Jersey Water

Water Resources and Drought Management Plan

Appendix E. Demand Forecast

JERSEY WATER RESOURCES AND DROUGHT MANAGEMENT PLAN

APPENDIX E. DEMAND FORECAST – EXECUTIVE SUMMARY

This document describes the methodology and detailed studies that have been undertaken to calculate the “baseline” water demand forecast for the Jersey Water Resource Zone across the planning horizon to 2045. Indicative demand forecasts extending to 2070 to provide a longer-term perspective have also been calculated. The baseline demand forecast excludes the effects of additional demand management measures identified by the options appraisal to determine the best value approach to resolving any supply-demand deficits or resilient requirements.

In 2017, Jersey Water supplied 20,100 cubic metres per day (m^3/d) on average to 37,000 homes and 3600 commercial properties across the island. Approximately 95% of properties are individually metered and so have a direct incentive to conserve water use to save on their water bills. Customers can benefit from water saving advice and devices that are available from Jersey Water.

It is expected that the average household consumption will reduce by 10% by 2045, as a result of continued water efficiency and expected changes in appliance use. However, strong growth in Jersey’s population and number of homes is expected. The overall effect is that domestic water consumption is expected to increase by 26% by 2045.

Total commercial water use is forecast to increase by a further 6% by 2045.

The estimated volume of leakage from Jersey Water’s distribution system and customer underground supply pipes has been successfully reduced from 3500 m^3/d in 2010 to 2560 m^3/d in the first half of 2018. Therefore, for the baseline demand forecast, leakage levels from 2018 onwards are estimated as 2560 m^3/d.

As a result, the total quantity of water supplied by Jersey Water is projected increase by 14% from 20,100 m^3/d in 2017 to 22,800 m^3/d in 2045, under normal weather conditions, and to about 23,900 m^3/d by 2045 under dry weather year conditions. There is uncertainty in the demand estimates and so a range of demand forecasts has been derived which apply alternative assumptions: the dry weather demands at 2045 from the alternative scenarios range between 17,000 and 32,000 m^3/d.

The pattern of water demand in the first half of 2020 has been very different to previous years due to Coronavirus, but it is too early to quantify the short-term effects on annual water demand or how long the impacts will last. It is likely that, in the long-term, demand patterns will return to “normal”, and so the demand forecast and uncertainty ranges are considered valid long-term projections.

The baseline demand forecast presented in this appendix has been used as an important part of deriving the initial water supply-demand balance. The demand forecast has therefore been used to help identify any supply deficits that occur and the analysis of options to determine the preferred plan to maintain adequate water supply reliability.

Contents

1 INTRODUCTION

1.1 PURPOSE

This Appendix describes the analysis that has been carried out to derive the baseline demand forecast across the planning horizon to 2045. Indicative demand forecasts extending to 2070 to provide a longer-term perspective have also been calculated.

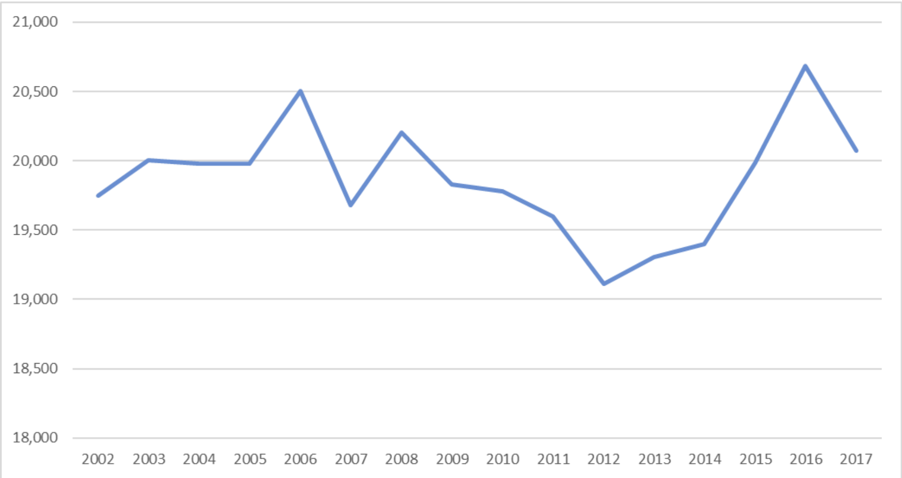
The focus of this document is on calculation of the “baseline” demand forecast which includes current demand management policies with respect to leakage reduction, customer metering and water efficiency programmes.

Baseline demand forecasts exclude the effects of additional demand management measures identified by the options appraisal to determine the best value approach to resolving any supply-demand deficits or resilient requirements. The impacts of such measures are included in the final planning demand forecasts that are summarised in the Main Report.

1.2 CURRENT WATER DEMAND

In 2017, Jersey Water supplied, on average, 20,073 cubic metres per day (m^3/d) to 37,000 homes and 3600 commercial properties across the island. Annual average demand has remained at around 20,000 m3/d since 2002 as shown by Figure 1. Demand reduced during 2009 to 2012 during a period of extensive metering of customers but has subsequently risen, however the demand levels in 2015 to 2017 were elevated partly due to increased leakage because of problems with leaking customer meters.

Figure 1 Total water put into supply by Jersey Water 2010 to 2017 (m^3/d)



1.3 DEMAND MANAGEMENT

There is extensive metering of water use across the Jersey Water Resource Zone. The water use at all new properties has been metered since the early 1990s and a free meter option scheme has been in place since 2000, by which domestic customers can voluntarily opt to be metered. In 2010 a universal metering programme commenced as an important water conservation measure to help ensure adequate water availability for the island. Therefore, water meters have been installed at all customer premises where possible. In consequence, water use at about 98% of properties is metered, of which about 95% are charged on an individually metered consumption basis, and about 3% are bulk metered (e.g. groups of flats). The other 2% of properties remain unmeasured as it was found to be impractical to install a meter because of common supply or complex pipework.

Many of the customer meters record meter readings on a frequent basis, so that cases of leakage or plumbing losses can be readily detected when the meter readings are next downloaded by Jersey Water using “drive-by” recording technology. The meter readings are routinely used to identify cases of high water consumption that may indicate underground supply pipe leakage or plumbing losses such as leaking or over-flowing toilet cisterns or dripping taps. Where appropriate site visits are undertaken and/or the customer contacted with the aim of achieving prompt resolution of the leaks or water wastage.

Jersey Water have been actively targeting leakage reduction, and have successfully reduced leakage by a quarter from about 3500 m3/d in 2010 to about 2600 m3 in 2018. This has resulted from their intensive monitoring of night-flows in each District Meter Area (DMA, each of which is a small discrete part of the distribution network): each day the information is used to direct leakage detection activity. Jersey Water has a dedicated leak detection team which determine the exact location of leaks identified by Jersey Water’s flow monitoring or reporting by customers. Leaks are generally repaired within 6 hours of the location being determined. The estimated volumes of leakage are low relative to UK norms.

In addition, Jersey Water carries out a range of activities to promote water efficiency by customers to help them save water. These include:

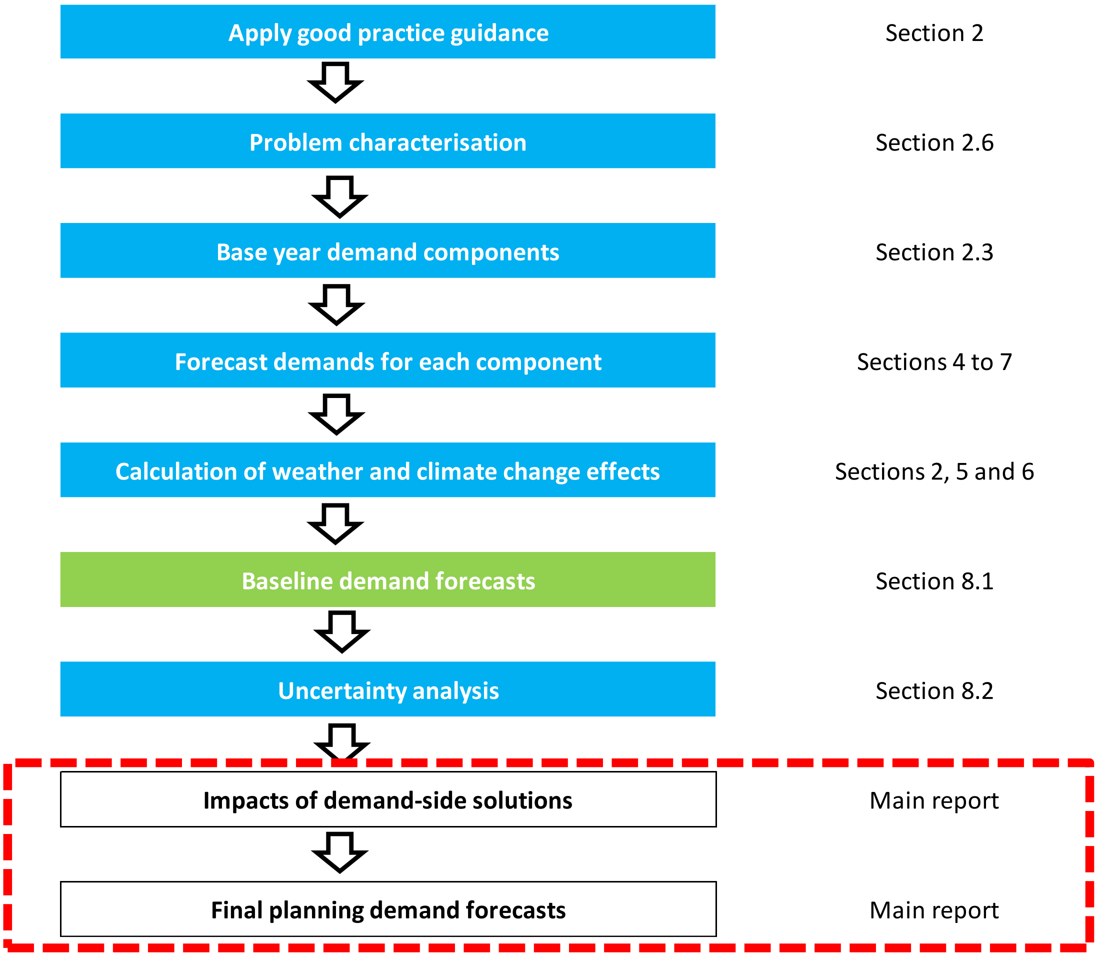
- Benchmark information presented on billing leaflets to help customers compare their consumption with that of a typical home
- Water saving tips published on Jersey Water’s website
- Free water saving devices available for example from Jersey Water’s website
- Free water audits and advice to customers found to have high consumption
- Free school visits and water saving advice
- Water audits and advice to commercial customers (on a chargeable basis)
- Media campaigns by radio, social media and TV to promote water savings tips during the summer and pipe protection during the winter
- Meetings with key customers including farmers, housing associations to discuss opportunities for water saving
- Water fittings visits to commercial sites to check compliance with regulations and provide advice on efficient appliances

- Attendance by Jersey Water at major framing and trade shows on the island to offer advice.

1.4 STRUCTURE OF DOCUMENT

Figure 2 summarises the key stages of the demand forecasting approach and how this document is structured to describe them.

Figure 2 Stages in demand forecasting



2 DEMAND FORECASTING APPROACH

2.1 METHODOLOGY

Water demand forecasting for water resources planning has been undertaken in the UK for many years. As a result, the UK has developed an extensive set of good practice methods for carrying out the calculations: in particular the methods developed by UK Water Industry Research Limited (UKWIR) and the national guidance for water resources planning prepared by the Environment Agency (2017). The key methodology documents are listed in Table 1 together with summary descriptions of their application.

Table 1 Main UK demand forecasting methodologies and guidance

Document	Summary description
Water Resources Planning Guideline (Environment Agency and Natural Resources Wales, April 2017)	Section 5 describes the principles that UK water companies should use in calculating their demand forecasts
Population, household property and occupancy forecasting – Guidance Manual (UKWIR/ Environment Agency, 2015, report 15/WR/02/08)	Provides guidance on how to forecast population and households for use in water resources management plans
Household consumption forecasting (UKWIR/ Environment Agency, 2015, report 15/WR/02/9)	Provides guidance on the steps involved and alternative methods for forecasting household consumption
Customer Behaviour and Water Use: A good practice manual and roadmap for household consumption forecasting (UKWIR/ Environment Agency, 2012, report 12/CU/02/11)	Provides detailed guidance on how to undertake micro-component analysis for household water consumption
Integration of behavioural change into demand forecasting and water efficiency practices (UKWIR/ Environment Agency, 2016, report 16/WR/01/15)	Provides guidance on how to take account of differences in behaviour of different types of household customer
Future estimation of unmeasured household consumption (UKWIR, 2017, report 17/WR/01/16)	Provides guidance on how to ensure adequate monitoring of unmeasured household consumption now and in the future
Forecasting water demand components (UKWIR, 1997, report 97/WR/07/01)	Describes the use of econometric modelling for forecasting non-household water consumption. Getting out of date.
Demand forecasting methodology (UKWIR, 1995, report 95/WR/01/1)	Seminal general demand forecasting methodology. It includes description of the use of maximum likelihood estimation for reconciliation of the water balance. Getting out of date.

Document	Summary description
Peak water demand forecasting (UKWIR, 2006, report 06/WR/01/7)	Provides a framework methodology for the calculation of peak (critical period) demand.
Managing Leakage 2011 (UKWIR, 2011, report 10/WM/08/42)	Updated guidance for water companies on leakage management planning and analysis.
Providing Best Practice Guidance on the Inclusion of Externalities in the Economic Level of Leakage calculation (Ofwat, 2008)	Describes how to assess the sustainable economic level of leakage (SELL) for water resource zones
Impact of Climate Change on Water Demand (UKWIR/ Environment Agency, 2013, report 13/CL/04/12)	Examines the evidence and provides estimates for the impact of climate change on water demand.

In line with good practice, the starting position for forecasting future demand is to first assess the total water put into supply and each demand component in the base year (2017). Each demand component can then be forecast from that starting point into the future over the planning horizon to 2045, and beyond. The demand components are then summed to calculate the total demand in each year. In order to achieve this, the population and property growth and forecast volumes of water for each demand component have been estimated using the good practice approaches described in the following sections (Sections 3 to 7).

2.2 DEMAND COMPONENTS

For Jersey, demand forecasting has been undertaken for each of the following demand components:

- **Measured domestic consumption** – i.e. water use at homes with a meter that are charged according to their measured consumption
- **Unmeasured domestic consumption** – i.e. water use at homes without a water meter
- **Measured commercial consumption** – i.e. water use at commercial (non-domestic) premises with a meter that are charged according to their measured consumption
- **Unmeasured commercial consumption** – i.e. water use at commercial premises without a water meter
- **Minor water use** – e.g. water used at hydrants by the fire service and local authorities etc., and operational water use by Jersey Water
- **Total leakage** – including distribution losses from Jersey Water's water distribution system and underground supply pipe leakage from customer pipes
- **Unaccounted for water** – i.e. the small volume of water put into supply in 2017 that cannot be specifically allocated to one of the above components.

The values for these components sum to the total water put into supply from water treatment works, known as "distribution input". Domestic consumption is calculated by multiplying the number of domestic customers by the estimated average per property consumption (PPC)[1]. Hence the calculation of total demand can be expressed as presented in the following text box:

Equation for calculation of total demand

Distribution Input (m^3/d) =

Measured domestic properties * Measured domestic PPC

+ Unmeasured domestic properties * Unmeasured domestic PPC

+ Measured commercial consumption

+ Unmeasured commercial consumption

+ Minor water use

+ Total leakage

+ Unaccounted for water

Measured commercial customers have been sub-divided into the following six sectors and the demand has been analysed and forecast for each sector (as described in Section 6):

- Agriculture
- Industry
- Miscellaneous
- Offices and retail
- Public services
- Tourism and leisure

The calculation approach that has been used for each demand component is summarised in Table 2, with more detailed descriptions provided in the following sections. The way in which forecasting methods have been applied reflects the data availability. In many cases, very good data are available and so comprehensive application of methods has been undertaken. However, in some cases less detailed application has been appropriate where less data are available, for example the forecasting of future domestic water consumption rates which has relied on UK studies instead of Jersey data.

[1] Alternatively, domestic consumption can be calculated by multiplying the population by the estimated average per capita consumption (PCC).

Table 2 Basis for calculation of demand components

Demand component	Method of calculating past water volumes	Method for forecasting future volumes
Measured domestic consumption	Total metered consumption estimated from volumes recorded at customer billing meters at homes that receive bills on metered tariffs	Forecast average consumption per metered domestic property (PPC) (incorporating expected future changes in water appliance use) *Multiplied by:* Forecast number of metered households
Unmeasured domestic consumption	Average consumption per property (PPC) at unmeasured domestic properties (estimated from volumes recorded at properties that have been recently metered) *Multiplied by:* Number of unmeasured domestic properties as estimated from the billing system	Forecast average consumption per unmeasured domestic property (incorporating expected future changes in water appliance use) *Multiplied by:* Forecast number of unmeasured domestic properties
Measured commercial consumption for each of 6 sectors: Agriculture; Industry; Miscellaneous; Offices and retail; Public services; and Tourism and leisure	Total metered consumption for each sector estimated from volumes recorded at customer billing meters	Forecast volumes for each sector are based on analysis of past trends, but a "decay" factor has been applied to avoid unrealistically high predicted growth.
Unmeasured commercial consumption	Average consumption per property (PPC) at unmeasured commercial properties (estimated from volumes recorded at properties that have been recently metered) *Multiplied by:* Number of unmeasured commercial properties as estimated from the billing system	Forecast average consumption per unmeasured commercial property *Multiplied by:* Forecast number of unmeasured commercial properties
Minor water uses	Estimated as 2% of distribution input, based on UK assessments	Continuation of 2017 water use volume
Total leakage	Estimated from Jersey Water's daily monitoring of leakage volumes	*For 2018:* the reduced leakage volume recorded for first half of 2018. *2019 onwards:* The baseline forecast of total leakage assumes continuation at the 2018 level
Unaccounted for water	Estimated as the difference between total water put into supply and the sum of the above component volumes	The baseline forecast of unaccounted for water assumes continuation at the 2017 level

2.3 BASE YEAR WATER BALANCE

The starting position is to first determine the "base year" demand – the base year for this Water Resources and Drought Management Plan (WRDMP) is 2017.

This is achieved by deriving the base year water balance from the water volumes measured by Jersey Water's extensive monitoring systems. In particular:

- Recorded volumes from meters at Jersey Water's water treatment works at Handois and Augrès.
- Billing system information on customers and the quantities supplied to those that are metered
- Flow and pressure recording across the distribution network that is used each day to estimate leakage volumes.

The quantity of water put into supply from the treatment works (distribution input) is compared with the sum of component volumes. As is common, a small variance is found. In the UK it is usual practice to "spread" this variance volume across the demand components. But, as Jersey Water calculates leakage levels differently to the calculation methods used in the UK (see Section 7.2), it was unclear what extent of the variance should be allocated to leakage, and so the total (small) variance volume has been allocated as "unaccounted for water". The estimated water balance for 2017 is shown below.

Table 3 Water balance 2017

Component	Average volume in 2017 (m^3/d)	% of total demand in 2017
Measured domestic consumption	10,476	52%
Unmeasured domestic consumption	573	3%
Measured commercial consumption	4755	24%
Unmeasured commercial consumption	219	1%
Minor water uses	400	2%
Total leakage	3055	15%
Unaccounted for water	596	3%
Distribution Input	**20,073**	**100%**

Note: Values may not sum exactly due to rounding

2.4 DEMAND PLANNING SCENARIOS

Water resources planning requires assessment of a variety of demand scenarios in order to take account of a range of planning and weather conditions. Demand forecasts have been assessed for each of the following scenarios:

- Baseline normal year annual average (NYAA)
- Baseline dry year annual average (DYAA)
- Baseline dry year peak week demand (DYPW)
  (The DYAA and DYPW demands are calculated by applying factors to the NYAA demands)
- Final planning versions of the above to include the effects of any new demand management options in the preferred plan – see the Main Report

In addition, four alternative uncertainty scenarios that use different data values and assumptions are used to explore potential uncertainties in the baseline demand forecasts, as described further in Section 8.2. The scenarios evaluated have been called:

- *Base, Very high, High, Low and Very Low*

Also, the impact of winter freeze-thaw conditions and of water use restrictions on water demand have been considered.

Further details of the calculations for these demand scenarios are presented in Section 3.

2.5 IMPLICATIONS OF 2020 CORONAVIRUS PANDEMIC

The world-wide Coronavirus pandemic and the consequential "lockdown" across Jersey resulted in major changes in water using behaviour during spring 2020. Many more people worked at home than usual, many people stayed at home because their place of work was closed, visitor numbers to Jersey were greatly reduced, and many businesses - including shops, cafes/restaurants, holiday accommodation and hotels - were fully closed for some months. Domestic water consumption was therefore higher than normal, but commercial water demand was significantly lower. Some of these changes in water use could persist for a longer time into the future, or to some degree might become permanent: home-working may become more prevalent; some people may be less willing to travel or go restaurants or hotels to avoid risk of illness; and more people may be out-of-work due to the effects of economic recession in the UK and elsewhere.

For these reasons, the pattern of water demand in spring 2020 has been very different to previous years, but it is not yet possible to reliably quantify the effects on water demand or how long such impacts will last. It is considered likely that, in the long-term, demand patterns will return close to "normal". Therefore, the demand forecast to 2045 and the uncertainty ranges, calculated before the pandemic, are considered to remain as valid long-term projections.

An adaptive planning approach has been used in developing and testing the WRDMP to ensure that it is a flexible and robust plan. As a result, the potential implications of future water demand being significantly higher or lower than anticipated by the 'central' demand forecast have been examined to check the robustness of the proposed plan to such uncertainties (see Main Report and Appendix K).

2.6 ASSUMPTIONS

The demand forecasting has been based on appropriate data sources and assumptions. The main assumptions that have been applied are as follows:

- The whole of Jersey Water's water supply system can be treated as a single water resource zone, as confirmed by the water resource zone integrity assessment (see Appendix A)
- The base year providing the latest complete data set of outturn (actual) information is 2017
- Forecasts are required for each year of the planning horizon to 2045, and indicative forecasts to 2070 to give a longer-term perspective
- Jersey Water's billing system provides a reliable source of information on customers and their volumes of water consumed for 2017 and previous years
- All new properties in Jersey will be served by Jersey Water and will be metered
- No targets have been set for leakage reduction, extra customer metering or water efficiency activity, but demand management options are considered as part of the option appraisal (as described in the Main Report)

2.7 PROBLEM CHARACTERISATION

Problem characterisation, as described by UKWIR/Environment Agency (2016), provides a framework for reviewing the risks and uncertainties that a water company needs to consider in order to develop a justifiable and proportionate response to future water resources planning requirements.

The problem characterisation assessment (see Appendix B), concluded that (in a UK-wide context), the issues and challenges faced by Jersey Water are of a medium level of concern. This indicates that a medium level of complexity of demand forecasting should be undertaken. Simple demand forecasting making significant use of typical benchmarks is not appropriate. Use of highly complex analytical techniques is not necessary. Existing tools and techniques developed by the UK water industry for water demand forecasting, supported by good data, should be adequate to support Jersey Water's decision-making processes.

2.8 DATA REQUIREMENTS AND GAP ANALYSIS

All water companies carry out progressive improvement in data collection and studies to improve their understanding of current or future demand. A data requirements and data gap analysis has been carried out to help Jersey Water to further improve its data.

The following table summarises the data that would ideally be available to allow detailed demand forecast analyses. Much of the more important data is currently collected for the Jersey Water Resource Zone and is of good quality, but some potential data gaps have been identified. It is recommended that Jersey Water should consider the topics which have been categorized in the table as “Poor” or “Fair” adequacy of existing data collection and identify any priority improvements for data collection or studies. The cost of undertaking such actions needs to be considered alongside the benefits in deciding which improvements to carry out.

Potential improvements to the method for assessing leakage volumes are considered later in Section 7.2.

Table 4 Data requirements and gap analysis

Topic area	Data requirement	Why data is needed	Adequacy of existing data
Water treatment works (and transfers)	• Daily (or else weekly) output volume from each water treatment works	Water treatment works (and transfer) volumes of treated water are used to define current demand in each WRZ. It is vital that these volumes are accurately defined, as they set the starting position for the demand forecast. Collecting daily (or weekly) data over several (or many) years enables understanding and modelling of how demand varies with weather and some other key factors.	Good
Properties	• Number of properties in each category: a) Metered domestic b) Metered commercial c) Unmeasured domestic d) Unmeasured commercial e) Empty properties f) Private supplies (i.e. not currently served by Jersey Water) • Jersey State official data and projections of future household numbers • Details of the numbers of each customer category in each DMA	The property numbers are an important means of defining the customers, and so enable allocation of people and water demand across different demand components. Accurate current domestic properties combined with growth trends (new dwellings) for the area are important in the assessment of growth in domestic demand.	Good
Population	• Jersey State official population data and projections of future population	Domestic demand is affected by occupancy, and so both property and population numbers/forecasts are needed to assess domestic demand.	Good

Topic area	Data requirement	Why data is needed	Adequacy of existing data
Domestic consumption	• Annual (or quarterly or monthly) measured volume supplied to domestic customers with a meter installed • Details of the DMA for each customer	Reliable domestic consumption data are needed to ensure accurate estimation of domestic demand across Jersey and in each DMA.	Good
	• Consumption volumes at unmeasured domestic properties for example using check meters • Details of the DMA for each customer	Reliable domestic consumption data are needed to ensure accurate estimation of domestic demand at unmeasured properties across Jersey and in each DMA.	Fair (there is scope for more detailed analysis of existing data)
	• Customer surveys of occupancy, property characteristics, appliance ownership and appliance use by representative domestic customers	Understanding of domestic customer water use is important for forecasting how domestic water use may change in the future as a result of technological and behavioural changes. Detailed data is needed, for example, to undertake micro-component analysis of domestic consumption and forecasts.	Poor
	• Daily (or weekly) volumes from a representative sample of metered domestic properties, together with recording of key characteristics of the property and occupants.	Collecting daily (or weekly) data over several years enables understanding and modelling of how demand varies with weather and key property factors. It can also help in improving understanding of leakage levels.	Fair (there is scope for more detailed data collection and analysis)
	• Monitoring studies to continuously measure water use at representative samples of domestic customers.	Collection of 15-minute (or more frequent) flow records enables understanding and modelling of diurnal domestic consumption patterns. This is important for understanding night use and plumbing losses for improving leakage estimates. It is also useful for asset sizing.	Poor
Commercial consumption	• Annual (or quarterly or monthly) measured volume supplied to each metered commercial customer	Reliable metered commercial consumption data are needed to ensure accurate estimation of commercial demand across Jersey and in each DMA.	Good

Topic area	Data requirement	Why data is needed	Adequacy of existing data
	• Details of the DMA for each customer		
	• The sector for each metered commercial customer. • Note: customer sector refers to whatever categories are applicable for Jersey Water	Understanding of how the demand by each sector has varied through time is important to enable better forecasting of commercial demand. Detailed data is needed, for example, to undertake econometric modelling and forecasting of commercial demand of each sector.	Good
	• Continuous monitoring of water consumption at large commercial customers and representative samples of other commercial properties. This can be achieved for example by installing loggers on revenue meters	Understanding of flow variations is important for understanding how weather or other factors affect commercial consumption. It also enables more precise assessment of plumbing losses and night use for improving leakage estimates.	Poor
Meter under-registration	• Results from studies of meter under-registration volumes at domestic and commercial properties	Allowance for meter under-registration is necessary in order to improve the estimation of domestic and commercial demands from recorded meter volumes.	Poor (but may be of low priority)
Unmetered commercial consumption	• Number of unmetered commercial properties categorised by different customer types • Estimates of average consumption by each type of unmetered commercial customer. Potentially this can be obtained using metered volumes records from similar properties that are metered. • Details of how many commercial properties will become metered in the coming years • Details of the DMA for each customer	Reliable data on unmetered commercial properties and their consumption are needed to ensure accurate estimation of unmetered commercial across Jersey and in each DMA	Fair (there is scope for more detailed analysis of existing data)
Other water use	• Maintain recording of operational water use by Jersey Water, use at Jersey	Such records can be used to obtain better estimates of operational use and water taken	Poor

Topic area	Data requirement	Why data is needed	Adequacy of existing data
	Water buildings, authorised use of water hydrants or known illegal use of water	unbilled. This will affect the accuracy of estimating the base year water balance.	
Leakage	• District meter area (DMA) monitoring of the entire distribution system and analysis of night-flows to estimate leakage levels in each DMA.	Detailed analysis of DMA data, supported by leakage studies can be used to better understand UFW. Over time it should be possible to no longer use the term "UFW", and instead all water can be accounted for as either leakage or usage. Note: Studies or assessments of customer night-use, plumbing losses and pressure correction factors are required in the leakage estimation.	Fair (St Helier is not DMA-ed. Also see recommended data improvements in Section 7.2)
Customer supply pipe leakage	• Maintain records of numbers, and estimated duration and flowrate of customer supply pipe leakage events • Monitoring studies of customer supply pipe leakage	Such records can be used to achieve better estimates of supply pipe leakage (at properties where meters have been installed externally e.g. at property boundary). They will also enable better understanding of the extent to which UFW is occurring in the distribution network or at customer properties, and so improve leakage control activity.	Fair (there is scope for more detailed analysis of existing data)

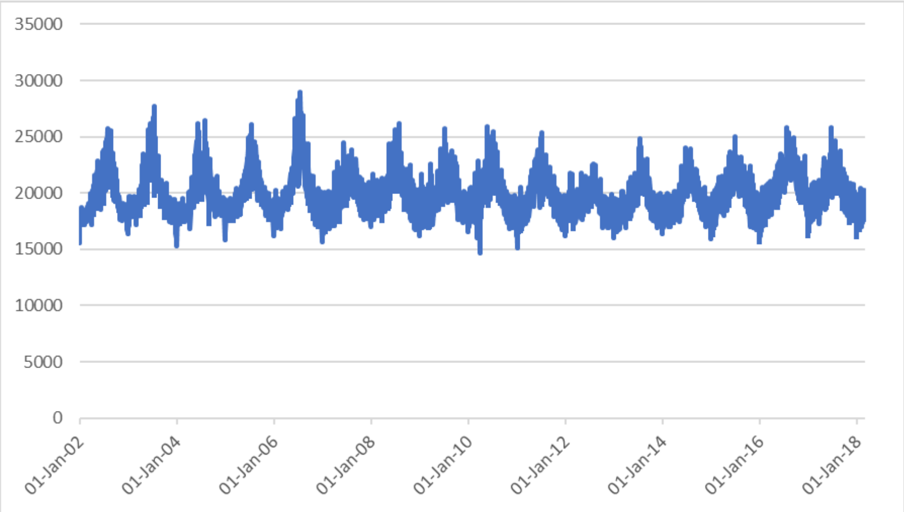
3 WEATHER AND PLANNING SCENARIOS

3.1 SUMMER EFFECTS ON DEMAND

Rainfall and temperature can have a strong influence on customer demand, and in particular domestic consumption. In general, during the summer months, periods of wet weather mean that there is less need for customers to use water outside the home. In contrast, dry conditions accompanied by sustained high temperatures can significantly increase domestic customer consumption, particularly through "discretionary" water use such as garden watering and other outside uses. This has been observed by many UK studies including UKWIR research "Impact of Climate Change on Demand" (2013).

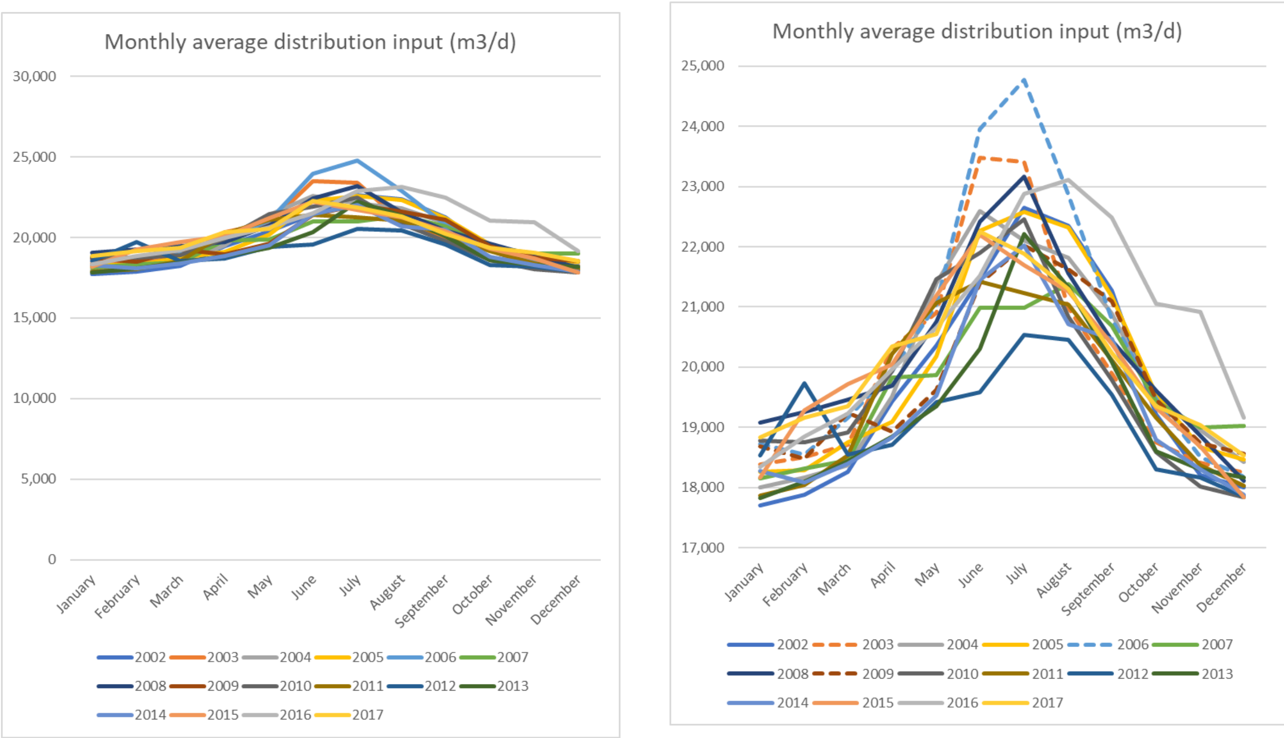
The impact of summer weather on demand is supported by Figures 3 and 4, which show the strong pattern of elevated volumes of water put into supply in summer months by Jersey Water. Although the volumes vary from year to year, the degree of variation within each year is greater than the variation in volumes between years. The right-hand graph of Figure 4 presents the same data as in the left-hand graph, but shows the three driest summers with dashed lines, and so demonstrates that the elevation in summer demand tends to be greater in drier summers.

Figure 3 Daily distribution input 2002 to 2017 (m^3/d)



The UKWIR study also examined the impact of weather on commercial demand but was unable to find conclusive relationships. Some water companies have applied dry weather effects to some elements of commercial consumption. For Jersey, it has been assumed that hot/dry weather affects demand by the agriculture and tourism/leisure sectors, and, in the absence of other robust information, it is assumed that the same factors can be applied as derived for domestic consumption.

Figure 4 Monthly pattern for distribution input 2002 to 2017 (m³/d)



3.2 DRY YEAR UPLIFT FACTOR

For water resources planning, it is important to quantify the influence of weather on demand so that the supply-demand balances are assessed on a consistent basis comparing dry weather demand with dry weather source yield. This is commonly done by calculating a "dry year uplift factor" which should be applied to the average demand in a normal weather year to estimate average demand in a dry weather year.

The UKWIR/Environment Agency project "WRMP19 methods: Household consumption forecasting" (2015) identifies several potential methods that can be used to estimate the dry year uplift factor, depending on the data availability and the complexity of analysis. The "increased summer demand" and "weather-demand modelling" approaches have been undertaken using Jersey demand and weather data, as outlined below.

3.3 INCREASED SUMMER DEMAND APPROACH

This method investigates the extent to which demand increases for different summer (April to September) weather conditions. In 2006, which had the driest summer[2] of recent years, the average summer distribution input was 18.4% higher than the average winter distribution input, whilst for a normal (i.e. "average") summer-weather-year such as 2016 the elevation was 11.1%. The dry year

[2] Summer for this purpose refers to the period April to September, with the other 6 months being classed as winter.

effect for summer demand is therefore estimated as 1.035[3], or 3.5%. If it is assumed that the uplift should be applied to domestic consumption and the agriculture and tourism/leisure commercial sectors but not to other demand elements, the dry year uplift factor becomes **5.5%**[4].

3.4 WEATHER-DEMAND MODELLING APPROACH

This alternative method for assessing the dry year uplift factor involves statistical analysis to derive a model relationship between demand, weather parameters and other potential explanatory factors. However, only a very weak relationship was found between distribution input and weather parameters, possibly because the dominant effect of the monthly patterns "swamped" the analysis of day-to-day variations. The derivation of a robust estimate of the dry year uplift factor using this method was not feasible.

3.5 COMPARISON WITH UK WATER COMPANIES

The following table compares the estimated dry year uplift factor from analysis of Jersey Water data with latest values derived for domestic consumption by selected other water companies in the southern part of the British Isles. The Jersey value of 5.5% is similar to most other estimates, and so has been used.

Table 5 Comparison of estimates of dry year uplift factors

Water company	Estimate of dry year uplift factor on domestic consumption
Jersey Water	5.5%
Guernsey Water	4.0%
Southern Water	5.8%
South East Water	1.8%
South West Water	5.3%
Wessex Water	4.1%

3.6 CLIMATE CHANGE IMPACTS

The impacts of climate change on domestic consumption and commercial consumption are addressed in Sections 5.5 and 6.4, respectively.

[3] Calculated as (1.184+1)/(1.111+1) = 1.035 with the "+1" elements included to spread the summer half-year effect across whole year
[4] Calculated as 3.5/0.64 = 5.5 as domestic + agriculture + tourism and leisure consumption accounts for about 64% of total distribution input.

3.7 SUMMER PEAK WEEK DEMAND

It is important to understand peak week demand so that assessment can be made of whether there is adequate infrastructure capacity and water source capacity to meet peak demands.

Therefore, the ratio of summer peak week distribution input to annual average distribution input was assessed for each year from 2002 to 2017. The peak week factors ranged from 1.15 to 1.31, with an average of 1.22. The value of **1.31** occurred in 2003 and 2006 and is the value chosen for estimating maximum peak week demands.

Hence: *Peak week distribution input = 1.31 * Annual average distribution input*

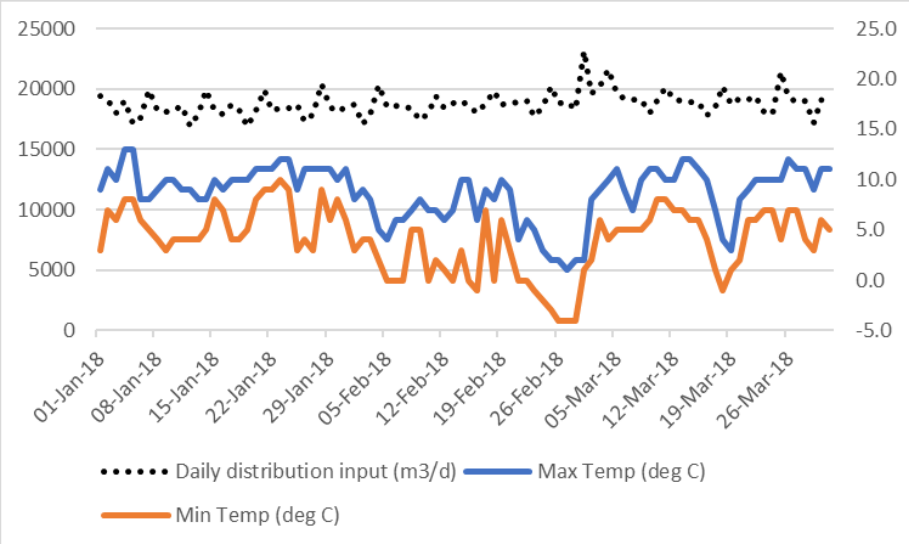
The size of this factor reflects the peak summer conditions as well as the general strong elevation in summer demand.

3.8 WINTER PEAK WEEK DEMAND

Although Jersey enjoys generally mild winters, it is important that the potential risk of occurrence of peak winter demands caused by freeze-thaw incidents should be considered to help ensure resilience to such incidents. This is because some parts of the UK have experienced serious difficulties in maintaining supplies following freeze-thaw events.

The coldest period that has occurred for many years on Jersey was experienced earlier in 2018, when minimum air temperatures were below zero from 23 to 28 February, although maximum temperatures on those days were above zero. The minimum temperature recorded at Jersey Water's weather station was minus 4 °C which occurred on 26th, 27th and 28th February. This is illustrated by the following graph, which also shows that there was a small but discernible increase in distribution input in the following days. The average distribution input in the 7 days to 24 February averaged 18,700 m^3/d but was 6% higher at 19,900 m^3/d over the 7 days to 3 March. The temperatures involved in Jersey in February were not sufficiently severe to generally impact on water mains, and so the elevation in demand was probably mainly caused by external and internal customer pipework bursting after thawing.

Figure 5 Daily temperature and distribution input at Jersey Water's main weather station January to March 2018



The impact on water demand was very much lower than experienced in the UK (in February and on other occasions in recent years) where much more severe and sustained freezing temperatures have led to very large increases in water demand.

In conclusion, although the February 2018 or similar cold weather events in Jersey can present significant short-term operational difficulties and cause substantial supply disruption to customers, they do not have a significant impact on the summer water supply availability and so do not need to be specifically addressed by this WRDMP.

3.9 RESTRICTED DEMANDS DURING DROUGHT EVENTS

In the event of water use restrictions being imposed on customers during a drought period, it can be expected that customer demand would reduce. As it is many years since water use restrictions have been applied in Jersey, there are no reliable data from Jersey Water to estimate the impact of such restrictions on demand. UK studies such as UKWIR (2007) and Environment Agency (2013), indicate that a reduction of at least 5% typically occurs, and so this value has been applied in the water source yield modelling.

4 PROPERTIES AND POPULATION FORECASTS

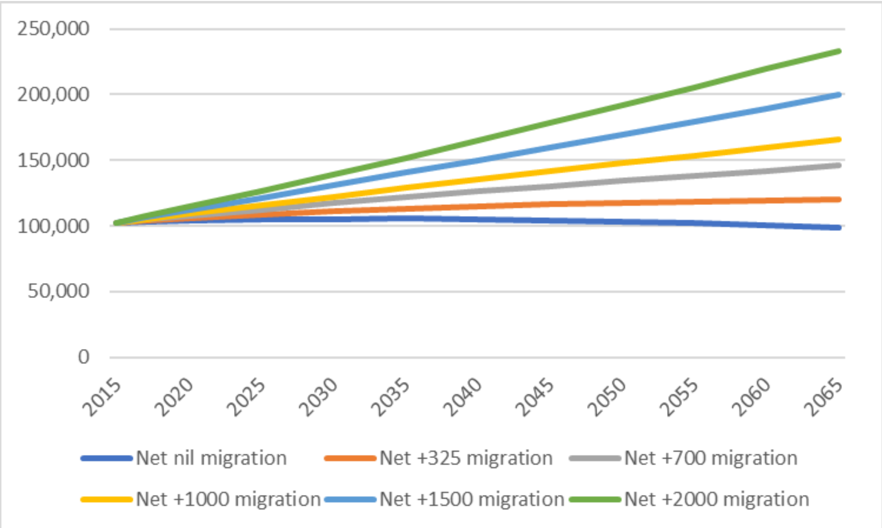
4.1 METHODOLOGY

The population and household projections published by the States of Jersey Statistics Unit (2016a and 2016b) for a range of demographic scenarios have been used as the primary data source for forecasting domestic properties and population. The published demographic scenarios are for a variety of net migration assessments as illustrated in Figures 6 and 7:

- Net nil migration
- Net +325 migration
- Net + 700 migration
- Net + 1000 migration
- Net + 1500 migration
- Net + 2000 migration

The principal (base) demand forecast has been based on the 700 per year net migration scenario[5] as this is consistent with recent population growth rates. Alternative migration scenarios have been used for the uncertainty analyses.

Figure 6 Resident population projections for Jersey to 2065

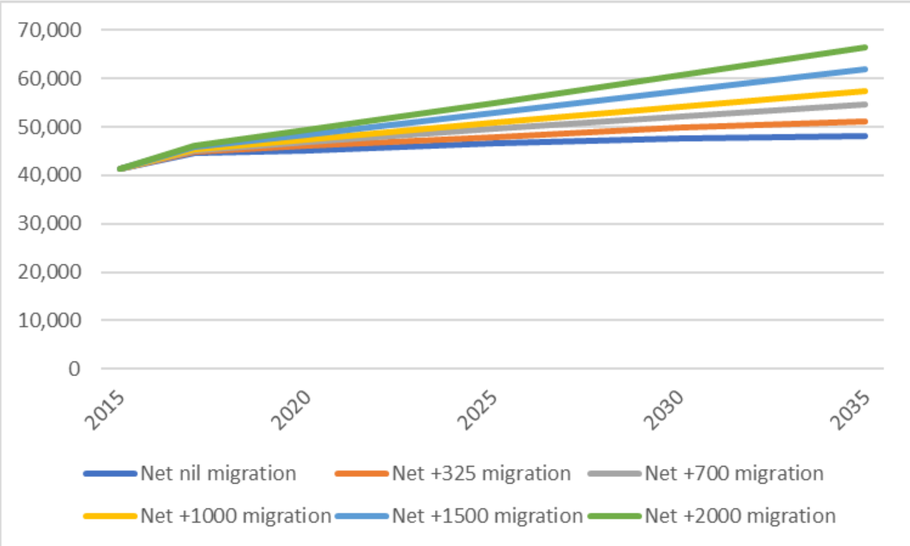


Resident population comprises people who normally live on Jersey and so excludes short-term working visitors and tourist visitors.

[5] In this case, the population change each year is estimated as: Population in previous year + Estimated births – Estimated deaths + 700 net migration

There is no current Island Development Plan and so there are no official planned growth rates for development. Therefore, the household projection scenarios derived by States of Jersey have been used as the basis for household growth estimates. They are illustrated in the following graph.

Figure 7 Household projections for Jersey to 2035



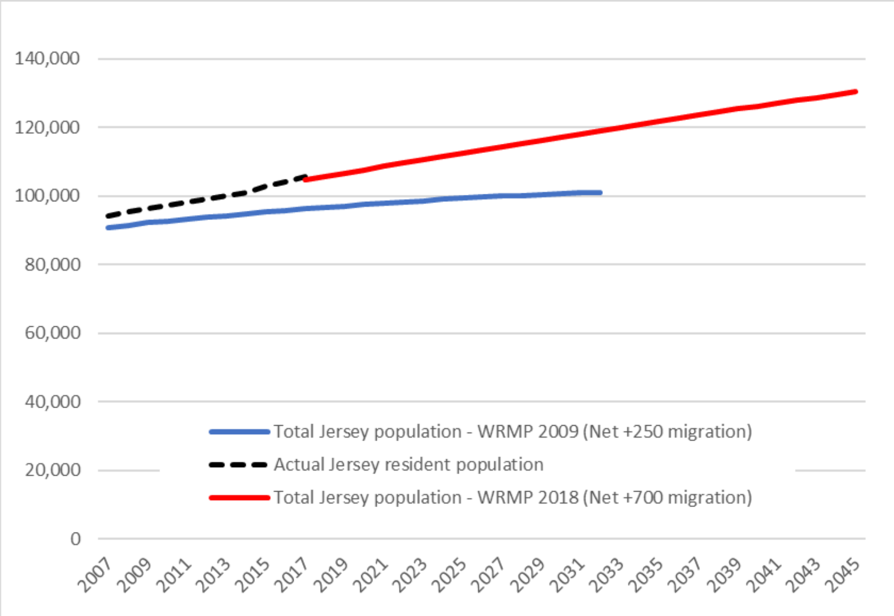
4.2 COMPARISON WITH PREVIOUS WRMP

The following graph (Figure 8) shows that the forecast total resident population used in Jersey Water's previous water resources management plan (WRMP), prepared in 2009, is significantly lower than the latest forecast (WRDMP 2018). For example, the 2009 WRMP expected that the total resident population would be 96,300 at 2017, whereas the latest States of Jersey statistics record an estimate of 104,700. The underestimates made in the 2009 WRMP are because:

- **Actual population in 2007 was higher than estimated.** The total resident population in Jersey recorded by the 2007 census and used in the 2009 WRMP was too low at 90,800: the States of Jersey subsequently revised the 2007 population at 94,000.

- **The rate of population growth has been higher than expected.** The base population projection used in the 2009 WRMP applied the "Net +250 migration" scenario, as at that time the States of Jersey population scenarios ranged between "Net Nil migration" and "Net +650 migration". Actual net migration since 2007 has averaged about 800 per year, with rates of over 1000 per year since 2014, and so population growth has been significantly greater than expected in 2009.

Figure 8 Comparison of population forecasts for WRMP 2009 and WRMP 2018 (this Plan)



4.3 PROPERTIES SERVED BY JERSEY WATER

The States of Jersey Statistics Unit projections data has been combined with Jersey Water data to derive forecasts of domestic properties and population served by Jersey Water, described as follows.

The properties supplied with water by Jersey Water each year since 2010 are summarised in the following table. The numbers have been derived from the billing system. It shows the results from Jersey Water's metering programme to install meters at as many customer properties as practically feasible, so that the extent of metering has risen from 43% in 2010 to 95% in 2017. However, as described in Section 1.3, the issue is more complex as some meters are on shared properties (e.g. groups of flats) and so the total number of customers with water meters is about 98%.

Table 6 Properties served 2010 to 2017

	2010	2011	2012	2013	2014	2015	2016	2017
Measured domestic	14,540	18,619	22,655	26,780	29,995	31,956	34,263	35,053
Measured commercial	2428	2572	2759	2857	2974	3106	3226	3256
Unmeasured (domestic + commercial)	22,474	19,353	15,459	11,305	8028	6105	3776	2031
% metered	43%	52%	62%	72%	80%	85%	91%	95%

Notes: Unmeasured customers are grouped because it is difficult to accurately allocate some unmeasured properties as "domestic" or "commercial" from the billing system details. It is estimated that in 2017 there were 1727 unmeasured domestic properties and 304 unmeasured commercial properties.

The numbers relate to property references on the billing system. Some are for shared properties (for example groups of flats), and so the number of individual dwellings served is likely to be higher than the billed numbers quoted in this table.

The following table (Table 7) summarises the forecasts of domestic properties. It is noteworthy that:

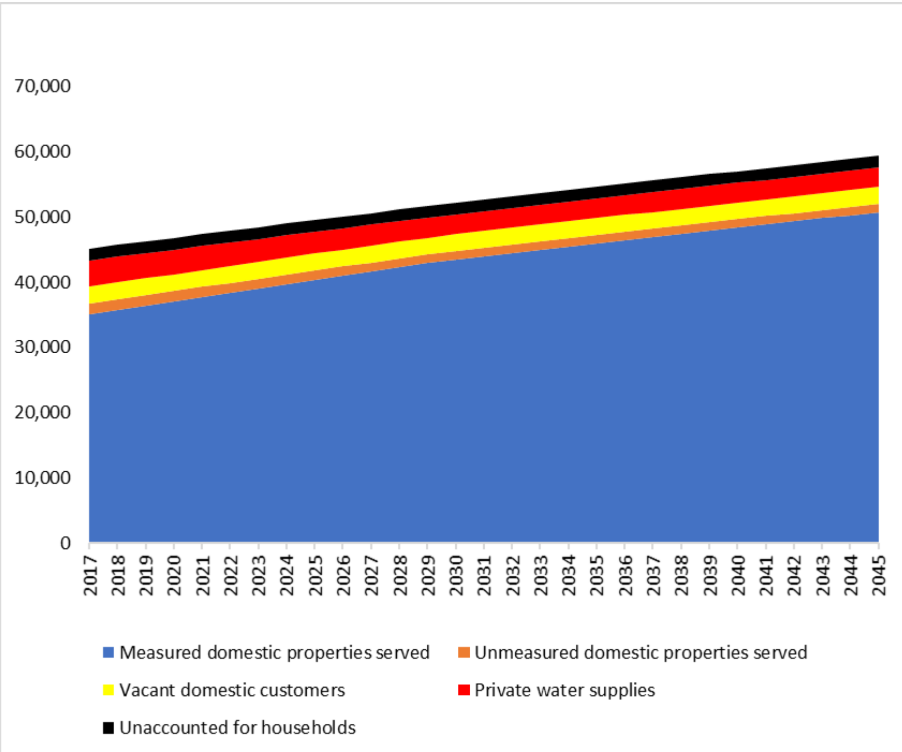
- The total households in Jersey is based on the States of Jersey "Net + 700 migration" scenario
- Jersey Water estimate that there are up to 4000 properties that currently receive private water supplies. There are no plans for any of these properties to be supplied by Jersey Water, but it is possible that some property owners will request connection to Jersey Water's distribution network and so cause a small additional demand for water. For the purpose of the demand forecast it is assumed that 25% (i.e. 1000 properties) will request to be transferred by 2030.
- The total number of domestic customers served is predicted to increase each year according to the island's projected growth in households, and an assumed transfer over time of some homes currently receiving private water supplies to being supplied by Jersey Water.
- The number of measured domestic properties served will increase, as it is assumed that: all new homes will be metered; all homes transferred from private supply will be metered; and that 25% of homes served by Jersey Water that are currently unmeasured will be metered over time.
- Unmeasured domestic customers served by Jersey Water are expected to reduce over time as opportunities arise for further metering.
- For the purpose of the demand forecast, the estimated number of vacant properties has been assumed to remain at the 2017 level.
- The remainder (i.e. total households in Jersey minus number of private supplies minus domestic properties served by Jersey Water) are assumed to be households that are served by Jersey Water but are not individually counted on the billing system. This arises because there are differences in the methods of counting households by States of Jersey and Jersey Water, in particular because the States of Jersey count multiple households within single dwellings. Similar differences are found by UK water companies.
- The trends are illustrated in Figure 9.

Table 7 Forecast domestic properties served

	2017	2025	2045
Total households in Jersey (States of Jersey "Net +700 migration" scenario)	45,150	49,540	59,420
Estimated number of private supplies (i.e. properties not served by Jersey Water)	4000	3385	3000
Domestic properties served by Jersey Water:			
Measured	35,053	40,324	50,755
Unmeasured	1727	1461	1295
Vacant	2575	2575	2575
Total	39,355	44,360	54,625
Estimated number of households served by Jersey Water but not counted above because of multiple occupancy	1795	1795	1795

Note: Values may not sum exactly due to rounding

Figure 9 Domestic property forecasts 2017 to 2045



Note: This graph presents the "Base" forecast which applies the "Net + 700 migration" demographic scenario.

4.4 COMMERCIAL PROPERTIES

For the purpose of the demand forecast, it is assumed that the number of commercial properties served by Jersey Water will remain at 2017 levels: estimated as 3256 measured and 304 unmeasured. This assumption has negligible effect on the overall demand forecast as the volume supplied to measured commercial properties is calculated based on modelled volume trends which do not depend on the numbers of properties.

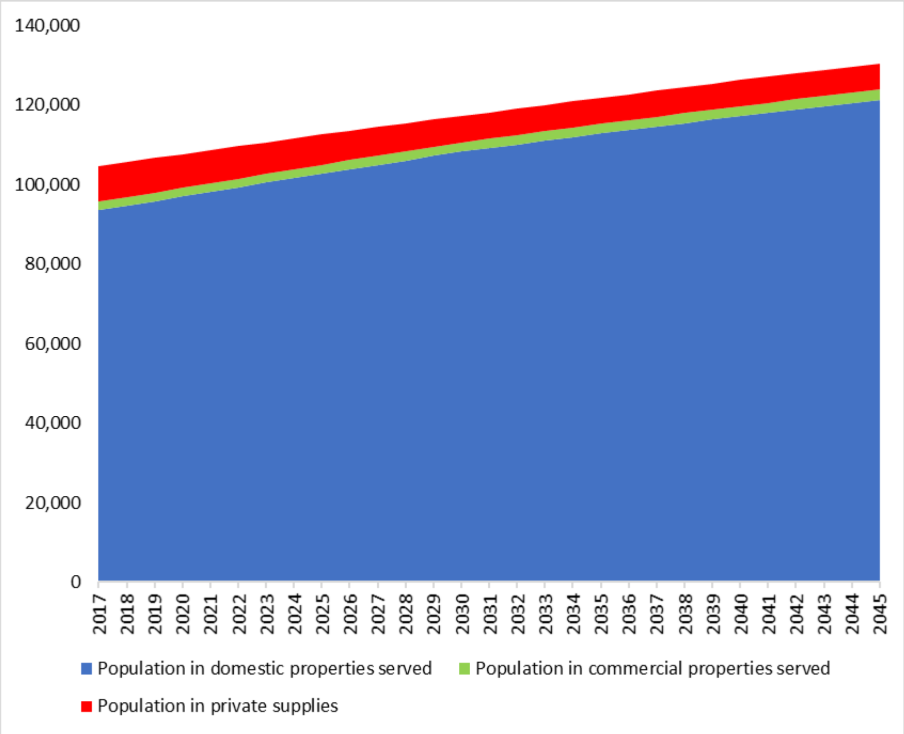
4.5 POPULATION SERVED BY JERSEY WATER

The resident population served by Jersey Water is forecast to increase by 30% from 95,610 in 2017 to 123,853 in 2045, as summarised in Table 8 and Figure 10. This population comprises people resident in domestic properties served and non-domestic population (i.e. people living in communal establishments such as care homes, lodging houses/hostels, and the prison). The non-domestic population has been estimated as 2% of total population based on census data for the UK. The estimated average occupancy of domestic properties is predicted to reduce from 2.54 in 2017 to 2.33 in 2045, consistent with the States of Jersey demographic projections.

Table 8 Forecast population served

	2017	2025	2045
Total resident population in Jersey (States of Jersey "Net +700 migration" scenario)	104,700	112,500	130,300
Resident population served by Jersey Water:			
Domestic population	93,516	102,718	121,247
"Non-domestic" population	2094	2250	2606
Total	95,610	104,968	123,853
Resident population in properties with private supplies (i.e. properties not served by Jersey Water)	9090	7532	6447
Average occupancy for domestic customers served	2.543	2.458	2.329

Figure 10 Resident population forecasts 2017 to 2045



Note: This graph presents the "Base" forecast which applies the "Net + 700 migration" demographic scenario.

5 DOMESTIC CONSUMPTION FORECAST

5.1 METHODOLOGY

The analysis of domestic consumption has been undertaken in line with UK good practice guidance, in particular UKWIR/Environment Agency's "Household consumption forecasting" (2015). The approach has therefore included:

- Taking account of the medium problem characterisation category that was determined for the Jersey Water Resource Zone. So, detailed analyses have been applied making best use of available data from the billing system, but complex additional methods of analysis are not necessary.
- Basing current consumption rates on the measured volumes at domestic properties that are metered, with adjustment based on UK studies for properties that are not metered.
- Applying the results from UK studies for future changes in water use by domestic customers
- Evaluating the impact of uncertainties on domestic water consumption.

5.2 CURRENT CONSUMPTION RATES

The average per property consumption (PPC) rates for measured domestic properties in recent years are shown in the following table. They have been estimated from:

- The number of metered domestic properties in each year estimated from the billing system (see Section 4.2). Some property references on the billing system are for shared properties (for example groups of flats), and so the number of individual properties is likely to be higher than the billed numbers quoted below (see Section 4.2).
- And the total volume of water supplied to these properties. The volumes presented for metered customers have been estimated from the meter readings as recorded on the billing system, but after adjustment for meter under-registration and supply pipe leakage included in the meter readings in line with normal UK practice.

The PPC values for measured domestic properties increased up to 2014 but have been reducing since to 299 litres per property per day (l/prop/d) at 2017 – this pattern may be associated with the metering programme whereby many unmeasured properties became billed on a metered basis and customers learnt over time to reduce their consumption.

It is not feasible to accurately allocate some unmeasured properties as "domestic" or "commercial" from the billing system details. It is estimated that the 2031 unmeasured properties served by Jersey Water in 2017 comprised 1727 domestic and 304 commercial properties. UK studies (e.g. UKWIR, 2003) have found that domestic customers reduce their consumption, typically by 10% to 15%, after being metered. Therefore, it is reasonable to assume that the average PPC at unmeasured domestic properties in 2017 was about 332 l/prop/d, which is 10% higher than the average PPC at measured properties in 2017 of 299 l/prop/d.

The overall average PPC in 2017 across all domestic properties (measured and unmeasured) is estimated as 300 l/prop/d.

Table 9 Domestic consumption rates 2010 to 2017

	2010	2011	2012	2013	2014	2015	2016	2017
Number of billed metered domestic properties	14,540	18,619	22,655	26,780	29,995	31,956	34,263	35,053
Measured volume at metered domestic properties (m^3/d)	4071	5250	6403	7924	9632	9990	10,281	10,476
Average PPC at metered domestic properties (l/prop/d)	280	282	283	296	321	313	300	299
Estimated average PPC at unmeasured domestic properties in 2017 (l/prop/d)								332
Average PPC for all domestic properties in 2017 (l/prop/d)								300

Note: l/prop/d = litres per property per day.

5.3 FUTURE CONSUMPTION RATES

The derivation of forecast domestic consumption rates should take account of the ways in which domestic water use is likely to change in the future. Consumption can be expected to reduce because of:

- wider installation of modern water-efficient toilets, washing machines and dishwashers
- wider use of water efficiency measures such as shower flow regulators and water butts
- more people washing by showering instead bathing
- increased awareness of the benefits of water saving for the environment and reduced energy bills (for water that is heated)
- reducing average occupancy
- increasing proportion of homes that are metered.

However, consumption rates may tend to increase because of:

- more frequent personal washing using showers
- increased affluence, which may result in consumers using new or higher water using appliances than currently
- the impacts of climate change on the way consumers use water.

On balance average PPC is likely to reduce in the future.

Micro-component analysis has been widely used by UK water companies for forecasting future domestic consumption rates. It is a method that takes these issues into account: it estimates the consumption rates associated with each component of household consumption e.g. toilet flushing, personal washing (showering and bathing), clothes washing, dishwashing, other internal use and external use. The application of micro-components analysis is described in detail by UKWIR/Environment Agency (2012).

It is common practice in carrying out micro-component analysis to undertake detailed customer surveys to understand ownership of water using appliances and how water is used in the home. Jersey Water has not undertaken such surveys to date and so the assessment of future domestic water use has been based on UK studies, in particular the work of the Market Transformation Programme sponsored by the Department for the Environment and Rural Affairs (Defra). The results are presented in Table 10 and Figures 11 and 12:

- Table 10 and Figure 11 summarise the forecast changes in average consumption rates for each micro-component, which show expected gradual reductions
- Figure 12 shows how the forecasts of total PPC and total per capita consumption (PCC[6]) are consistent with those derived by selected water resource zones for UK water companies in their 2019 Water Resources Management Plans. The presented forecasts are for baseline demand forecasts for measured domestic customers to facilitate direct comparability. It should be noted, however, that several UK companies are forecasting significant reductions in future consumption as a result of metering programmes and enhanced water efficiency programmes.

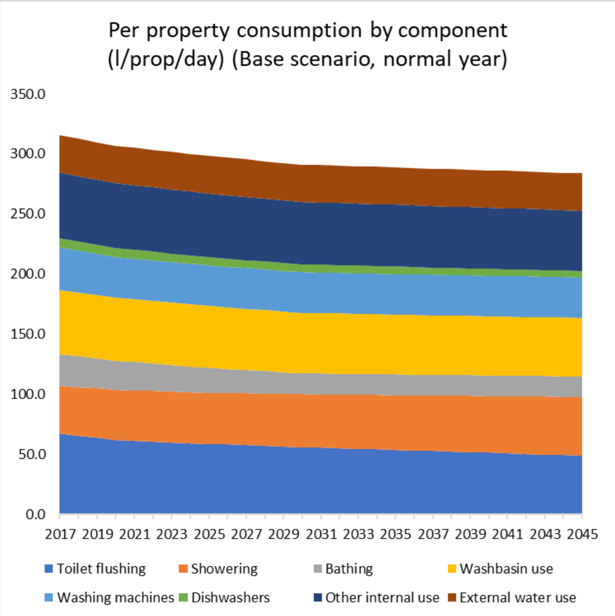
Table 10 Forecast average PPC values by micro-component 2017 to 2045 (l/prop/d) under normal weather conditions

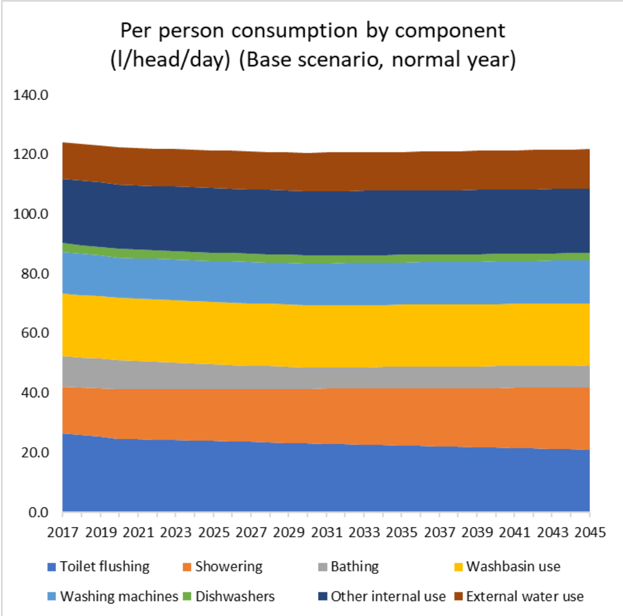
Component	PPC 2017	PPC 2025	PPC 2045	Comment
Toilet flushing	64.1	55.4	45.6	Reducing due to installation of lower flush volume toilets
Showering	37.5	40.7	46.8	Increasing due to more use of showers
Bathing	25.2	19.5	15.9	Reducing due to less use of baths
Washbasin use	50.6	48.8	46.0	Reducing due to reducing occupancy
Clothes washing	34.1	32.0	32.0	Reducing due to more efficient washing machines
Dish washing	7.0	6.6	5.1	Although ownership is increasing, water use is reducing due to more efficient dishwashers
Other internal use	52.3	50.4	47.5	Reducing due to reducing occupancy
External water use	29.6	29.6	29.5	Reducing due to reducing occupancy
Total PPC	300.4	283.1	268.5	

[6] In the UK it is common to express domestic consumption in terms of per capita consumption (PCC, litres/person/day)

Note: These values are weighted average values across measured and unmeasured homes. Values may not sum exactly due to rounding.

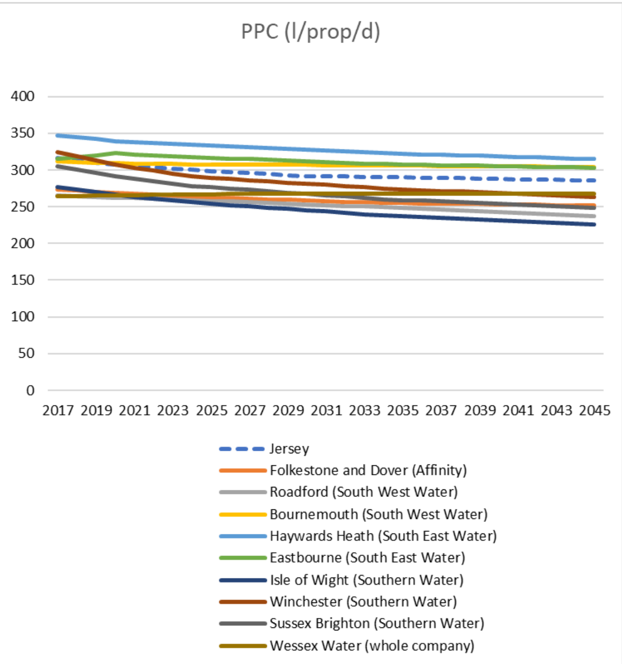
Figure 11 Forecast average PPC and PCC values by micro-component 2017 to 2045 under normal weather conditions

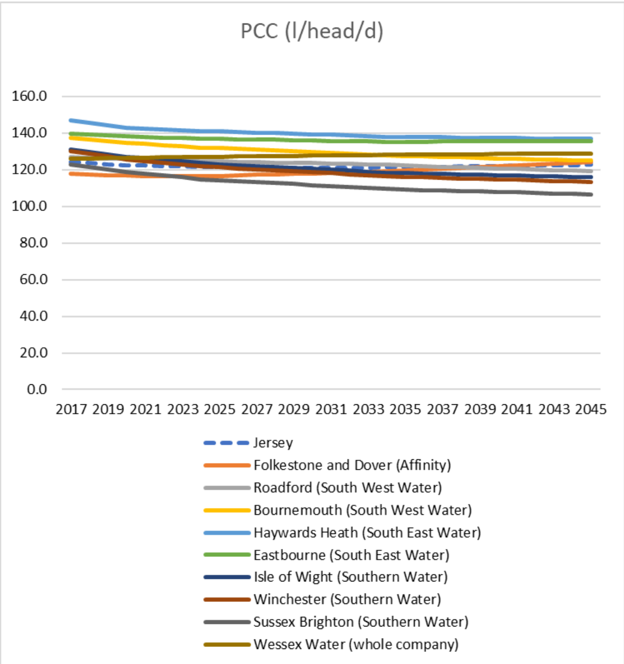




Note: These values are weighted average values across measured and unmeasured homes.

Figure 12 Comparison of DYAA Jersey Water and selected Southern England PPC forecasts and PCC forecasts





Note: These values are dry weather annual average (DYAA) values for measured domestic properties – to facilitate direct comparisons

5.4 DOMESTIC CONSUMPTION FORECAST

The domestic consumption forecast is summarised in the following table. The consumption volumes are expected to increase in the future as a result of significant growth in the number of domestic customers despite reductions in per property consumption (PPC).

Table 11 Summary of baseline domestic consumption forecast

	2017	2018	2025	2035	2045
NYAA PPC for measured domestic properties (l/prop/d)	299	296	282	273	268
NYAA PPC for unmeasured domestic properties (l/prop/d)	332	331	322	310	298
NYAA weighted average PPC (l/prop/d)	300	298	283	274	269
Number of domestic properties served by Jersey Water	36,780	37,398	41,785	47,230	52,050
NYAA domestic consumption (m^3/d)	**11,049**	**11,124**	**11,828**	**12,920**	**13,976**
DYAA weighted average PPC (l/prop/d)	317	314	300	291	287
DYAA domestic consumption (m^3/d)	**11,657**	**11,761**	**12,536**	**13,741**	**14,916**

Note: NYAA = normal year annual average, DYAA = dry year annual average

In the UK and across much of Europe it is common to express domestic consumption rates as per capita consumption (PCC) measured as litres per head per day (l/hd/d). So, in the following table, estimated average occupancy rates have been used to calculate estimated PCC values for Jersey Water's baseline demand forecast.

Table 12 Summary of domestic consumption rates

	2017	2018	2025	2035	2045
NYAA average PPC (l/prop/d)	300	298	283	274	269
DYAA average PPC (l/prop/d)	317	314	300	291	287
Average occupancy of domestic properties	2.543	2.531	2.458	2.388	2.329
NYAA average PCC (l/hd/d)	118	117	115	114	115
DYAA average PCC (l/hd/d)	125	124	122	122	123

5.5 CLIMATE CHANGE EFFECTS

It is expected that climate change will result in warmer, drier summers in the future, and therefore result in increased water use by domestic customers. The UKWIR study "Impact of climate change on demand" (2013) applied the UK Climate Impact Projections 2009 (UKCIP09) to calculate estimated effects on domestic water demand for each UK Water Framework Directive River Basin District. The factors for the South West England River Basin District have been used for Jersey.

The effect of climate change on domestic water use is estimated to increase annual average consumption by 1.2% and peak week consumption by 3.1% by 2045. These impacts have been included in the DYAA and DYPW forecasts, respectively.

5.6 UNCERTAINTIES

There is inevitable significant uncertainty around future domestic consumption as customers change the way they use water in the future. In deriving the base forecasts presented in Table 11, specific assumptions have been made about the future ownership of water using appliances, how they will be used and future technological improvements. Actual levels of ownership and usage may vary from the base estimates, and so a range of consumption forecasts has been evaluated as shown below.

Figure 13 PPC and PCC forecasts for alternative scenarios under normal weather

6 COMMERCIAL CONSUMPTION FORECASTS

6.1 METHODOLOGY

Commercial premises comprise properties that receive drinking water supplies but are not classed as domestic properties. This includes water used by agriculture, offices, hotels, retailers, hospitals, schools, local authorities, communal establishments, factories and utilities.

The analysis of commercial consumption has been undertaken in line with UK good practice guidance (Environment Agency, 2017 and UKWIR/Environment Agency, 1997). The methodology has therefore included:

- Taking account of the medium problem characterisation category that was determined for the Jersey Water Resource Zone. So, detailed analyses have been applied making best use of available data from the billing system, but complex additional methods of analysis are not necessary.
- Carrying out statistical analysis of past sectoral consumption to assess economic and other factors that may affect water consumption by each commercial sector.
- Developing consumption forecasts for a range of planning scenarios.
- Assessing the uncertainty in commercial consumption forecasts.

6.2 ANALYSIS OF COMMERCIAL CONSUMPTION

6.2.1 Data

The primary data source used for the analyses was the billing system, which provided details of customer numbers and volumes at those customers with a meter for each year from 2010 to 2017.

When undertaking commercial consumption forecasting, it is usual good practice to segment (i.e. categorise) customers into broad sectors so that differences in trends between sectors can be examined. Commercial customers were allocated to the following sectors:

- Agriculture
- Industry
- Miscellaneous
- Offices and retail
- Public services
- Tourism and leisure
- Unmeasured commercial

The data on the billing system for 2017 (the base year) is summarised in the following table. The volumes presented for metered customers are based on meter readings, but after adjustment for meter under-registration and supply pipe leakage in line with normal UK practice. The estimated unmeasured consumption was derived using an assumed average per property consumption of 719 l/prop/d, estimated from analysis of consumption at commercial properties that have been metered in recent years.

Table 13 Summary of commercial customers 2017

Sector	Estimated number of properties	Estimated consumption in 2017 (m^3/d)
Agriculture	92	98
Industry	253	239
Miscellaneous	766	791
Offices and retail	899	670
Public services	521	1203
Tourism and leisure	725	1754
Unmeasured commercial	304	219
Total	3560	4973

Note: Values may not sum exactly due to rounding

6.2.2 Measured consumption

Economic data in the form of Gross Value Added (GVA) for the island of Jersey was obtained from the States of Jersey website for each measured commercial sector for the period 2010 to 2016. Some correlations between sectoral demand and sectoral GVA were found, but in each case sectoral demand was found to be more strongly related to time trend and secondary relationships with GVA were very weak. Therefore, predicted demands were based on past time trends without using GHVA data.

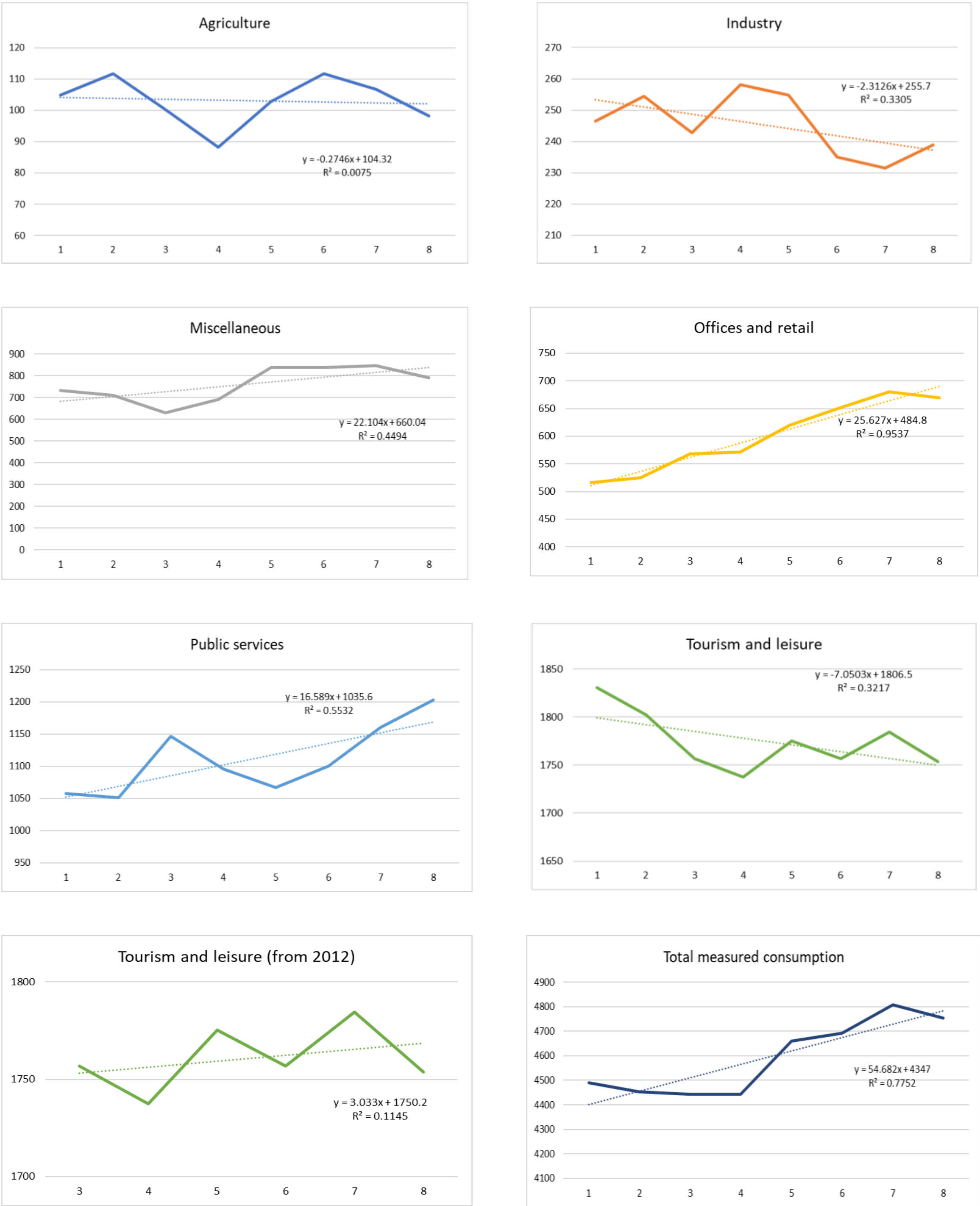
The graphs in Figure 13 present the recent annual data for each sector and provide indication of potential time trends:

- **Agriculture:** Water consumption by agriculture has fluctuated from year to year with a possible slight downward trend, but it is not statistically significant. The total export value of Jersey agriculture has continued to decline in recent years, but the total area of land farmed has remained steady at about 6000 hectares. The future volume of water supplied to agriculture has therefore been estimated to remain at the 2017 level.
- **Industry:** Water consumption by industry has been steadily reducing, and the trend is statistically significant. The forecasting of future water use by industry has assumed that the downward trend will continue but at a progressively slower rate.

- **Miscellaneous:** This category includes, for example, lodging houses/hostels, laundries, and washdown facilities. Metered water use has increased each year recently, although this may be partly as a result of some such properties being metered in recent years and so being added to the properties allocated as measured on the billing system. The forecast of miscellaneous water use has assumed that the upward trend will continue but at a progressively slower rate.
- **Offices and retail:** There has been strong growth in the measured volume of water consumption by the offices and retail sector. This may be partly as a result of some such properties being metered in recent years and so being added to the properties allocated as measured on the billing system. The rate of growth is likely to be unsustainable in the long-term. The forecast of water use by this sector has assumed that the upward trend will continue but at a progressively slower rate.
- **Public services:** This category includes, for example, water use at local authority buildings, hospitals, schools, and health and community centres. The comments for offices and retail also apply to the public services sector.
- **Tourism and leisure:** This category is the largest consumer of water as shown in Table 13. It includes, for example, hotels, restaurants, pubs, golf courses, and sports and leisure centres. Water use declined during 2010 to 2012, but has been steady or possibly increasing since. The number of tourism bed spaces on Jersey has steadily reduced from 20,000 in the mid-1990s to about 10,000 now. The number of visitors to the island has also reduced but has been steady at about 700,000 per year since 2010. It is hoped to increase the promotion of Jersey as a tourist location and so increase (or maintain) visitor numbers. On balance, it was decided to assume that future water use by the tourism and leisure sector will remain at the 2017 level, but alternative forecasts are considered by the uncertainty analyses.

The past growth rates in recent years for some sectors would, if applied indefinitely, result in very high commercial consumption volumes in the future, and so are unlikely to be sustainable in the long-term. It was therefore decided to apply progressively reducing rates of growth (or decline in the case of industry). This was achieved by applying a decay factor of 20% whereby the volume of growth in a particular year would be estimated as 80% of the volume growth in the previous year. The resulting forecasts are shown in Figure 14.

Figure 13 Trends in sectoral water consumption (m3/d)



Note: The x-axis in these graphs refers to years. Year 1 = 2010, Year 2 = 2011, … Year 8 = 2017

Figure 14 NYAA commercial consumption forecast by sector 2017 to 2045 (m3/d)

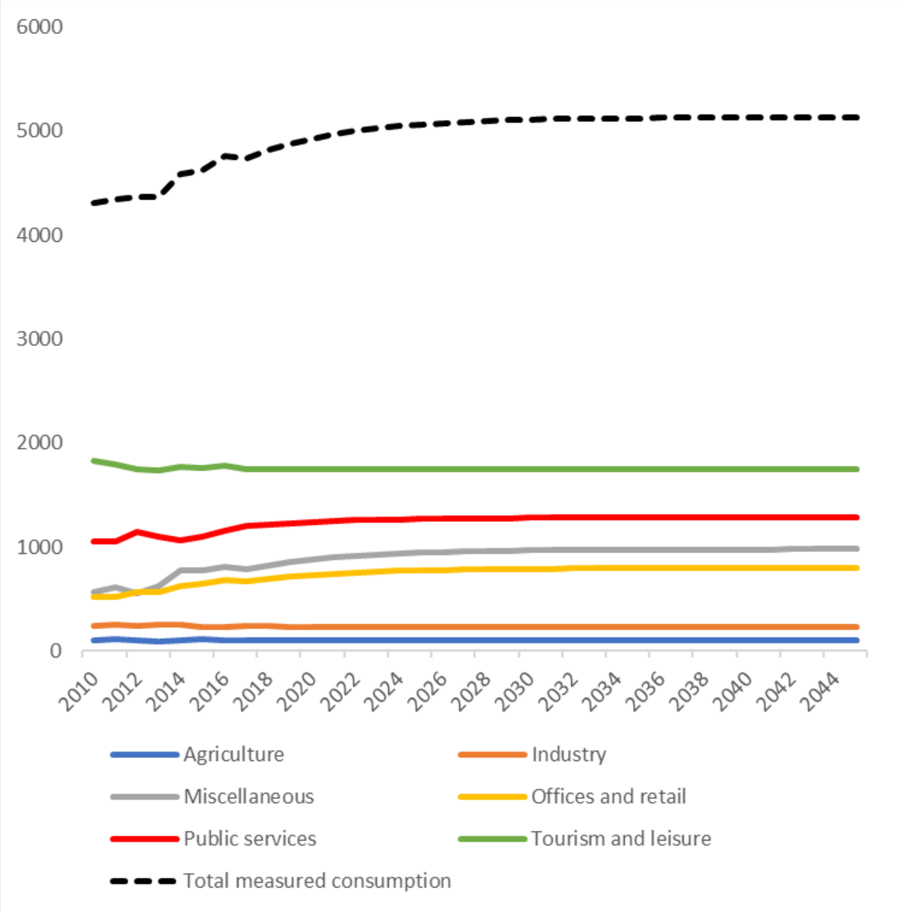
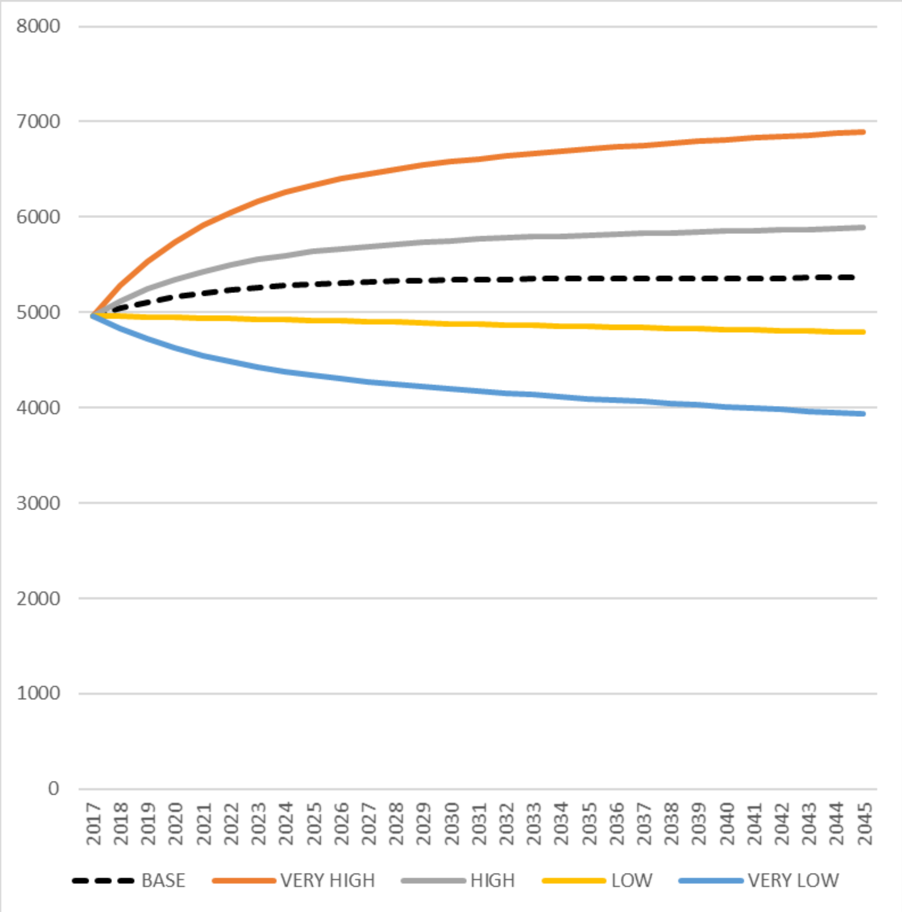


Figure 15 summarises the forecasts of measured commercial consumption by sector. Total measured commercial consumption is forecast to increase by 13% from 4755 m3/d in 2017 to 5064 m3/d in 2045, under normal weather conditions.

Figure 15 NYAA forecasts of total commercial consumption for alternative scenarios



6.2.3 Unmeasured consumption

Consumption by unmeasured commercial properties is forecast to remain at the 2017 level of 219 m^3/d. This is a small component, representing about 1% of total demand.

6.3 TOTAL COMMERCIAL CONSUMPTION FORECAST

Total water consumption by commercial properties is forecast to increase by 6% from 4973 m3/d in 2017 to 5283 m^3/d in 2045 in a normal weather year, and to 5407 m^3/d under dry weather year conditions, as shown in the following table.

Table 14 Summary of baseline commercial consumption forecast

	2017	2018	2025	2035	2045
Consumption by measured commercial properties (m^3/d):					
Agriculture	98	98	98	98	98
Industry	239	237	229	228	227
Miscellaneous	791	813	883	899	901
Offices and retail	670	695	776	796	798
Public services	1203	1220	1272	1285	1286
Tourism and leisure	1754	1754	1754	1754	1754
Total	4755	4817	5013	5059	5064
Consumption by unmeasured commercial properties (m^3/d)	219	219	219	219	219
NYAA commercial consumption (m^3/d)	**4973**	**5035**	**5231**	**5278**	**5283**
DYAA commercial consumption (m^3/d)	**5075**	**5141**	**5342**	**5395**	**5407**

Note: Values may not sum exactly due to rounding

6.4 WEATHER AND CLIMATE CHANGE EFFECTS

It is not possible to separate the effects of weather on commercial water use from the impacts on domestic water use in Jersey. Also, there is inadequate evidence from UK studies (e.g. UKWIR) to precisely quantify the effects of weather or climate change on water use by commercial sectors. However, it is likely that water consumption by the agriculture and tourism/leisure sectors is influenced by weather, with increased use occurring if the summer weather is hotter/drier than usual.

In the absence of specific values for commercial water use, the same dry year uplift factor as derived in Section 3.2 and the same climate change factors as reported in Section 5.5 for domestic water consumption have been also applied to agriculture and tourism/leisure water consumption.

6.5 UNCERTAINTIES

There is inevitable uncertainty in estimates of future commercial consumption. Economic and employment profiles are inherently uncertain, but particularly so at present as the potential effects of Brexit are unknown and not feasible to evaluate. The future prospects for tourism and leisure on the island and the degree of further efficiency drives to reduce water use where possible are also uncertain. A significant degree of uncertainty has therefore been allowed for in the alternative demand forecast scenarios, as shown in Figure 15.

7 MINOR WATER USE, LEAKAGE AND UNACCOUNTED FOR WATER

7.1 MINOR WATER USE

Minor water use includes:

- Standpipe use for fire-fighting, fire service training, road cleaning, and building works
- Operational water use by Jersey Water for mains cleaning or cleaning of other distribution system assets, after repair or new installation
- Unbilled use at Jersey Water offices and sites
- Water taken illegally by customers (either knowingly or unknowingly).

Jersey Water do not record all such activities. Minor water use in 2017 has been estimated as 400 m3/d (i.e. 2% of distribution input based on estimates derived by UK water companies), and is assumed to stay at this level in the future.

7.2 BASELINE TOTAL LEAKAGE

Total leakage comprises losses from the distribution system (including water mains, trunk mains and service reservoirs) and losses from customer underground supply pipes.

7.2.1 Methodology used by Jersey Water

Jersey Water calculates leakage levels from daily analysis of minimum night flows in the distribution system, but using a different approach to normal UK practice. The approach used by Jersey Water enables effective monitoring of changes in leakage through time and therefore helps direct leakage reduction activity. However, it may not accurately calculate total leakage levels and so may underestimate leakage in the water balance calculations. Some of the water identified as "unaccounted-for-water" may be leakage.

It is recommended that Jersey Water consider the merits of applying UK approaches more closely, including implementing parts of the guidance in the recent report "Consistency of reporting performance measures: Leakage" (UKWIR, 2017). The main elements of UK good practice which may be different to Jersey Water's approach in estimating leakage levels include the following:

- All areas should be covered by discrete District Meter Areas (DMAs) - there are currently difficulties in setting up discrete areas in St Helier
- Leakage levels should be based on 15-minute DMA night-time flowrates – at present Jersey Water use hourly distribution input data which does not enable as much precision and consistency in leakage estimation

- Leakage levels should be based on analysis of daily minimum night-flows across a week (or longer) to help take account of fluctuating night-use volumes
- Specific local monitoring (and/or studies) of customer night-use should be used, including assessment of seasonal and within-week variations in customer night use
- Monitoring studies to assess the hour-day factor for each DMA
- Estimation of losses upstream of DMAs using flow-balance approach (this is already done for service reservoir losses element)
- There should be a written methodology for the calculation of the annual leakage volume
- "Top-down" and "bottom-up" estimates of annual total leakage should be derived, and maximum likelihood estimation (MLE) should be applied to reconcile the differences.

7.2.2 Future leakage levels

In the UK, it is good practice and usual policy to maintain total leakage at, or below, the "sustainable economic level of leakage" (SELL) calculated in accordance with national guidance (Ofwat, 2007, 2012). Jersey Water has not undertaken detailed SELL studies but considers that this would be unnecessary as its leakage levels are low compared with UK norms.

Average monitored levels of total leakage in 2017 was 3055 m^3/d but has reduced to 2558 m^3/d during 2018 (average for January to July), particularly as a result of repairing a batch of faulty water meters. Baseline total leakage for Jersey is therefore forecast to remain at the first-half of 2018 level of 2558 m^3/d. Potential further reduction in total leakage has been considered as part of the option appraisal, and incorporated in the final planning leakage levels and demand forecast summarised in the Main Report.

7.3 UNACCOUNTED FOR WATER

Unaccounted for water in 2017 is the small volume of water (596 m^3/d) that could not be allocated to a specific demand component, as explained in Section 2.3. It represents 3% of total distribution input in 2017. It is assumed that, for the base scenario demand forecast, the volume of unaccounted for water will stay at the 2017 level.

7.4 WEATHER AND CLIMATE CHANGE EFFECTS

Extreme cold weather events can lead to sharp, temporary increases in leakage levels as discussed in Section 3.5. It is assumed that variations in weather have negligible impact on annual volumes of minor water use or unaccounted for water, and that climate change will have negligible impact on these or total leakage.

7.5 UNCERTAINTIES

There are uncertainties in the estimation of the 2017 water balance volumes for minor water uses, total leakage and unaccounted for water, and how these components may change in the future irrespective of any new demand management measures. The impact of uncertainties is explored further in Section 8.2.

8 DEMAND FORECAST

8.1 TOTAL BASELINE DEMAND FORECAST

This section summarises the baseline demand forecasts. These exclude the effects of additional demand management measures that are part of the preferred plan and are included in the final planning forecasts presented in the Main Report.

Although, domestic consumption rates are predicted to reduce, Table 15 and Figures 16 and 17 show that distribution input is expected to increase steadily. This is mainly a result of the expected large growth in homes and population, which have a bigger upward impact than the downward impact of reductions in consumption rates. Also, the effect of climate change on consumption is expected to gradually increase.

Table 15 Baseline demand forecasts by demand component and planning scenario (m^3/d)

	2017	**2018**	**2025**	**2035**	**2045**	**2070**
Measured domestic consumption	10,476	10,564	11,357	12,518	13,590	16,226
Unmeasured domestic consumption	573	560	471	401	385	345
Measured commercial consumption	4,755	4,817	5,013	5,059	5,064	5,070
Unmeasured commercial consumption	219	219	219	219	219	219
Minor water uses	400	400	400	400	400	400
Total Leakage	3,055	2,558	2,558	2,558	2,558	2,558
Unaccounted For Water	596	596	596	596	596	596
Distribution input (normal year) (m^3/d)	**20,073**	**19,713**	**20,613**	**21,751**	**22,812**	**25,414**
Distribution input (dry year) (m^3/d)	**20,782**	**20,456**	**21,432**	**22,690**	**23,877**	**26,600**
Distribution input (normal year peak week) (m3/d)	**26,296**	**25,824**	**27,003**	**28,494**	**29,884**	**33,292**
Distribution (dry year peak week) (m^3/d)	**27,225**	**26,798**	**28,075**	**29,724**	**31,279**	**34,846**

Note: Dry year forecasts include dry weather effect and climate change impacts

There was a temporary increase in leakage levels in 2017 due to leakage for a batch of leaking customer meters, as explained in Section 7.2.2, and so, from 2018, the forecast leakage levels are at a revised baseline of 2558 m^3/d.

A large number of customers have been metered since 2010, and so their water use has reduced and in consequence overall demand has not been rising. Now that the metering programme has been completed, demand is expected to increase in the future because of predicted steady growth in population and homes.

Figure 16 Baseline NYAA demand forecast by demand component (m3/d)

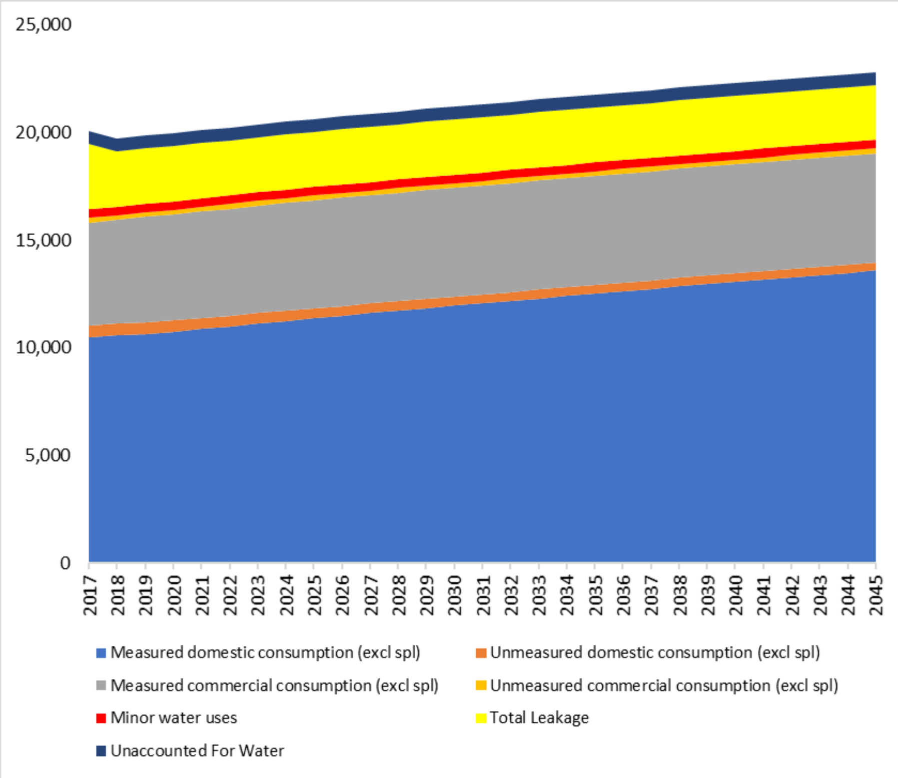
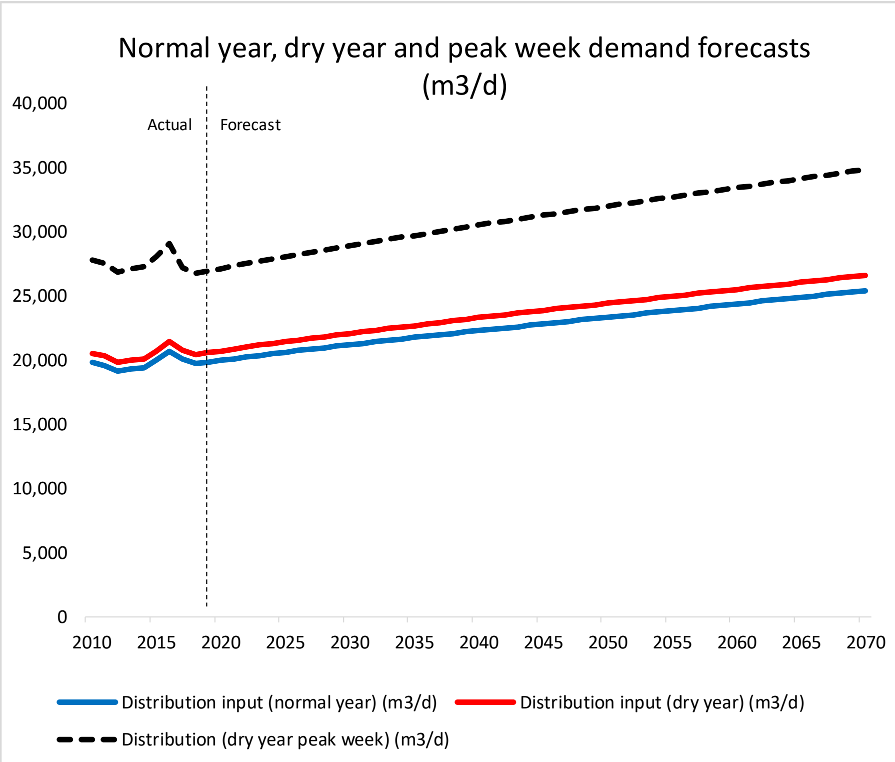


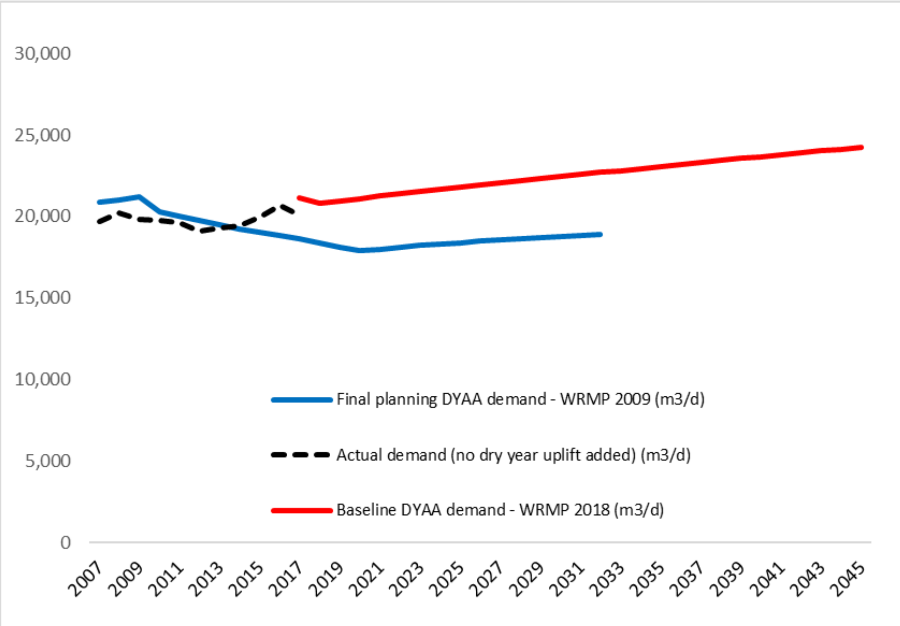
Figure 17 Baseline demand forecasts by planning scenario



8.2 COMPARISON WITH PREVIOUS WRMP

The following graph (Figure 18) compares the demand forecasts used in Jersey Water's previous WRMP (MWH, 2009) with the current WRDMP demand forecast. It shows that actual water demand (black dashed line) and the latest demand forecast (red line) are significantly higher than forecast by the 2009 WRMP. For example, the 2009 WRMP expected that demand in 2017 under dry weather conditions would be 18,600 m^3/d whereas the current plan estimates it as 2,600 m^3/d higher at 21,200 m^3/d, which has been derived from the actual 2017 demand level of 20,100 m3/d and the dry year uplift factor of 5.5%.

Figure 18 Comparison of demand forecasts for WRMP 2009 and current WRDMP



The main reasons for the underestimates of forecast demand in 2009 WRMP are:

- **The demand reductions were overestimated.** Significant reductions in demand, amounting to about 5000 m^3/d, were expected to be achieved by 2020 due to customer metering and leakage reduction measures, which contribute to the downward trend between 2010 and 2020 in the 2009 WRMP forecast (blue line). These estimates were optimistic, in particular the expectation that total distribution input would reduce by about 15% due to the metering programme.

- **Population growth, and hence demand increases associated with additional population, was underestimated.** As explained in Section 4.2, net migration in recent years has been much greater than previously expected by the States of Jersey Statistics Unit. For example, total resident population in 2017 was about 104,700 whereas the central projection available at the time of the 2009 WRMP was 96,300. The current plan has applied a

population growth scenario of "Net + 700 migration per year"
whereas the 2009 WRMP used a "Net +250 migration per year" scenario.

8.3 UNCERTAINTY APPRAISAL

There is significant uncertainty in demand forecasts as it is difficult to accurately predict future trends. For example, growth in households, population growth, water use patterns by customers and climate change impacts may be different to the current best assessments. Also, the pattern of water demand in spring 2020 has been very different to previous years due to Coronavirus, but it is too early to quantify the effects on annual water demand or how long the impacts will last. It is considered likely that, in the long-term, demand patterns will return to "normal", and so the demand forecast to 2045 and the uncertainty ranges are considered to be valid long-term projections.

The following graphs summarise the range of forecasts that have been calculated.

Figure 19 DYAA and DYPW baseline demand forecasts by uncertainty scenario

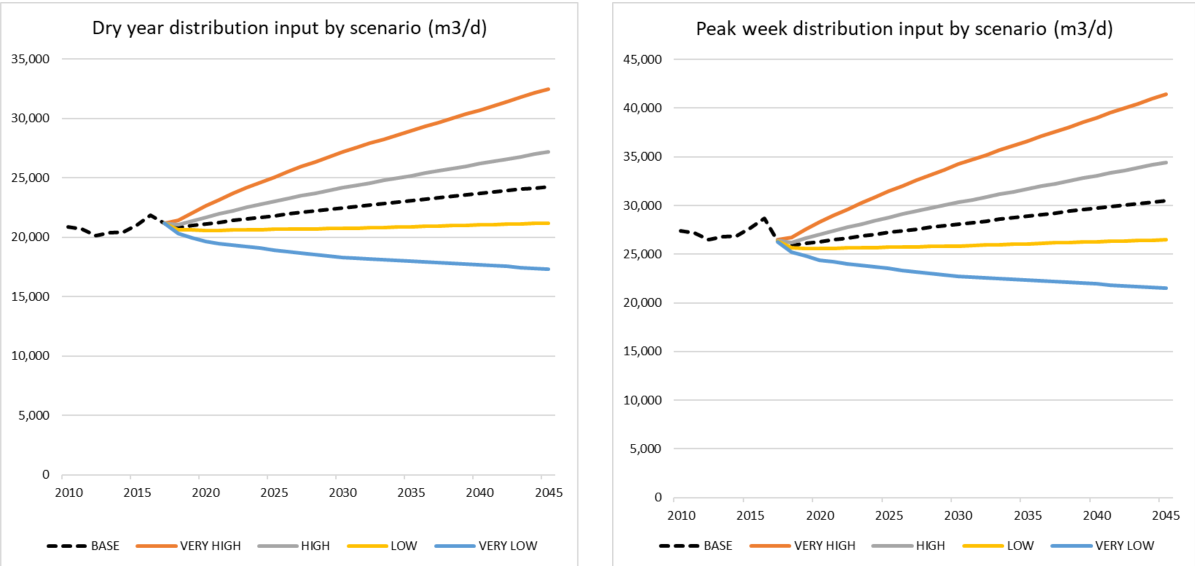


Figure 20 (see next page) examines the degree of sensitivity of the dry year annual average demand forecasts to a range of key assumptions. The largest sources of uncertainty in overall demand result from the uncertainties in the forecast domestic property numbers (dark blue areas) and forecast per property consumption rates (light blue areas), as domestic customers change the way they use water in the future. These contribute about two-thirds of the variation between the uncertainty scenarios. The other uncertainties have relatively much lower impacts on the demand forecast.

Figure 21 shows how the demand forecast varies by just changing the demographic (property and population projection) scenario.

Table 16 summarises the key assumptions used for calculating each uncertainty scenario (Very Low, Low, Base, High and Very High). It shows that the base scenario DYAA demand forecast at 2045 is 23,900 m^3/d, but because of uncertainties in each element it is possible that the actual demand could be as much as 6000 m^3/d lower (i.e. 17,000 m^3/d, for Very low scenario) or as much as 8100 m^3/d higher (i.e. 32,000 m^3/d, for Very high scenario).

The results from the demand uncertainty assessments have been used in the target headroom (see Appendix G) and risk-based options appraisal (see Main Report).

Figure 20 Sensitivity of the baseline DYAA demand forecast at 2045 (m^3/d) to key assumptions for each uncertainty scenario

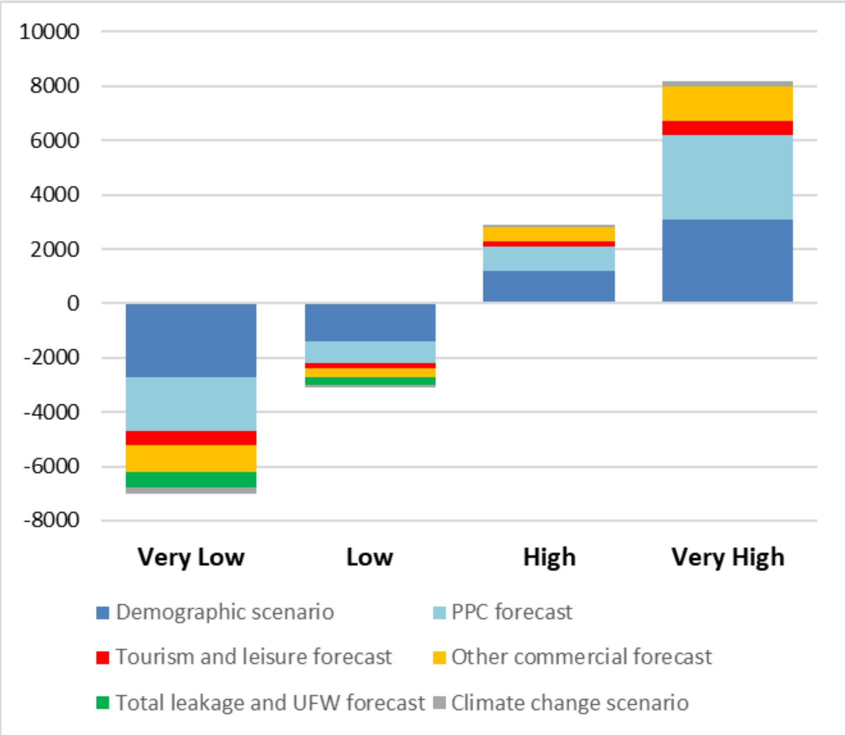


Figure 21 The impact of choice of demographic scenario on the baseline DYAA demand forecast (m³/d)

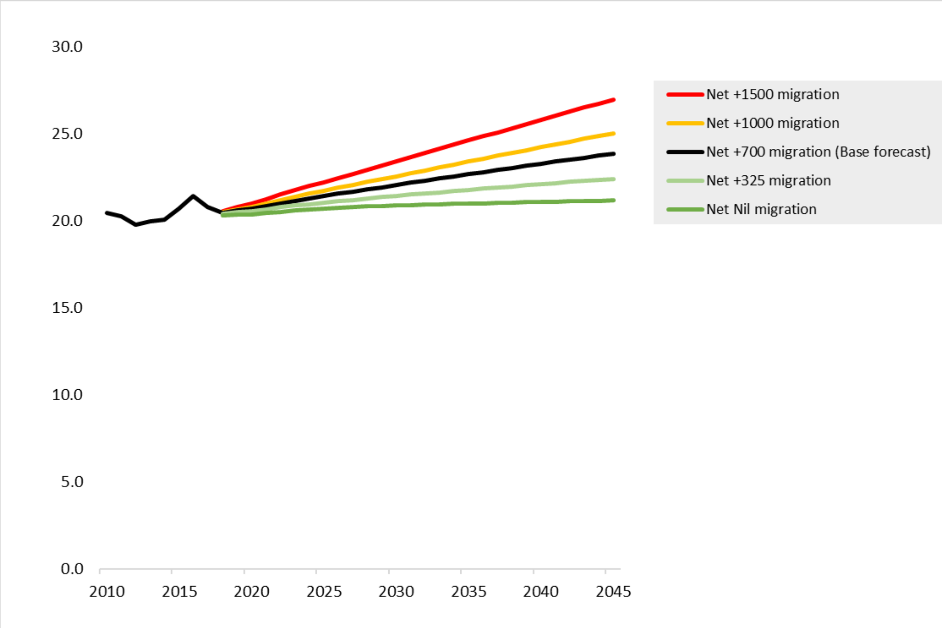


Table 16 Basis used for each demand forecast uncertainty scenario

Element	Uncertainty Scenario	Assumption (at 2045)
Domestic properties served	Base	51,116 props based on "Net + 700 migration" scenario
	Very high	61,976 props based on "Net + 1500 migration" scenario
	High	55,206 props based on "Net + 1000 migration" scenario
	Low	46,056 props based on "Net + 325 migration" scenario
	Very low	41,666 props based on "Net nil migration" scenario
Average (DYAA) PPC	Base	287 l/prop/d (10% reduction from 317 l/prop/d at 2017)
	Very high	336 l/prop/d assuming 5% increase from 2017 level
	High	304 l/prop/d assuming 5% reduction from 2017 level
	Low	272 l/prop/d assuming 15% reduction from 2017 level
	Very low	240 l/prop/d assuming 25% reduction from 2017 level
Tourism and leisure consumption	Base	No change from 2017 level
	Very high	25% increase from 2017 level
	High	10% increase from 2017 level
	Low	10% reduction from 2017 level
	Very low	25% reduction from 2017 level
Other commercial consumption	Base	13% increase from 2017 level based on past trends
	Very high	50% increase from 2017 level
	High	25% increase from 2017 level
	Low	No change from 2017 level
	Very low	20% reduction from 2017 level
Total leakage and unaccounted for water	Base	No change from 2017/18 levels
	Very high	No change from 2017/18 levels
	High	No change from 2017/18 levels
	Low	10% reduction from 2017/18 levels
	Very low	20% reduction from 2017/18 levels
Climate change	Base	1% increase in demand - as derived by UKWIR
	Very high	2 times Base estimates
	High	1.5 times Base estimates
	Low	0.5 times Base estimates
	Very low	No climate change impact
All elements	Base	DYAA demand at 2045 = 23,900 m^3/d
	Very high	DYAA demand at 2045 = 32,000 m^3/d
	High	DYAA demand at 2045 = 26,800 m^3/d
	Low	DYAA demand at 2045 = 20,800 m^3/d
	Very low	DYAA demand at 2045 = 17,000 m^3/d

9 CONCLUSIONS AND RECOMMENDATIONS

In 2017, Jersey Water supplied 20,100 m^3/d on average to 37,000 homes and 3600 commercial properties across the island. Approximately 95% of properties are individually metered and so have a direct incentive to conserve water use to save on their water bills. Customers can benefit from water saving advice and devices that are available from Jersey Water.

It is expected that the average household consumption will reduce by 10% from 300 l/prop/d to 269 l/prop/d by 2045, as a result of continued water efficiency and expected changes in appliance use. However, strong growth in Jersey's population and number of homes is expected, and so it is anticipated that the number of domestic properties served will increase will increase by 42% to 52,000 by 2045. The overall effect is that domestic water consumption is expected to increase by 26% by 2045.

Commercial water consumption, in particular by the office/retail and public service sectors, has increased in recent years. Total commercial water use is forecast to increase by a further 6% by 2045.

The estimated volume of leakage from Jersey Water's distribution system and customer underground supply pipes was about 3000 m^3/d in 2017 but has reduced to 2600 m^3/d in the first half of 2018. These are low levels compared with leakage levels reported in many parts of the UK, but it is noted that the method of calculation is different to that used in the UK. For the initial, baseline demand forecast it leakage levels are estimated as the 2018 level.

As a result, the total quantity of water supplied by Jersey Water is projected increase by 14% from 20,100 m^3/d in 2017 to 22,800 m^3/d in 2045, under normal weather conditions, and to about 23,900 m^3/d by 2045 under dry weather year conditions. There is uncertainty in the demand estimates and so a range of demand forecasts have been derived which apply alternative assumptions: the dry weather demands at 2045 from the alternative scenarios range between 17,000 and 32,000 m^3/d.

The latest forecasts of future demand are significantly higher than those anticipated by the previous plan prepared in 2009. This is because:

- Demand reductions due to the proposed customer metering and leakage reduction measures were overestimated, and
- Population growth, and hence demand increases associated with additional population, was underestimated.

The baseline demand forecast presented in this appendix (central estimate and the uncertainty envelope) has been used as an important part of deriving the initial water supply demand balance and carrying out uncertainty analysis as part of the decision-making process. The demand forecast has therefore been used to help identify any supply deficits that occur and the analysis of options to determine the preferred plan to maintain adequate water supply reliability.

It is recommended that Jersey Water should consider implementing the following data improvements, after examining the potential merits and costs associated them:

- Analysing records of volumes of consumption at individual domestic properties to understand how water use varies between different types of domestic property to help improve demand forecasting.
- Undertaking sample customer surveys of occupancy, appliance ownership and water use to better understand how different types of domestic customer water use behaviour.
- Undertaking high frequency monitoring of customer water use at samples of domestic and commercial customer properties to enable better understanding, for each customer type, of how water use varies through time and with changes in weather for improved demand forecasting, and enable better quantification of customer night-use for improved leakage calculations.
- Improve the monitoring and calculation of leakage levels to be more consistent with UK practice and enable improved management of leakage control.

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11 GLOSSARY

DMA	District Meter Area – DMAs are set up as small discrete areas of the distribution network, and for which all flows into or out of the DMA are monitored
DYAA	Dry year annual average demand (m^3/d)
DYPW	Dry year peak week (critical period) demand (m^3/d)
GVA	Gross Value Added – a measure of economic activity
hd	head i.e. person
l/hd/d	litres per head per day
l/prop/d	litres per property per day
MCA	Micro-components analysis
m^3/d	Cubic metres per day (1 cubic metre = 1000 litres)
NYAA	Normal year annual average demand (m^3/d)
PCC	Per capita consumption (litres per head per day, l/hd/d)
PPC	Per property consumption (litres per property per day, l/prop/d)
prop	property
SELL	Sustainable economic level of leakage
SPL	Underground supply pipe leakage
UKWIR	UK Water Industry Research Limited
WRMP	Water Resources Management Plan
WRDMP	Water Resources and Drought Management Plan