and discharges, main rivers and floodplains.

8.3.2 Geology and Hydrogeology

(i) Stratigraphy

The geological formations within the South East Route Section of the Crossrail area are described in the following sub-sections. A summary of the general stratigraphy is presented
in the table below. An overview of the geological stratigraphy in relation to the vertical alignment of Crossrail Line 1 is shown in Appendix C.

### Table 8.3: Stratigraphy – South East Route Section

<table>
<thead>
<tr>
<th>Period</th>
<th>Group</th>
<th>Formation</th>
<th>Description</th>
<th>Hydrogeological Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent</td>
<td>Made Ground</td>
<td>Made Ground Alluvium</td>
<td>Brickearths.</td>
<td>Permeable shallow aquifer in direct continuity with River Thames and other surface waters.</td>
</tr>
<tr>
<td>Quarter-</td>
<td>Drift</td>
<td>Langley, Ilford, Crayford and Dartford Silts</td>
<td>Gravel. Clayey and sandy in part.</td>
<td></td>
</tr>
<tr>
<td>nary</td>
<td>River Terrace</td>
<td>Deposits / Floodplain Gravels (including Boyn Hill Gravel and Taplow Gravel)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glacial Sands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and Gravels.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palaeocene</td>
<td>Thames Group</td>
<td>London Clay Formation</td>
<td>Stiff grey brown heterogeneous clay with closely spaced fissures.</td>
<td>Very low permeability aquitard separating shallow and deep aquifers.</td>
</tr>
<tr>
<td>/Tertiary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Harwich</td>
<td></td>
<td>Dense to very dense black rounded and sub-rounded, medium to coarse flint gravel, occasional cobbles, dark brown silty or clayey fine to medium sand matrix.</td>
<td>Weak aquifer</td>
</tr>
<tr>
<td></td>
<td>Formation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reading</td>
<td></td>
<td>Stiff red, blue, grey and brown laminated silty clay with fine to medium sand in the top part.</td>
<td>Aquitard</td>
</tr>
<tr>
<td></td>
<td>Formation</td>
<td></td>
<td>Stiff/hard buff blue, grey, black, sometimes mottled purple blocky slightly sandy silty clay, with occasional calcareous concentrations and limestone.</td>
<td>Aquitard</td>
</tr>
<tr>
<td></td>
<td>Woolwich</td>
<td></td>
<td>Shelly occasionally laminated silty clay or clayey silt with a little fine sand and impersistent hard limestone beds.</td>
<td>Aquitard</td>
</tr>
<tr>
<td></td>
<td>Formation</td>
<td></td>
<td>Dark grey shelly silty clay including oysters, sometimes in layers forming hard beds, with occasional laminated grey clay</td>
<td>Aquitard</td>
</tr>
</tbody>
</table>
(ii) Drift Geology

The surface geology along the proposed Crossrail South East route comprises unconsolidated deposits commonly grouped as ‘Drift’, which consists of artificial ‘Made Ground’, alluvium, assorted sands and gravels. The highly permeable sands and gravels dominate the hydrogeological properties of the Drift, and, as such, this geological unit is considered to form an upper, shallow aquifer. This shallow aquifer is typically in hydraulic continuity with the River Thames, and other watercourses. The shallow aquifer receives both urban and natural recharge, and infiltration from streams. The aquifer discharges to rivers, streams and, probably, buried services especially deep sewers. The sands and gravels typically have a thickness of less than 10 m, with a variable permeability, ranging from 10 m/d to more than 500 m/d. CIRIA (1993) quotes Foster (1971) as giving values in the range 50 to 150 m/d with a specific yield of 10 to 20%. Occasionally, the sands and gravels may be confined by a thin, (i.e. less than 3 m) cover of overlying alluvial clay deposits. This tends to occur along the alignment of the Thames and other rivers. There are also places where the shallow aquifer is locally thickened by infilling of scour hollows although these are mostly reported north of the Thames in east London especially around the confluence with the Lea.

<table>
<thead>
<tr>
<th>Period</th>
<th>Group</th>
<th>Formation</th>
<th>Description</th>
<th>Hydrogeological Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mottled blue grey and brown laminated silty clay/clayey silt/fine to medium sand, with occasional wood fragments.</td>
<td>Aquitard</td>
</tr>
<tr>
<td>Upnor Formation</td>
<td>Green, grey, grey-blue and mottled brown rounded fine to coarse flint gravel, sometimes in a sandy clay matrix with sporadic shells.</td>
<td>Weak aquifer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thanet Sands</td>
<td>Mottled green brown and orange slightly clayey sand with glauconitic medium sand and occasional scattered pebbles. May have ‘salt and pepper’ speckled appearance.</td>
<td>Weak aquifer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Greenish and brownish grey, silty, fine-grained sand. Bioturbation. Bullhead Beds at base.</td>
<td>Minor aquifer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chalk</td>
<td>Poorly cemented and porous, typically massively bedded and well jointed, fissured white limestone.</td>
<td>Major aquifer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(iii) Thames Group

The London Clay is a stiff clay containing sandy lenses and nodular concretions. Due to the complex folding of the strata, the exact position of the upper and lower boundaries of the clay are not well defined unless verified by site investigation. The London Clay has a very low permeability (the vertical permeability is typically less than $5 \times 10^{-6}$ m/d) and therefore acts as a very low permeability aquitard, overlying the Lambeth Group. Although some groundwater exists in sandy lenses within the London Clay, it is considered to be effectively isolated from the shallow and deep aquifers.

The Harwich formation lies beneath the London Clay and is generally less than 2 m thick, however it is often absent. It is part of the same group as the London Clay, but is considered to be a separate unit. Typically, the Harwich Formation comprises flint gravel with occasional cobbles, in a dark brown, fine to medium sand matrix. Although groundwater usually exists in the Harwich Formation, it is considered to be effectively isolated from the shallow and deep aquifers.

(iv) Lambeth Group

The Lambeth Group, formerly termed the Woolwich and Reading Beds, consists of three main lithologies:

- The Reading Formation: dominated by clay, which is characteristically mottled brown, grey green and bluish grey. It contains extremely closely spaced fissures.
- The Woolwich Formation: interdigitates with the Reading Formation in central and south-east London. It comprises laminated, grey, fine to medium-grained sands, silts and clays with shelly clay beds.
- The Upnor Formation: forms the basal bed of the Lambeth Group and consists of green and brown, glauconitic, medium-grained sands and pebbly (flint) sands.

The Woolwich and Reading Formations collectively form a folded layer beneath the London Clay and they have a moderate to low permeability. As such they may be classified as an aquitard which forms a hydrogeological extension of the overlying London Clay aquitard. Sand lenses, where present, may contain groundwater under pressure. These layers may be recharged at the sub-crop in the bed of the River Thames but may be otherwise separate from the shallow and deep aquifers.

The Upnor Formation is in hydraulic continuity with the underlying Thanet Sands, which together form the arenaceous part of the deep aquifer.

A detailed lithostratigraphic correlation of the Lambeth Group along the Jubilee Line Extension (JLE) in south-east London was described in a report prepared by Ellison (1991) for LUL. The lithological sub-division established comprises seven sub-units in line with earlier work by Ellison (1983), Hester (1965) and King (1981). Howland (1991) also presents a similar scheme in a paper describing the engineering geology of London’s Docklands. A summary of the succession in descending stratigraphic order, identified during the JLE investigation is presented in Table 8.4. It should be noted that not all of these units may be present and the presence of dissimilar units cannot be ruled out.
## Table 8.4: Description of Facies Presented in the Lambeth Group

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
<th>Average Thickness (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Shelly Clay</td>
<td>Shelly occasionally laminated silty CLAY or clayey SILT) with a little fine sand and impersistent hard limestone beds.</td>
<td>1 to 3</td>
</tr>
<tr>
<td>Upper Mottled Clay</td>
<td>Stiff red, blue, grey and brown blocky silty CLAY with fine to medium sand in the top part.</td>
<td>1 to 4</td>
</tr>
<tr>
<td>Laminated sands and silts</td>
<td>Mottled blue grey and brown laminated silty CLAY/clayey silt/fine to medium SAND, with occasional wood fragments.</td>
<td>0.5 to 3</td>
</tr>
<tr>
<td>Lower Shelly Clay</td>
<td>Dark grey shelly silty CLAY including oysters, sometimes in layers forming hard beds, with occasional laminated grey clay and silt.</td>
<td>0.5 to 3</td>
</tr>
<tr>
<td>Lower Mottled Clay</td>
<td>Stiff/hard buff blue, grey, black sometimes mottled purple blocky slightly sandy silty CLAY, with occasional calcareous concentrations and limestone.</td>
<td>0.5 to 3</td>
</tr>
<tr>
<td>Pebble Bed</td>
<td>Green, grey, grey-blue and mottled brown rounded fine to coarse flint GRAVEL, sometimes in a sandy clay matrix and with sporadic shells.</td>
<td>1 to 2, up to 5</td>
</tr>
<tr>
<td>Glaucnitic Sand</td>
<td>Mottled green brown and orange slightly clayey SAND with glauconitic medium sand and occasional scattered pebbles. May have ‘salt and pepper’ speckled appearance.</td>
<td>3 to 4</td>
</tr>
</tbody>
</table>

(v) **Thanet Sands**

The Thanet Sands comprise a thin, folded layer of fine grained sands and silty sands, with a distinctive basal bed of green coated flints, which are well-developed in places. The Upnor Formation and the Thanet Sands form the arenaceous part of the deep aquifer. In the South-East Route Section, this aquifer is locally separated from the shallow aquifer by the intervening aquitard formed by the Woolwich and Reading Formation and the London Clay. To the south-east of the Royal Victoria Dock, where the aquitard is absent, the shallow and deep aquifers are in hydraulic continuity with each other and also with the river.

(vi) **Chalk**

The Upper Chalk underlies the Thanet Sands and forms the carbonate, bedrock part of the deep aquifer. Due to the small size of the connected pore space the Chalk has relatively low matrix permeability, on average less than 0.01 m/d. The much higher permeability of the aquifer as a whole (generally between 1 and 500 m/d) is due to secondary permeability associated with extensive fissure systems.
Geological Structure

Geological desk study or intrusive site investigation data for the South East Route Section are of limited availability although further data and interpretive reports would become available in future. This assessment of the baseline is based on BGS Sheet 271 and geotechnical studies for the section between Custom House to Plumstead and a desk study from Plumstead to Abbey Wood. Historic water wells located on the BGS Sheet 271 close to the South East route alignment have been identified and summary records have been reviewed. The London Basin Groundwater Model (LBGM) was originally developed in 2000 by Mott MacDonald for Thames Water and the Environment Agency (Thames Region), with further refinements recently undertaken and completed during 2004. This five-layer model covers the South East Route Section to beyond Abbey Wood and has been referred to in order to obtain elevation data for the base of the London Clay/clay facies of the Lambeth Group (where relevant to this route section) and used to predict the likely impacts of dewatering in the Central Section on the groundwater environment. These impacts extend into the South East Route Section.

An indicative geological long section for the route from Stepney Green (route window C9) to Victoria Portal (route window SE2) is given on Figure C.10 in Appendix C. The long section is based on data from site investigations carried out for Crossrail and does not contain any details of inferred faulting or local folding. No geological section has been prepared for the remainder of the South East Route Section. Instead a geological section through the Thames tunnel and a figure showing the solid geology around the Plumstead portal are presented within the text of the relevant route windows.

The London Basin forms a large, gentle, north-east to south-west trending synclinal fold which plunges towards the east. The major syncline has been greatly affected by folding and faulting. The 1:50 000 geological maps show two major faults, the Greenwich and Woolwich faults running across the south-east of the Crossrail alignment. However, recent work suggests the structure is more complex. The University of Reading have suggested a pattern of orthogonal dip and strike faults with intermediate synclines. This interpretation is a more coherent explanation of the original data because it integrates structure within the Docklands to all nearby areas. However, Berry (1979) discounts certain data for the top of the Chalk ascribing some low elevation values to scour hollows. These hollows have also left occasional windows in the London Clay and some windows of high vertical permeability through the Woolwich and Reading Formation.

Confirmation as to whether the dominant structures are tight folds or are faults may only prove possible by further investigation. Not all of the structural features have a direct impact on groundwater flows. However, base maps prepared for the London Basin Groundwater Modelling study (Mott MacDonald March 2003) contain internal aquifer zone boundaries as inferred from review of both the geological structure and the piezometry. The aquifer zone boundaries act as low permeability barriers to groundwater flow and are more relevant to the hydrogeology than the purely structural features. Where available, site investigations for Crossrail can provide more localised data on structure than the regional studies.

The Crossrail alignment and the geological structure are such that the solid geology along the South East Route Section changes significantly from west to east; from the London Clay overlain by river alluvial deposits, to outcrops of the Thanet Sands and Chalk also overlain by river alluvial deposits, to Chalk Downs in the south-east away from the river.
At the Limmo Peninsula, the surface geology comprises river alluvial deposits overlain by London Clay. The University of Reading structural assessment of the area shows a major north-west / south-east trending fault running along the northern side of the Limmo Peninsula. The rock units here dip gently to the north-west, and, at the Royal Victoria Dock, the Lambeth Group underlies the surface deposits. The Greenwich Fault (north-east / south-west trend) is traditionally shown to cross the Docklands area, running across the western end of the Royal Albert Dock but an alternative interpretation is discussed above.

To the east of the docks, the alignment passes over gently dipping sub-crops of Lambeth Group, Thanet Sand and Upper Chalk in succession from north-west to south-east. These are overlain by surface deposits. The River Thames is directly underlain by Chalk with a thin cover of superficial deposits in places. Seismic data shows an erosion feature in the river bed filled with unconsolidated sediment at the Woolwich Reach.

On the southern bank of the River Thames the Chalk is overlain by the Thanet Sands, plus a layer of superficial deposits. At Warren Lane and Arsenal Way shafts, the Thanet Sands are approximately 15 m thick and the superficial deposits are only a few metres thick.

Beyond Plumstead, the alignment runs along the edge of the alluvial superficial deposits which are only present to the south of the route alignment for a few hundred metres. Geotechnical data obtained for four bridges between Plumstead to Abbey Wood Station indicate that the superficial deposits comprise Made Ground, (up to 2 m thick), underlain by Alluvium (between 0.6 to 8.5 m thick) and River Terrace Deposits (4.9 to 9.1 m thick). At the southern end of Harrow Manorway (located immediately to the east of Abbey Wood station) a 10.2 m thick layer of Colluvium was also recorded.

An area of Chalk sub-crop where the Thanet Sands have been fully eroded runs along part of the route alignment between Plumstead and a point west of Erith. The northern margin of this sub-crop of Chalk is caused by a tight fold or fault. In the north of this area, the Thanet Sands and Chalk are both overlain by superficial deposits comprising alluvium and some areas of Head deposits (silt, sand and clay with variable gravel). Up to Abbey Wood, the route alignment runs along this northern margin of the Chalk sub-crop (so the Thanet Sands underlie the superficial deposits to the north). However, from Abbey Wood Station to the point west of Erith the alignment passes above the Chalk directly although the superficial deposits thin out. Figure 8.12 shows the geology between Plumstead Portal and Abbey Wood Station.

(viii) Occurrence of Aquifers in the South East Route Section

There are three distinct hydrogeological situations in the South East Route Section:

1. Shallow aquifer separated from deep aquifer

This situation occurs at Limmo Peninsula where the shallow aquifer comprising the recent river alluvium is separated from the deep aquifer by a layer of London Clay.

2. Shallow aquifer directly above deep aquifer

This situation occurs where the deep aquifer sub-crops directly beneath the shallow aquifer. The confining London Clay and upper Lambeth Group are usually absent along the South
East route to the east of the Royal Victoria Dock. In this situation there would be a hydraulic connection between the deep aquifer and the River Thames and other watercourses in hydraulic contact with the sands and gravels of the shallow aquifer.

3. Shallow aquifer not present, deep aquifer at surface

This situation occurs where the Chalk or Thanet Sands are at the surface (for example, south of Abbey Wood Station), with no covering of superficial deposits.

(ix) Groundwater Levels

Abstraction from the Chalk in the London area began in 1823, and peaked prior to World War Two with a consequential lowering of groundwater levels and the formation of extensive cones of depression. Since the mid 1960’s reduction in groundwater usage has led to a gradual rise in groundwater levels and recovery of groundwater levels within the cones of depression. Superimposed on the rising trends at certain locations are short-term fluctuations resulting from construction dewatering for projects such as Canary Wharf, the Jubilee Line and the CTRL. In general, at present, Chalk groundwater levels along the South East Route Section are stable. Dewatering for construction of the Channel Tunnel Rail Link (CTRL) around Stratford may have lowered the groundwater levels slightly at the Limmo Peninsula area. Groundwater levels along the route south of the River Thames have not been modified at a regional scale by historic pumping.

(x) Groundwater Quality

The shallow aquifer receives recharge from rainfall infiltration, urban and natural runoff, and stream infiltration. The water is very rarely of a quality suitable for potable supply within central and east London and is therefore seldom abstracted.

Groundwater in the deep aquifer is usually abstracted from the Chalk since well construction is much easier than in the overlying Thanet Sands. Groundwater quality is generally good under the Chalk outcrop towards the eastern end of the route section where there are some major public water supplies.

At the western end of the route section, the River Thames is tidal throughout the area of interest to Crossrail and therefore contains a both temporally and spatially varying proportion of seawater and freshwater. Under natural conditions of groundwater flow, which occurred until the early nineteenth century, the River Thames below Poplar and Rotherhithe was one of the main outlets for groundwater moving through the confined aquifer from the outcrops in the Chiltern Hills and North Downs. The head of groundwater in the aquifers was sufficient to prevent the ingress of saline water, except in the immediate vicinity of the river, where some intrusion probably occurred at high tides and during floods caused by tidal surges. As groundwater abstraction increased through time, the natural discharge into the river decreased, and eventually the hydraulic gradient reversed. This has allowed saline water to move into the Lower London Tertiaries and the Chalk wherever these aquifers are in hydraulic continuity with the river (Water Resources Board, 1972).

Generally, in West Essex, background chloride concentrations in Chalk groundwater are between 50 and 100 mg/l (Water Resources Board, 1972). Concentrations above 100 to
250 mg/l are assumed (A.SE.2) to indicate that the River Thames is, or has been in the past, in hydraulic continuity with the aquifer, that saline intrusion has occurred and therefore the water is non-potable. High electrical conductivities (above about 1500 µS/cm) also indicate brackish conditions.

A zone of the expected extent of saline intrusion has been estimated based on the limited historic records and groundwater monitoring results and is shown on the Drawings. Appendix C contains two figures showing the extent of saline intrusion based on the 150 mg/l isochlor and 5 mmol/l across London. Typically the width of the saline zone on the north bank of the River Thames exceeds 3 to 4 km over considerable lengths of the river. Between the Limmo Peninsula and the Thames Tunnel, groundwater is likely to be non potable. Appendix C contains a map extending from Stepney to Limmo Peninsula Shafts (Route window C9 to SE1), with deep groundwater chloride concentrations labelled.

A Durov triplot in Appendix C shows that water sampled from the River Thames has far higher ratio values of sodium and chloride than groundwater samples. This reflects its higher total salinity. The River Thames water also shows lower concentrations of bicarbonate, similar concentrations of calcium and higher concentrations of magnesium. The river water from the Thames measured at half tide shows a decreased salinity relative to high tide.

The width of the zone of saline intrusion on the south bank is considerably less than that north of the river, commonly being no more than 0.8 km. The geological structure of the region complicates the pattern of saline intrusion; the low permeability boundaries within the Chalk act as a partial barrier to groundwater flow and thus saline migration.

At Plumstead the geological structure limits the extent of saline intrusion on the south side of the River Thames. In general, at Plumstead and to the east, the water quality in the deep aquifer is expected to be reasonable.

(xi) Groundwater Vulnerability

The western end of the South East Route Section runs along what has been classified as a ‘Minor Aquifer (variably permeable)’ with a soil class score of HU (High Leaching Potential). The HU rating is given because soil information for urban areas is less reliable and based on fewer observations than in rural areas, so the worst case is assumed (A.SE.3). As such, land is classified as having high leaching potential (HU) until proved otherwise (Groundwater Vulnerability of West London, Sheet 39, 1:100 000 map). At Greenwich, the South East Route Section crosses over a narrow band classified as ‘Major Aquifer (Highly Permeable)’ again with a soil class score of HU due to a lack of reliable information in the area. Beyond Woolwich the entire route runs along ‘Major Aquifer (Highly Permeable)’. This classification relates to the Chalk aquifer.

(xii) Groundwater Abstractions

All groundwater abstractions located within a 500 m corridor either side of the route alignment, within a 1000 m radius of each station, or those which may have a source protection zone that extends into this buffer zone, have been identified. These groundwater abstractions consist of licensed wells, protected groundwater rights and abstractions in determination and Section 32 consents. Appendix C lists details of all groundwater
abstractions along the Central and Eastern routes. The tables in Appendix C indicate whether the abstractions are located in an area where the tunnel is constructed in the London Clay. In such areas, water quality at abstractions in the main aquifer are assumed (A.SE.4) not to be affected by any works as the London Clay and upper Lambeth Group clays would act as a low permeable barrier between the tunnel and the aquifer below.

There are three groundwater abstractions along the South East Route Section. One abstracts from the river gravels, and two from the Chalk, one of which is a protected groundwater right. All abstract water for industrial purposes.

The Environment Agency has not established source protection zones (SPZs) for any of the abstractions above. In order to evaluate these abstractions without an associated SPZ, calculations have been undertaken by Mott MacDonald to produce approximate time of travel zones (TTZ), corresponding to a travel time of 50 days and 400 days. This is discussed in more detail in Appendix D.

The inner SPZ is defined as the 50 day travel time area; (with a minimum 50 m radius), and the outer as the 400 day travel time area or 25% of the total catchment, whichever is bigger. It must be noted that the TTZs calculated by Mott MacDonald are approximations used to determine whether the catchment area to the well would extend into the route window and, therefore, potentially could be affected by the works. Even if the 50 or 400 day SPZ or TTZ does not cross the route alignment, the associated abstraction well could still be subject to impacts if the travel time is more than 400 days. A travel time zone of up to 5 years has therefore also been considered in the assessment of impacts on groundwater abstractions. Inner and outer source protection zones as provided by the Environment Agency, and TTZs estimated by Mott MacDonald are shown on the Drawings and are discussed further in the impact assessment for each route window below.

8.3.3 Surface Water

(i) Main Rivers and Other Watercourses

The Thames Estuary is the main surface water body in the area and watercourses crossing the Crossrail route alignment eventually flow into the estuary. All main rivers are shown on the drawings. Appendix C also contains a table listing rivers within 500 m along the route alignment and within 1000 m of existing stations, including ordinary and some minor watercourses. The main rivers along the South East Route Section are the River Thames, the River Lea, Great Breach Dyke, Butts Canal, Horse Head Dyke and the Corinthian Dyke.

Great Breach Dyke, Butts Canal, Horse Head Dyke and Corinthian Dyke form part of a network of pumped surface drains known as the “Marsh Dykes” and are all located between a point east of Plumstead Station and Slade Green Station which is west of Abbey Wood Station. The Marsh Dykes area is crosscut by a number of drainage ditches and sewers. These are a mixture of main rivers, ordinary watercourses with some fully piped sections. Figure 8.2 shows the locations of the relevant dykes.
Figure 8.2: Marsh Dykes

- Great Breach Dyke
- Horse Head Dyke
- Green Level Dyke
- Keats Road Dyke
- Corinthian Dyke
- Wickenham Valley Watercourse
- Picardy D.
- Pickle Factory D.
- Upper Bedon St

Catchments:
- Cray
- Crayford
- Crossness
- Great Breach
- Green Level
- Severs
- Tip Brook
(ii) Floodplains and Flood Levels

The Environment Agency has developed Flood Zone Mapping. Zone 3 shows the extent of a 1:100 year flood for main rivers and the 1:200 year flood for the Thames Estuary. The mapping shows the possible extent of a flooding event and highlights areas defended by flood-prevention structures. The route alignment lies on the Thames tidal zone to beyond Abbey Wood. However the functional floodplain (see below) runs much closer to the Thames and the route alignment falls within the area currently protected from tidal surges. The extents of the flood zones (both tidal and fluvial) are shown on the Drawings. No works on cross drainage structures on watercourses have been identified in the South East Route Section.

Tidal flood levels at key points along the Thames estuary have been obtained from the Environment Agency for the year 2060 condition with allowances for both a sea level rise of 6 mm/yr and a river flow increase. The results are shown in the below.

<table>
<thead>
<tr>
<th>Location</th>
<th>Flood Level (m AOD) for return periods of the following (years):</th>
<th>Existing Level of Service of Flood Defence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Thames - River Lea&lt;sup&gt;1)&lt;/sup&gt;</td>
<td>5.90</td>
<td>6.04</td>
</tr>
<tr>
<td>Thames – Barrier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thames – Gallions&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>5.98</td>
<td>6.12</td>
</tr>
<tr>
<td>Thames - River Roding&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>5.93</td>
<td>6.05</td>
</tr>
<tr>
<td>Thames – Erith&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>5.78</td>
<td>5.91</td>
</tr>
</tbody>
</table>

Notes: 1) Assuming Thames Barrier is open
2) Assuming Thames Barrier is closed

In this table, the flood levels downstream of the Thames Barrier are based on the assumption (A.SE.5) that the Barrier is closed but the levels upstream assume the Barrier to be open. The level of service is based on freeboard provision of 0.7 m downstream of the Barrier with a variable amount upstream, (minimum 0.4 m) depending on the whether the Barrier is open or closed. The Environment Agency has commissioned several river modelling studies and results are due within the next few years. The data obtained for Crossrail are based on the latest available modelling results obtained from the Environment Agency in October 2003.

In order to take climate change into account, most developments have been asked to use results from model runs using 100 year flows plus a 20 % increase in discharge according to the Office of the Deputy Prime Minister (ODPM) Planning Policy Guidance Note, PPG25. Water levels for 200 year return period flows, where they exist, are likely to give similar water levels.
PPG25 also refers to ‘functional floodplain’ and this is an important distinction from ‘floodplain’ since, where effective flood defences exist, the functional floodplain may be much smaller than the topographic floodplain. An area protected by a flood defence and shown by the Environment Agency as being in a Defended Flood Zone is assumed (A.SE.6) to be classed as not being on the functional floodplain and therefore new development would be exempt from a need to consider compensatory storage. The Environment Agency has confirmed that the London area is regarded as fully protected from tidal floods by the estuary flood defences as shown on the Flood Zone mapping.

(iii) Surface Water Quality

Water quality information for the major rivers in the area has been provided by the Environment Agency (Environment Agency). The River Quality Objective (RQO) represents the target water quality for each river. RQOs are mainly used to set conditions in the licenses granted to industry and commerce for surface water discharges. The General Quality Assessment (GQA) is the Environment Agency’s national method for classifying water quality in rivers and canals. The water quality is assessed using four separate categories: chemistry, biology, nutrients, and aesthetics. Further details are given in Appendix C.

GQA and RQO have been reported, where data is available, for all river reaches crossing or downstream of the Crossrail route alignment. The data are from 2003 and are presented in Appendix C. The GQA and RQO scores are only determined for fresh water. In the South East Route Section, the northward flowing rivers are generally of good quality.

Within the South East Route Section, the River Thames is estuarine; the GQA and RQO scores have not been determined for these reaches. The classification is instead based on a score of biological, aesthetic and chemical quality. In 2000 the Thames estuary was classified as ‘good’ for 25% of its length and ‘fair’ for the remainder. No stretches of the Thames were classified as poor or bad. The area around Isle of Dogs appears to be classified as ‘fair’. The quality is expected to improve as the quality of discharges along the Thames is improving.

This part of the River Thames is dominated by the tidal flow in the estuary and the resulting tidal current influences the transport of sediments and substances. The water quality in the estuary downstream of the Isle of Dogs is influenced by discharges to the estuary (these include the wastewater treatment plants at Beckton and Crossness) as the water is transported upstream and downstream with the tidal current.

Water quality in the tidal reaches of the River Thames has improved considerably in the last few years, primarily due to improvements in the treatment of wastewater discharged to the river. However, the impact of wastewater discharges to the river can still clearly be seen in the measured concentrations of a range of determinands. Generally the Thames has a high content of suspended solids and nutrients resulting in algae growth. Water quality records for the Thames are shown in Appendix C.

(iv) Surface Water Abstractions

The methodology for the assessment of licensed surface water abstractions considers primarily, sites within the route window and secondarily, intakes further downstream of the...
corridor. It is anticipated that any objection by the Environment Agency to a temporary or permanent discharge or, possibly, a temporary abstraction would be governed by their RQO for the surface water body since this encompasses potential derogation of surface water quality.

(v) Surface Water Discharges

The Environment Agency has provided details of consented surface water discharges along the route section. There are several surface water discharges in most of the route windows along the South East Route Section. These discharge mainly to tributaries to the River Thames. The majority of the surface water discharges are consented to Thames Water by the Environment Agency.

Appendix C shows details of the consented surface water discharges to beyond Abbey Wood and their locations are marked on the drawings.

8.3.4 Designated Nature Conservation Sites

Digital data sets of all designated national and international nature conservation sites (SSSI, SPA, SAC, NNR and Ramsar) have been obtained from English Nature. Sites within 2 km of the route and those downstream of river crossings have been noted and the citations reviewed to establish which sites have water features that may be susceptible to impacts imposed by the works. Further consideration of ecological designations and aquatic ecology issues is provided within the Ecology Technical Report.

8.4 Impacts and Mitigation – South East Route Section

8.4.1 Potential Impacts on Groundwater and Generic Mitigation

This section presents an overview of the route section wide impacts in the South East Route Section and the reasons why certain potential impacts are considered as not applicable or insignificant after generic mitigation. A summary of the route section wide impacts and generic mitigation register is given in Appendix F. In general, the route section wide impacts are taken, by default, to be applicable in all route windows and are therefore not discussed in the text for each. However, those impacts discussed below that are related to tunnelling are only relevant to parts of route windows SE1 to SE5.

Exceptions to the default position can occur where either the work is different from the general case or there are environmental receptors that have special features. The locations of the exceptions are listed in the text below and further details are discussed in the later sections on the relevant route windows.

The route wide impacts on groundwater and generic mitigation (see Chapter 4) are not examined below. In particular, many construction activities leading to potential pollution of surface and groundwater as temporary impacts would be dealt with through the provisions for generic mitigation described in Appendix B and are therefore not discussed in detail herein.
(i) Groundwater Levels and Flows

Temporary: In general, groundwater levels and flows in the deep aquifer of the Chalk, Thanet Sands and lower Lambeth Group would not be significantly altered since dewatering in these layers is not normally required. Exceptions occur at the western end of the route section and are described in route windows SE1, SE4, SE5 and SE6.

A second type of influence may occur where the shallow aquifer has good hydraulic continuity with the deep aquifer and the latter is being dewatered. This is described in the relevant route windows SE2, SE3, SE4 SE5 and SE6.

Permanent: In general, no significant, permanent effects on groundwater levels and flows are expected. Exceptions would occur where long cut off walls are constructed in the shallow aquifer such as at portals (route windows SE2, SE4 and SE6) and retained cuttings (route windows SE2, SE4 and SE6).

(ii) Groundwater Quality

Temporary: Temporary impacts on water quality in the shallow aquifer could occur as a result of site operations and these are considered elsewhere under route wide impacts (see Chapter 4). In the west of the route section, the shallow aquifer is generally non-potable and not utilised and so any water quality impacts would be minor. Near the River Thames and the Docks, any dewatering of the shallow aquifer would tend to induce infiltration of river water. However, the groundwater quality in this area is already affected by the Thames and, therefore, impacts would not be significant. A more general set of exceptions may occur where contaminated land or groundwater exists and the groundwater flow regime in the shallow aquifer is modified by the works. These potential impacts would be investigated and any necessary mitigation measures proposed during the detailed design and construction phases as part of the procedures for dealing with contaminated land.

Water quality in the deep aquifer in the west of the route section (see Chapter 4) would be temporarily affected by tunnel construction. Grouts, concreting by-products, spoil conditioners and tailskin grease would come into contact with groundwater and there are also risks associated with other chemicals such as hydraulic fluids and bearing greases. However, the impacts are expected to be minor since groundwater is usually seeping into the works and, as discussed under route wide generic mitigation, relatively benign or biodegradable chemicals would be used and their consumption would be monitored. There is a greater risk that the turbidity of groundwater flowing in fissured Chalk would increase and this may indicate movement of some other contaminants to an abstraction. Turbidity increases would themselves be treated as warranting further investigation even if the limit under the Drinking Water Standard was not exceeded.

Water quality in the deep aquifer in the remainder of the South East Route Section, could be impacted by site operations since the aquifer is not usually protected by low permeability overlying strata. This is a route wide generic risk and would be managed through the provisions for generic mitigation described in Appendix B.

Permanent: South of the River Thames, minor permanent impacts on water quality are foreseen in the shallow and deep aquifers wherever track drainage is modified. Special cases occur where new track and related drainage is constructed over SPZs or TTZs (route
window SE6. North of the Thames, the shallow aquifer is usually non-potable and not utilised (although an exception occurs in SE1) and any water quality impacts would be minor. Where induced infiltration from the River Thames and the Docks would occur in the deep aquifer within SE1 to SE5, the water quality has already been affected by historic infiltration and so the impacts are not significant.

There is a small, generic, residual risk that dewatering or tunnelling would activate a drift filled hollow, scour hollow, fault or back filled water well and create a hydraulic pathway through the London Clay or upper Lambeth Group and allow cross contamination to occur. The few known hollows, faults and wells on the alignment are discussed in the relevant route window. It is possible that new sites would be identified as the construction work progresses. There are potential impacts on groundwater quality related to decommissioning of temporary works such as dewatering wells. These are referred to in the individual route windows but the arrangements for sealing them up would be detailed in the provisions for generic mitigation described in Appendix B.

There is a small, generic, residual risk of piling for new foundations providing a hydraulic pathway through the London Clay or upper Lambeth Group and allowing cross contamination to occur. Where piling would not extend more than 10 m there would not be an impact where there is a sufficient thickness of low permeability strata. Sites with less than 10 m of suitable strata and with contaminated shallow groundwater would be identified as the geotechnical studies for foundations progress and alternative foundation designs or suitable piling methods would be adopted as required.

(iii) Mitigation and Compensation at Existing Wells

The following strategy would minimise and manage the residual risks to groundwater abstractions. This is described in the relevant route windows where abstraction sources or Time of Travel Zones occur.

A DESIGN check as part of the EIA and consultation process would focus on the spatial relationship between the railway and the abstraction well. Construction levels would be compared with data on lengths of borehole already sealed off by grouting and casing, data on zones of inflow that supply the abstraction boreholes and adits, as well as data from stratigraphy and deeper site investigation (SI) drilling. The actual risk of derogation of quality at the borehole would be refined after examination of both the horizontal and vertical separation of the source and receptor of the potential pollutants.
A WELL YIELD impact assessment would be made to determine the effect at an abstraction source of predicted drawdowns due to dewatering as given in Appendix E. The main issues are firstly whether the pump is or can be set low enough within a section of suitable borehole geometry to maintain pumping. The second issue is whether the extra drawdown might cause a drop in available yield from the aquifer to the borehole because of a drop in effective saturated thickness. The seriousness of either issue is often small in central London because wells were often built with many metres of suitably sized blank steel casing to pass through all the overlying strata to reach the depth at which fissured Chalk is encountered. Furthermore, pump settings are often deep enough to withstand some extra drawdown because they were often determined on the basis of the much deeper rest water levels which obtained several decades ago. If mitigation is deemed necessary, measures could include lowering an existing pump, well cleaning to reduce the drawdown requirement, or provision for an alternative source (usually public water supply) to be used in a drought.

An agreement with the well owner would be sought on the scope for routine water quality MONITORING at abstraction sources. The need for intermediate monitoring holes and procedures for water and contaminant testing during construction and operation would be discussed with the well owner and the Environment Agency.

MANAGEMENT solutions would be sought. These could cover the scope for minimal or no pumping by the owner when construction is going on nearby, checks on what the water quality needs are and what water treatment is in place at the sources, checks on arrangements to provide bulk supply from elsewhere, and checks for possible needs to restructure licenses and scope for the Environment Agency to facilitate this.

CONTINGENCY PLANNING would include use of sources to pump to waste, possible use of site investigation or other boreholes for scavenging pumping of contaminated water and disposal of oils or fire fighting chemicals from shafts during construction and operation.

Consultation with well owners has commenced in order to obtain the site specific data on the well owner’s arrangements for routine water quality monitoring at abstraction sources.

8.4.2 Potential Impacts on Surface Water and Generic Mitigation

The route wide impacts on surface water and generic mitigation described in Chapter 4 are not re-examined in this section. As described for groundwater in Section 8.4.1 above, potential temporary pollution of surface water from construction activities would be dealt with through the provisions for generic mitigation described in Appendix B.

(i) Floodplains and Cross-Drainage Structures

Temporary and Permanent: In general, no remodelling of cross-drainage structures or construction on unprotected floodplains is planned that may reduce the floodplain storage by taking up storage space below the design 1:100 year plus 20% level required by PPG25 (issued by ODPM). Tunnelling work is assumed (A.SE.7) not to affect floodplain storage except at any temporary surface construction works at undefended sites.
(ii) **Surface Runoff Intensity**

**Temporary and Permanent:** It is assumed (A.SE.8) that all runoff and tunnel drainage in the South East section west of Plumstead Portal would go to combined sewer after achieving runoff intensities that are not worse than existing, or as otherwise acceptable to Thames Water, and the generic assessment is, therefore, that there are no impacts. Site specific exceptions have been identified where hard surfaces such as roofs, trackbed and access roads are replacing permeable surfaces such as parks, gardens or surface rail track. These are discussed in the relevant route windows such as SE1 to SE4.

East of Plumstead Portal, it is assumed (A.SE.9) that all runoff would go to stormwater sewer or surface drainage after achieving additional runoff intensities that are attenuated to greenfield rates or as otherwise acceptable to the Environment Agency and Thames Water.

In a few cases, temporary work sites would occupy permeable surfaces and create the potential to increase runoff to sewers with a resulting temporary loss of available sewer capacity. Discussions with the utility company would take place to arrange appropriate consents and therefore no residual impacts are predicted. Exceptions occur where, after consultation with the Environment Agency, British Waterways, the Local Authority or the utility company, a discharge consent is to be obtained from the Environment Agency. Such consents and a suitable disposal route for any effluent from pumping of groundwater during construction may be sought at Limmo Shaft and Victoria Dock, North Woolwich and Plumstead Portals (route windows SE1 to SE6).

(iii) **Surface Water Quality**

**Temporary:** The proposed works are assessed as having no generic temporary impacts on surface water quality since, through the provisions for generic mitigation described in Appendix B construction site practices would be organised to avoid pollution as discussed under route wide generic mitigation. Specific exceptions occur where discharges from dewatering are planned or where works would take place in or near water bodies. These are discussed in the relevant route windows such as SE1 to SE6 and SE6A.

**Permanen:** The works would generate no permanent impacts on surface water quality in general because there are no discharge consents being sought. There are a few potential, minor changes in runoff planned where surface runoff is discharged to watercourses as at Abbey Wood, (route window SE8). There would also be some betterment where existing track and platform drainage arrangements are upgraded with the possible inclusion of silt or oil interceptors.
8.5 Route Window SE1 – Blackwall Way & Limmo Peninsula Shafts

8.5.1 Scheme Description

(i) Overview

Within this route window the main Crossrail works would involve construction of the Blackwall Way shaft, the construction of the Limmo Peninsula shaft and the construction of twin-bore tunnels.

The figure below shows the main features within the route window.

Figure 8.3: Route Window SE1 – Blackwall Way & Limmo Peninsula Shafts

(ii) Blackwall Way Shaft

The Blackwall Way shaft would be used as an EIP. It would consist of a 9 m diameter shaft located immediately to the south of Blackwall Way and adjacent to the Reuters Building car park and Virginia Quay Development.

The main construction works at Blackwall Way would proceed as set out below:

- Piling to the perimeter of where the basement box would be constructed followed by excavation to base level. A dewatering system would be installed prior to excavation and construction.
- Excavation of a circular shaft constructed using pre-cast concrete rings and subsequently the installation of a concrete base slab and drainage sump.
• Excavation of a central intervention passage from the base of the shaft and completion of shaft lining over a period of approximately four months.

• The TBMs would then pass through the area and the connecting passages would be excavated and lined.

• Construction of a surface level building to house equipment, the fitting of the emergency services lift and the construction of a surface level hard standing would take approximately nine months.

(iii) Limmo Peninsula Shaft

The Limmo Peninsula shaft would be used as an EIP, ventilation and evacuation facility, and a principal tunnelling site. It would consist of a 25 m diameter shaft located at the southern end of the Limmo Peninsula.

The main construction works at Limmo Peninsula would proceed as set out below:

• Site set-up, mobilisation and site clearance followed by shaft and passageways construction. A dewatering system would be installed prior to excavation and construction if required. The top section of the shaft would be constructed by excavation and sinking of pre-fabricated concrete rings followed by construction using sprayed concrete lining as excavation proceeds. TBMs would then be assembled and launched from the shaft to construct the twin-bored tunnels towards Victoria Dock portal to the east. The TBMs would then be reassembled at Limmo Peninsula shaft to drive the tunnels to the Isle of Dogs station to the west which would take approximately 11 months, followed by clean out, trackbed, and installation of walkways and building services.

• The shaft and passageways would be secondary lined and fitted out. At the same time the above ground structure would be constructed and fitted out. A surface level hard standing would also be constructed which would be landscaped to form part of a green area for use by pedestrians and for leisure.

Excavated material will be removed by barge from a loading facility that will be constructed on the edge of the River Lea via a conveyor from the shaft.

(iv) Twin-bore Tunnels

The tunnelled section would comprise twin-bored segmental lined tunnels. Both the eastbound and westbound rails would lie at a depth of approximately 40 m below ground level at the Blackwall Way shaft and 30 m at the Limmo Peninsula shaft.

(v) Duration of Works

The construction of Blackwall Way shaft including fitting out and commissioning would be undertaken over a period of approximately four years and three months.
The construction of Limmo Peninsula shaft including fitting out and commissioning would be undertaken over a period of approximately four years and three months.

8.5.2 Additional Scheme Description Assumed for Water Resources Assessment

Blackwall Way Shaft: Rail level is 65.3 mATD. A surface water sump would be provided in the tunnel invert bringing the deepest level of work to 57.4 mATD. Work would, therefore, take place within the Thanet Sands and significant dewatering would be required with disposal probably to the nearby River Thames.

Limmo Peninsula Shaft: The formation level of the shaft (66.15 mATD) is approximately 42 m below ground level. From ground level to 91.5 mATD, a distance of 16 m, the shaft would be constructed using pre-cast concrete segments. A caisson would be sunk through the superficial deposits, and would toe-in to the London Clay, thus cutting off the shallow aquifer. Grouting would be undertaken within the superficial deposits to secure the lining and prevent water ingress; however the option for dewatering within the shallow aquifer has been considered in view of the potentially greater environmental impacts. The deeper parts of the shaft would be constructed using sprayed concrete, with a typical advance length of 1 m, which would allow any water ingress from sand lenses in the London Clay to be managed. The base of the shaft would most likely consist of a reinforced concrete domed plug to resist the long-term heave effects expected in the London Clay. Construction would not take place within the deep aquifer, but significant dewatering may be necessary to reduce the risk of base heave or seepage.

A covered excavated material conveyor would be constructed on the mainland, projecting out into the River Lea. The River Lea is tidal in this reach, so the barges would moor against piles bored in the River Lea.

Dredging would be required within the Lea. The dredging worksite would be within the buffer zone of the River Lea.

8.5.3 Baseline Data

Geotechnical investigations close to the Blackwall Way site show that the geology comprises Made Ground from ground level at 105.5 mATD, underlain by Alluvium and Terrace Deposits. The London Clay is found from around 94.3 mATD with a thickness of about 10 m. Below the London Clay is a 2 m thick layer of Harwich Formation. The Lambeth Group below is approximately 15 m thick, the top of the Thanet Sands is at 64.5 mATD and the top of the Chalk at 52.9 mATD. Water levels in the deep aquifer are around 90-95 mATD.

Geotechnical information from the Lower Lea Crossing site investigation is available in the area surrounding the Limmo Peninsula Shaft. There are five boreholes in the area; sunk in 1989. The majority of these are offset by around 75 m from the Crossrail alignment. All the boreholes terminate in the London Clay except one (BH5A) which terminates in the underlying Lambeth Group. The available data indicates that ground level is at 107.5 mATD, with superficial deposits comprising made ground, floodplain deposits and terrace deposits. The anticipated top of the London Clay is at approximately 93 mATD and the top of the Lambeth Group is at 59.9 mATD. The thickness of the Lambeth Group would be confirmed during future ground investigations. Geological maps show a very disturbed interface.
between the London Clay and the overlying alluvial deposits. There is a high risk of a scour hollow in this area due to the close proximity to the Rivers Lea and Thames. Young and Rutty (1991) describe the Terrace Gravels as being typically 5 m thick but extending to 14 m (84 mATD) at a site in this area. The University of Reading structural assessment of the area shows a major north-west / south-east trending Chalk fault running along the northern side of the Limmo Peninsula.

Geotechnical investigations at Blackwall Way Shaft have shown the piezometric head in the shallow aquifer to be 99.6 mATD. Piezometer readings indicate that the pressure head is 98.2 mATD within the Lambeth Group and 95.4 mATD within the Thanet Sands suggesting some underdrainage is taking place. Observations from boreholes at Limmo peninsula suggest that the shallow groundwater is at a level of around 100 mATD. Environment Agency data indicates that in 2003, the Chalk groundwater level was 90 to 95 mATD in the Limmo Area also suggesting underdrainage. Sand lenses in the London Clay and Lambeth Group would contain confined groundwater, which may be recharged at the sub-crop in the bed of the River Thames. The presence of infilled scour hollows may increase the hydraulic connection between the surface and deep aquifer. Water in the deep aquifer is non potable due to the saline influx from the River Thames.

One borehole (Id 52) abstracts water from the superficial deposits for the supply of top up water. This well is licensed to the Lea Valley Regional Park Authority. There are no protected rights within the route window.

Within route window SE1, the tunnel alignment passes under the River Lea, which flows into the River Thames in the south of the route window. In this reach the River Lea has been given a chemical GQA of D (fair) and an RQO Grade 4. There are no locks on the River Lea between Limmo Peninsula and the River Thames. The National River Flow Archive has data for the gauging station at Lea Bridge (TQ 352 872); the flow recorded at this station represents the inflow to the River Thames from the Lea. The mean flow is 5.55 m³/s, with a Q₉₅ of 3.17 m³/s and a Q₁₀ of 8.75 m³/s.

The River Thames crosses the south-east corner of the route window; it is tidal in this reach. Even though the water quality in the Thames has improved considerably in recent years, the impact of wastewater discharges to the river can still clearly be seen in the measured concentrations of a range of determinands. Generally, the Thames has a high content of suspended solids and nutrients resulting in algae growth.

There are no surface water abstractions in the route window. There is one surface water discharge into Bow Creek licensed to Pura Foods Ltd (CNTM.1680). The entire route window is located on the tidal Flood Zone 3. The defended flood level is 105.23 mATD, based on the assumption (A.SE.10) that the Thames Barrier is closed.

Baseline data relevant for route window SE1 are summarised in the table below.
### Table 8.6: Summary of Baseline - Route Window SE1

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<th>Drawing</th>
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</thead>
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<td>Solid geology</td>
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<td>2</td>
<td>Chalk groundwater Levels</td>
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<td>3</td>
<td>Groundwater quality</td>
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<td>6b</td>
<td>Other watercourses</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>River quality</td>
<td>High concentration of suspended solids and nutrients, algae growth GQA: Fair RQO: Grade 4</td>
<td>River Thames</td>
<td>River Lea</td>
</tr>
<tr>
<td>8</td>
<td>Surface water abstractions</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Surface water discharges</td>
<td>1 to River Lea</td>
<td>CNTM.1680</td>
<td>E2E00-E00-F-00201</td>
</tr>
<tr>
<td>10</td>
<td>Floodplains and flood levels</td>
<td>Flood Zone 3 protected to 105.23 mATD Thames Estuary u/s of Thames Barrier</td>
<td></td>
<td>E2E00-E00-F-00201</td>
</tr>
</tbody>
</table>

### 8.5.4 Impact Assessment

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation measures have been identified and assessed as described below. A summary is given in Appendix F.
(i) Groundwater

Temporary: At Blackwall Way the work would extend 10 m into the Thanet Sands. The groundwater level in this formation is around 94 mATD and so extensive dewatering of the deep aquifer would be required.

The formation level of the Limmo Peninsula shaft would lie within the London Clay and, therefore, the deep aquifer would not be reached. However, the base of the shaft (66.15 mATD) does lie close to the anticipated top of the Lambeth Group (64.5 mATD). In 2003 the Chalk groundwater level was at approximately 90 to 95 mATD. The thickness of the Lambeth Group would be confirmed during future ground investigations. However, at Blackwall Way Shaft, the Lambeth Group is approximately 17 m thick. Therefore, at Limmo, the top of the Thanet Sands may be no more than 17 m below the excavation level. The excavation level is around 25 to 30 m below the Chalk groundwater level, thus giving a risk of base heave and seepage. It is therefore predicted for the purposes of environmental assessment that dewatering of the deep aquifer would be undertaken at Limmo Peninsula.

Due to the potentially high volumes of water involved, it is assumed (A.SE.11) for the purposes of the impact assessment that dewatering would be undertaken using external wells in the Chalk or Thanet Sands, rather than internal pressure relief wells within the shaft during construction. Dewatering of the deep aquifer for construction of Lowell Street Shaft, Hertsmere Road Shaft, Isle of Dogs Station, Blackwall Way Shaft and Limmo Shaft would create an extensive cone of depression of the water table in the deep aquifer. The impacts on the groundwater levels have been calculated using the London Basin Groundwater model as described in detail in Appendix E. As the dewatering at the different Crossrail sites would take place simultaneously, it is not possible to refer a possible impact on a groundwater abstraction back to a specific site. Therefore, all impacts on groundwater levels caused by the dewatering of the deep aquifer at the above mentioned sites are reported within route window C11, Section 6.16.3 of this report.

The dewatering operations would also affect the water quality of the deep aquifer, as saline water from the River Thames would be drawn into the aquifer. However, since in this area the Chalk groundwater is already of poor quality due to historic and continuing infiltration, there would be no residual impact.

Although in practice full dewatering of the shallow aquifer at Limmo Peninsula might not be necessary if the ground is generally stable or if selected grouting is adopted, it is assumed (A.SE.12), for assessment purposes, that a ring of dewatering wells would also be constructed in the shallow aquifer around the shaft to assist with caisson sinking. Calculations (see Appendix E) indicate that full dewatering would create a cone of depression with the 2 m drawdown contour line being up to 217 m from the site and the 0.5 m drawdown contour at a distance of around 925 m. However, the River Lea is expected to act as a hydrological recharge boundary and it may be possible that some water would be drawn from the river during pumping and there would be significantly less drawdown further away.

In practice such high flow rates would only be possible if a discharge consent to the River Lea was obtained. The approach may only be acceptable if treatment is provided if shallow groundwater contains excessive pollutants and it is assumed (A.SE.13) this would be
determined during the detailed design phase. The salinity would reflect that of the tidally affected river water and would not present a problem.

There is one well abstracting from the river gravels (Id 52) within the route window, approximately 380 m from the shaft, on the other bank of the River Lea. It is considered unlikely that there would be any impacts in terms of level or quality on this abstraction.

Construction would take place in formations above the deep aquifer at Limmo Peninsula and no impacts on the groundwater quality from grouting etc. are envisaged as the nearest Chalk groundwater abstraction is more than 1 km away; the groundwater quality is already poor and the dewatering would reduce the spreading of any contaminants. However, during construction the water levels and quality would be monitored to mitigate for any potential impacts caused by dewatering or the existence of any scour hollows.

**Permanent:** None.

(ii) **Surface Water**

**Temporary:** The water from groundwater dewatering at Blackwall Way Shaft would be discharged to the River Thames although the discharge rate would be small relative to the flow of the Thames. The discharge would be low turbidity water with a salt content close to that in the Thames. Therefore the potential change in the salinity of the Thames caused by discharge of dewatering effluent is far less than the natural fluctuation in salinity of the Thames during the year and the impact on the water quality is expected to be negligible (see Appendix E). Approval from the Environment Agency would be sought regarding the disposal location, quantities and quality of the effluent. If mitigation measures are needed, these could include aeration or altering the point of discharge, leading to no significant residual impacts.

At the Limmo Peninsula, it is probable that the River Lea would be utilised for a surface water discharge of dewatering effluent from the deep aquifer, rather than disposing to sewer. Approval from the Environment Agency would be sought regarding the disposal location, quantities and quality of the effluent. The dewatering volumes involved (nominally <100 l/s) are small compared to the flow and tidal flows in the river and water quality problems are not expected. If mitigation measures are needed, these could include aeration or altering the point of discharge, leading to no significant residual impacts. Any large discharges from the shallow aquifer dewatering would only be discharged to river if the contamination levels were acceptable, they would otherwise have to be passed to sewer or treated.

There would be a risk of ground settlement when tunnelling under the River Lea. However, this impact can be mitigated for by the appropriate choice of construction method, monitoring of ground settlement, and making good flood defences to ensure that the defended level continues to be achieved. Specific measures would be included in the provisions for generic mitigation described in Appendix B relating to tunnelling under rivers. Consultation with the Environment Agency would also be undertaken as required under the provisions for generic mitigation described in Appendix B.

Good site practice would be required to avoid impacts on the water quality of the River Lea by polluted site runoff from the Limmo Peninsula worksite. The worksite at the River Lea would be on the river buffer zone, and, therefore, approval from the Environment Agency and British Waterways would be required as specified in the provisions for generic mitigation.
described in Appendix B. Good site practice would be enforced via the provisions for generic mitigation described in Appendix B and there would be no residual impacts.

The River Lea may be used for transportation of materials to the site, and for the removal of tunnelling spoil by barge. Utilisation of barges may have an impact on the quality and ecology of the river. Care would be taken so that disturbance of the bank is minimised, and that barge loading and unloading procedures do not result in spoil or other contaminants entering the watercourse. The barge loading facility may require some localised dredging in addition to insertion of some fender/mooring piles. These activities would affect the stream bed, change the sediment deposition or suspension and intertidal zone morphology and, possibly, affect the tidal flood defences. Such temporary impacts are expected to be minor since the area affected is small, the river has previously been used for barges and has a wide flow range due to the tide. The approval of the Port of London Authority would be obtained and, since the works fall within 16 m of the tidal flood defences, the Environment Agency would also be consulted. Good site practice would be enforced through the provisions for generic mitigation described in Appendix B, leading to no significant residual impacts.

**Permanent:** The Limmo Peninsula is an area of semi derelict land currently used as a construction worksite for the new DLR extension to London City Airport. The Limmo Peninsula Vent Shaft site would reduce natural infiltration of rainfall into the shallow gravels, and, therefore, the design for the site would mitigate for any additional runoff. The site drainage can be directed to soakaway via a catchpit to overcome this unless a sewer connection is preferred. If the sewer option is preferred there would be a small increase in the discharge to sewer. The final option chosen would depend on the final design of the ground level development, and the views of relevant stakeholders, such as the Environment Agency, Thames Water etc. There would be no residual impact.

The Blackwall Way and Limmo Peninsula shafts are sited on the defended floodplain but could become partially inundated under some flood defence breach or Thames Barrier failure scenarios. This would be mitigated by suitable design of the cill or water entry levels. There would be no residual impact.

(iii) **Residual Impacts**

There would be no significant residual impacts from temporary or permanent works since, as assessed, the design cill or water entry elevations and control measures would prevent flooding of the tunnels.

Dewatering would result in a significant temporary lowering of groundwater levels. Consultation with the individual well owners is taking place and appropriate monitoring, mitigation and compensation measures would be agreed as required to give a minor, temporary, non significant residual impact.

There would be a minor, temporary, non significant residual impact on water quality in the River Thames and the River Lea caused by discharge of dewatering effluent. Dredging and transportation of materials by barge on the River Lea would also result in a risk of minor, temporary, non significant residual impacts on water quality.
8.6 Route Window SE2 – Custom House Station

8.6.1 Scheme Description

(i) Overview

Proposed works within the route window comprise the construction of the Victoria Dock portal, a new station at Custom House station, the installation of overhead line electrification equipment, and the construction of twin-bore tunnels.

The figure below shows the main features within the route window.

![Figure 8.4: Route Window SE2 – Custom House Station](image)

(ii) Victoria Dock Portal

The Victoria Dock portal would be located approximately 150 m east of Royal Victoria DLR station, and its location is determined by the gradients of the Crossrail tunnels, which must meet safety requirements. It would be constructed on the current alignment of Networks Rail’s North London Line (NLL), which is assumed (A.SE.14) to have ceased operation between North Woolwich portal and Stratford with the opening of the proposed DLR route to Stratford. The eye of the tunnels would be located opposite 250 and 250A Victoria Dock Road from where a ramp would be contained within a cut and cover box to the portal opposite 251A Victoria Dock Road. From this point, Crossrail would run in a retained cut to join existing track levels immediately to the west of Custom House station. A 22 m by 22 m by 27 m deep chamber would be constructed to allow removal of the TBMs at the tunnel eye. On the north side of the structure a hardstanding area will be provided for emergency assembly, emergency and maintenance vehicles on existing railway land.
The Crossrail portal site at Victoria Dock would require the diversion of the Docks Surface Water Sewer southwards between Victoria Dock DLR station and the east end of Custom House station. The sewer would therefore be diverted around the portal site to run between the railway corridor and the ExCeL Centre. This diversion would take place prior to the main construction period. There would also be general utilities diversions at this location.

(iii) Custom House Station

A new station at Custom House would be provided to serve the Royal Docks area. In order to accommodate this, the existing station at Custom House would be demolished although the DLR platform would be retained. Crossrail trains would use a new island platform on the north side of the station that would be 10 m wide at the west end and 5 m wide at the east end. Canopies would be constructed for the Crossrail and DLR platforms. A deck will be constructed over the tracks that will support a concourse area and station building.

(iv) OHLE and Railway

OHLE would be installed throughout the route window. This would also include a feeder station on the site of an existing substation located to the northwest of Prince Regent DLR station, to supply the High Voltage power to the Railway.

(v) Duration of Works

The construction of Custom House station including the fitting out and commissioning would take approximately three years and four months to complete.

The construction of Victoria Dock portal including the fitting out and commissioning would take approximately two years and ten months to complete.

8.6.2 Additional Scheme Description Assumed for Water Resources Assessment

**Victoria Dock Portal:** At the tunnel eye a shaft is required for removal of the TBMs which would drive the running tunnels from Limmo Peninsula. To the east of the shaft, the trains would run in a new section of cut and cover for 60 m, before passing into the retained cut for a further 520 m to Custom House Station. At the shaft, the toe of the diaphragm walls would be at 85.25 mATD (approximately 17 m deep), and at the end of the cut and cover tunnel the diaphragm walls would be at 90.25 mATD (approximately 12 m deep). Limited geological information indicates that, at the tunnel eye, the top of the Lambeth Group is at a level of approximately 84 mATD. Therefore, the diaphragm walls are likely to terminate in the base of the London Clay or top of the Lambeth Group depending on the exact stratigraphy.

Appendix G contains details of utility works in relation to water resources.

8.6.3 Baseline Data

The surface geology of the route window comprises approximately 5 to 10 m of superficial deposits including recent River Alluvium. Underlying the River Alluvium in the west of the
route window is the London Clay, which dips gently to the west, resulting in a sub-crop of the Lambeth Group to the east of the centre point of the Royal Victoria Dock. The Greenwich Fault (north-east/south-west trend) is traditionally shown to cross the Docklands area, running across the western end of the Royal Albert Dock. However, geological modelling of the area carried out for the London Dockland’s Development Corporation has suggested that the Greenwich Fault may not be present; rather that the dominant structural feature is a north-plunging syncline, which has been termed the Greenwich Syncline (Howland, 1992). At the tunnel eye, the top of the Lambeth Group would be at approximately 84 mATD, with a thickness of approximately 12 m. It is assumed (A.SE.15) for assessment purposes that any such fault or feature does not provide a barrier to lateral groundwater flow in the deep aquifer and that a fault, if present, does not provide a vertical pathway through the London Clay.

Sand and gravel horizons up to 2 to 3 m thick have been found at the base of the London Clay. These sand horizons, and any sand lenses in the Lambeth Group, would contain confined groundwater, which may be recharged at the sub-crop in the bed of the River Thames.

The Environment Agency report that 2003 Chalk groundwater levels in route window SE2 were between 90 to 95 mATD. The water quality in the deep aquifer is likely to be non potable in this area due to saline influx from the River Thames. The shallow groundwater level was measured as 99.6 mATD in 2004. The water quality in the shallow aquifer is also expected to be non potable from water quality analysis on water from borehole CH23 (Appendix C). There are no groundwater abstractions or TTZs within the route window.

There is one surface water body near the alignment within the route window; Trinity Sewer. The Royal Docks lie on the southern edge of the route window. Selected historic data on water quality in the Royal Docks has been reviewed. Currently, the water in the Royal Docks is of better quality than the River Thames water and has been confirmed as being suitable for water contact sports. Litter, debris and flotsam are routinely removed from the docks. However, the docks occasionally suffer from reduced transparency depth, and have an average pH above 8.5. Historically, the docks showed evidence of algal blooms and evidence of contamination with faecal indicator organisms. Concentration of metals, pesticides and other pollutants were found to be low in historical data.

There are no surface water abstractions or discharges within the route window. The entire route window is located on the Flood Zone 3 of the River Thames. Downstream of the Thames Barrier the defended flood level is 107.2 mATD. Upstream, the defended flood level is 105.23 mATD, which assumes (A.SE.10) the Thames Barrier is closed. The Thames Barrier is located on the River Thames south of the Royal Victoria Dock.

Baseline data relevant for route window SE2 are summarised in the table below.
Table 8.7: Summary of Baseline - Route Window SE2

<table>
<thead>
<tr>
<th>Item</th>
<th>Subject</th>
<th>Details</th>
<th>Id</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Geology – Superficial deposits</td>
<td>Made Ground, river alluvium (5 to 10 m thick)</td>
<td></td>
<td>E2E00-E00-F-00301</td>
</tr>
<tr>
<td>1b</td>
<td>Solid geology</td>
<td>London Clay and Lambeth Group (from approx 84 mATD) in east of route window</td>
<td></td>
<td>E2E00-E00-F-00301</td>
</tr>
<tr>
<td>2</td>
<td>Chalk groundwater levels</td>
<td>90 to 95 mATD (2003)</td>
<td></td>
<td>E2E00-E00-F-00301</td>
</tr>
<tr>
<td>3</td>
<td>Groundwater quality</td>
<td>Surface: Non-Potable</td>
<td></td>
<td>E2E00-E00-F-00301</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deep aquifer: Increased salinity</td>
<td></td>
<td>E2E00-E00-F-00301</td>
</tr>
<tr>
<td>4</td>
<td>Groundwater abstractions and protected rights</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Groundwater protection zones/Time of travel zones</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6a</td>
<td>Main rivers</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6b</td>
<td>Other watercourses</td>
<td>Trinity Sewer</td>
<td></td>
<td>E2E00-E00-F-00201</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Royal Victoria Dock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>River quality</td>
<td>Not applicable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Surface water abstraction</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Surface water discharge</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Floodplains and flood levels</td>
<td>U/s of Thames Barrier, Flood Zone 3 protected to 105.23 mATD</td>
<td></td>
<td>Thames Estuary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D/s protected to 107.2 mATD</td>
<td></td>
<td>Thames Estuary</td>
</tr>
</tbody>
</table>

8.6.4 Impact Assessment

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation measures have been identified and assessed as described below. A summary is given in Appendix F.

(i) Groundwater

Temporary: The diaphragm walls at Victoria Dock Portal are likely to terminate in the base of the London Clay or top of the Lambeth Group depending on the exact stratigraphy. It is predicted that dewatering of the deep aquifer would not be required at Victoria Dock Portal. From the limited geological data available, it is assessed that there would be an adequate thickness of London Clay and Lambeth Group deposits, based on a Chalk groundwater level of approximately 90 to 95 mATD, to prevent a risk of base heave caused by the underlying groundwater pressure. This would require further investigation during the detailed design.
process. It is assumed (A.SE.16) that sand wick drains would not be used to improve the vertical permeability of the Lambeth Group.

It is likely that some localised pumping from or grouting of the superficial deposits of the shallow aquifer and sand lenses within the London Clay and Lambeth Group would be required during construction. However, it is unlikely that this would impact upon groundwater levels or quality elsewhere in the shallow or in the deep aquifers. It is assumed (A.SE.17) that such effluents would be disposed of to sewer rather than to the Docks. Therefore, no impacts are considered likely.

Construction of the diversion of the Royal Docks Surface Water Sewer (AW/019) involves significant tunnelling at deeper elevations than the adjacent Crossrail works and would require dewatering of the shallow aquifer around the shafts and micro tunnelling. Dewatering effluents would be disposed of to the combined sewer system. It is predicted, based on preliminary desk study, that the proposed sewer tunnel inverts are within the Lambeth Group and London Clay or the superficial deposits. The alignment does not appear to pass through the deep aquifer and the impacts on the deep aquifer would therefore be attenuated as described for the portal itself. Good practice would be enforced via the provisions for generic mitigation described in Appendix B, and therefore there would be no significant residual impacts from the sewer diversion.

**Permanent:** The portal and retained cut would require a long cut-off wall which would act as a barrier to lateral groundwater flow in the shallow aquifer over a width of approximately 340 m. As described in Appendix E, a maximum rise and fall in the groundwater levels 20 m away from the structure of up to around 1m to 2 m have been predicted assuming (A.SE.18) plausible aquifer properties. However, the walls of the retained cut may not extend into the underlying clays over the whole length of the approach ramp thus reducing the effective length of the barrier. In addition, regional flows are already affected by the dock walls. Shallow groundwater levels would be monitored as described in Appendix B and the consequences of impeded flow can be mitigated, where required, by providing drainage through or around the cut-off walls leading to no significant residual impacts.

**(ii) Surface Water**

**Temporary:** Good site practice would be required to avoid pollution of Trinity Sewer by polluted site runoff. This would be enforced via the provisions for generic mitigation described in Appendix B, leading to no residual impacts.

**Permanent:** The Victoria Dock Portal would lead to increased surface run-off to drainage where rainfall falls over the base slab. However, runoff would pass through the tunnel drains to a pump sump discharging to the Thames Water combined sewer system.

At Custom House, the track level would be lowered by around 2 m to 101 mATD but this would remain the high point on the vertical alignment between the Victoria Dock Portal and Connaught Tunnel. The normal impounded water level in the Royal Victoria and Royal Albert Docks is at 104.2 mATD (Halcrow, 1989). The Thames Barrier (downstream) defended flood level is 107.2 mATD. Crossrail would run across the defended floodplain and could become partially inundated to the east of the portal under some flood defence breach or Thames Barrier failure scenarios. This would be mitigated by suitable design, possibly incorporating
flood gates at the Victoria Dock portal. This would ensure that flood water could not travel westwards through the tunnel system. There would be no residual impact.

It is assumed (A.SE.19) that the existing drainage has the capacity to accommodate additional runoff and existing drainage information would be collected in the detailed design phase to verify this. In order to discharge any additional runoff, the existing drainage system would be extended and use the same or equivalent outlets. This would ensure there are no adverse impacts on surface water resources.

(iii) Residual Impacts

There would be no significant residual impacts from temporary or permanent works since, as assessed, the design elevations and control measures would prevent flooding. There would be a minor, permanent, non significant residual impact on groundwater levels in the shallow aquifer caused by the tunnel portal acting as a barrier to groundwater flow.

8.7 Route Window SE3 – Connaught Tunnel

8.7.1 Scheme Description

(i) Overview

The proposed works within the route window comprise the alteration and refurbishment of the Connaught Tunnel to OHLE, the demolition of Silvertown station, and the installation of OHLE. The Connaught Tunnel passes beneath Connaught Passage with Royal Victoria Dock to the west and Royal Albert Dock to the east. The north tunnel is adjacent to the Royal Albert Dock to the north and the Royal Victoria Dock to the south.

The figure below shows the main features within the route window.
(ii) **Connaught Tunnel**

Permanent works would consist of the alteration and refurbishment of the Connaught Tunnel to accommodate OHLE. The tunnel would become ellipse shaped and the floor lowered. Network rail currently uses the eastern bore of the Connaught tunnel. Crossrail would use both bores for its twin tracks.

The main construction works at the Connaught Tunnel would proceed as set out below:

- Site set up, followed by removal of existing track, ballast and drainage system between Custom House station to the west and Silvertown station to the east of the Connaught tunnel. The demolition of Custom House Station. These works will take place over approximately five months.

- Civil works to increase the tunnel profile to allow for OHLE to be installed for use by Crossrail trains. These works will be carried out by removal of the existing tunnel approaches’ arch struts and of the existing tunnel lining at the base of the tunnel in sections, consisting of brick, concrete or steel. Temporary structural supports will be installed followed by excavation works and installation of new struts and lining. These works will be completed over a period of about one year and six months.

- Formation of concrete track beds and installation of the subsurface track drainage system.
(iii) Silvertown Station

The alignment of the tracks through the existing station would be unsuitable for use by Crossrail trains. The station would therefore be demolished although passive provision would be made for a future Crossrail station in the event of the development of adjacent properties.

(iv) Duration of Works

The alteration and refurbishment works at the Connaught Tunnel to include fitting out and commissioning would be undertaken over a period of approximately four years and two months.

8.7.2 Additional Scheme Description Assumed for Water Resources Assessment

Connaught Tunnel: The Connaught Tunnel is located between the existing Prince Regent and Silvertown stations. It is approximately 550 m long and has two draft relief shafts, one on either side of Connaught Bridge. At the eastern end of the tunnel the proposed Crossrail lines would continue to follow the existing track alignment to Silvertown.

A detailed condition survey of Connaught Tunnel has been undertaken. Significant water ingress was found and it was concluded that there is a need to reduce this. High rates of water ingress are currently believed to take place at the approach ramps on either side of the tunnel. It is proposed to install a concrete slab to prevent further water ingress. It is further proposed to undertake some repair work, replace tracks and install a new drainage system.

Silvertown: At Silvertown the track would be at a level of 101.79 mATD. To the east of Silvertown Station, the route alignment falls at a gradient of 1 in 40 in a new cutting towards North Woolwich Portal (route window SE4).

8.7.3 Baseline Data

According to BGS mapping, the geology of the route window comprises recent Alluvium at the surface, overlying sub-crops of Lambeth Group, Thanet Sand and Upper Chalk in succession from north-west to south-east. The Greenwich Fault (north-east/south-west trend) is traditionally shown to cross the Docklands area, running across the western end of the Royal Albert Dock. Geological modelling of the area carried out for the London Dockland’s Development Corporation has suggested that the Greenwich Fault may not be present; rather that the dominant structural feature is a north-plunging syncline, which has been termed the Greenwich Syncline (Howland, 1992). However, recent work suggests the structure is more complex. The University of Reading have suggested a pattern of orthogonal dip and strike faults with intermediate synclines. This interpretation is a more coherent explanation of the original data because it integrates structure within the Docklands to all nearby areas. It is assumed (A.SE.15) for assessment purposes that any such fault or feature does not provide a barrier to lateral groundwater flow in the deep aquifer.

Geological records from 6 boreholes along the northern part of the tunnel show that the ground level is around 104 to 105 mATD. The Lambeth Group (Woolwich and Reading Formations) are observed from 92 to 93 mATD underlain by the Upnor Formation from 91 to
The Lambeth Group (Woolwich and Reading Formations) are only around 2 m thick in the central part of the tunnel. The Thanet Sands are dipping to the north and are found from levels between 85 and 81 mATD. The top of the Chalk is recorded in one borehole close to the central part of the tunnel at a level of 68.75 mATD. According to the Haswell Study the tunnel invert is at a level of around 90 mATD and the deepest part of the tunnel would, therefore, extend a few metres into the Lambeth Group (Woolwich and Reading Formations). The tunnel approach ramps would be mainly within the River Gravels.

The shallow groundwater levels in the vicinity of the tunnel are thought to be influenced by water leaking from the Docks, rainfall and leaking water pipes. Dock losses from West India and Royal Victoria have been estimated to be 200 m$^3$/d for a one metre head difference between the dock and shallow groundwater. Groundwater discharge is likely to comprise flow into sewers, drains, Connaught Tunnel, lateral flows out of the area and some vertical leakage to the deep aquifer. A 1991 estimate of infiltration to sewers in the general area suggests flows exceed 2,800 m$^3$/d.

According to the Environment Agency, 2003 groundwater levels in this area were approximately 95 to 100 mATD. The Chalk groundwater levels are thought to be confined by the 7 to 8 m thick Lambeth Group (Woolwich & Reading Formations and Upnor Formation) present above the Thanet Sands. The Chalk groundwater quality in this area is likely to be poor due to the influx of saline water from the River Thames.

There is one protected groundwater right (ID 97) located on the northern bank of the Thames. It is owned by Thames refinery in Silvertown. The associated TTZ is within the window but does not cross the alignment.

The River Thames is the only river within the route window. The route window also contains the Royal Victoria Dock, the Royal Albert Dock and the King George V Dock. Selected historic data on water quality in the Royal Docks has been reviewed. Currently, the water in the Royal Docks is of better quality than the River Thames water and has been confirmed as being suitable for water contact sports. Litter, debris and flotsam are routinely removed from the docks. However, the docks occasionally suffer from reduced transparency depth, and have an average pH above 8.5. Historically, the docks showed evidence of algal blooms and evidence of contamination with faecal indicator organisms. Concentration of metals, pesticides and other pollutants were found to be low in historical data.

There are no surface water abstractions in the route window. There is one surface water discharge into the River Thames in the route window licensed to Tate and Lyle Industries Ltd (CNTW.0853). The entire route window lies on the Flood Zone 3. Downstream of the Thames Barrier the defended flood level is 107.2 mATD.

Baseline data relevant for route window SE3 are summarised in the table below.
Table 8.8: Summary of Baseline - Route Window SE3

<table>
<thead>
<tr>
<th>Item</th>
<th>Subject</th>
<th>Details</th>
<th>Id</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Geology – Superficial deposits</td>
<td>Recent alluvium (approximately 5 to 10 m thick)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1b</td>
<td>Solid geology</td>
<td>Sub-crops of Lambeth Group, Thanet Sand and Chalk from north-west to south-east.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chalk groundwater Levels</td>
<td>95 to 100 mATD (Environment Agency, 2003)</td>
<td>E2E00-E00-F-00301</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Groundwater quality</td>
<td>Shallow: Non-Potable Deep: Increased salinity</td>
<td>E2E00-E00-F-00301</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Groundwater abstractions and protected rights</td>
<td>1 protected right</td>
<td>97</td>
<td>E2E00-E00-F-00301</td>
</tr>
<tr>
<td>5</td>
<td>Groundwater protection zones/Time of travel zones</td>
<td>1 nr 50 and 400 day</td>
<td>97</td>
<td>E2E00-E00-F-00301</td>
</tr>
<tr>
<td>6a</td>
<td>Main rivers</td>
<td>River Thames</td>
<td>E2E00-E00-F-00201</td>
<td></td>
</tr>
<tr>
<td>6b</td>
<td>Other water bodies</td>
<td>Royal Docks</td>
<td>Royal Victoria Dock, Royal Albert Dock, King George V Dock</td>
<td>E2E00-E00-F-00201</td>
</tr>
<tr>
<td>7</td>
<td>River quality</td>
<td>High concentration of suspended solids and nutrients, algae growth</td>
<td>River Thames</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Surface water abstraction</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Surface water discharge</td>
<td>4, to the River Thames</td>
<td>CNTW.0853, TEMP.2679, CSSC.9966, CSAB.0529, CSAB.0523</td>
<td>E2E00-E00-F-00201</td>
</tr>
<tr>
<td>10</td>
<td>Floodplains and flood levels</td>
<td>Flood Zone 3 protected to 107.2 mATD.</td>
<td>Thames Estuary d/s of Thames Barrier</td>
<td>E2E00-E00-F-00201</td>
</tr>
</tbody>
</table>

8.7.4 Impact Assessment

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation
measures have been identified and assessed as described below. A summary is given in Appendix F.

(i) Groundwater

Temporary: Details of the remedial drainage works to the tunnel are not available, but it is envisaged that grouting would be undertaken as part of works to lower the invert. It is predicted that if necessary minor pumping/dewatering would be required. The use of grout could have an impact on groundwater quality. The TTZ for the nearest groundwater abstraction (Id 97) is some 700 m away and seepage into the tunnel and natural attenuation within the strata and dilution in the main aquifer would reduce the likelihood of any impacts in terms of groundwater quality. Therefore, no significant impacts are expected on groundwater quality at abstraction Id 97.

Permanent: Controlling the water ingress to Connaught Tunnel would also have implications for flow patterns. Sealing the tunnel would create a barrier to groundwater flow, some of which, at present, enters the tunnel. There would, therefore, be a reduction in seepage from the docks or a rise in shallow groundwater levels as groundwater flows adjust to the barrier. Groundwater levels would be monitored during construction and if they show a significant rise, the Environment Agency would be notified. If the tunnel is found to act as a major barrier, drainage would be installed around the tunnel if needed ensuring that no significant impacts occur.

(ii) Surface Water

Temporary: The drainage system at Connaught Tunnel would be replaced, and a new section of drainage constructed at Custom House. Overall discharges of effluent from the tunnel would be reduced.

Good site practice would be required to avoid pollution of the Royal Victoria Dock by polluted site runoff. This would be enforced via the provisions for generic mitigation described in Appendix B, leading to a no residual impacts.

Permanent: Connection to the tunnels at Limmo increases the consequences of inundation of the railway. Crossrail would run across the defended floodplain but could become partially inundated under some flood defence breach or Thames Barrier failure scenarios. This would be mitigated by suitable design, possibly incorporating flood gates at the Victoria Dock portal. No residual impacts on surface water resources would occur.

(iii) Residual Impacts

There would be no significant residual impacts from temporary or permanent works since, as assessed, the design elevations and control measures would prevent flooding.
8.8 Route Window SE4 – North Woolwich Portal & Thames Tunnel

8.8.1 Scheme Description

(i) Overview

The proposed works within this route window comprise the construction of the North Woolwich portal, the twin bore Thames Tunnel, Warren Lane shaft, and the installation of OHLE equipment. The route window lies within LB Newham and LB Greenwich. The Thames Crossing tunnels would run between the North Woolwich and Plumstead portals.

The sewer beneath Albert Road would be diverted from a point to the east of the existing footbridge for a distance of approximately 50 m - it would be rebuilt but would remain beneath the alignment of the existing carriageway. The Royal Dock sewer under Factory Road would be diverted by up to 50 m to the south in a new tunnel between Winifred Street and Store Road.

The figure below shows the main features within the route window.

Figure 8.6: Route Window SE4 – North Woolwich Portal & Thames Tunnel

(ii) North Woolwich Portal

Crossrail would use the existing rail corridor located between Albert Road and Factory Road, and currently occupied by the North London Line. To the east of the junction of Tate Road and Albert Road Crossrail would descend into an open cut ramp to the portal. The tunnel portal itself would be located between the junctions of Winifred Road and Fernhill Street with Albert Road, from where the line would run in a cut and cover box to the tunnel eye. At the tunnel eye, located near to the junction of Henley Road and Factory Road, a chamber would
be constructed to receive the TBMs that would be used to construct the main Thames Tunnel from Plumstead. This would be incorporated into the tunnel eye as a widening of the cut and cover works requiring some works outside the existing railway boundary. Some dewatering may be necessary during excavation and construction of the approach ramp and portal structures.

At the tunnel eye a shaft containing emergency escape stairs and EIP would lead to a surface structure housing plant rooms.

(iii) Thames Tunnel

Crossrail would construct a new twin-bore tunnel beneath the Thames between North Woolwich and Plumstead portals. Beneath the Thames, the tunnel would follow an alignment to the east of the Woolwich Ferry. At Warren Lane shaft on the south bank of the Thames, the eastbound and westbound tracks would lie at a depth of approximately 36 m.

(iv) Warren Lane Shaft

The shaft would be located on the corner of Warren Lane and Beresford Street and would contain EIP and ventilation facilities. The shaft would be 13.5 m in diameter and a building (10 m tall by 18 m in diameter) would be constructed on the surface to house emergency intervention and ventilation equipment.

The main construction works for Warren Lane shaft would proceed as follows:

- Excavation of a piled basement box structure. A base slab would be cast on the floor of the basement box once excavation is completed.
- Excavation and construction of the shaft from the base of the box to tunnel level in sections using pre-cast segment rings.
- Construction of a central ventilation passage from the shaft and construction of cross passages connecting to where the eastbound and westbound tunnels would be excavated.
- Construction of a central intervention passage connecting from the shaft to where the tunnels would be excavated.
- Some dewatering may be necessary during excavation and construction of the basement box and shaft structures.

(v) Duration of Works

The construction of the North Woolwich approach ramp, tunnel portal, tunnel eye and shaft including fitting out and commissioning would take approximately four years.

The construction of Warren Lane shaft including fitting out and commissioning would take place over a period of approximately four years.
8.8.2 Additional Scheme Description Assumed for Water Resources Assessment

**North Woolwich Portal:** To the east of Silvertown Station the tunnel alignment falls towards North Woolwich Portal to pass under the Thames River walls. The track bed would be excavated with an approximately 290 m long open cut section descending at a gradient of 1 in 40. There would then be an approximately 160 m long cut and cover section descending at a gradient of 1 in 30 to the tunnel eye. At the tunnel eye the track level would be at approximately 90.6 m ATD with the ground level at approximately 102 m ATD.

It is proposed that diaphragm walling would be used for all excavations deeper than 4 m. For excavations less than 4 m, sheet piling is considered appropriate. During construction, it is proposed that the portal be excavated without using conventional dewatering techniques, owing to the presence of a layer of peat. Therefore, the diaphragm walls would be required to toe into the Chalk in order to provide a cut off wall, and the Chalk would be grouted.

The track in this section would be rebuilt and a new section of drainage, in accordance with Railway Group Standard GC/RT5014, issue 2, would be constructed along the approach ramp connecting to a sump located at the tunnel eye. The pipe would fall towards the sump at the same gradient as the track.

Appendix G contains details of utility works in relation to water resources.

**Thames Crossing Tunnel:** The tunnel works would comprise twin bored 6 m internal diameter tunnels driven from Plumstead to North Woolwich. The majority of the drive would be through water bearing ground, sands, Chalk and flint bands. This would lead to a tendency to instability in the tunnel face. In general, however, the conditions should be suitable for tunnelling using mechanical closed face excavation. The gradient of 2.5 % continues on the crossing of the Thames to approximately chainage 20 260 before changing to 0.5 % towards Warren Lane Shaft which would be set as a low point for drainage purposes. A minimum distance of approximately 8 m between the bed of the River Thames and the top of the tunnel has been adopted for the design. It is proposed to use a slurry machine for the tunnelling. Slurry machines are a common method of excavating tunnels in unstable ground conditions.

On the northern side of the river, the tunnels would pass under the Thames Barrier Flood Retention Walls (TBFRW). The bored tunnels would avoid the design toe level of the piled foundations of the TBFRW. The Crossrail tunnels would not impact on the retention walls on the southern side of the river.

Drainage would be required along the track bed of the tunnel. A cross track drainage system and pumping sump would be required at each tunnel portal.

**Warren Lane Shaft:** The shaft design would comprise a 13.5 m internal diameter shaft located centrally between the running tunnels with separate cross passages. The ground level is between 107 and 109 m ATD. The works proposed at Warren Lane Shaft include the construction of a piled basement structure and the shaft constructed to a depth of approximately 48 m below ground level (approximately 59 m ATD), with rail level at around 72 m ATD. The tunnel crown through Warren Lane Shaft would be approximately 14 m below the top of the Chalk strata. A sump would be provided at the low point in the shaft, and a pumped discharge main would take the tunnel drainage water to a local sewer.
The shaft would be constructed using SGI ring segments with the use of a circular caisson to sink the segments. Dewatering in the deep aquifer would be required to lower the water table to enable excavation to proceed with reduced water pressures. The secant piles forming the basement structure would act as a cut off and reduce the need for pumping in the shallow aquifer.

### 8.8.3 Baseline Data

Geological and hydrogeological data for the route window can be divided into three separate areas: north of the River Thames, in the River Thames, and south of the River Thames.

**North of the River Thames:** Five boreholes have been constructed as part of the Crossrail site investigations in the area around the North Woolwich portal. The geology consists of superficial deposits (Made Ground, Peat, Alluvium and River Terrace Deposits), overlying the Upper Chalk. The ground level is approximately 102.7 mATD. The top level of the Upper Chalk increases sharply from 84 mATD at chainage 19 278 to 90 mATD at chainage 19 357 (between Silvertown Station and the tunnel portal), which implies a thickness for the superficial deposits of approximately 12.8 m.

Groundwater levels were measured during the site investigations at different levels within the deep aquifer. Initial inspection of the data indicates that water pressures are close to hydrostatic throughout the strata. The Environment Agency reported that the Chalk groundwater levels in 2003 were between 103.5 and 106 mATD. However, during 2004 geotechnical investigations Chalk groundwater levels were found to be much lower, varying between 98.9 and 100.27 mATD (boreholes NW12 and NW16-NW18, see Appendix C). There may be an influence on Chalk water levels by the tidal sequence of the River Thames, particularly in boreholes closest to the river. Shallow groundwater is saline in many SI holes and contains over 1500 mg/l chlorides with EC’s > 10,000 µS/cm. Shallow groundwater levels measured in 2004 were virtually the same as those in the Chalk, varying from 99.4 to 100.29 mATD.

**Within the River Thames:** Geophysical surveys of the proposed Thames Crossing have been undertaken. The bathymetry of the river bed was determined using sonar surveys. Seismic surveys were undertaken to identify the stratigraphy at the crossing. Further geophysical surveys were undertaken to identify the presence of any UXOs (unexploded ordnances) on the river bed, prior to the selection of sites for boreholes. Five boreholes along the proposed tunnel alignment were constructed with depths of between 33 to 39 m below the river bed.

The following figure summarises the results of the geological and geophysical investigations:
The results indicate that the superficial deposits are very thin, except for an infilled basin feature of limited lateral and vertical extent, (thought not to be a palaeo-channel). This is 6 to m thick at the deepest point. Below the superficial deposits, lies the Chalk which was found to be weak, medium density and fragmented within part of the tunnel horizon. Key flint bands were identified. The water level in the Chalk is assumed (A.SE.20) to be the same as the water level in the River Thames. The high water pressures and face stability issues pose a risk to tunnelling. A possible fault with limited throw was identified towards the centre of the river.

South of the River Thames – Warren Lane Shaft: To date, no site investigation boreholes have been constructed for Crossrail south of the River Thames. However, a desk study of available information has been undertaken. Initial review of the data suggests that the geology is complex, with the possible presence of faulting and solution features in the Chalk in this area. The following table summarises geological data for the area:

Table 8.9: Geological Data for Warren Lane Shaft

<table>
<thead>
<tr>
<th>Environment Agency boreholes for Thames Flood Protection work ¹</th>
<th>Two old water well records ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH508A</td>
<td>BH508B</td>
</tr>
<tr>
<td>Ground level (mATD)</td>
<td>105.26</td>
</tr>
<tr>
<td>Thickness Superficial Deposits (m)</td>
<td>10.3</td>
</tr>
<tr>
<td>Thickness Thanet Sands (m)</td>
<td>0</td>
</tr>
<tr>
<td>Top of Chalk (mATD)</td>
<td>94.96</td>
</tr>
</tbody>
</table>

¹ Located within 140 m of Warren Lane Shaft site.
Located approx 200 to 300 m to the south-east.

The track level at Warren Lane Shaft would be at approximately 72 mATD. The Environment Agency boreholes indicate that the base of the shaft would be constructed within the Chalk; however, the water well data suggests the possibility of the tunnels being partly or wholly within the Thanet Sands. The groundwater levels in this area are expected to be between 100 to 105 mATD (Environment Agency, 2003).

There is one protected groundwater right (Id 97) located on the northern bank of the Thames. It is owned by Thames Refinery in Silvertown. The associated TTZ is within the window but does not cross the alignment.

The route alignment passes under the River Thames in the northern half of the route window. Even though the water quality in the Thames has improved considerably in recent years, the impact of wastewater discharges to the river can still clearly be seen in the measured concentrations of a range of determinands. Generally, the Thames has a high content of suspended solids and nutrients resulting in algae growth.

There are no surface water abstractions within the route window. There are eight surface water discharge consents located on the northern bank of the Thames. Six of these are licensed to Thames Water Utilities Limited, and discharge to the Woolwich Reach (TEMP.2679 and TEMP.3043), and the River Thames (CSSC.9966, CSAB.0529, CSAB.0523, TEMP.2366). The last two discharges to the River Thames (CTWC.1330 and CNTW.0853) are licensed to Waldair Court Management Co Ltd and Tate & Lyle Industries.

The majority of the route window falls within the Flood Zone 3. Potential flooding of the tunnel section would be prevented by the Thames Barrier and the downstream retaining walls to a level of 107.2 mATD (tidal surge to 106.9 mATD plus 0.3 m freeboard) to accommodate the 1 in 1000 year flood level predicted for 2030.

Baseline data relevant for route window SE4 are summarised in the table below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Subject</th>
<th>Details</th>
<th>Id</th>
<th>Drawing 1E0421-</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Geology – Superficial deposits</td>
<td>Made Ground, Alluvium Peat and River Terrace Gravels (variable thickness)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1b</td>
<td>Solid geology</td>
<td>Chalk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chalk groundwater Levels</td>
<td>Portal: Approx 98.9 to 100.27 mATD (GCG, 2004) or 103.5 to 106 mATD (Environment Agency, 2003) Warren Lane: Approx 100 to 105 mATD (Environment Agency, 2003)</td>
<td></td>
<td>E2E00-E00-F-00301</td>
</tr>
</tbody>
</table>
### Item Subject | Details | Id | Drawing 1E0421-
---|---|---|---
3 | Groundwater quality | Shallow: Non-potable Deep: Increased salinity (borehole NW18R) | E2E00-E00-F-00301
4 | Groundwater abstractions/protected rights | 1 protected right | 97 | E2E00-E00-F-00301
5 | Groundwater protection zones/Time of travel zones | 1 nr 400 day and 50 day TTZ | 97 | E2E00-E00-F-00301
6a | Main rivers | River Thames | E2E00-E00-F-00201
6b | Other water courses | None | E2E00-E00-F-00201
7 | River quality | High concentration of suspended solids and nutrients, algae growth | River Thames | E2E00-E00-F-00201
8 | Surface water abstraction | None | E2E00-E00-F-00201
9 | Surface water discharge | 8 | TEMP.2679, TEMP.3043, CSSC.9966, CSAB.0529, CSAB.0523, TEMP.2366, CTWC.1330, CNTW.0853 | E2E00-E00-F-00201
10 | Floodplains and flood levels | Tidal floodplain protected to 107.2 mATD | Thames Estuary d/s of Thames Barrier | E2E00-E00-F-00201

#### 8.8.4 Impact Assessment

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation measures have been identified and assessed as described below. A summary is given in Appendix F.

(i) **Groundwater**

**Temporary:**

**North Woolwich Portal:** The shallow aquifer directly overlies the deep aquifer and the two are hydraulically connected. Groundwater levels are expected to be 98.9 to 100.29 mATD based on 2004 geotechnical investigations. At the tunnel eye, the track level is expected to be approximately 90.6 mATD. It is proposed that the portal be excavated without using conventional dewatering techniques, owing to the presence of a layer of peat. Therefore, the diaphragm walls would be required to toe into the Chalk in order to provide a cut off wall, and the Chalk would be grouted. Therefore, only limited dewatering would be required during construction of the portal prior to completion of the base slab. It is predicted that the sewer
diversion works are minor relative to construction of the portal. The TTZ to the nearest groundwater abstraction (Id 97) is located approximately 870 m to the west of the portal and there would not be an impact on the water quality at this location. Consultation with the well owner is taking place and appropriate monitoring, mitigation and compensation measures would be agreed as required.

Any dewatering is also likely to have the effect of drawing saline water from the River Thames into the shallow aquifer. However, since in this area the Chalk groundwater is already of poor quality due to historic infiltration, the impact of this would not be significant. No impacts are, therefore, considered likely.

**Thames Tunnel:** The tunnelling would take place within the Chalk with the potential risk of contaminating the aquifer. There are no abstractions within 1000 m and the groundwater is generally not utilised in this area. Potential adverse impacts on the groundwater quality can be mitigated by careful construction methods and by monitoring grout loss as described in Appendix B. There would be no residual impacts.

**Warren Lane Shaft:** The deepest level of construction would be approximately 59 mATD and the water level is expected to be 100 to 105 mATD based on Environment Agency data; therefore dewatering of the deep aquifer would be required during construction. It is expected that, depending on the construction methodology, dewatering would be used to draw the groundwater levels down to below the base of the shaft. Due to the potentially high volumes of water involved, it is assumed (A.SE.11), for the impact assessment, that dewatering would be undertaken using external wells in the Chalk, rather than internal pressure relief wells within the shaft during construction.

Dewatering of the deep aquifer for construction of Warren Lane Shaft, Lowell Street Shaft, Hertsmere Road Shaft, Isle of Dogs Station, Blackwall Way Shaft and Limmo Shaft would create an extensive cone of depression of the water table in the deep aquifer. The impacts on the groundwater levels have been calculated using the London Basin Groundwater model as described in detail in Appendix E. As the dewatering at the different Crossrail sites would take place simultaneously, it is not possible to refer a possible impact on a groundwater abstraction back to a specific site. Therefore, all impacts on groundwater levels caused by the dewatering of the deep aquifer at the above mentioned sites are reported within route window C11, Section 6.16.4 of this report. The nearest abstraction from the Chalk is the protected right Id 97, which is located approximately 1 400 m from the shaft site. The results above indicate that there would be little, if any, impact on groundwater levels at this well. Consultation with the well owner is taking place and appropriate monitoring, mitigation and compensation measures would be agreed as required.

The dewatering operations would also affect the water quality of the deep aquifer, as saline water from the River Thames would be drawn into the aquifer. However, since in this area the Chalk groundwater is already of poor quality due to historic and continuing infiltration, the impact of this is assessed as being not significant.

**Permanent:** At the North Woolwich Portal, the retained cut and cut and cover section west of the tunnel eye would create a barrier to lateral flows in the surface aquifer over a width of approximately 190 m. As described in Appendix E, a maximum rise and fall in the groundwater levels 20 m away from the structure of around 1.1 m has been predicted assuming (A.SE.18) plausible aquifer properties. However, some flow under the structure
would still be likely since there is no significant barrier formed by underlying clays. In addition, the regional flows are already affected by the dock walls, pumped drainage and the Thames flood defences. The width and potential groundwater flows within the superficial deposits would be investigated further through site investigation and monitored during construction. Potential mitigation measures could include provision of drainage installed around the portal structures to overcome excessive groundwater level rises. There would be no significant residual impacts.

(ii) Surface Water

Temporary:

**North Woolwich Portal:** Good site practice would be implemented to avoid significant pollution of, or runoff to the Thames, from the worksites caused by overland flow or discharge into drainage pipes or storm water sewers connected to the river. Due to the high flow in the Thames, there would be a high degree of dilution of any contaminated discharge. Approval from the Environment Agency would be sought regarding the disposal locations (on the north and south of the river), quantities and quality of the dewatering effluent. Good site practice would be enforced via the provisions for generic mitigation described in Appendix B and, therefore, there would be no significant residual impacts.

**Thames Tunnel:** The track would be lowered to pass under the Thames Barrier Flood Retention Walls (TBFRW). There would be a risk of ground settlement when tunnelling under the River Thames. However, this impact can be mitigated for by monitoring of ground settlement, and making good the Thames Barrier Flood Retention Wall to ensure that the defended level continues to be achieved. Specific measures would be included in the provisions for generic mitigation described in Appendix B relating to tunnelling under rivers to mitigate for any risk of flooding during this period. These may include the provision of temporary flood walls. Following reinstatement of the walls the original defended level would continue to be achieved. The Environment Agency would be notified since the work would be undertaken within the River Thames buffer zone. There would be no residual impacts.

**Warren Lane Shaft:** It is probable that the River Thames would be utilised for surface water discharges of dewatering effluent, rather than disposing to sewer. Approval from the Environment Agency would be sought regarding the disposal locations (on the north and south of the river), quantities and quality of the effluent.

The discharge would be low turbidity water with a salt content close to that in the Thames and so there would not be an effect on the Thames itself since the salinity of the Thames would remain within its normal range as described in Appendix E. These parameters and the iron content would be monitored near the outlets. The Environment Agency may require other parameters to be also monitored under the terms of the required approvals for the discharge. If mitigation measures are needed, these could include aeration or altering the point of discharge. There would be no significant residual impacts.

Good site practice would be implemented to avoid significant pollution of, or runoff to the Thames, from the worksites caused by overland flow or discharge into drainage pipes or storm water sewers connected to the river. Due to the high flow in the Thames there would be a high degree of dilution of any contaminated discharge. Good site practice would be
enforced via the provisions for generic mitigation described in Appendix B and, therefore, there would be no residual impacts.

**Permanent:** Construction of the cut west of North Woolwich Portal would have an impact on the drainage and recharge into the surface aquifer. It is proposed that the new section of track would drain to appropriate sumps at the portal and would then be discharged to sewer. It is assumed (A.SE.21) that the available capacity in the sewer is adequate to accommodate the extra volumes of water involved. Consultation with Thames Water has been initiated. There would be no residual impacts.

The tunnel drainage sump at Warren Lane would be connected to Thames Water’s sewer system. Consultation has started, appropriate permits would be obtained and there would be no impact.

Lowering of the track at North Woolwich Portal and connection to the tunnels in central London increases the consequences of inundation of the railway. Crossrail would run across the defended floodplain but could become partially inundated under some flood defence breach or Thames Barrier failure scenarios. There is the risk of inundation through a failure at the Thames Tunnel and the additional possibility of flooding passing northwards or southwards through the tunnel leading to localised flooding of the protected floodplain. This would be mitigated by suitable design, possibly incorporating flood gates at the Victoria Dock, North Woolwich and Plumstead portals. The cill or water entry level at Warren Lane shaft would be above the flood level, which would ensure that no residual impacts occur.

(iii) **Residual Impacts**

There would be no significant residual impacts from temporary or permanent works since, as assessed, the design elevations and control measures would prevent flooding. There would be a minor, permanent, non significant residual impact on groundwater levels in the shallow aquifer caused by the tunnel portal acting as a barrier to groundwater flow.

Dewatering would result in a significant temporary lowering of groundwater levels. Consultation with the individual well owners is taking place and appropriate monitoring, mitigation and compensation measures would be agreed as required to give a minor, temporary, non significant residual impact.

There would be a minor, temporary, non significant residual impact on water quality in the River Thames caused by discharge of dewatering effluent.

### 8.9 Route Window SE5 – Arsenal Way Shaft

#### 8.9.1 Scheme Description

(i) **Overview**

The proposed works within this route window comprise the construction of the twin bored Thames Tunnel and Arsenal Way shaft. Having passed beneath the River Thames, the twin-bored tunnel would follow an alignment along the southern edge of the Royal Arsenal.
• Construction of a central intervention and evacuation passage connecting from the shaft to where the eastbound and westbound tunnels would be excavated over approximately ten months.

• Some dewatering may be necessary during excavation and construction of the basement box and shaft structures.

(iii) Duration of Works

The construction of Arsenal Way shaft including the installation of equipment and commissioning would be undertaken over a period of approximately three and a half years.

8.9.2 Additional Scheme Description Assumed for Water Resources Assessment

The Arsenal Way Shaft would comprise a 16 m internal diameter shaft located centrally between the running tunnels with separate cross passages. The ground level is around 106.7 mATD. The works proposed include the construction of a basement structure and then a shaft constructed to a depth of approximately 34 m below ground level, with rail level at around 74 mATD. A sump would be provided at the low point in the shaft, and a pumped discharge main would take the water to a local sewer. The deepest level of work at the sump would be around 66.5 mATD.

The shaft would be constructed using SGI ring segments with the use of a circular caisson to sink the segments. Dewatering would be required to lower the water table to enable excavation to proceed with reduced water pressures. It is likely that the dewatering effluent would be discharged to sewer.

East of Arsenal Way Shaft the alignment would rise sharply towards Plumstead Portal.

8.9.3 Baseline Data

Geological information has been provided by GCG based on review of two boreholes for the DLR Woolwich extension. The boreholes are approximately 160 m from the proposed shaft site. The superficial deposits are 5 m to 9 m thick comprising Made Ground and Terrace Gravels. These are directly underlain by the Lambeth Group and Thanet Sands (between 102.85 and 93.6 mATD). The top of the Chalk is at approximately 90 mATD. The geological strata are likely to have been disturbed by a fault (see Section 8.3.2). There is no information on water levels available, but the Chalk groundwater levels in this area are expected to be between 100 to 105 mATD (Environment Agency, 2003).

There are no groundwater abstractions within the route window. The route alignment passes under the River Thames in the northern part of the route window. The shaft is located some 400 m to the south of the Thames. There are no surface water abstractions, but there is one discharge located on the northern bank of the Thames. The route alignment is immediately to the south of Flood Zone 3 at Arsenal Way. Potential flooding of the tunnel section would be prevented by the Thames Barrier and downstream retaining walls to a level of 107.2 mATD (tidal surge to 106.9 mATD plus 0.3 m freeboard) to accommodate the 1 in 1000 year flood level predicted for 2030.
Baseline data relevant for route window SE5 are summarised in the table below.

### Table 8.11: Summary of Baseline - Route Window SE5

<table>
<thead>
<tr>
<th>Item</th>
<th>Subject</th>
<th>Details</th>
<th>Id</th>
<th>Drawing 1E0421-</th>
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</thead>
<tbody>
<tr>
<td>1a</td>
<td>Geology – Superficial deposits</td>
<td>Made Ground and Terrace Gravels (5 to 9 m thick)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1b</td>
<td>Solid geology</td>
<td>Lambeth Group, Thanet Sands (from 102.85 and 93.6 mATD) and Chalk (from 90 mATD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chalk groundwater levels</td>
<td>100 to 105 mATD (2003)</td>
<td>E2E00-E00-F-00301</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Groundwater quality</td>
<td>Shallow: Non-potable Deep: Increased salinity</td>
<td>E2E00-E00-F-00301</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Groundwater abstractions and protected rights</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Groundwater protection zones/Time of travel zones</td>
<td>None</td>
<td></td>
<td></td>
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<tr>
<td>6a</td>
<td>Main rivers</td>
<td>River Thames</td>
<td>E2E00-E00-F-00201</td>
<td></td>
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<tr>
<td>6b</td>
<td>Other water courses</td>
<td>None</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>River quality</td>
<td>High concentration of suspended solids and nutrients, algae growth</td>
<td>River Thames</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Surface water abstraction</td>
<td>None</td>
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<td>9</td>
<td>Surface water discharge</td>
<td>1</td>
<td>CTWC.1330</td>
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<tr>
<td>10</td>
<td>Floodplains and flood levels</td>
<td>Flood Zone 3 protected to 107.2 mATD Thames Estuary d/s of Thames Barrier</td>
<td>E2E00-E00-F-00201</td>
<td></td>
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</tbody>
</table>

### 8.9.4 Impact Assessment

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation measures have been identified and assessed as described below. A summary is given in Appendix F.

(i) **Groundwater**

**Temporary:** The deepest level of construction would be approximately 66.5 mATD and the ground water level is expected to be 100 to 105 mATD, therefore dewatering of the deep aquifer would be required during construction. It is expected that, depending on the construction methodology, dewatering would be used to draw the groundwater levels down to below the base of the shaft. Due to the potentially high volumes of water involved, it is assumed (A.SE.11), for the impact assessment, that dewatering would be undertaken using
external wells in the Chalk, rather than internal pressure relief wells within the shaft during construction.

Dewatering of the deep aquifer for construction of Lowell Street Shaft, Hertsmere Road Shaft, Isle of Dogs Station, Blackwall Way Shaft and Limmo Shaft would create an extensive cone of depression of the water table in the deep aquifer. The impacts on the groundwater levels have been calculated using the London Basin Groundwater model as described in detail in Appendix E. The modelling shows that a local cone of depression would be created around Arsenal Way Shaft. No groundwater abstractions in this area would be affected by more than a 2 m drawdown. There is a groundwater abstraction (Id 27) located just outside the 2 m drawdown contour and there may therefore be a small impact in terms of water levels. Consultation with the well owner is taking place and appropriate monitoring, mitigation and compensation measures would be agreed as required. There would be no significant residual impacts.

Construction would take place within the Chalk with the potential risk of contaminating the aquifer especially from grouting. There are no abstractions within a distance of 1000 m from the shaft and the groundwater is generally not utilised in this area. Potential adverse impacts on the groundwater quality can be mitigated through careful construction methods and by monitoring grout loss. There would be no significant residual impacts.

Dewatering is also likely to have the effect of drawing saline water from the River Thames into the aquifer. However, as discussed in Appendix E, the Chalk groundwater in this area is likely to be of somewhat increased salinity due to historic infiltration, and so the impact of this would not be significant.

Permanent: None.

(ii) Surface Water

Temporary: Discharge of dewatering effluent, which is likely to be at a considerable flow rate, would lead to a temporary loss of available sewer capacity over several months. The necessary permit would be sought. Consultation with Thames Water has been initiated. There would be no residual impact.

The potential impact on the water quality of the Thames as a result of discharge of dewatering effluent has been considered collectively across route windows C10 to SE5 and is expected to be negligible. This is discussed further in Route Window C11 and Appendix E.

Permanent: None.

(iii) Residual Impacts

There would be no significant residual impacts from temporary or permanent works.
8.10  Route Window SE6 – Plumstead Portal

8.10.1  Scheme Description

(i)  Overview

The proposed works within the route window comprise the construction of the twin bore Thames Tunnel, Plumstead portal, White Hart Road Bridge, track realignment of the existing railway corridor, and the installation of OHLE equipment.

The figure below shows the main features within the route window.

Figure 8.9: Route Window SE6 – Plumstead Portal

(ii)  Plumstead Portal

The Thames Tunnel would follow the existing alignment of the North Kent Line (NKL) from a point immediately to the west of Plumstead station to the surface just west of Church Manorway Footbridge (see Route Window SE7). This would be located on the site of Plumstead Goods Yard, located to the east of Plumstead High Street. The tunnel eye of the Thames Tunnel would be located towards the south west corner of the goods yard. From the tunnel eye to the portal an approximate 100 m long cut and cover box with associated surface structures would be constructed. A ramp contained within an open cut would then bring Crossrail to existing track level opposite 139 Marmadon Road, to the west of Church Manorway. At the tunnel-eye, a 21 m by 30 m chamber would be constructed which would house the emergency escape and EIP facilities from the twin-bore tunnels. At surface level the facilities will be housed in an approximate 20m by 25m size surface structure. On the north side of the structure a hardstanding area will be provided for emergency assembly, emergency and maintenance vehicles on existing railway land.

8-55
Construction of the rectangular shaft at the tunnel eye followed by construction of the cut and cover approach ramp. The shaft will be used as the access point during construction of the tunnels and will subsequently become the permanent intervention and escape shaft.

Installation of Crossrail track and systems throughout the tunnel from North Woolwich portal to Abbey Wood. The existing NKLs will be repositioned on a new track formation with one line each side of the existing two line railway.

To accommodate Crossrail, changes would be made to the layout of the NKL. To replace stabling sidings that would be removed to accommodate the tunnel, a new 250 m long siding would be installed on the south side of the line to the east of Plumstead High Street. The siding would also feature a 20 m long headshunt at the western end. Crossrail would occupy a position between NKL tracks so that cross platform interchanges between Crossrail and NKL trains can be provided at Abbey Wood. From a point east of White Hart Road, the northernmost NKL track would move northwards and would use a new bridge over the Crossrail tracks to reach the northern side of the railway alignment. The realigned track would move by up to 20 m until it runs adjacent to the Crossrail tracks to the east of Church Manorway. To accommodate these works, Crossrail would acquire an approximately 15 m wide strip of land along the northern boundary of the railway between North Road and Church Manorway.

General utility diversions would be undertaken prior to the main construction period. These would include the diversion of the electricity cables beneath White Hart Road eastwards to an alignment beneath the Timber Yard.

(iii) Duration of Works

The construction of the Plumstead portal including fitting out and commissioning would take approximately four years.

The construction of the Thames Tunnels including fitting out and commissioning would take approximately two years and two months.

8.10.2 Additional Scheme Description Assumed for Water Resources Assessment

The new railway is in a tunnel over the western part of the route window and emerges in cutting at Plumstead Portal just east of the existing Plumstead Station.

From the portal, the length of retained cut would be 420 m.

At the tunnel eye the track level would be at approximately 90.3 mATD, but construction of the shaft walls would take place to a depth of 76.5 mATD. A combination of diaphragm walling and piling techniques would be used to form the walls in the sections of cut. The toe levels of these walls would be up to 12 below the base slab. Permanent concrete props would be required between the walls for a distance of 170 m, along the alignment at the deeper end of the cut. Since the groundwater levels in this area would be approximately 100 to 105 mATD and there is hydraulic connection between the shallow and deep aquifer, it is predicted that dewatering would be required during construction of the shaft and cuttings.
The railway in tunnel would be on slab track and would require construction of tunnel track drainage. A sump would be located below the TMB shaft.

Appendix G contains details of utility works in relation to water resources.

8.10.3 Baseline Data

Limited geotechnical information is available for the area around Plumstead. At the portal, data indicates that ground level is at 105 mATD. The superficial deposits comprise Made Ground, Alluvium and River Terrace Deposits (approximately 5 to 12 m thick). The Thanet Sands are present and have an approximate thickness of 4 to 5 m. Underlying the Thanet Sands, the Bullhead Beds may be present, with an approximate thickness of 0 to 4 m. The Chalk has been recorded at levels of 95 to 84 mATD. The 2003 Chalk groundwater level in the area was between 100 and 105 mATD. The deep aquifer groundwater in this area is expected to be of reasonable quality.

There is one licensed groundwater abstraction in the route window approximately 650 m north-east of Plumstead Portal. The source is licensed to European Colour (Pigments) Ltd (Id 27), for general use relating to a secondary category. The 400 day TTZ crosses the alignment for a length of approximately 500 m between the portal and Custom House Station.

There are no surface water bodies in the route window and no surface water abstractions. The edge of the River Thames tidal Flood Zone 3 extends slightly south of the route alignment, covering the northern half of the route window. There are no surface water abstractions or discharges within the route window.

Baseline data relevant for route window SE6 are summarised in the table below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Subject</th>
<th>Details</th>
<th>Id</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Geology – Superficial deposits</td>
<td>Made Ground, Alluvium, River Terrace Gravels (5 to 11 m thick)</td>
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<td>E2E00-E00-F-00301</td>
</tr>
<tr>
<td>1b</td>
<td>Solid geology</td>
<td>Thanet Sands (approx 3.8 to 5 m thick), underlain by Chalk (top from 84 to 95 mATD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chalk groundwater levels</td>
<td>100 to 105 mATD (2003)</td>
<td>E2E00-E00-F-00301</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Groundwater quality</td>
<td>Shallow aquifer: Likely to be non-potable Deep: Expected to be reasonable with increased salinity near the River Thames</td>
<td>E2E00-E00-F-00301</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Groundwater abstractions and protected rights</td>
<td>1 abstraction license</td>
<td>27</td>
<td>E2E00-E00-F-00301</td>
</tr>
</tbody>
</table>
8.10.4 Impact Assessment

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation measures have been identified and assessed as described below. A summary is given in Appendix F.

(i) Groundwater

Temporary: At Plumstead Portal, the shallow aquifer directly overlies the deep aquifer. Groundwater levels are expected to be 100 to 105 mATD. At the tunnel eye, dewatering would be required for construction of the shaft and cut and cover tunnel base slab. The amount of dewatering required would depend on the amount of grouting carried out beforehand and the dewatering method adopted. There is one groundwater abstraction connected to shallow groundwater located within 500 m of the portal, where groundwater levels are likely to be affected by the dewatering. As described in Appendix E the impacts are likely to be small and no significant residual impacts would occur. Consultation with the well owner is taking place and appropriate monitoring, mitigation and compensation measures would be agreed as required.

The Chalk groundwater in the area is generally vulnerable to pollution as there are no significant impermeable strata above the aquifer. The eastern end of the portal would be constructed over the 400 day TTZ for borehole Id 27. Good site practice would be implemented to avoid significant pollution of groundwater, particularly within the 400 day TTZ. Monitoring would be undertaken. Consultation with the well owner is taking place and appropriate monitoring, mitigation and compensation measures would be agreed as required. A specific risk is present as contamination may be mobilised from ground breaking works in land currently assessed as being polluted. The scope of the contaminated land and geotechnical site investigations would include deeper boreholes to confirm the presence of low permeable strata of significant thicknesses to provide a sufficient barrier to migration of polluted water. Contaminated land remedial work needs to include suitable mitigation measures to protect groundwater and this is covered in the associated contaminated land technical report. Good practice would be enforced via the provisions for generic mitigation described in Appendix B and therefore there would be no significant residual impacts.
towards Network Rail’s NKL at Plumstead. Both the eastbound and westbound rails would lie at a depth of approximately 35 m below ground level at Arsenal Way Shaft.

The figure below shows the main features within the route window.

**Figure 8.8: Route Window SE5 – Arsenal Way Shaft**

(ii) **Arsenal Way Shaft**

The shaft would be located at the south eastern end of Woolwich Barracks Car Park with Plumstead Road to the south. It would have a diameter of 16 m and contain ventilation, EIP and emergency evacuation facilities.

The main construction works at Arsenal Way would proceed as set out below:

- Excavation of a piled basement box structure. A base slab would be cast on the floor of the basement box once excavation is completed. An opening would be left in the base slab for shaft construction.

- Excavation and construction of the shaft from the base of the box to tunnel level in sections using pre-cast concrete segmental lining. A base slab would be cast to the floor of the shaft once excavation is completed and would be fitted with a drainage sump.

- Construction of a central ventilation passage from the shaft and construction of cross passages. From the ventilation passageways, the tunnel enlargements would be constructed.

- TBMs would pass through the area during which time, the internal structural walls within the shaft, tunnel enlargements and ventilation passage ways would be installed.
The electricity cable diversion (AW/0055) also involves some ground break but the work is shallower than at the main portal. Good practice would be enforced via the provisions for generic mitigation described in Appendix B and therefore there would be no significant residual impacts.

**Permanent:** The long section (up to 600 m) of retained cut and cut and cover section east of the tunnel eye would create a barrier to flow within the aquifer. As described in Appendix E, a maximum rise and fall in the groundwater levels of up to 3.1 m at 20 m away from the structure has been predicted assuming (A.SE.18) plausible aquifer properties. However, the walls of the retained cut may not extend into the underlying strata over the whole length of the approach ramp thus reducing the effective length of the barrier. At this location, there is hydraulic continuity between the shallow and deep aquifers so there is not likely to be a significant impact on groundwater flows and levels. The width and potential groundwater flows around the portal and approach section would be investigated further through site investigation and in the detailed design. Mitigation measures could include provision of drainage to overcome excessive groundwater level rises. There would be no significant residual impacts.

(ii) **Surface Water**

**Temporary:** It is predicted that all dewatering effluents would be discharged via the Southern Relief Sewer, which would lead to a temporary reduction in sewer capacity. Consultation with Thames Water has been initiated. Good site practice would be enforced through the provisions for generic mitigation described in Appendix B, leading to no residual impacts.

**Permanent:** There would be an increase in intercepted drainage from the tunnel approach ramp and areas of hard standing. The drainage would probably be directed to a sump and then to a connection to the combined sewer system. Consultation with Thames Water has been initiated. There would be no residual impacts.

The Plumstead Portal is on the defended floodplain but could become partially inundated under some flood defence breach or Thames Barrier failure scenarios. The portal and tunnel might allow flood water to pass to or from the north bank of the Thames and extend the area affected by flooding. This would be mitigated by suitable design, possibly incorporating flood gates at the Plumstead portal. There would be no residual impacts.

(iii) **Residual Impacts**

There would be no significant residual impacts from temporary or permanent works since, as assessed, the design elevations and control measures would prevent flooding.

8.11 **Route Window SE6A – Manor Wharf**

**8.11.1 Scheme Description**

The proposed works within the route window comprise the refurbishment of Manor Wharf at the site of the former Belvedere power station. This would be required in order create a
barge loading facility, at which excavated material, removed from Plumstead portal and the intervention shafts at Arsenal Way and Warren Lane, would be loaded onto barges for transport down river to landfill in Rainham, Essex.

Works would require the replacement of fendering to the jetty, with works undertaken from boats, and some dredging of the wharf to enable barge access. A conveyor would be constructed to allow excavated material to be loaded onto barges. The conveyor would run from an excavated material handling point on the shore within the former Ford car park (disused), south of the River Thames, north of the wharf where it would connect to the barge loading point.

The figure below shows the main features within the route window.

![Figure 8.10: Route Window SE6A – Manor Wharf](image)

8.11.2 Additional Scheme Description Assumed for Water Resources Assessment

An application for consent to construct and operate a Resource Recovery Plant comprising an Energy from Waste power station on a site fronting the River Thames at Norman Road, Belvedere has been made by Riverside Resource Recovery Limited.

Norman Road is an un-adopted public highway which is in a very poor condition. Its current width is too narrow to carry the expected number of lorry movements and therefore temporary widening will be necessary. The open drain along Norman Road forms part of the area’s pumped drainage system and would be temporarily culverted where the road is widened to improve access.
8.11.3 Baseline Data

The geology comprises London Clay overlain by Bagshot Beds and superficial deposits. Superficial deposits are likely to comprise Alluvium and River Terrace Deposits in unknown thicknesses. The Chalk groundwater levels are approximately 100 mATD. There are no groundwater abstractions or groundwater protection zones in the area.

The jetty is located at the banks of the Thames. The river side of the jetty is around 25 m from the tidal defences and existing bed levels are between 1.1 to 1.8 above chart datum which means they will be exposed at low tide (the mean tide ranges are 4.5 m and 6.03 m for neap and spring tides respectively). The intertidal zone extends from the flood defences to around 10 m beyond the jetty.

The land to the south of the jetty is occupied by the Erith Marshes which are crossed by a network of dykes. The entire route window lies on the tidal Flood Zone 3; a paddock to the south of the proposed sites is known to flood in the winter. There is one surface water abstraction from Great Breach Dyke to the west of the site, licensed to Thames Water Utilities Limited. There is one surface water discharge consent, licensed to Lidl Uk (CASM.0331), discharging to the Thames.

Baseline data relevant for route window is summarised in the table below.

### Table 8.13: Summary of Baseline - Route Window SE6A

<table>
<thead>
<tr>
<th>Item</th>
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<th>Id</th>
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<tbody>
<tr>
<td>1a</td>
<td>Geology – Superficial deposits</td>
<td>Alluvium, River Terrace Gravels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1b</td>
<td>Solid geology</td>
<td>Bagshot Beds, London Clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chalk groundwater levels</td>
<td>Approx 100 mATD (2003)</td>
<td>E2E00-E00-F00302</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Groundwater quality</td>
<td>Shallow aquifer: Likely to be non-potable, Deep: Increased salinity</td>
<td>E2E00-E00-F00302</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Groundwater abstractions and protected rights</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Groundwater protection zones/Time of travel zones</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6a</td>
<td>Main rivers</td>
<td>Thames Estuary, Dykes within Erith Marshes</td>
<td>E2E00-E00-F00202</td>
<td></td>
</tr>
<tr>
<td>6b</td>
<td>Other watercourses</td>
<td>Norman Road Ditch</td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>River quality</td>
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<td></td>
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<td>8</td>
<td>Surface water abstraction</td>
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<td>Surface water discharge</td>
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<td>CASM.0331</td>
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</tr>
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<td>10</td>
<td>Floodplains and flood levels</td>
<td>Flood Zone 3 protected to 107.2 mATD</td>
<td>Thames Estuary d/s of Thames Barrier</td>
<td>E2E00-E00-F00202</td>
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</tbody>
</table>
8.11.4 Impact Assessment

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation measures have been identified and assessed as described below. A summary is given in Appendix F.

(i) Groundwater

None.

(ii) Surface Water

Temporary: Good site practice would be implemented to avoid significant pollution of, or runoff to, surface waters, specifically the Erith Marshes which could be affected via existing drainage pipes from the work and spoil handling sites.

Manor Wharf is located at a distance of over 16 m from the river defences. The construction works to the jetty and dredging could result in increased suspended solids in the Thames. Good site practice would reduce the impacts and it is assessed that any residual impact would be minor considering the general high levels of suspended solids in the estuary water. The conveyor and loading facilities would be constructed to minimise any spill of the spoil material or polluted runoff into the Thames. Dredging at the wharf would be undertaken taking into account the issues raised by archaeological specialists and with the approval of the Port of London Authority, as set out in Appendix B, and therefore no residual impacts would occur. Good practice would be enforced via the provisions for generic mitigation described in Appendix B and therefore there would be no significant residual impacts on surface water quality.

The Environment Agency would be notified about any work taking place within the buffer zone to surface water flood defences.

The detailed design of drainage may need to be combined with the Energy from Waste power station.

The drain along Norman Road forms part of the area’s pumped drainage system. Converting this to a pipe would reduce the flood storage available and additional water storage or pumping equipment would be provided after consultation with the Local Authority and Environment Agency so there would be no significant residual impact.

Permanent: The site is assessed as not utilising floodplain storage and no impacts are envisaged.

(iii) Residual Impacts

There would be no significant residual impacts from temporary or permanent works. Dredging and transportation of materials by barge on the River Thames would result in a risk of minor, temporary, non significant residual impacts on water quality.
8.12 Route Window SE7 – Church Manorway Bridge

8.12.1 Scheme Description

(i) Overview

The proposed works within the route window comprise track realignment and the provision of two additional tracks within the existing railway corridor, the construction of new footbridges at Church Manorway and Bostall Manorway, the strengthening of Eynsham Drive Bridge, a 2 m high noise barrier would be erected for the length of the route window on both sides of the railway, and the installation of OHLE equipment.

The figure below shows the main features within the route window.

![Figure 8.11: Route Window SE7 – Church Manorway Bridge](image)

(ii) Track Works

The NKL would be reconstructed and four tracked throughout the length of this route window. To accommodate the two Crossrail tracks in the centre, the Dartford and London bound tracks would be moved to the north and south respectively. To accommodate four tracks and to be made fully accessible, the existing footbridge at Church Manorway would be demolished and replaced. To accommodate four tracks and to be made fully accessible, the existing footbridge at Bostall Manorway would be demolished and replaced.

(iii) Duration of Works

The construction works within Route Window SE7 would have the following approximate durations:
• Church Manorway Bridge: four months;
• Eynsham Drive Bridge: five months;
• Bostall Manorway Bridge: four months; and
• Subject to possession planning requirements and excluding final commissioning, the construction of the Plumstead portal and Abbey Wood station trackworks would take about three years to complete.

8.12.2 Additional Scheme Description Assumed for Water Resources Assessment

The works would comprise the widening of the existing railway corridor to four-track width, with the provision of one track either side of the existing two track railway. From Plumstead to Abbey Wood station this would require widening of some 2000 m of track bed. This would also require some provision of earth retaining structures to provide additional width at formation level, re-alignment of the existing tracks on the North Kent Line, construction of new ballasted track with concrete sleepers, reconstruction of any existing railway drainage along the four track section and the reconstruction of a sewer (AW/036) that is too weak to carry a four track railway. Reconstruction would be by pipe jack.

The footbridges at Church Manorway and Bostall Manorway would require replacement. This would also require a long diversion of some underground 132 kV electricity cables (AW/038), to be completed by pipe jack at a depth of 1-2 m. Work sites would require some land take on either side of the railway line. Piled foundations up to 10 m in depth may be required. Bridge piers must be strengthened on the existing road over-bridge at Eynsham Drive Road.

8.12.3 Baseline Data

The figure below shows an extract from BGS sheet 271. This data indicates that the majority of the route alignment would run over superficial deposits underlain by Thanet Sands. The boundary between the Thanet Sands and the Chalk subcrops are present immediately to the south of the route alignment.
Figure 8.12: Geology between Plumstead Portal and Abbey Wood Station

Geotechnical data has been obtained for boreholes at four bridges between Plumstead Portal and Abbey Wood. The locations of the bridges are shown in the figure above. This geological data has been summarised in the following table:

Table 8.14: Geological Strata Thicknesses (mATD)

<table>
<thead>
<tr>
<th></th>
<th>Church Manorway</th>
<th>Blithdale Site (west of Eynsham Drive)</th>
<th>Bostal Manorway</th>
<th>Harrow Manorway</th>
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<tr>
<td>Made Ground</td>
<td>2.2</td>
<td>0.3 – 0.6</td>
<td>0.9 – 2.1</td>
<td>0.6 – 1.5</td>
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<tr>
<td>Alluvium</td>
<td>1.2</td>
<td>0.6 – 2.1</td>
<td>1.1 – 3.6</td>
<td>6.4 – 8.5</td>
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<td>River Terrace</td>
<td>4.9</td>
<td>&gt; 7.3</td>
<td>&gt; 6.7</td>
<td>3.6 – 9.1</td>
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<td>Deposits</td>
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<td>Colluvium</td>
<td>-</td>
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<td>Thanet Sands</td>
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<td>6.1 (northern end only)</td>
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<td></td>
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</tr>
<tr>
<td>Chalk</td>
<td>&gt; 3.7</td>
<td></td>
<td></td>
<td>&gt; 15.6</td>
</tr>
</tbody>
</table>

2003 Chalk groundwater levels were between 100 to 105 mATD. There is one groundwater abstraction license located within the window (Id 27). The source is licensed to European Colour (Pigments) Ltd, for general use relating to a secondary category abstracting from the Chalk aquifer. The 400 TTZ crosses the route alignment.
Figure 8.2 in Section 8.3.3 shows details of dykes in the area. The Wickenham Valley Watercourse is flowing along parts of the alignment and may run through or be connected to one of the sewers to be diverted. The route alignment runs on the Flood Zone 3. There are no surface water abstractions or discharges within the route window.

Baseline data relevant for route window SE7 are summarised in the table below.

Table 8.15: Summary of Baseline - Route Window SE7

<table>
<thead>
<tr>
<th>Item</th>
<th>Subject</th>
<th>Details</th>
<th>Id</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Geology – Superficial deposits</td>
<td>Made Ground, Alluvium, River Terrace Gravels</td>
<td></td>
<td>E2E00-E00-F-00302</td>
</tr>
<tr>
<td>1b</td>
<td>Solid geology</td>
<td>Thanet Sands and Chalk</td>
<td></td>
<td>E2E00-E00-F-00302</td>
</tr>
<tr>
<td>2</td>
<td>Chalk groundwater levels</td>
<td>Approx 100 to 105 mATD (2003)</td>
<td>E2E00-E00-F-00302</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Groundwater quality</td>
<td>Shallow aquifer: Likely to be non-potable Deep: Likely to be good quality</td>
<td>E2E00-E00-F-00302</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Groundwater abstractions and protected rights</td>
<td>1 abstraction license</td>
<td>27</td>
<td>E2E00-E00-F-00302</td>
</tr>
<tr>
<td>5</td>
<td>Groundwater protection zones/Time of travel zones</td>
<td>1 nr 400 day and 50 day TTZ</td>
<td>27</td>
<td>E2E00-E00-F-00302</td>
</tr>
<tr>
<td>6a</td>
<td>Main rivers</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6b</td>
<td>Other watercourses</td>
<td>Dykes and ditches</td>
<td>Figure 8.2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>River quality</td>
<td>Not applicable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Surface water abstraction</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Surface water discharge</td>
<td>None</td>
<td></td>
<td>E2E00-E00-F-00202</td>
</tr>
<tr>
<td>10</td>
<td>Floodplains and flood levels</td>
<td>Flood Zone 3 protected to 107.2 mATD Thames Estuary d/s of Thames Barrier</td>
<td>E2E00-E00-F-00202</td>
<td></td>
</tr>
</tbody>
</table>

8.12.4 Impact Assessment

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation measures have been identified and assessed as described below. A summary is given in Appendix F.

(i) Groundwater

Temporary: The Chalk groundwater in the area is generally vulnerable to pollution as there are no significant impermeable strata above the aquifer. A section of the widened track runs over the outer part of the 400 day TTZ for borehole Id 27. Good site practice would be required to avoid pollution of the existing groundwater abstraction resulting from construction activities or work on contaminated land. This would be enforced via the provisions for generic
mitigation described in Appendix B and particular attention paid to measures related to refuelling, leaks and use of drip trays in unprotected areas within the protection zones. Consultation with the well owner is taking place and appropriate monitoring, mitigation and compensation measures would be agreed as required. The sewer and cable diversions would not be very deep and the diversions are outside the 400 day TTZ for borehole Id 27. Even if the ground is contaminated, water quality in the deep aquifer would not be adversely affected since good site practice would be required as described above. There would be no residual impact.

**Permanent:** None.

(ii) **Surface Water**

**Temporary:** In addition to the sewer, some local ditches may be present. Good site practice would be implemented to avoid significant pollution of, or runoff to these surface waters which may be connected via existing drainage pipes or storm water sewers. Good practice would be enforced via the provisions for generic mitigation described in Appendix B and therefore there would be no significant residual impacts.

It is assumed (A.SE.22) that there is no existing piped track drainage although, in places, there may be a ditch at the toe of, or pipe drainage within, the railway embankment. Remodelling of any ditches, construction of embankment retaining walls and the earthworks on the new four track section would present a particular risk to the ditch from silt-laden or contaminated runoff. The discharge from the ditch would be controlled nearer its outlet by provision of bunds and silt fences. This would be enforced via the provisions for generic mitigation described in Appendix B leading to no significant residual impacts.

**Permanent:** If it is found that there is piped track drainage system in place, this would be reconstructed along the length of the route window. It is assumed (A.SE.23) that any such drains now outfall to the sewers or to existing ditches. Other than in the cut section, it is predicted that little or no change in runoff would occur since the works would mainly comprise remodelling of earthworks and not provision of new hard surfacing. Any increases in runoff could be accommodated by remodelling the ditch and possibly including some form of outlet control near the connection to the receiving watercourse. Consultation with Network Rail, Thames Water and the Environment Agency would be undertaken as part of the detailed design phase to confirm if the existing drainage outfalls (to be identified,) are adequate to support the new drainage system or if any new outfalls and associated discharge consents are required.

As described in the Flood Risk Assessment (see Appendix H) the site falls within the area protected by the Thames Barrier and its associated tidal flood protection works. These flood defences provide greater than 1 in 1000 year flood protection and therefore it is assessed that there is no significant flood risk at this site.

(iii) **Residual Impacts**

There would be no significant residual impacts from temporary or permanent works. There would be a minor, temporary, non significant residual impact on the water quality in the ditches due to the risk of contaminated site runoff.
8.13 Route Window SE8 – Abbey Wood Station

8.13.1 Scheme Description

(i) Overview

The proposed works within the route window comprise the reconstruction of Abbey Wood station, track realignment, the provision of two additional tracks within the existing railway corridor, and the installation of OHLE equipment.

The figure below shows the main features within the route window.

Figure 8.13: Route Window SE8 – Abbey Wood Station

(ii) Abbey Wood Station

The station would be rebuilt to accommodate terminating Crossrail services, and would include the partial rebuilding of Harrow Manor Way Bridge to accommodate the new platforms. The existing platforms would be extended to the east and west, and would become islands with new tracks constructed to the north and south. The existing station building would be demolished and replaced by a new station building and concourse constructed on a raft structure built above the tracks.

The NKL would be reconstructed to accommodate the two new Crossrail tracks in the centre and the rebuilt station at Abbey Wood. The Dartford and London bound tracks would be moved to the north and south respectively. To the east of Abbey Wood station, Crossrail trains would reverse and head back to Central London. Further east at a point 200 m to the east of Parkway Primary School, the line would revert to the current double track alignment.
The main construction works at Abbey Wood station would proceed as set out below:

- Dismantling and removal of the existing bridge structure at Harrow Manorway Bridge, ensuring that two lanes of traffic remain in use at all times. Construction of the new bridge with the installation of new piers using Y-beams, formwork and pre-cast decking.

- Construction of the platform extensions, requiring the removal of eastbound platform and existing track, and extensions to the existing westbound platform, using a modular or conventional system which consists of individual pre-cast concrete platform sections.

- Construction works to extend the eastern platform.

- Demolition of existing station and construction of new elevated station on piled foundations and built up using a steel frame system.

- During the station works, construction of the four-tracking would take place from Plumstead portal to Abbey Wood.

- Construct two additional tracks - the ground level of the embankments either side of the existing tracks would be raised by 0.5 m – 1 m using low retaining walling.

- Throughout the construction works, the four tracking would be extended east of Abbey Wood station for the construction of four new sidings. To enable this, the ground level of the embankments either side of the existing tracks would be raised by 0.5 m – 1 m using low retaining walling.

OHLE equipment would be installed throughout the route window.

(iii) Duration of Works

The construction works would be concurrent within Route Window SE8, and would have the following approximate durations:

- Subject to possession planning requirements and excluding final commissioning, the construction of the new platforms and new elevated station at Abbey Wood would take about two years and eight months to complete.

- Subject to possession planning requirements and excluding final commissioning, the construction of Abbey Wood sidings would take approximately three and half years to complete.

- Subject to possession planning requirements and excluding final commissioning, the reconstruction of Harrow Manorway Bridge would take approximately one year to complete.

- Track works at Abbey Wood station would take approximately eight months to complete.
8.13.2 Additional Scheme Description Assumed for Water Resources Assessment

The surface runoff characteristics at the new Abbey Wood Station would be changed owing to the increased surface area of the four platform layout and canopy roof of the station and appropriate mitigation measures would be incorporated within the detailed design for surface water drainage design.

The railway drainage would be reconstructed generally as described for the route section and generic mitigation above although additional mitigation measures would be included at the turnback sidings. Civil engineering work would be undertaken within the buffer zone of Great Breach Dyke.

Crossrail station works would necessitate the construction of a sewer (AW/037) to the west of the existing sewer. This diversion would be 50 m long, 1000 mm diameter, and constructed by cut and cover. Appendix G contains details of utility works in relation to water resources.

8.13.3 Baseline Data

The borehole around Harrow Manorway (see SE7) indicates that the superficial deposits are 11 to 20 m thick comprising, Made Ground, Alluvium, Terrace Deposits and Colluvium. The solid geology comprise Thanet Sands and Chalk. The Chalk is found from about 15 m BGL. BGS Sheet 271 indicates that the boundary between the Thanet Sands and the Chalk subcrop is present immediately to the south of the route alignment, except at Abbey Wood Station itself where the alignment appears to run on the southern side of the boundary and therefore the Thanet Sands would not be present. This would be confirmed by further site investigations. The 2003 groundwater level was between 100 and 105 mATD.

There are no groundwater abstractions within the route window.

Two surface watercourses originate within the route window. The watercourses are shown on Figure 8.2 in Section 8.3.3; they are Butts Canal and the Great Breach Dyke. In the west of the route window, the Wickham Valley Watercourse (WVV) is a piped stormwater drain which crosses from south to north under the route, runs parallel to the railway for several hundred metres before turning northward towards its outfall in a lake which feeds though one of the Marsh Dykes to Tripcock Pumping Station. It is not classed as a Lost River, although similar in form and history, since it is now the responsibility of the Borough Council and not Thames Water Utilities or the Environment Agency. The ditch in Mottisfont Road, on the north-west side of Abbey Wood Station, has been observed with water in, but it is not clear if this is connected to the WVV or continues east of Abbey Wood Station where the head reach of the Great Breach Dyke runs eastwards along the north side of the embankment by Aliske Road. Alternatively, the ditch may be part of the system feeding the consented discharge (TEMP.2364) which is discussed below. The edge of the Flood Zone 3 runs parallel to and slightly south of the route alignment: the alignment lies within the Flood Zone.

There is one surface water abstraction from Great Breach Dyke (TEMP.2364) downstream of the route window. This is licensed to Thames Water Utilities Limited. There are three surface water discharges within the route window. One is licensed to Thames Water Utilities Ltd (TEMP.2364) discharging to a railway ditch. The other two are licensed to TE & LR Duffy at the same location apparently discharging to the Colne Brook.
Baseline data relevant for route window SE8 are summarised in the table below.

**Table 8.16: Summary of Baseline - Route Window SE8**

<table>
<thead>
<tr>
<th>Item</th>
<th>Subject</th>
<th>Details</th>
<th>Id</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Geology – Superficial deposits</td>
<td>Made Ground, Alluvium, Terrace Deposits and Colluvium (11 to 20m thick)</td>
<td></td>
<td>E2E00-E00-F-00302</td>
</tr>
<tr>
<td>1b</td>
<td>Solid geology</td>
<td>Thanet Sands and Chalk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chalk groundwater levels</td>
<td>100 m to 105 mATD (2003)</td>
<td>E2E00-E00-F-00302</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Groundwater quality</td>
<td>Shallow aquifer: Likely to be non-potable; Deep: Likely to be good quality</td>
<td>E2E00-E00-F-00302</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Groundwater abstractions and protected rights</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Groundwater protection zones/Time of travel zones</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6a</td>
<td>Main rivers</td>
<td>Great Breach Dyke</td>
<td>E2E00-E00-F-00202</td>
<td></td>
</tr>
<tr>
<td>6b</td>
<td>Other watercourses</td>
<td>Butts Canal, Wickham Valley Watercourse (sewered)</td>
<td>E2E00-E00-F-00202, Figure 8.2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>River quality</td>
<td>Not applicable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Surface water abstraction</td>
<td>1</td>
<td>28/39/44/0041*</td>
<td>E2E00-E00-F-00202</td>
</tr>
<tr>
<td>9</td>
<td>Surface water discharge</td>
<td>3</td>
<td>TEMP.2364 CATM.3314 CANM.3314</td>
<td>E2E00-E00-F-00202</td>
</tr>
<tr>
<td>10</td>
<td>Floodplains and flood levels</td>
<td>Flood Zone 3 protected to 107.2 mATD; Thames Estuary d/s of Thames Barrier</td>
<td></td>
<td>E2E00-E00-F-00202</td>
</tr>
</tbody>
</table>

*) Located downstream of the route window

**8.13.4 Impact Assessment**

Chapter 4 and Section 8.4 describe route wide and route section wide impacts and generic mitigation measures respectively. In addition, route window specific impacts and mitigation measures have been identified and assessed as described below. A summary is given in Appendix F.
(i) **Groundwater**

**Temporary:** The sewer diversions would not be very deep and the diversions are outside the 400 day TTZ of any abstractions. Even if the ground is contaminated, water quality in the deep aquifer would not be adversely affected since good site practice would be enforced via the provisions for generic mitigation described in Appendix B, leading to no significant residual impact.

**Permanent:** None.

(ii) **Surface Water**

**Temporary:** Good site practice would be required to avoid pollution of the Wickham Valley Watercourse, which is sewered, while earthworks and retaining walls are being built adjacent to or over it. Good site practice would be enforced by the provisions for generic mitigation described in Appendix B leading to no significant residual impacts.

It is assumed (A.SE.22) that there is no existing piped track drainage although, in places, there is a piped sewer, ditch or the Great Breach Dyke at the toe of the railway embankment. Any remodelling of these watercourses, construction of embankment retaining walls and the earthworks on the new four track section would present a particular risk from silt-laden or contaminated runoff. Civil engineering work would be undertaken within the buffer zone to the Great Breach Dyke, and, therefore, approval from the Environment Agency would be required as specified in the provisions for generic mitigation described in Appendix B. The discharge from the watercourses would be controlled near their outlets by provision of bunds and silt fences. Good site practice would be enforced through the provisions for generic mitigation described in Appendix B, leading to no significant residual impacts.

**Permanent:** If it is found that there is piped track drainage system in place, this would be reconstructed along the length of the route window. It is assumed (A.SE.23) that any such drains now outfall to the sewers or to existing ditches. It is predicted that little or no change in runoff would occur in general since the works would mainly comprise remodelling of earthworks and not provision of new hard surfacing. Any increases in runoff from could be accommodated by remodelling the ditch and possibly including some form of outlet control near the connection to the receiving watercourse.

The proposed new platforms and sidings would lead to an increase in drainage of surface runoff and appropriate design would take place during the detailed design stage. It is assumed (A.SE.24) that the runoff would be discharged to sewer leading to an increase in runoff to sewer. There would be no significant residual impacts. Consultation with Thames Water has been initiated.

(iii) **Residual Impacts**

There would be no significant residual impacts from temporary or permanent works. There would be a minor, temporary, non significant residual impact on the water quality in the Wickenham Valley Watercourse, Great Breach Dyke and other watercourses due to the risk of contaminated site runoff. There may be a minor, non significant residual impact on the flows in the watercourses due to due to remodelling of the drainage.
8.14 Summary of Significant Impacts and Assessment – South East Route Section

There would be no residual significant impacts from temporary or permanent works in the South East Route Section.