

Thames Water  
Draft Water Resources  
Management Plan 2019

**Technical Appendices**

**Appendix G: Non household water demand**



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Note: This appendix consists of a foreword and an external report containing its own table of contents and its own page-numbering.

Appendix G.

## Non household water demand

### A. Non-Household Long-Term Demand Forecasting

#### **Foreword**

- G.1 Thames Water commissioned Servelec Technologies (formerly Tynemarch Systems Engineering) to develop a model to produce forecasts of non-household demand in the future for our draft Water Resources Management Plan 2019.
- G.2 The Water Resource Planning Guidelines<sup>1</sup> lists the requirements for non-household forecasts.
- How we have estimated demand forecast for non-households
  - How we have derived the figures and assumptions you have made
  - The makeup of non-household demand in different sectors either by using the service and non-service split (identifying key sectors) or by using Standard Industrial Classification categories published by the Office for National Statistics
- G.3 Servelec undertook a statistical analysis of non-household consumption data and potential explanatory factors to derive relationships that describe how these factors affect non-household consumption and produce future forecasts of likely levels of consumption for non-households in the future. This was carried out over our whole planning period to 2100.
- G.4 Section 3 contains an overview of household demand and the forecasts used within this plan.
- G.5 This appendix contains the final report from Servelec Technologies which details the methods used to produce the models upon which our forecasts of non-household demand have been based.

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<sup>1</sup> Environment Agency and Natural Resources Wales, Water Resources Planning Guideline: Interim Update April 2017



# Non-Household Long-Term Demand Forecasting

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## 1 INTRODUCTION

Thames Water Utilities Ltd (TWUL) is required to develop forecasts for non-household water demand as part of its long-term strategy for water resources management. It is anticipated that the next Water Resources Management Plan (WRMP) will require forecasts for the period to 2045.

Servelec Technologies<sup>2</sup> provided a report<sup>3</sup> and associated spreadsheet<sup>4</sup> detailing a non-household forecast to 2045. TWUL has asked Servelec Technologies to develop a longer term non-household forecast over a 50-100 year horizon. Whilst not a direct requirement for WRMPs, this will help provide the context for future options for balancing supply and demand.

The first set of model results<sup>5</sup> have been updated to incorporate updated population forecast data provided by TWUL.

The intended audience for this document is Ross Henderson and colleagues in TWUL involved with the preparation of the WRMP.

## 2 PROJECT OVERVIEW

### 2.1 Aim

The aim of this work is to provide a review of the potential non-household demands over a 50-100 year horizon. A detailed forecast is inappropriate given the timeframe, but broad estimates as to the likely demands can be made.

### 2.2 Scope

Non-household demand in all of the Water Resource Zones (WRZs) in the TWUL area has been considered.

### 2.3 Approach

The challenge in forecasting demands over a longer period to 2100 is based on the growing uncertainties in the assumptions used for the explanatory factors. There is therefore a need to understand the drivers of the explanatory factors and assess whether their projected values remain reasonable over this timescale. Similar assumptions and industry groupings have been used as per the previous forecast.

The non-household demand in the WRZ London has been divided into three regions, as per the previous forecast. The demand for WRZ London is the combined demand from these regions. The developed spreadsheet<sup>6</sup> includes a comparison of the London combined model with a single model of London. The current and previous forecasts are similar with one another for the period to 2045.

Each explanatory factor, (with the exception of population for which a full forecast has been provided), has been extrapolated by setting limitations based on proportions of employed people compared to the population and evidence from centuries of economic data (GDP) for the UK.

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<sup>2</sup> Tynemarch Systems Ltd trading as Servelec Technologies

<sup>3</sup> Document reference J1562\GD\002\02, dated 06 May 2016

<sup>4</sup> Spreadsheet reference J1562\GD\003\01, dated 20 April 2016

<sup>5</sup> Spreadsheet reference J1662\GD\003\01, dated 06 September 2016

<sup>6</sup> Spreadsheet reference J1662\GD\003\04, dated 04 July 2017

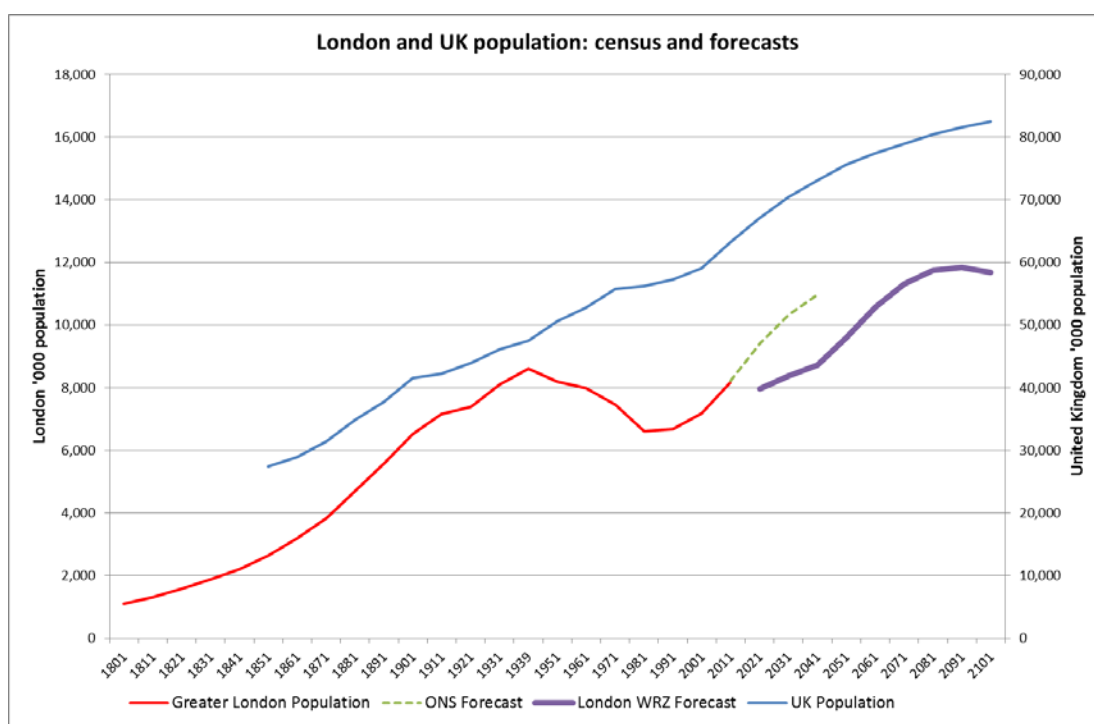
The proposed approach uses the extrapolation of the previous forecast as a baseline and then assesses whether both the explanatory factors and the outputs are reasonable at those levels, and whether there are limiting factors that should be incorporated into the result.

### 3 EXTRAPOLATION OF EXPLANATORY FACTORS

#### 3.1 Population growth and density

A projection of population for each resource zone has been provided by TWUL. This projection shows lower levels of population growth in the first 25 years than had previously been assumed based upon Office for National Statistics (ONS) forecasts, but over the longer term shows population returning to the previous trend and finally levelling off around 2100,

The population for WRZ London has been divided into three regions: London Inner East and London Inner West, and Outer London. A pro-rata approach has been used to develop forecasts for the three areas, based on the previous population forecasts developed by the ONS.



**Figure 1: Historical and forecasts of populations for London and the UK**

The forecast provided remains consistent with the following potential constraints on the population in London:

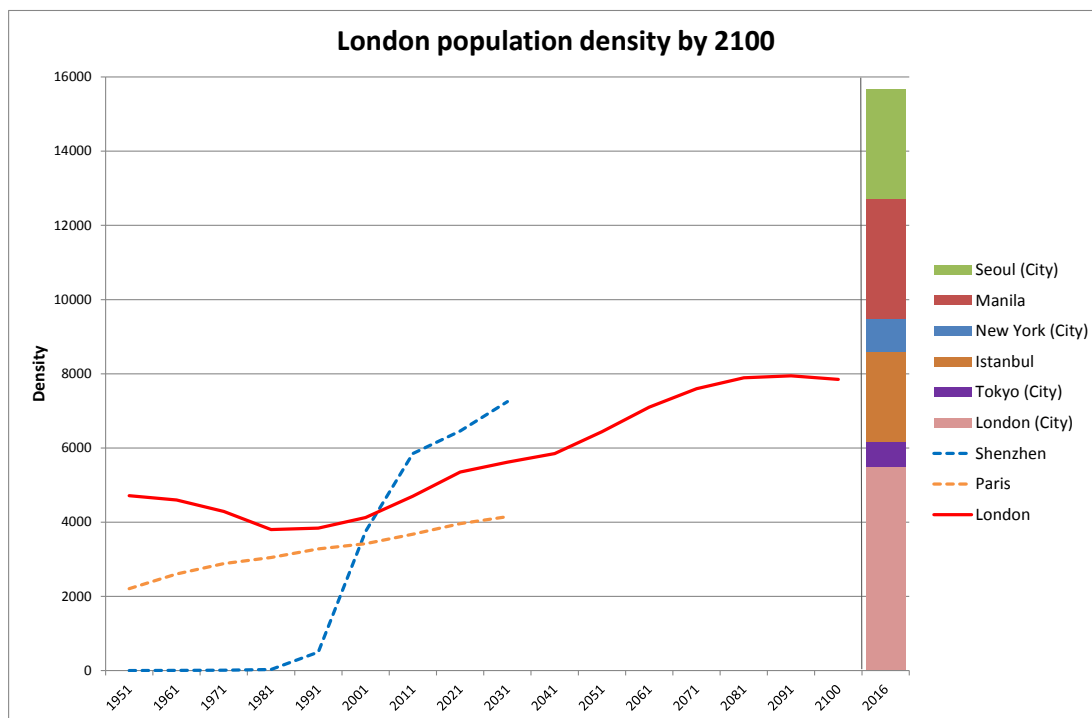
- The historical profile of proportions between the populations in London and in the UK as a whole. The UK population has been forecast by the United Nations<sup>7</sup>. The UK population growth rate is expected to steadily decrease over the forecast period.
- The historical trend of the population in the urban area of London since 1801. The projected trend for 21<sup>st</sup> century is aligned with the 19<sup>th</sup> century trend under the central

<sup>7</sup> World Population Prospects: The 2015 Revision (Medium Variant); File 'Total population by major area, region and country, annually for 1950-2100 estimates



scenario. A comparison between the populations in London and in the UK is shown in **Figure 1**.

- The achievability of the relative population density of London in 2100 compared to current developed *megacities*. The density of London is projected to reach a similar level as the current density (2016) of Istanbul, but will not surpass that of the city of New York as shown in **Figure 2**.



**Figure 2: Projected population density of London by 2100**

The population in the urban area of London in the 19<sup>th</sup> century showed continued growth, and this has continued until the first half of the 20<sup>th</sup> century. However, the second half of 20<sup>th</sup> has been marked by different events and trends (recessions, people moving out into new towns, etc.), affecting the population growth in London. For the remainder of the 21<sup>st</sup> century, the forecast provided implies that population growth will follow a similar trend as that of the 19<sup>th</sup> century and the recent past.

Under the central scenario, the population in the London urban area is estimated to reach 11.7 million inhabitants by 2100, with a density reaching 6,726 people per square kilometres. Alternative scenarios are considered in Section 6.

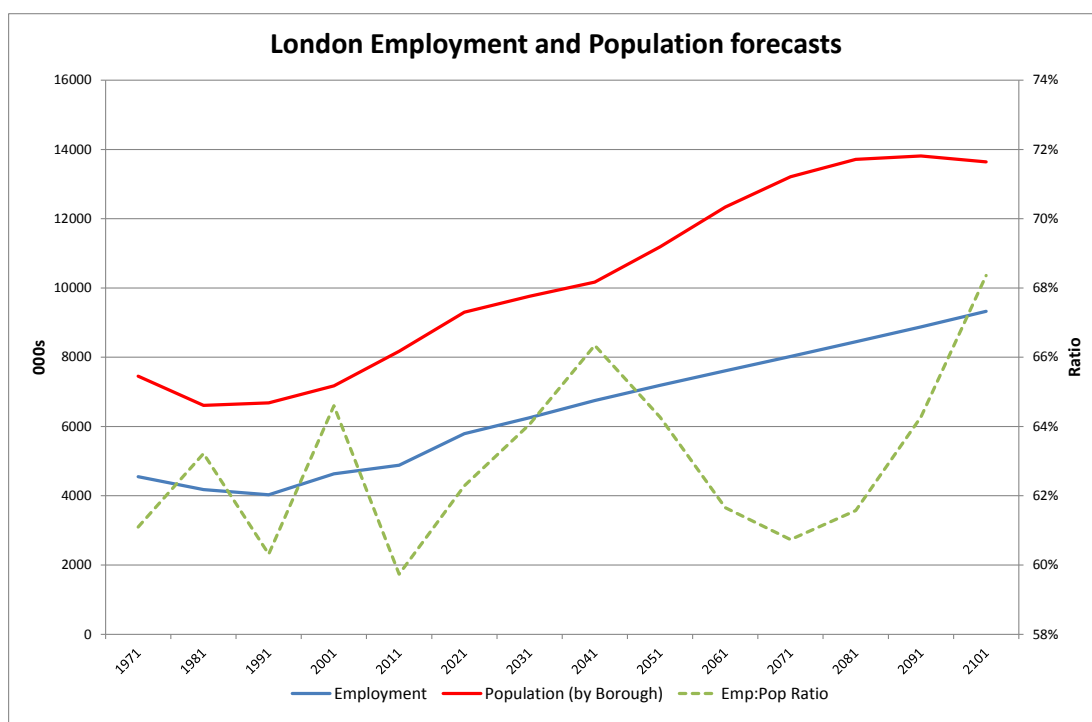
The forecast for the remaining WRZs all show increases in population.

### 3.2 Employment and population ratio

The overall numbers in employment are expected to steadily increase during the forecast period as discussed in further detail below. The employment growth rate in the urban area of London is forecast to decrease from 0.8% in 2016 to 0.5% in 2100. In the South East regions, employment growth rate is also forecast to decrease from an average of 0.9% in 2016 to an average of 0.5% at the end of the forecast period.

The projection of employment in London is obtained from extrapolation of the GLA Economics forecasts from 1971 to 2041<sup>8</sup>. An average growth rate of 0.8% has been used from 2016 to 2041. The forecast growth rates are assumed to be decreasing from 0.7% in 2042 to 0.5% in 2100 because of the relative impacts of different sectors. Employment in London is projected to reach 9.3 million by the end of the 21<sup>st</sup> century.

The projection of employment is constrained by its ratio with the population in London. The ratio is expected to marginally increase over time; this is shown in **Figure 3**. Note that this may be as a result of increased commuting to London, rather than a higher employment rate for the resident population.



**Figure 3: Projected employment and population in London**

The GLA Economics analysis of the past 30 year data concluded that London has seen a strong growth in professional and business support services, while the manufacturing sector has shown a considerable decline of number of employees. It is assumed that London will remain specialised in various service activities, whereas non-service activities (including agriculture, mining and quarrying, and electricity and gas) will slowly decrease by 2100.

The projection of employment in the South East is obtained by extrapolation of the UK Commission for Employment and Skills (UKCES) forecast from 1990 to 2024<sup>9</sup> (where employment has been disaggregated by industry sectors, but not by local authorities). An average growth rate of 0.6% has been used between 2015 and 2024. This rate is assumed to decrease from an average of 0.8% in 2025 to an average of 0.5% in 2100.

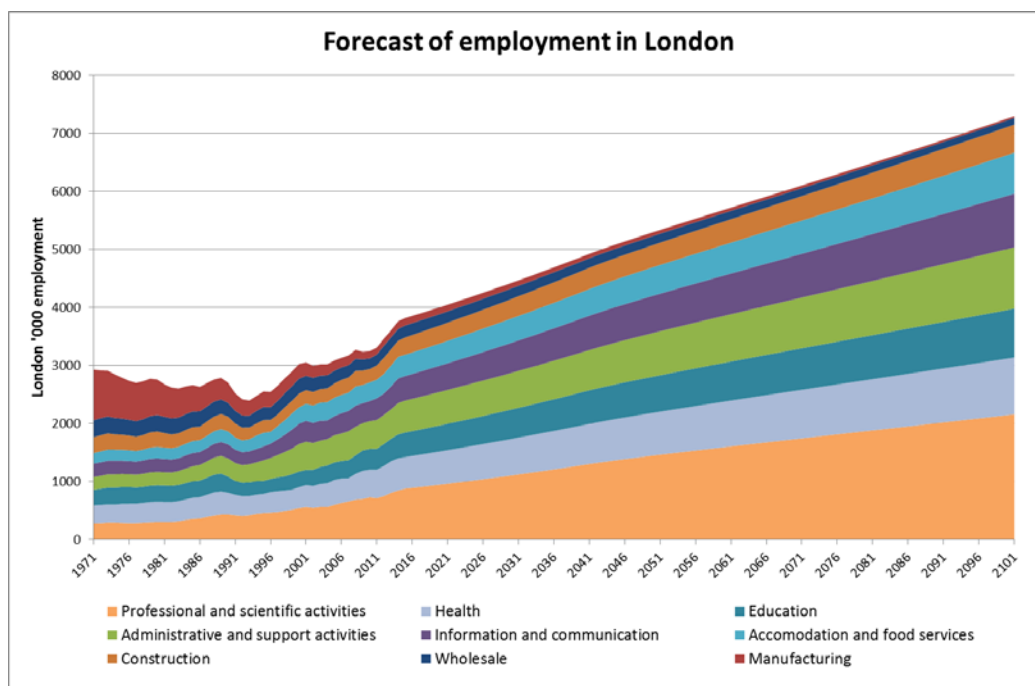
The projection of employment in the South East is constrained by its ratio with the population. The ratio is projected to increase from an average of 64.7% in 2015 to an average of 66.8% in 2100.

While most industries will maintain steady growths (e.g. professional and scientific activities, health, and education) other industries will potentially decrease in size (e.g. wholesale and

<sup>8</sup> 2016 employment projections by sector: Number of jobs by GLA Economics sector from 1971 to 2041

<sup>9</sup> UK Labour Market Projections 2014 to 2024, UKCES

manufacturing) in London. The employment projections to 2100 for selected industries in London are shown in **Figure 4** below.



**Figure 4: Forecast of employment in selected industries in London**

### 3.3 Rise and decay of economy

The review of the historical Real GDP (chained volume measure<sup>10</sup>) since 1830 to 2009 provided by the Bank of England<sup>11</sup> concluded that, under the central scenario (crises-free) an average annual growth of 2.0% (equivalent to 21.9% per decade) is appropriate for the forecast period. However, as shown in **Figure 5**, any economic crises can result in decades of recovery during which periods the growth rates will be higher. The used assumption also aligns with the reported UK total GDP growth rate forecast by HSBC Global Research<sup>12</sup> which will increase from 1.7% in 2020 to 2.2% by 2050. The UK GDP average growth rate estimated by the Environment Agency<sup>13</sup> for the UK is 2%, under the 'Restoration' scenario (sustainability-led governance, dematerialised UK consumption), whereas under the 'Alchemy' scenario (sustainability-led governance, material consumption) the annual growth is estimated at 2.5%.

The GVA growth rate in each of the WRZs in the TWUL regions has therefore been assumed at 2%, with the exception of London whose regional economy is expected to grow faster in which the GVA growth rate is assumed 2.5%.

However, the growth rate of the UK GDP, particularly in London, may slowly decrease by 2100. The urban agglomeration of London is already a *developed city* and will continue to develop, although the economic growth is forecast to be outpaced by fast growing *developing cities* (e.g. some cities in China and India).

<sup>10</sup> A chained volume economic data series removes the effects of inflation by computing for each year the production volume in the prices of the preceding year

<sup>11</sup> 'The UK recession in context – what do three centuries of data tell us?', Bank of England

<sup>12</sup> The World in 2050, HSBC Global Research, Global Economics 2012

<sup>13</sup> Environment Agency scenarios 2030, Science Report SC050002/SR1, 2006

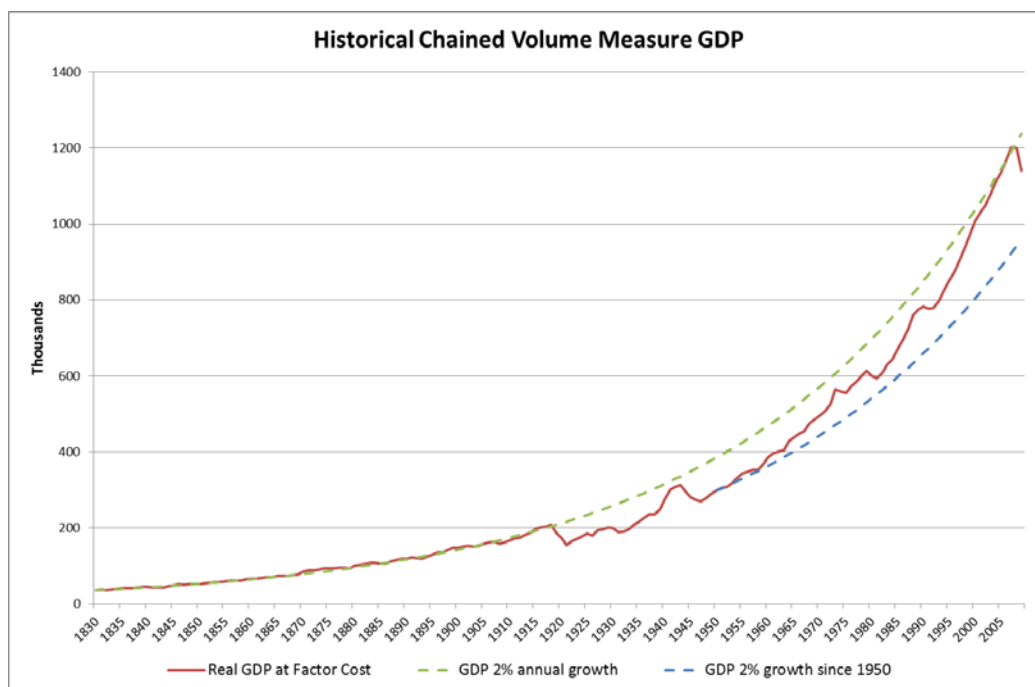


Figure 5: Historical Real GDP from 1830 to 2009<sup>14</sup>

### 3.4 Comparison with other long-term scenarios

The GLA Economics forecast<sup>15</sup> of employment in London ranges from 1971 to 2041, whereas the UKCES forecast<sup>16</sup> ranges from 1990 to 2024. The UKCES forecast estimated over 100 thousands more employees in 2014, however this difference decreases over the years and the two forecasts eventually coincide by 2024.

The 2014-based ONS forecast<sup>17</sup> of population in London ranges from 2014 to 2039, whereas the GLA Economic forecasts<sup>18</sup> range from 2001 to 2041 for both the 'short-term' and 'long-term' resident populations. However, in 2016, the ONS forecast estimated about 60 thousand and 100 thousand more population than the GLA Economics' short-term and long-term forecasts, respectively. These differences are growing over the forecast period to 2039, and reach about 215 and 585 thousand more population estimated by the ONS forecast than the short-term and long-term forecasts by the GLA Economics. As the forecasts are showing similar trends, it is assumed that the difference between the two forecasts may be explained by difference of boundary used.

The population in the urban agglomeration of London has been estimated by the United Nations forecast<sup>19</sup> ranging from 1950 to 2030. However, the United Nations forecast for London is much higher than that of the forecast provided as the agglomeration includes the neighbouring urban areas of Guildford, St. Albans and Harlow. Nevertheless, the United Nations forecast<sup>20</sup> for the population in the UK is smaller than the ONS forecast<sup>21</sup>. The latter estimated over 200 thousand more population in 2015, but this difference continues to

<sup>14</sup> The UK recession in context – what do three centuries of data tell us?, Bank of England

<sup>15</sup> 2016 employment projections by sector: Number of jobs by GLA Economics sector from 1971 to 2041

<sup>16</sup> UK Labour Market Projections 2014 to 2024, UKCES

<sup>17</sup> 2014-Based Subnational Population Projections for Local Authorities and Higher Administrative Areas in England, ONS

<sup>18</sup> GLA 2015 Round Trend-Based Projections, GLA Economics, 2016

<sup>19</sup> World Urbanization Prospects: The 2014 Revision; File: 'Population of Urban Agglomerations with 300,000 Inhabitants or More in 2014, by Country, 1950-2030

<sup>20</sup> World Population Prospects: The 2015 Revision (Medium Variant); File 'Total population by major area, region and country, annually for 1950-2100 estimates

<sup>21</sup> 2012-Based National Population Projections by Single Year of Age and Sex, ONS

increase: by 2050 the ONS forecast estimated 1.6 million more population than the United Nations forecast, and this difference reaches about 7.6 million more population by 2100. The two population forecasts for the UK in 2030 are slightly higher than estimated by the Environment Agency<sup>22</sup> in 2006 under the 'Jeopardy' scenario (growth-led governance, material consumption).

### 3.5 Long-term impact of climate change

The climate change in the UK for the 21<sup>st</sup> century has been forecast in the UK Climate Projections 2009<sup>23</sup> (UKCP09) and published by the Department for Environment, Food and Rural Affairs (Defra). Under the 'medium emissions' scenario, the projected increase in average summer temperatures in the South East are 1.6°C during the 2020, 2.8°C in 2050 and 3.9°C in 2080. The temperature is forecast to continue increase over the years. According to the MET Office<sup>24</sup>, the climate in the UK will see drier hotter summers, and milder wetter winters.

The agriculture sector is expected to be affected by the climate changes, potentially requiring more water abstraction and the number of abstraction licences may increase. However, water demand in this sector is about 3.1 MI/d which accounts 0.7% of the total water demand in the TWUL region in 2015, thus have negligible impact over the overall demand forecast.

Private abstraction in agriculture (excluding spray irrigation) in 2014 is estimated at 2,427 MI/d across the Thames region based upon public domain information<sup>25</sup>. The licensed private abstraction is substantially higher at 8,629 MI/d in the same year. Therefore, it is assumed that climate change will not lead to substantial additional demand from TWUL in respect of organisations licensed to abstract water privately.

A few other sectors may be affected by the climate change, including:

- The food products, beverages and tobacco (non-service) sector may be impacted by the climate change, as productions may increase during hotter summers, thereby slightly increasing water demands. This sector requires about 24.4 MI/d of water in 2015, representing about 5.5% of the demand in the TWUL regions.
- Human health and social work activities: Extreme weather could affect emergencies and hospitals as (older) people may suffer from hotter temperatures. This sector requires 32.0 MI/d (accounting about 7.2%, including 5.3% in London alone) of the total consumption in the TWUL regions in 2015.
- Accommodation and food service activities: Warmer temperature (in spring, summer and autumn) may attract more tourists, thus potentially increasing water demand. This sector requires 46.0 MI/d (accounting about 10.3%, including 8.4% in London alone) of the total consumption in the TWUL regions in 2015.
- Arts, entertainment and recreation activities: Warmer temperatures may increase different entertaining activities, for example in sports and in tourist areas, potentially increasing water demands. This sector requires 69.4 MI/d (accounting about 15.6%, 11.9% in London alone) of the total demand in the TWUL regions in 2015.

However, no specific inclusion for climate change has been included as it could be argued that any effect will be captured at least to some extent in the historical data. Also, the findings

<sup>22</sup> Environment Agency scenarios 2030, Science Report SC050002/SR1, 2006

<sup>23</sup> UK Climate Projections; Report: 'Adapting to climate change', 2009, Data available from the Department for Environment, Food and Rural Affairs (Defra) without charge

<sup>24</sup> 'Too hot, too cold, too wet, too dry: Drivers and impacts of seasonal weather in the UK', MET Office Hadley Centre

<sup>25</sup> 'Total estimated abstractions and licensed abstractions from all sources by purpose', Environment Agency/NRW charge region (2000-2014); 'Abstraction licences in force and new licences determined: 2000-2014', Environment Agency

of recent research by UKWIR<sup>26</sup> suggest that the effect of climate change to non-household demand will have no substantial impact, except for the agriculture and horticulture sector.

## 4 MODELLING SETUP

The grouping approach and the details of the SIC groups used in the previous work by Servelec<sup>27</sup> has been retained for this project. Thus, a similar modelling setup as in the previous work was used, except for London which currently is treated as a single water resource zone.

Similar to the previous modelling setup, the SIC groups have been classified into five groups for each WRZ as follows:

- Grp1 – A combination of the SIC groups O, P and Q
- Grp2 – SIC groups R, S and T combined with the SIC groups O and/or Q
- Services – The remaining SIC groups that relate to service industries (G, H, I, J, M and N)
- Non-Services – The remaining SIC groups that relate to non-service industries
- Unknown – The consumption without a known sector.

## 5 MODELLING RESULTS

The general model previously used for each sector group in each area has been retained, with the following form:

$$\ln(\text{Consumption}_i) = C + \alpha_1 \text{Empl}_i + \alpha_2 \ln(\text{GVA}_i) + \alpha_3 \text{Pop}_i + \alpha_4 \text{Year}_i + \alpha_5 \text{Tariff}_i$$

Where:

- *Consumption<sub>i</sub>* - the consumption in year *i* for the particular sector group in the particular area
- *Empl<sub>i</sub>* – the number of employees in the sectors modelled (in London for the 3 London areas and in South East England for the other WRZs) in year *i*
- *GVA<sub>i</sub>* - the GVA in £million for the relevant SIC groups in the relevant area in year *i*. (Note that the GVA figures obtained were in basic prices, which were rebased using the GDP deflator to take account of inflation)
- *Pop<sub>i</sub>* - the population resident in the relevant area in year *i*
- *Year<sub>i</sub>* - the year, which is used to give an absolute trend to the model
- *Tariff<sub>i</sub>* - the general user water tariff in £/m<sup>3</sup> in year *i*

<sup>26</sup> 'Impact of Climate Change on Water Demand', Ref 13/CL/04/12, UKWIR

<sup>27</sup> J1562\GD\002\02 Non-Household Demand Forecasting, dated 06 May 2016

- $\alpha_{1-5}$  are the coefficients determined through linear regression. A coefficient of zero means that the explanatory factor is not used
- $C$  – a constant term determined by the regression analysis.

This form was preferred over other forms, such as those without the logarithm being taken of the consumption or GVA terms, since it gave an improved fit to the historical data.

$\alpha_{1-5}$  and  $C$  were found using a standard multiple linear regression technique applied to the data for the period FY06 to FY15.

The models for each industry sector within an area are summed to obtain the forecast for the area, and then the areas summed to give the forecast for TWUL as a whole.

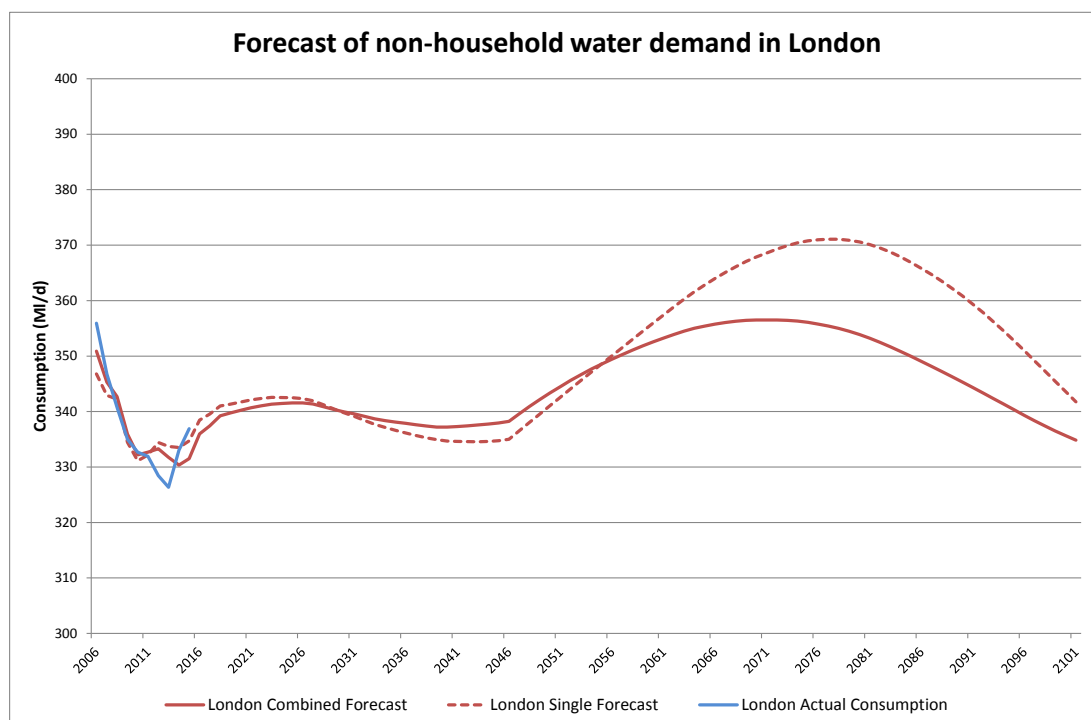
Note that, although the projected trends in some individual models can be argued to be influenced by issues with historical assignment (particularly in the case of the unknown model), and by over-fitting of the explanatory factors (e.g. Tariff) due to fluctuations in demand, the combined outputs at WRZ levels have been assessed to forecast the most probable trends.

## 5.1 London

As per the previous modelling, the population figures in LO East and West refer to the Inner London East and West NUTS areas, and the population in LO Outer refers to the Outer London NUTS area.

Water demand in London is forecast to rise in nearly all service sectors. The non-service sector and unknowns are forecast to decrease over the forecast period. The overall combined demand from LO East, West and Outer of London is shown in **Figure 6**, and this has been compared with a single model of the demand in London as a whole. The two graphs generally agree until the 2050s, then diverge and follow different trends until 2100. This difference is due to a slight loss of detail in the London single model, requiring two assumptions to balance demand between the non-service and unknown sectors:

- Non-services in the London single model was assumed to remain relatively constant, whereas decreasing trends are assumed in the London Inner East and West regions for the combined model.
- Unknowns sector from the two models show decreases in demand, however the London single model is showing a much faster fall.



**Figure 6: Model forecast for London**

The service industries are projected nearly exactly the same in both models, they are forecast to gradually increase their water demands over the forecast period. The main difference in the two models is therefore the handling of the non-Service industries (which have downward trends in all LO East, West and Outer) and unknown sectors.

Demand in the WRZ London is projected to see alternate successions of increases and decreases. Increases of demand are driven by the service sector, whereas the non-service and unknown sector demands are expected to decrease over the forecast period. Demand in London will reach 343.4 MI/d (about 3.6% increase compared to 2015 level) by 2050. After this period, an increase in demand to reach 347.2 MI/d is forecast in around 2070, and a decrease in demand in the remaining period.

## 5.2 London Inner East

Water demand from service industries are projected to increase. The non-service sector is decreasing by 28.4% in 2050 and 50.5% in 2100.

The overall non-household demand generally increases, driven by service industries. Demand is expected to rise by about 11.4% in 2050 and 20.7% in 2100 compared to the level in 2015. The magnitude of increase in 2050 is 13.8 MI/, and by 2100 an increase of 25.2 MI/d will be achieved.

## 5.3 London Inner West

The overall demand will see increases and decreases. Demand will increase by about 18.3 MI/d in around 2065 compared to the 2015 level. The magnitude of the decrease from 2065 to 2100 is estimated about 32.7 MI/d.

## 5.4 Outer London

The overall demand will slightly decrease till the 2050s, and then slightly increase during the remaining period to 2100. The decreases are driven by the non-service industries. The non-



service model forecasts a decrease by 20.3% in 2050 and a decrease about 63.7% by 2100 compared to level in 2015.

Demand from service industries are projected to continue its growth and will ultimately overcome the offsets from the non-service industries. The projected demand in the Outer London regions in 2100 will only be about 7.5 MI/d lower than the level in 2015.

## 5.5 Guildford

The overall demand will increase in general, driven by the service sectors except the Grp2 (SIC groups R, S and T) group (Other Services and Household activities), whereas the non-service sector is a small demand compared to the overall service sector in Guildford.

A demand increase by 38.2% in 2050 is expected compared to 2015, and by 2100 demand will rise to about 1.8 MI/d.

## 5.6 Henley

The overall demand in Henley is forecast to decrease till the 2060s and then stay level throughout the remaining period. Only the service sector demand from SIC groups G, H, I, M, N and J is forecast to increase, but will not make any significant effect in the long term. The non-household water demand in Henley is negligible compared to the overall TWUL demand, and thus will not change much the general forecast trend at the company level.

## 5.7 Kennet Valley

Water demand is expected to increase in the service sector, whereas the non-service sector is forecast to remain level throughout. Demand will marginally decrease till mid-century, decreasing by 4.6% in 2050 compared to 2015 level, and then slightly increasing throughout the remaining period to 2100. However, the magnitude of increase between 2050s and 2100 is only about 2.5 MI/d.

## 5.8 Slough, Wycombe and Aylesbury (SWA)

The combined sector consisting of the groups Grp1 and Serv is forecast to decrease over the forecast period. The non-service sector is assumed to rise.

Demand is projected to decrease till the 2050s, decreasing by 12.9% in 2050 compared to 2015 level, and then increasing throughout the remaining period to 2100, reaching 22.8 MI/d. The first half decrease is driven by demand from service industries in Grp2 and unknown sector, whereas the second half increase is driven by the demand from the remaining service industries and the non-service sector. The magnitude of increase between 2050 and 2100 is estimated at about 5.6 MI/d.

The increase of demand in the non-service sector has been driven by the demand from the Arla Foods Plc industry. However, assuming that only few of such an industry may be developed over the forecast period, demand for the non-service sector has been assumed to remain constant over the second half of the forecast period.

## 5.9 Swindon and Oxfordshire (SWOX)

Only the Grp1 (SIC groups P and Q) group is forecast to increase its demand over the forecast period. Demand from the service SIC groups G, H, I, M, N and J is expected to decrease by 47.9% in 2050 and by 57.4% in 2100 compared to 2015 level.

The decrease of demand in the Grp2 (SIC groups R, S, T and O) is driven by the ceasing of operation of the Didcot power station, and the reduction of demand from Defence (MOD) sites. However, it can be argued that a continued decline will not be sustained for such a

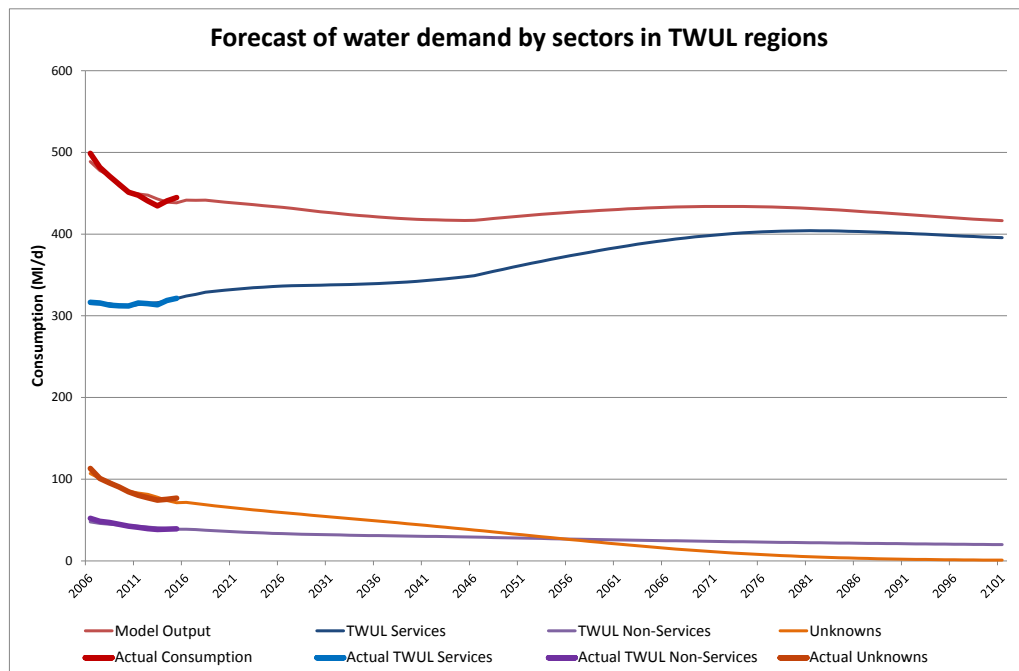
group of service industries. Hence a constant demand is assumed over the second half of the forecast period.

The overall demand will decrease till mid-century, with 42.1% decrease in 2050 compared to 2015. Then, demand will slowly decrease throughout the remaining period to 2100.

**5.10 Overall model fit**

The overall demand in the TWUL regions will see decreases and increases. The first step change going from a decreasing to an increasing trend will occur in 2045 with demand forecast to be 21.5 MI/d lower than the 2015 level. The other step change going from an increasing to a decreasing trend is around 2070 with demand forecast to be only 4.3 MI/d lower than the 2015 level. Demand in 2100 is forecast to be similar to that in 2045 with forecast demand 21.2 MI/d lower than in 2015. The overall increases are driven by the WRZs Guildford and London, which will be joined by SWA in around 2050s. Demands in the remaining WRZs are generally decreasing.

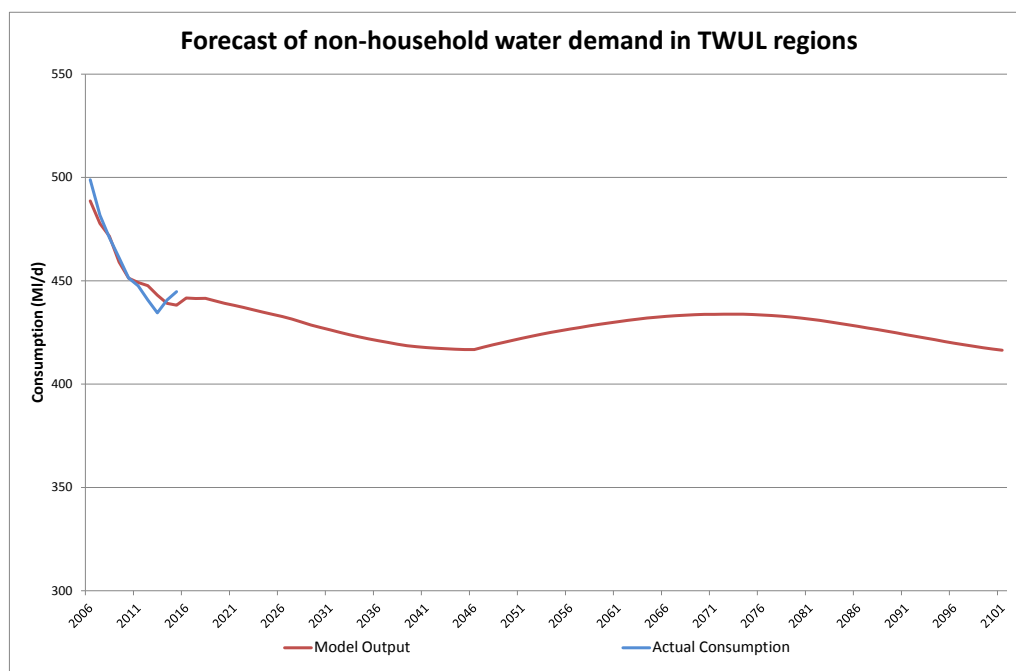
Most service sectors are forecast to increase (as per the previous modelling), but this is offset by the decrease of demand in the unknown sector. Demand from the service industries will generally increase and reach a level of 396 MI/d in 2100. The unknown sector demand will steadily decrease throughout the forecast period. The non-service industries are forecast to slowly decrease over the forecast period. The demand forecast for all industries across the TWUL regions are shown in **Figure 7**, and the overall forecast for non-household demand in TWUL in **Figure 8**.



**Figure 7: Model forecast for all services, non-services and unknown sectors**

The demand from the service sector in the WRZ London is driving the demand from service sector in the TWUL regions. By the 2100s, non-household demand from service industries in London is forecast to use about 70.4 MI/d more water than the level in 2015. The ratio London/TWUL for service industry demands is relatively maintained over the forecast period.

Overall, the maximum forecast change in demand at TWUL level is less than 25MI/d (reduction).



**Figure 8: Overall model forecast**

The modelling of the unknown sector demand, in particular, is limited and it is assumed to decrease on a yearly basis due to increase in water tariff. The highest uncertainty lies within this group, whereas demand in the service sector is showing a more consistent gradual increase and demand in the non-service sector slowly decreasing. However, demand in the unknown sector has fallen since 2006 but then saw some increases during the last three years. Only the population and tariff were usable as explanatory factors due to the nature of this group. More work may be required to fully understand this group (e.g. how much of the properties are in the service industries) and to provide a more accurate projection of the associated demand. Demand in this group is forecast to fall from its 2015 level of 76.9 Ml/d to nearly 1.0 Ml/d in 2100.

## 6 SCENARIO ANALYSIS

The central scenario is a combination of positive population and economic growths. Although not incorporated into the model, a continuation of current trends have also been assumed, including positive effects from environmental pressures, water efficiency programmes, technology advancement to reduce water used by appliances, and water-efficient behaviour of individuals for example towards climate change.

### 6.1 High consumption scenario

The high consumption scenario is a combination of two assumptions, H1 and H2.

**H1:** London is strengthening its position across the cities in the world. The city's development is ahead of the population growth, as per the high consumption scenario discussed in the previous project. The effects are spread across the whole of the South East region.

**H2:** Over the long-term forecast period, higher water demand may be (partly) caused by:

- Limitation of environmental pressures to industries
- Limitation of water efficiency programmes

- Climate change and less water-efficient behaviour of individuals, e.g. due to high temperatures.

The representation of this scenario using explanatory factors is based on:

- Higher population growth, with average growth rate decreasing from 2% to 0.5% in London, and from 1.9% to 0.4% in the South East over the forecast period
- Higher economic growth, with employment average growth rate decreasing from 1.1% to 0.75% in London and from 1.1% to 0.6% in the South East between 2017 and 2100. The GVA growth rates are assumed at 3.0% in London and 2.5% in the South East
- Lower tariff growth 1.9% compared to the central scenario.

The result of the high scenario is shown in **Figure 9**.

## 6.2 Low consumption scenario

The low consumption scenario is a combination of two assumptions, L1 and L2.

**L1:** London is overtaken by other European/Asian cities. The city's development is behind the population growth, as per the low consumption scenario discussed in the previous model. The situation in London affects the South East region.

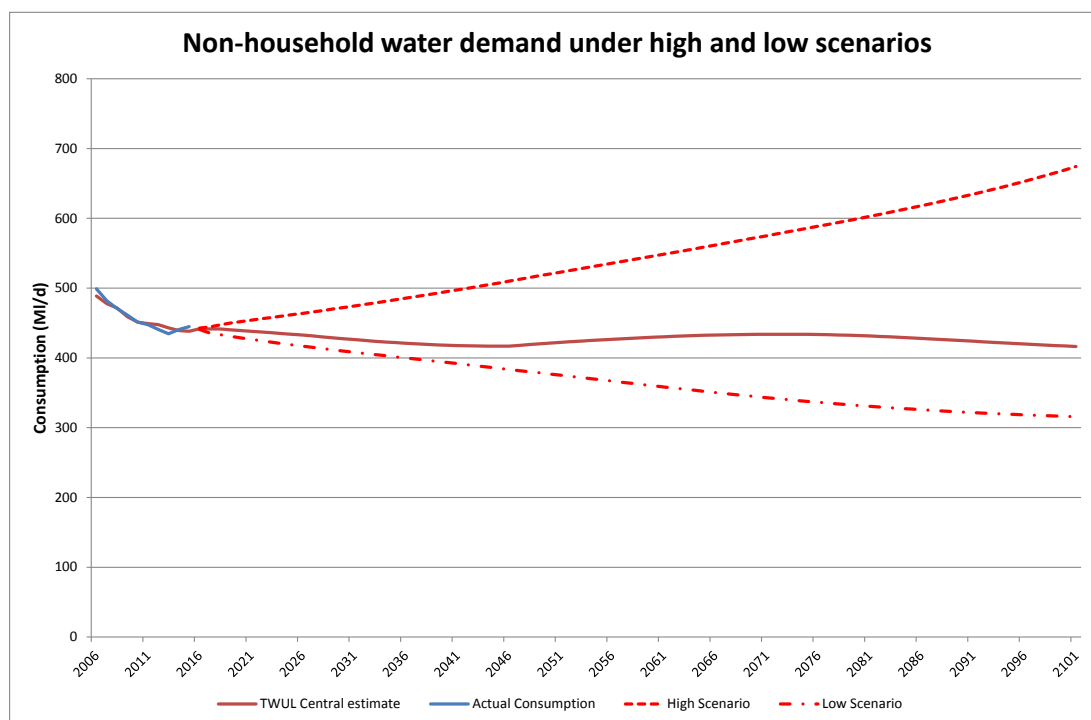
**L2:** Over the long-term forecast period, lower water demand may be (partly) driven by:

- Effective environmental pressures applied to industries
- Fast technology advancement, leading to reduced water used by appliances
- Sustained water efficiency programmes
- Water-efficient behaviour of individuals, e.g. responding to concerns regarding climate change and its impacts.

In terms of representing these using explanatory factors, this has been done as follows:

- Population remains broadly constant over the period
- Slower economic growth (or collapse of economy including any crises such as recessions), with employment average growth rate of 0.25% in London and 0.2% in the South East. The GVA growth rates are assumed at 1.5% in London and 1% in the South East

The results of the high and low scenarios are shown in **Figure 9**.



**Figure 9: Non-household consumption in TWUL region under high and low scenarios**

## 7 SPREADSHEET IMPLEMENTATION OF THE MODEL

The models have been implemented within the spreadsheet provided<sup>28</sup>. This contains worksheets for:

- Input of detailed consumption data
- Input of explanatory factor history and forecasts
- Overall model output for the company as a whole
- Detailed modelling sheets for each WRZ or sub area
- Overall view of each WRZ, including the aggregate of the industry sector models at the WRZ level.

Each detailed modelling sheet contains:

- The explanatory factors used in the model and the resulting coefficients
- The SIC groups modelled
- The historic values for consumption in the area
- The modelled values based on the selected explanatory factors and fitted coefficients, and the forecast values
- Graphs showing the model fit against the historical data, and the forecast of future consumption.

<sup>28</sup> Spreadsheet reference J1662\_GD003\_01, dated 02 September 2016

A full index of the worksheets at the front describes each sheet in more detail.

The aim of the spreadsheet is that it will allow further exploration of scenarios. By altering the future assumptions in the explanatory values, the impacts on each WRZ can be observed.

## 8 CONCLUSION

As per the previous work by Servelec<sup>29</sup>, the modelling has developed detailed models of areas and groups of industry types, showing a wide variety of different patterns. The modelled demand up to 2045 is lower than the previous forecast, driven by the lower forecast for future population.

The extension of the model shows slight rises until the 2080s, then slight decreases until the 2100s. Increase of demand in the service sector, notably in London, has been forecast, whereas demand from the non-service sector is projected to remain relatively constant over the forecast period. The unknown sector demand is forecast to largely decrease by the end of the forecast period.

The forecasts are sensitive to the assumptions used for the explanatory factors. The difference between the high and low consumption scenarios is considerably large, growing from 140 MI/d difference in 2050 to about 360 MI/d difference by 2100. Hence, care is needed when applying and/or updating the assumptions used for the explanatory factors Employment, Population, GVA and water tariff, the associated implications for the higher and lower consumption scenarios will require regular review.

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<sup>29</sup> J1562\GD\002\02 Non-Household Demand Forecasting, dated 06 May 2016

## Appendix A. MAPPING OF TECCURA CODES TO SIC INDUSTRY CODING

Teccura Sector	SIC Code	SIC Description
_MIXED	S	Other service activities, construction, finance, insurance, real estate activities
_UNKNOWN	Un	Industry not elsewhere classified
Activity Centres	R	Arts, entertainment and recreation
Airports	H	Transportation and storage
Animal Shelters	A	Agriculture, forestry and fishing
Automotive Manufacturers	C	Manufacturing
Banks	S	Other service activities, construction, finance, insurance, real estate activities
Bingo Halls	R	Arts, entertainment and recreation
Bowling Centres	R	Arts, entertainment and recreation
Breweries	CA	Food products, beverages and tobacco
Brickworks	C	Manufacturing
Bus Depots	H	Transportation and storage
Bus Stations	H	Transportation and storage
Business Parks	N	Administrative and support service activities
Car Washes	N	Administrative and support service activities
Caravan Sites	R	Arts, entertainment and recreation
Cash & Carries	S	Other service activities, construction, finance, insurance, real estate activities
Casinos	R	Arts, entertainment and recreation
Catering Equipment Hire	CA	Food products, beverages and tobacco
Cemeteries	S	Other service activities, construction, finance, insurance, real estate activities
Chemical Manufacturers	C	Manufacturing
Cinemas	R	Arts, entertainment and recreation
Clubs & Societies	R	Arts, entertainment and recreation
Coffee Shops	CA	Food products, beverages and tobacco
Colleges	P	Education
Concrete Batching	C	Manufacturing
Conference Centres	M	Professional, scientific and technical activities
Council Depots	O	Public administration and defence; compulsory social security
Court Houses	O	Public administration and defence; compulsory social security
Crossrail	H	Transportation and storage
Datacentres	M	Professional, scientific and technical activities
Decontamination & Sterilisation	S	Other service activities, construction, finance, insurance, real estate activities
Department Stores	H	Transportation and storage
DIY Stores	H	Transportation and storage
Electronics Manufacturers	C	Manufacturing
Embassies	O	Public administration and defence; compulsory social security
Entertainment Venues	R	Arts, entertainment and recreation
Equestrian Centres	R	Arts, entertainment and recreation
Farms	A	Agriculture, forestry and fishing

Teccura Sector	SIC Code	SIC Description
Fast Food	CA	Food products, beverages and tobacco
Flat & Office Complexes	T	Activities of households
Flats	T	Activities of households
Flight Training Centres	H	Transportation and storage
Food Manufacturers	CA	Food products, beverages and tobacco
Garden Centres	R	Arts, entertainment and recreation
Gas Works	BCDE	Production, mining, quarrying, electricity, water supply
Glass Manufacturers	C	Manufacturing
High Street Stores	H	Transportation and storage
Hospitals	Q	Human health and social work activities
Hostels	I	Accommodation and food service activities
Hotels	I	Accommodation and food service activities
Industrial Bakers	CA	Food products, beverages and tobacco
Industrial Estates	BCDE	Production, mining, quarrying, electricity, water supply
Inset Agreement	S	Other service activities, construction, finance, insurance, real estate activities
Laboratories	P	Education
Launderettes	N	Administrative and support service activities
Laundries	N	Administrative and support service activities
Marinas	BCDE	Production, mining, quarrying, electricity, water supply
Markets	G	Wholesale and retail trade; repair of motor vehicles
Metal Finishers	C	Manufacturing
Metal Refineries	C	Manufacturing
MOD Sites	O	Public administration and defence; compulsory social security
Museums	R	Arts, entertainment and recreation
Night Clubs	R	Arts, entertainment and recreation
Nursing Homes	Q	Human health and social work activities
Office Blocks	M	Professional, scientific and technical activities
Paint Manufacturers	C	Manufacturing
Parks & Gardens	R	Arts, entertainment and recreation
Petrol Stations	S	Other service activities, construction, finance, insurance, real estate activities
Pharmaceutical Manufacturers	C	Manufacturing
Police Stations	O	Public administration and defence; compulsory social security
Power Stations	BCDE	Production, mining, quarrying, electricity, water supply
Printing & Publishing	J	Information and communication
Prisons	O	Public administration and defence; compulsory social security
Product Manufacturers	C	Manufacturing
Public Toilets	S	Other service activities, construction, finance, insurance, real estate activities
Pubs & Restaurants	R	Arts, entertainment and recreation
Quarries	BCDE	Production, mining, quarrying, electricity, water supply
Racehorse Training Centres	A	Agriculture, forestry and fishing
Religious Buildings	Q	Human health and social work activities
Retail Park Stores	G	Wholesale and retail trade; repair of motor vehicles
Retirement Homes	Q	Human health and social work activities



<b>Teccura Sector</b>	<b>SIC Code</b>	<b>SIC Description</b>
Schools	P	Education
Service Areas	S	Other service activities, construction, finance, insurance, real estate activities
Shopping Centres	G	Wholesale and retail trade; repair of motor vehicles
Sports Facilities	R	Arts, entertainment and recreation
Stadia & Arenas	R	Arts, entertainment and recreation
Storage & Distribution Depots	H	Transportation and storage
Student Accommodation	P	Education
Supermarkets	G	Wholesale and retail trade; repair of motor vehicles
Synthetics Manufacturers	C	Manufacturing
Telephone Exchanges	J	Information and communication
Television & Film Studios	J	Information and communication
Theatres	R	Arts, entertainment and recreation
Tourist Attractions	R	Arts, entertainment and recreation
Train Depots	H	Transportation and storage
Train Stations	H	Transportation and storage
Transport Depots	H	Transportation and storage
Universities	P	Education
Vehicle Sales & Servicing	G	Wholesale and retail trade; repair of motor vehicles
Waste Disposal & Recycling	BCDE	Production, mining, quarrying, electricity, water supply
Water & Sewerage Works	BCDE	Production, mining, quarrying, electricity, water supply

## Appendix B. SIC INDUSTRY CODING

<b>SIC</b>	<b>Industry</b>	<b>Status</b>
A	Agriculture, forestry and fishing	Non-Services
CA	Food products, beverages and tobacco	Non-Services
C	Manufacturing	Non-Services
P	Education	Services
Q	Human health and social work activities	Services
I	Accommodation and food service activities	Services
G	Wholesale and retail trade; repair of motor vehicles	Services
H	Transportation and storage	Services
R	Arts, entertainment and recreation	Services
O	Public administration and defence; compulsory social security	Services
M	Professional, scientific and technical activities	Services
N	Administrative and support service activities	Services
J	Information and communication	Services
T	Activities of households	Services
S	Other service activities, construction, finance, insurance, real estate activities	Services
BCDE/BDE	Production, mining, quarrying, electricity, water supply	Non-Services
Un	Industry not elsewhere classified	
MN	Business service activities	Services
GHI	Distribution; transport; accommodation and food	Services
RST	Other services and household activities	Services
OPQ	Public administration; education; health	Services
F	Construction	Non-Services
K	Financial and insurance activities	Services
L	Real estate activities	Services