Thames Water

Final Water Resources Management Plan 2019

Technical Appendices

Appendix N: Metering

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Metering

A. Introduction

N.1 Our supply area was designated as being in an area of serious water stress[1] and, in 2012, legal powers were granted to us to compulsory meter properties across our area by the Secretary of State. In the Water Resources Management Plan 2014 (WRMP14), this led to our Progressive Metering Programme (PMP) being initiated within the London WRZ.

N.2 The Water Services Regulation Authority (Ofwat), Department for Environment, Food and Rural Affairs (Defra), the Greater London Authority (GLA) and the Consumer Council for Water (CCWater) have all stated support for metering as the fairest way for customers to pay. Metering also has broad customer support, recognising that it is fair to pay according to how much water is used.

N.3 Our programme of progressive metering is underway in London with over 243,564 smart meters installed by the end of 2017/18 (Section 2: Water resources programme 2016-2020). The data from these meters is being used to educate customers on their water consumption, inform our Water Efficiency Smarter Home Visit (SHV) programme and build up our database on water consumption and customer side leaks.

N.4 This section provides an overview of our metering delivery programme in AMP6, the information used to determine our metering programme for AMP7 and beyond and the interconnections between metering and other demand management interventions.

N.5 This appendix should be considered in conjunction with Section 2: Water resources programme 2016-2020 and Section 8: Appraisal of demand options.

B. AMP6 programme

Metering delivery

N.6 The total demand reduction obtained from metering is dependent on the type of metering undertaken and whether it results in a usage reduction, leakage reduction or both. In AMP6, our metering programme included four delivery models: our PMP, bulk metering, optant metering and replacement metering.

[1] Environment Agency and Natural Resources Wales, 'Water stressed areas – final classification', July 2013

Progressive metering programme

N.7 Our PMP applies to any household property where a meter can be installed. This applies to detached, semi-detached and terraced properties as well as metering individual dwellings in small or large blocks of flats.

N.8 PMP metering on household properties provides both a usage benefit, from reduced customer consumption, and a leakage benefit, from the increased ability to detect and repair customer side leaks (CSL).

N.9 Meters can be fitted either externally or internally at a property. This means:

- **External**: a meter is fitted in the pavement in the boundary box which houses the outside stop valve. This meter is fitted at the property boundary so will record leakage on the customer's supply pipe, aiding quicker leakage repair. External meters are also easier to install and read.
- **Internal:** a meter is fitted at the first stop tap inside the property, for example under the customer's kitchen sink. An internal meter is fitted if the property does not have an individual supply pipe.

N.10 Due to the ability to achieve both a usage reduction and leakage reduction (through CSL repair) from an external meter installation, we attempt an external meter installation in the first instance. Where an external meter installation is not feasible, we will conduct an internal meter installation. Meter installations are conducted according to the following hierarchy:

- **External:**
  1) In an existing meter chamber
  2) To replace an existing outside stop valve (OSV)
  3) On the customer side if there is an existing meter chamber
  4) On the customer side to replace an existing OSV
  5) On the pavement side, at least 2m from the point of entry to the building
  6) On the pavement, less than 2m from the point of entry to the building but only where the contractor assesses there is a low risk of leakage or failure based on the material and condition of the supply pipe
- **Internal:**
  7) at the nearest practicable point after the inside stop valve (ISV)

N.11 It is not possible to meter all properties. This applies to properties that:

- Fall outside the above meter location hierarchy
- Have an unacceptable installation health and safety risk
- Are prohibitively expensive to meter
- Require more than two meters per supply to calculate consumption
- It is not physically possible to fit a meter in accordance with our meter installation specification

Bulk metering programme

N.12 Bulk metering refers to the installation of bulk meters on the supply pipes of a block of flats. A small block of flats refers to properties with up to 12 dwellings. These properties are typically converted houses or terraces which have been developed into multiple dwellings. A large block of flats is defined as a property with greater than 12 dwellings, and is typically purpose built rather than converted.

N.13 There is a leakage benefit associated with bulk metering due to the increased ability to detect CSL on the shared supply pipe with smart metering data. There is no additional usage benefit claimed against the options as bulk customers are not billed individually based on their water use.

N.14 Bulk meters are non-revenue meters that meter the supply to a multi occupancy building and thereby measure the water supplied to the whole building. In this case the data is used to understand consumption in the whole building, including communal use and customer supply pipe leakage.

Optant metering programme

N.15 Our optant metering programme applies to customers who request a meter. These meters are used for billing purposes and result in a reduction in usage from reduced customer consumption and reduction in leakage through the detection of CSL.

N.16 As we continue to roll out the fixed network infrastructure and there is greater available coverage, optant meters will be connected to the smart metering network.

Replacement metering programme

N.17 There are two components to our replacement metering programme in AMP6:

- Reactive replacement programme: response to a contact from a metered customer, meter reader or contractor reporting a possible leak, a meter not working or reduced flow. If the meter needs to be replaced, then, in London, a smart enabled meter will be installed. In the Thames Valley, an AMR meter is installed which will become smart enabled following the rollout of our fixed network infrastructure in AMP7.
- Planned replacement programme: generally meters greater than 15 years old (dumb meters) are replaced in London with a smart enabled meter. This can result in a leakage saving through CSL detection and repair. In the Thames Valley, an AMR meter is installed which will become smart enabled following the rollout of our fixed network infrastructure in AMP7.

Developer services programme – new build properties

N.18 Our developer services programme involves the installation of a meter on all new build properties. This meter installation is completed and financed by the developer. Currently, the installation of smart meters by the developer is not compulsory so meters installed under this programme are dumb or Automatic Meter Reading (AMR) meters.

Fixed network infrastructure

N.19 In addition to the type of metering programme undertaken, the type of meter installed influences the total demand reduction achieved. There are three types of meters currently installed on our network:

- **Advanced Metering Infrastructure (AMI):** using our fixed network meter system, meters are read automatically and remotely rather than by a physical meter reading. Electronic readings are passed from the meter through to utility offices for billing and network management purposes. With these systems it is possible to collect more frequent data on water consumption and alarm conditions (i.e. high CSLs).
- **Automatic Meter Reading (AMR):** a meter with a short range radio is installed at each property. The meter reader equipped with a meter reading device is required to walk by the meter in order to take a meter reading but does not require physical access to the meter. This process can also be undertaken in certain circumstances by vehicle, known as drive-by reading. The data is captured electronically.
- **Dumb meter:** a conventional meter is installed with a register dial. Meter reading is undertaken by a meter reader gaining physical access to the meter and visually recording the meter reading. The meter reading can either be recorded in a book or keyed into an electronic meter reading data capture device. Some data capture devices have bar-code readers to record/check the meter serial number.

N.20 In our plan we refer to both AMR and AMI meters as smart meters with the intention that AMI meters become the predominant smart meter in our network.

N.21 In WRMP14 we made the decision to use Advanced Metering Infrastructure (AMI) smart metering technology and phase out dumb meters. This is because smart metering data supports customer usage and wastage reduction, water efficiency programmes and achieves a greater leakage reduction; smart meters provide hourly information which allows continuous flow (indicative of CSL) to be easily and quickly identified. In comparison, dumb meters will only highlight significant changes in overall consumption.

N.22 Smart meters also provide greater insight into asset performance, improving the speed and effectiveness of decision making and enabling investments to be made on a more informed basis. There is also a reduction in the time and cost required to collect readings in comparison with a dumb meter, which requires driving street to street or conducting manual door to door reads. There is also added value for customers being able to access meter reads more regularly, enabling changes in behaviour and putting them in control of their water use. A description of the technology and the assessment of meter technologies can be found in Section 8: Appraisal of demand options.

N.23 To enable AMI smart metering, throughout AMP6 we undertook the process of commissioning a ‘fixed network’. This means we are working with existing telecommunication companies to use their masts as part of our smart metering roll out. These masts will communicate with our AMI smart meters and send the ‘real time’ meter readings to a database. The ‘real time’ data will be available at a minimum of an hourly scale and data is transmitted every three hours.

N.24 In AMP6, we have worked with telecommunications partners to commission 106 primary masts in London. In AMP7, we will commission primary masts in the Thames Valley and micro masts to fill in any coverage gaps created by the primary masts in both London and the Thames Valley. As the fixed network is rolled out, our smart meters are installed with Local Communication Equipment (LCE). These are initially set up as AMR with the capability to be switched to AMI as the fixed network communication masts become available. From 2017, smart meters are fitted in London for all domestic customers with LCEs fitted where a fixed network mast is available.

N.25 Prior to smart metering, we received roughly 2 million meter reads per year. From October 2017, with the rollout of our first smart meters, we received upwards of 5 million meter reads per day.

N.26 In our plan we refer to both AMR and AMI meters as smart meters with the intention that AMI meters become the predominant smart meter in our network.

Monitoring – Smart Metering Operations Centre (SMOC)

N.27 Following the commissioning of a fixed network in London in AMP6, we have established a Smart Metering Operations Centre (SMOC), to monitor the performance data from smart meters installed in AMP6. This team has been established to recognise potential leaks at a customer's property, identify disproportionate consumption to assist in our DMA enhancement programme (Section 8: Appraisal of Demand Management Options) and identify where a meter has gone missing resulting in a drop in communications. In response, the SMOC team will proactively dispatch technicians to investigate meters that are not performing as expected, and refer cases of suspected leakage onto our CSL repair team to facilitate a timely repair.

N.28 In contrast, with traditional or 'dumb' meters, meter issues and suspected leakage would not have been dealt with proactively but rather in response to biannual meter readings.

Metering performance

PMP

N.29 In WRMP14 we forecast that we would install 441,270 household meters over AMP6, however, following an optimisation of the different metering programme types, delivery for the remainder of the AMP was revised to a programme of 300,000. The reduction in household meters was due to the higher than expected number of attempted internal meter installations in flats and converted houses which share supplies. A higher volume of properties requiring an internal installation, particularly in London, meant that the total cost of metering increased as the mix of installations changed from predominantly external to predominantly internal in the areas of London that were being targeted by the PMP programme.

N.30 Internal installations are at a higher cost because of the additional cost to get in touch with customers, book an appointment and the high rate of failure owing to a customer not being at home for the time of that appointment. Internal installations also have a higher risk of being unmeterable due to the presence of communal water supplies and pipework being inaccessible. This incurs an abortive cost and also leads to poor customer satisfaction.

N.31 In response to these lessons from AMP6, planning for AMP7 has included varying the property mix we plan to meter, which directly impacts the installation mix. That is, in addition to our household metering programme, we will be targeting bulk meters to minimise the disruption and risk of failure from internal installations on dwellings within flats. Shifting the short term focus from many internal installations, to few shared supply installations (for leakage detection purposes) will also allow time for internal metering technology to evolve, reducing the volume of properties deemed unmeterable and subsequently moved on to an assessed household charge which is applicable for unmeterable properties.

N.32 Additionally, successful methods of customer engagement have prompted us to implement a multi channelled customer journey that utilises text messages, emails, and online appointment booking to secure appointments, to complement with a higher tariff for customers who refuse to engage with us. This improved method of customer communication has resulted in us installing more than 10,000 meters per month in 2017. Consequently, we are confident that, using these methods of customer communication we can maintain and exceed this level of installation in AMP7.

Bulk metering programme

N.33 In WRMP14, we planned to install approximately 4,700 bulk meters in AMP6, delivering 10 Ml/d of predicted leakage savings. However, we have found that greater leakage reduction benefits than anticipated are being achieved per meter, and this has resulted in early delivery of the leakage reduction target and with fewer meters. Due to this success, we have commissioned a second phase of bulk meter installation to deliver a further 10 Ml/d of leakage savings, and this is on track for delivery by the end of AMP6.

Optant metering programme

N.34 In WRMP14, we planned to install approximately 170,000 optant meters. This has been revised to 86,000 optant meters in AMP6. This is due to the impact that the rollout of PMP has had on our optant uptake. That is, by engaging with and installing meters for PMP customers, we have seen a reduction in the number of customers opting for a meter. This is likely due to the fact that we are proactively installing one for them, and is a pattern we expect to continue into future AMPs as the number of unmeasured customers reduces.

N.35 In 2017 we saw an increase in optant interest compared with the earlier part of the AMP, but this is due to the breaking up of the billing arrangements with some local authority housing into individual accounts; this is forecast to continue for the next few years.

C. Our revised AMP6 metering programme

N.36 Section 2: Water resources programme 2015-2020 outlines our revised metering programme for AMP6.

N.37 In addition, there are three major components to our revised programme: a change in the fixed network rollout and customer journey, a change in metering programme structure and a change to a demand management focus for metering.

Fixed network rollout

N.38 As a result of the challenges associated with internal meter installations, the PMP is expanding into more London Boroughs than originally planned to progress external meter installations. This has required an accelerated rollout of the fixed network across the London Water Resource Zone (WRZ). The forecast number of progressive meter installations in AMP6 has been reduced while the fixed network rollout occurs, and the number of targeted bulk meter installations has been increased to make up for any shortfall in leakage reduction benefits caused by the planned reduction in progressive meter installations by identifying and repairing additional customer side leaks.

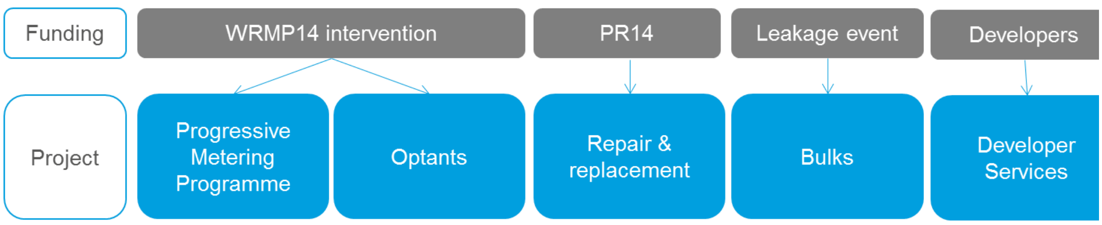
Customer journey

N.39 Our customer journey has also been through a number of changes and is constantly being updated in line with insight and feedback. At the start it was reliant on letters, but it is now multi channelled with emails and SMS. We've also digitalised the appointment booking process through the introduction of online appointment booking which allows our customers to book an appointment 24/7. Introducing new channels has been key in engaging more and more customers and driving appointment uptake at a much lower cost. The PMP has already engaged with over a quarter of a million customers. We are always looking to make changes and improvements to our processes. For example, moving towards doorstep engagement on the day of a meter installation to maximise the likelihood of a customer being home. Another pivotal customer journey change that has been made is the transition from a 2-year comparison journey (from an unmeasured to measured bill) to a 1-year journey. This has allowed us to enhance the comparison phase of the customer journey. With the shorter journey, customers benefit from more touch points over the 12 months via letter, email and text.

Metering programme structure

N.40 During the initial roll out in AMP6, the metering programme operated through the delivery of a series of workstreams funded through multiple routes and constrained by AMP regulatory mechanisms.

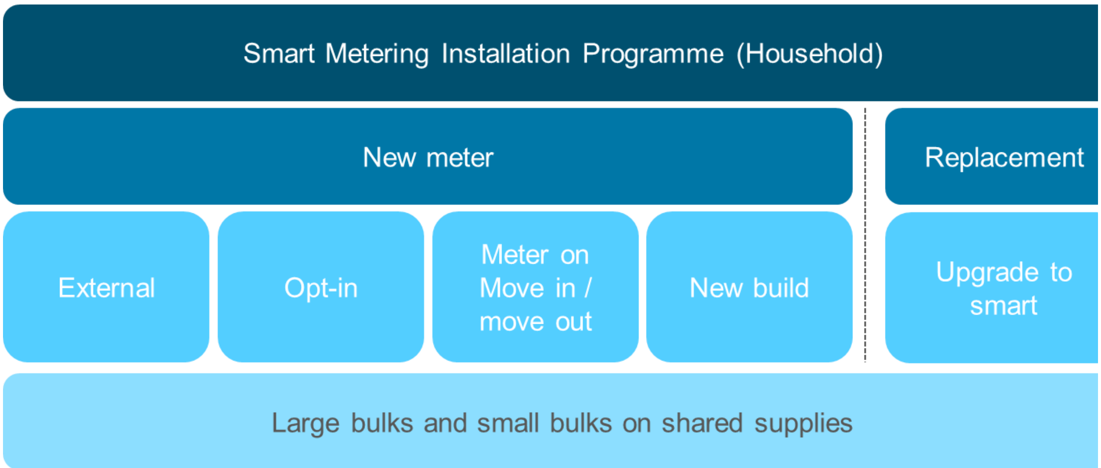
Figure N-1: A work stream/funding stream approach to metering



N.41 The acceleration of the fixed network roll-out in the London WRZ has also accelerated the need to employ a programme-level approach to metering for the remainder of AMP6 and into our future plan (Figure N-2). This is to ensure:

- Consistent messaging to customers in London around smart metering
- The amalgamation of the optant programme and PMP which will lead to an efficient delivery plan and a higher probability of meeting installation targets on both programmes
- The full utilisation of the fixed network and increasing the use of the network capacity under each mast.

Figure N-2: A programme approach to metering



N.42 The key driver for a change in the approach to the metering programme is to ensure that smart metering is viewed as a key strategic driver for our customers. It is critical that the outputs from the programme (improved data accuracy, visibility of our network, value generation from fair and accurate billing, etc.) are integrated into the way we operate as a business. An integrated programme approach will also lead to an efficient delivery programme.

N.43 The replacement programme has also been included in the enhancement programme due to the CSL benefits realised by switching from a dumb meter to a smart meter. A smart meter can detect continuous flow at a much higher resolution than a dumb meter. During a trial in Reading it was found that 11% of the 2,500 replaced meters identified continuous flow that was previously un-identified.

Revised meter roll out – cost implications

N.44 In year one and two of AMP6, there has been a focus on achieving the highest meter penetration by area. However, a high meter penetration by area approach has incurred higher customer engagement costs and higher implementation costs due to the costs incurred from meter installation failure.

N.45 These higher costs are predominantly driven by the higher number of internal meters required than expected in AMP6, and the high number of properties that are deemed unmeterable because they are on a common water supply. An internal meter also has higher ongoing maintenance costs due to the customer engagement required to gain property access for internal meter replacement. Trials have shown that a follow up at change of tenancy can increase meter penetration for previously 'no access' properties through the change of occupier process.

N.46 In years 3 to 5 of AMP6, a leakage reduction focus has been applied to the rollout of meters which has increased metering of shared supplies and small blocks of flats. By comparison, in a revenue only focussed programme, these bulk supplies would not have been a priority because they require bill apportionment. Bill apportionment is a system where a block of flats would be revenue billed for the water consumed and the usage would be split amongst residents. Historically this has not been well received as a proposition by customers.

N.47 Focussing on externally metered properties and shared supplies in the latter half of AMP6 has also focussed the acquisition of street permits for digs. This in turn allows a more cost effective roll out of optant and change of occupier meter installations because the costs associated with isolated street works have been avoided.

N.48 In future, due to the high importance placed on leakage and PCC reduction by both our regulators and customers, we are proposing a combination of household replacement and bulk meter roll out. This approach will also include recovery processes to monitor water savings achieved and assess how they align against our predicted savings, and to maintain a steady increase in our revenue metered customer base to improve our revenue meter penetration.

D. Our future direction for metering

N.49 Section 8: Appraisal of demand options outlines our approach to the optimisation of the level of metering considered in our plan. This includes details of the costs, benefits, delivery methods and constraints associated with metering. This information is used in the Integrated Demand Management (IDM) model to calculate the total benefit expected from metering. Metering is the only feasible demand option that delivers both a leakage and usage reduction.

Meter penetration

N.50 To determine the number of meters that can be installed across our area, we model the number of meters that can be installed externally and internally (based on the 'internal/external split') and then apply a 'survey to fit ratio' to account for the fact that not all properties can be metered.

Internal/External split

N.51 To model the distribution of external and internal meters in a district metered area (DMA), the internal-external split is input to IDM for each property type.

N.52 IDM is the optimisation modelling process we use to develop cost efficient demand management programmes. The IDM model optimises the demand management options by appraising each option individually and assessing the costs and benefits of options that can be promoted in combination. It also involves looking at the optimised combination of demand management options for each DMA and assessing the deliverability constraints.

N.53 The internal/external splits entered into IDM are presented in Table N-1. As an example, assuming 100 detached properties in a DMA, 85% or 85 of these will require an external meter and 15% of the detached properties will require an internal meter.

Table N-1: Internal/external split by property type

Property type	External	Internal
Detached	85%	15%
Semi-detached	80%	20%
Terraced	83%	17%
Small block of flats [dwellings]	25%	75%
Large block of flats [dwellings]	17%	83%
Small block of flats [bulk]	100%	N/A
Large block of flats [bulk]	100%	N/A
Unknown[2]	61%	39%

N.54 To ensure we can provide a realistic and achievable programme for the final WRMP19, we have used number of internal and external installations carried out over the last two and a half years of our PMP (i.e. 2015/16, 2016/17 and 2017/18 to November 2017). This data is the most accurate and current information of internal and external meter installations and allows for a higher proportion of internal installations in comparison with WRMP14.

Survey to fit ratios

N.55 It is not possible to fit a meter at all properties. This can be for a variety of reasons, both technical and economic. Technical reasons include modifications to internal plumbing which prevent fitting a meter (e.g. a fitted kitchen), or there may be more than one supply serving the property. Sometimes fitting a meter would be technically feasible but prohibitively expensive.

N.56 To accurately model the potential number of meters installed in a DMA, a survey to fit ratio is applied to each property type in IDM to identify the number of properties that can have a meter fitted. This means that out of all the properties we survey only a certain percentage can have a meter fitted.

N.57 Using the same example as above, assuming 100 detached properties in a DMA, 85 properties are available for an external meter and 15 an internal meter. Of the 85 properties available for an external meter, 97%, or 82 properties will have a successful external meter installation. Of the 15 properties available for an internal meter, 29%, or 4 properties will have a successful internal installation. This means of the 100 detached properties available for a meter installation, 86 properties will have a successful meter installation.

N.58 The survey to fit ratios applicable to the final WRMP19 are summarised in

N.59

N.60 Table N-2.

[2] If the property type is unknown in IDM, an internal/external split of 39% and 61% is applied respectively.

Table N-2: Survey to fit ratios by property type for the final WRMP19

Property type	External	Internal
Detached	97%	29%
Semi-detached	98%	20%
Terraced	98%	20%
Small block of flats [dwellings]	81%	19%
Large block of flats [dwellings]	73%	17%
Small block of flats [bulk]	65%	N/A
Large block of flats [bulk]	65%	N/A
Unknown[3]	95%	19%

N.61 The meter fit rates presented in

N.62

N.63 Table N-2 are based on access rates during the PMP in AMP6. Compared with WRMP14, the average survey to fit ratio across all properties has remained consistent but with slight changes in the distribution. This is considered to be the most accurate representation of the survey to fit situation into AMP7 and subsequent AMPs.

Customer side leakage reduction

N.64 When a customer has a meter fitted it will identify if there is a continuous flow of water on the property. Continuous flow is where the flow rate does not drop below a minimum consistently for a number of days. Continuous flow on an external meter indicates the customer either has a CSL on their supply pipe or wastage within their property (i.e. a leaking tap, toilet or internal small pipe leak). Continuous flow on an internal meter indicates the customer has wastage within their property.

N.65 When a property is identified as having continuous flow, it is labelled as a point of interest (POI) and our leakage teams will visit the property and prove whether there is a CSL or wastage. For the final WRMP19, it is assumed that a POI is applicable when a property has continuous flow greater than 10l/hr.

N.66 Based on our work in AMP6, the percentage of properties with POI is known by property type. The percentage of these properties that have resulted in a confirmed CSL and the volume of this CSL by property type is also known.

N.67 To optimise the expected CSL benefit from metering, the percentage of properties with a POI and the % of these confirmed as CSL is entered into IDM. IDM will apply this data at a DMA level to identify the metered properties which will result in a CSL. Then, the average CSL

[3] If the property type is unknown in IDM, a survey to fit ratio for external and internal properties of 95% and 19% is applied respectively.

volume expected from each CSL repair is applied to calculate the total expected saving from a CSL repair. This information is based on actual CSL repairs carried out in AMP6 and is summarised in Table N-3.

N.68 Continuing the example from above, assuming 100 detached properties in a DMA, 82 properties have received a successful external meter installation. Of these 82 externally metered properties, 7 properties will have a POI. Of these 7 properties, 57%, or 4 properties, will have a confirmed CSL. Each confirmed CSL is assumed to achieve an average saving of 1,418l/prop/day. Therefore, for the 82 externally metered detached properties in a DMA, a total CSL saving of 5,832 l/prop/day is expected.

Table N-3: Percentage of properties with a POI, % confirmed as CSL and average CSL saving

Property type	% properties with POI	% confirmed as CSL	CSL Saving (l/prop/day)[4]
Detached	8.8	57	1,418
Semi-detached	8.3	63	2,193
Terrace	8.6	60	1,264
Small block of flats [bulk]	7.2	57	1,606
Large block of flats [bulk]	8.7	71	1,050[5]
Unknown	8.5	60	1,484

Usage reduction

N.69 The reduction in customer usage as a result of metering is applied to household metering. This means that we have observed customers changing their behaviour in response to being charged specifically for the volume of water they use.

N.70 Section 8: Appraisal of demand options details the usage savings achieved through household metering for the final WRMP19, which are based on the study 'Using Household Consumption Models to Estimate the Impact of Metering, February 2017'[6] which shows an estimated a 17-19% reduction in overall usage if 20% of unmeasured flats and all unmeasured houses were metered. We have used the 17% figure to represent the change in customer behaviour resulting from being billed on a metered tariff. It does not include any savings achieved from a CSL fix or the customer taking part in any Water Efficiency interventions.

One year journey

N.71 The usage reductions are applied in IDM based on customers changing their behaviour over a one year journey. This is based on the current PMP which allows for an adjustment period of one year between the meter being installed and activated and the customer being billed on a

[4] Average saving based on properties with a leak greater than 10l/hr
[5] Total CSL savings for large blocks of flats are calculated based on the number of dwellings in each block
[6] Cocks R, '*Using Household Consumption Models to Estimate the Impact of Metering*', February 2017

meter reading. Within this one year window, customers receive comparative bills which show the cost of water on an unmeasured and measured tariff. This incentivises customers to save water prior to being put on a metered tariff at the end of their one year journey.

N.72 This information is included in the optimisation stage of modelling so that the savings expected from household metering do not occur at the same time as a meter install but rather one year after the meter install.

Costs

N.73 The metering costs used in the final WRMP19 are based on actual costs from AMP6. These are higher than the costs used in WRMP14. The differences between the costs used in WRMP14 and the final WRMP19 are due to underestimates in WRMP14 of:

- Overhead costs
- Customer engagement
- Cost of failure

Overhead costs

N.74 Project overheads, including the operation costs of depots, travel required to install meters, customer engagement and the requirement to extend the fixed network were not factored into the total costs for WRMP14. The supplier in WRMP14 also underquoted for the rollout of the metering programme and then did not deliver.

N.75 In AMP6, we have rectified the issues concerning the supplier by engaging a new supplier.

N.76 In the final WRMP19, we have rectified the underestimate of overhead costs by including all overheads including depot operation, travel and customer engagement costs in the total required for the installation of household and bulk meters. We have also included an additional fixed cost applied to the metering programme to continue to roll out and maintain our fixed network and enable our SMOC.

Customer engagement

N.77 In WRMP14 we did not anticipate the financial impact of the requirement to install more internal meters (as a result of shared supply pipes, flats, and houses converted into flats, particularly in London) than expected in our plan. This increase in cost was due to the higher level of customer engagement required to book an appointment with the customer and achieve a successful internal meter install. Customer engagement was often constrained by the busy lifestyles of individuals and tenants who wanted limited involvement in the process.

N.78 We also saw an increase in cost due to the customer engagement required for some external installations where an appointment with the customer was required.

N.79 In the final WRMP19, we have rectified the underestimate of customer engagement by using the actual customer engagement costs from AMP6 in our AMP7 plan. We have also implemented some customer engagement improvements such as extending the hours available to make an appointment for a meter installation and conducting a follow up on properties at the change of a tenancy.

Cost of failure

N.80 In WRMP14, we underestimated the cost of failure of meter installations. In AMP6, the upfront engagement costs required for an appointment with our customers, and the low percentage of successful internal meter installations carried a large cost of failure. We also had restrictions on the number of gangs working in any given area as defined on a borough by borough basis by the local highways authority.

N.81 Internal installations are a particular challenge because of the additional cost of getting in touch with customers to book an appointment and the high level of currently unmeterable properties (~63% due to communal water supplies & Pipework/ISV being inaccessible). These incur an abortive cost assigned to each meter install and also lead to poor customer satisfaction as an appointment has been undertaken without a successful installation outcome.

N.82 In the final WRMP19, we have rectified the underestimate of the cost of failure by using the actual customer engagement costs, including those incurred from failed meter installations from AMP6 in our AMP7 plan. We have also updated our 'internal and external split' and 'survey to fit ratios' to be based on data from AMP6. These numbers are used in our IDM model to plan the future metering roll out from AMP7 onwards. Throughout AMP6 and into AMP7, we will continue to work closely with boroughs to ensure we can efficiently roll out our metering programme within any restrictions from local highways authorities.

Billing and affordability

N.83 A measured bill is the fairest way for our customers to pay. Following the rollout of meters, customer bills will change depending on the customer's volume of usage. For many, this will mean a decrease in their bill, and for some this will mean an increase.

N.84 To mitigate the impact of moving to a metered tariff, we have implemented a number of programmes including our online portal, one year journey between being billed on an unmeasured and metered tariff, Smarter Home Visits (SHV) and social tariffs.

N.85 To help our customers adjust to a measured bill, we have ensured that an adjustment period follows the activation of a meter before the measured bill is implemented. This provision comes with a series of comparison bills and emails with the option to switch early if the customer wishes. The decision was made in AMP6 to reduce the period between meter activation and revenue billing as a large percentage of customers who would have been better off (89% of customers with a lower bill) didn't switch and so didn't save money. The initial adjustment period was two years but has been changed to one year as of 1st April 2018. In addition to customers not taking the savings available to them, it also delayed water savings at a network level as the act of the bill being associated with the readings is a key factor in changing behaviour.

N.86 We have also developed our online portal 'My meter online' which allows customers to directly access their meter information and monitor their usage.

N.87 We offer free water saving devices from our website and offer a Smarter Home Visit (SHV) to all customers who have had a meter installed. This water efficiency audit with plumber assistance for households with a meter ensures customers can save both water and money, including the energy costs associated with reduced hot water usage. We have also revised our CSL policy to offer free relays for most customer side leaks.

N.88 We currently offer a social tariff which is available to eligible customers. Enabling legislation for social tariffs was included in the Flood and Water Management Act (2010), and Defra issued guidance in June 2012. Under the guidance, companies can decide whether to introduce a social tariff, who should be eligible and who should pay, and how the tariff should be structured.

Additional metering benefits

Internal process and efficiency

N.89 Through the implementation of a meter data management system (MDMS) we are able to streamline processes and provide cost to serve efficiencies to the business. This data can be utilised across the business.

Water efficiency

N.90 Our AMP6 and AMP7 SHVs to newly metered customers are reliant on the roll out of smart meters.

N.91 See Appendix O: Water efficiency for a full description of our water efficiency programme.

District Metered Area Operability and Mains Replacement

N.92 Once smart meter penetration reaches a significant level within a District Metered Area (DMA), it can be used to more accurately account for usage and CSL within that DMA. This ability to more accurately assign water consumption can increase our DMA operability which, in turn, allows the mains replacement team to focus its interventions in areas with the most mains leakage, thus adding efficiencies to the mains replacement programme.

Innovative tariffs

N.93 The imposition of tariff or pricing controls can be an effective strategy for water demand management if the water rate structures contain strong incentives to conserve water. This view is supported by behavioural economic theory that indicates that consumers may respond to economic incentives by assuming behaviours that maximise their economic self- interest. Tariff charging can be implemented by reforming water rates, introducing surcharges or establishing penalties to deter high water or wasteful water usage practices, and encourage consumers to conserve water. However, tariff strategy with respect to water management has not been adopted in the UK mainly because it requires a high level of metering which may have significant financial impact on low income households of above average size.

N.94 For the final WRMP19, we have assumed a 5% reduction of measured household consumption with the introduction of tariffs in 2035. This is dependent on the successful rollout of the planned metering programme, as tariffs can only be introduced when meter penetration is at least 65% to ensure fairness to our customers.

Wider company benefits and DMA enhancement

N.95 Benefits to the water network will come from utilising the fixed network and metering a high proportion of connections to the network with revenue meters where possible and bulk meters where necessary. As the proportion of metered connections in a DMA approaches 100%, it will become possible to calculate the exact water balance of the DMA and understand the points at which water is being lost from the system. This will enable better understanding of leaks on the network and in buildings, illegal usage, and legitimate high usage.

N.96 There is also an opportunity to move towards an improved intelligence based business model and planning process. Transforming data to intelligence then insight and finally action is the key to helping us effectively improve management of our network and serve our customers. Metering can act as a part of the growing foundation of data being built into the future workings of our company.

Customer advocacy

N.97 Smart metering will help us to drive customer advocacy. Proactively engaging our customers through the progressive metering programme and regularly engaging them on their water use helps us to build a relationship with our customer base which in turn leads to trust and loyalty.

E. AIM demand model methodology report

N.98 Please see below for the report 'WRMP19 AIM Demand Model Methodology Report, July 2018', containing the detailed overview of our Integrated Demand Management (IDM) model.

F. Response to WRMP Directions 2017

N.99 Section F details our response to the Environment Agency representation with respect to Directions 3(f) and 3(h). Further details were requested regarding the cost and delivery method of our metering programme. Our response is presented under subheadings, Our consideration of Direction 3(f) and Our consideration of Direction 3(h).

N.100 **Direction 3(f)** — its intended programme for the implementation of domestic metering and its estimate of the cost of that programme, including the costs of installation and operation of meters

Our consideration of Direction 3(f)

N.101 The cost information provided in this consideration is based on the information published for the rdWRMP19.

N.102 In early 2019, we were challenged by Ofwat to identify cost efficiencies in our metering programme as part of the business planning process. Consequently, we expect the cost information provided in this consideration to decrease.

N.103 Our metering programme comprises Progressive, Bulk, Optant and Replacement meter categories. It is delivered by an outsourced contractor as an integrated metering programme. Section 8 and Appendix N provide detailed information on the different meter types and information on our implementation approach.

N.104 Tables 1 and 2 provide a summary of the cost information and the implementation approach respectively to comply with the Direction.

Cost Information

N.105 Table 1 summarises the combined installation, operation and meter data management costs for our metering programme.

N.106 These costs are provided at a company level for each AMP between AMP7 and AMP11 (2020-2045). A single cost at company level is provided for AMP12 to 22 (2045-2100). There is no new metering activity beyond AMP11, therefore all costs between AMP11 and 22 are maintenance costs (i.e. meter replacement and repeat customer side leakage (CSL) repair).

N.107 The costs provided in Table 1 are the total costs in millions of pounds.

(£ million)	Meter Type	AMP7	AMP8	AMP9	AMP10	AMP11	AMP12-22
Meter Installation and Replacement (CAPEX)	Progressive, Bulks (Small Blocks of Flats), Replacement (Proactive and Reactive), Optants	£439.70	£536.68	£219.52	£259.31	£257.53	£2,596.54
Meter Installation and Replacement (CAPEX)	Bulks (Large Blocks of Flats)	£17.64	£168.66	£4.49	£2.20	£20.99	£74.04
Operation and Maintenance (OPEX)	Progressive, Bulks (Small and Large Blocks of Flats), Replacement (Proactive and Reactive), Optants	£18.08	£16.41	£2.20	£3.62	£0.00	£39.13
Meter Data Management	Progressive, Bulks (Small and Large Blocks of Flats), Replacement (Proactive and Reactive), Optants	£14.30	£23.35	£24.54	£24.54	£23.70	£122.74

Table 1: Meter Installation, Operation and Data Management Costs (costs are shown as total costs in £ million)

N.108 The Meter Installation and Replacement cost includes the cost to engage with customers, survey the site and install a smart meter and meter chamber. From AMP9 onwards, this includes the cost to replace the smart meter once it reaches the end of its life (i.e. 15 years).

N.109 The costs presented in Table 1 are a combined Meter Installation and Replacement cost for our Progressive, Bulk (Small Blocks of Flats), Replacement (Proactive and Reactive) and Optant metering types and a single cost for our Bulk (Large Blocks of Flats) meters. Bulk (Large Blocks of Flats) are provided separately because they have a significantly higher unit cost than all other metering types.

N.110 The costs presented for Operation and Maintenance and Meter Data Management is a combined cost for our Progressive, Bulk (Small and Large Blocks of Flats), Replacement (Proactive and Reactive) and Optant metering types. The Operation and Maintenance cost includes the cost to identify and repair a customer side leak and replace the asset at the end of its life (i.e. replace the customers supply pipe after 40 years).

N.111 The Meter Data Management cost includes the cost to maintain the existing Smart Network (i.e. Fixed Network) masts in London and install and maintain new masts in the Thames Valley. It also includes the cost to expand and maintain our Smart Meter Operation Centre (SMOC). The SMOC teams monitor the performance data from smart meters (i.e. 'meter reads') to help identify potential wastage or leakage issues on a property. They also ensure that meters are operating within their normal parameters (i.e. by noting any erroneous readings that could indicate a meter fault) to highlight any meters that require repair.

N.112 Section 8.0 of the rdWRMP19 provides detail on the different types of metering. Section 8, paragraphs 8.95 to 8.106 describes the cost for different meter types. Paragraph 8.64 provides further detail about our SMOC team. Appendix N, paragraphs N.69 to N.78 includes further information on the type of costs included in each meter type.

Metering programme implementation – what determines which DMAs get metered first

N.113 The implementation of our metering programme will be designed to target areas of high unaccounted for water or leakage.

N.114 Previously, we used a borough by borough approach but, with a wider area of fixed network coverage, we are able to target our installs in a leakage driven methodology. This means that from AMP7 we will prioritise the roll out of the smart metering programme in areas with the highest volume of unaccounted for water. This will be accompanied by a holistic communications policy to clearly articulate instances where we target part of a borough, and, potentially years later, return to complete the remainder of the area.

N.115 As a priority, in areas with high unaccounted for water, we will implement our progressive metering programme throughout the DMA. In instances where it's not possible to install individual revenue meters, a bulk meter will be connected. This will increase the number of measured connection points in the DMA and reduce unaccounted for water and facilitate leakage detection.

N.116 Table 2 provides further details of the implementation approach for each metering type.

Metering type	Implementation approach
Progressive meters (PMP)	In 2015 TW started a progressive (compulsory) metering programme in London. TW proposes to continue the programme in London, followed by the Thames Valley, completing it by 2035. TW is installing smart meters and has installed a fixed network of radio masts to enable efficient collection of hourly data. The programme has been rolled out on a street by street, borough by borough basis with a preference for external meter fit, where this is possible. By 2020 we will have installed over 420,000 smart meters across 15 London boroughs. We intend to continue to roll out the programme on an area basis, however, commencing in AMP7, we will be doing this aligned with District Meter Areas (DMA) rather than on a borough by borough basis. This aids efficient delivery, enables clear local community and stakeholder engagement and will better align with our network operations and leakage detection programmes. This will inform our DMA Enhancement programme in AMP7 to assist with our understanding of the distribution of leakage on a customer's supply pipe and from our water pipe infrastructure.
Bulk meters	Bulk meters are installed on the supply pipes of a block of flats measuring the water supplied to the whole building. They are installed where internal household meter installations are not feasible, and in areas where we suspect

	high levels of leakage. Whilst bulk meters are non-revenue meters, they aid leakage detection through the identification of customer side leaks and to provide a more complete understanding of the distribution of customer side and Thames Water side leaks. The bulk meter installation programme is integrated with the PMP installation programme. This means it will be rolled out at a DMA level to ensure the metering in a DMA is as complete as possible.
Replacement meters	The replacement metering programme comprises two components – 1) Reactive replacement in response to a contact from a metered customer, meter reader or contractor reporting a possible leak, a meter not working or reduced flow. In London, a smart enabled (AMR meter) or AMI meter (Section 8, paragraph 8.59) will be installed and in the Thames Valley, an AMR meter (Section 8, paragraph 8.59) will be installed. AMR meters will become smart enabled following the rollout of our fixed network infrastructure in Thames Valley. 2) Proactive replacement programme: meters greater than 15 years old (dumb meters) are replaced. In London these meters are replaced with a smart enabled meter or AMI meter (Section 8, paragraph 8.59). In Thames Valley, we have not included a proactive replacement programme until the rollout of fixed network infrastructure in this area is complete. A proportion of the planned replacement programme will be rolled out at a DMA level in alignment with our PMP and bulk programmes to ensure smart metering in a DMA is as complete as possible.
Optant meters	Optant meters are installed when a customer requests a meter. TW cannot control the spatial and temporal distribution of requests from customers. All optant meters installed in London are smart ready or AMI meters to enable them to connect to the fixed network delivering usage and leakage saving benefits. All Optant meters in Thames Valley are AMR meters and will become smart enabled following the rollout of our fixed network infrastructure in Thames Valley.

Table 2 - Summary of the meter programme implementation approach

N.117 Direction 3(h) — assessment of the cost-effectiveness of domestic metering as a mechanism for reducing demand for water by comparison with other measures which it might take to meet its obligations under Part III of the Act

Our consideration of Direction 3(h)

N.118 Prior to WRMP09 the metering programme comprised:

- selectively meter new or converted properties, plus properties where a swimming pool is owned or sprinkler is used
- metering on change of occupancy
- optant metering, where a customer requests a meter.

N.119 TW completed assessments for WRMP09 to understand the cost effectiveness of different metering interventions to help decide how to take metering forward. This work concluded that targeted compulsory metering was the best value approach. WRMP09 was approved and TW implemented the compulsory, or progressive, metering programme. In addition TW continued with the optant metering and replacement programme. On approval of WRMP09, TW gained the legal powers to progress compulsory metering.

An extract of data from WRMP09 is provided which presents the AIC values for the meter types.

Table WRP2: Feasible list of water management options

			WATER MANAGEMENT OPTION COST AND SOLUTION - TO BE COMPLETED FOR ALL FEASIBLE OPTIONS										
ROW Ref.	DERIVATION	OPTION DESCRIPTION *(Insert / delete non-numbered lines to suit)*	OPTION REFERENCE No.	WAFU ON FULL IMPLEMENTATION (Ml/d)	EARLIEST POTENTIAL OPTION START DATE (YEAR)	NPV of WAFU (Ml)	CAPEX NPV (£000)	OPEX NPV (£000)	NPV of OPEX SAVINGS (£000)	SOCIAL & ENV. NPV (£000)	TOTAL NPV (£000)	AIC (p/M^3)	AISC (p/M^3)
54	Input as appropriate	Customer Side Management. Specify Below...											
		Change of Occupier (Compulsory Current Powers)		117.52	2010/11	654826.41	334505.74	48283.85	-19842.25	-12378.30	370411.29	55.46	53.57
		Targetted compulsory metering (New Powers)		117.52	2010/11	654826.41	234897.59	40236.54	-19842.25	-12378.30	262755.83	39.02	37.13
		Enhanced water efficiency		10.71	2010/11	38511.57	0.00	57562.69	-1177.98	294.26	57856.95	146.41	147.17
		Optant Metering (Included in Baseline)		8.04	2010/11	45919.81	130720.01	12465.70	-834.59	10400.59	153586.30	310.43	333.08

N.120 Since WRMP09 TW has continued with the strategy approved at WRMP09, namely progressive metering, it has not revisited the cost effective assessment to compare the different types of metering.

N.121 In WRMP14 TW presented a range of integrated demand management programmes which included the different meter types alongside water efficiency programmes, and presented these costs in the WRMP14 data tables. The costs were presented as AIC values (p/m3) to enable comparison with other options. An extract is provided.

London DYAA External Worksheet WRP3

Row ref	Option name	Earliest potential option start date (Year)	Costs based on capacity	WAFU on full implementation (Ml/d)	NPV of WAFU (Ml)	CAPEX NPV (£000)	OPEX NPV (£000)	NPV of opex savings (£000)	NPV of carbon (£000)	Social & Env. NPV (£000)	TOTAL NPV (£000)	AIC (p/m^3)	AISC (p/m^3)
59.1a	Options to reduce Distribution Losses												
	LON-100-0	2015-16	Capacity	177.4	1172457.36	341195.78	89544.00	0.00	2.00	2.41	430744.19	36.74	36.74
	LON-100-35-20	2015-16	Capacity	232.2	1510671.55	526304.90	109059.34	0.00	3.00	3.01	635370.26	42.06	42.06
	LON-100-25	2015-16	Capacity	200.9	1361903.08	509149.53	109891.68	0.00	3.00	3.01	619047.23	45.45	45.45
	LON-105-0	2015-16	Capacity	178.5	1198307.63	366356.50	99582.75	0.00	2.00	2.41	465943.67	38.88	38.88
	LON-105-25	2015-16	Capacity	186.0	1270695.96	520301.68	122213.08	0.00	3.18	3.11	642521.05	50.56	50.56
	LON-110-0	2015-16	Capacity	179.0	1218789.32	393769.88	109868.83	0.00	2.04	2.44	503643.18	41.32	41.32

N.122 For WRMP19 we have presented the updated AIC values for Progressive metering (PMP), Bulk Metering, Replacement Metering and Optant metering in Table 2.

References:

N.123 Information on our metering programme is included in the following sections of our final WRMP19:

N.124 Section 8 and Appendix N include detailed information on metering options.

N.125 Section 11 sets out our preferred programme, this includes the proposed programme to manage demand including metering in each Water Resource Zone.

N.126 Appendix A of the final plan is the data tables.

A Report for

Thames Water

WRMP19 AIM Demand Model Methodology Report

July 2018

Contents

Introduction

Overview

ICS Consulting has been working with Thames Water to update and enhance the WRMP14 AIM Demand Model (IDM) for WRMP19. This is built in the Risk Wrapper framework using the ICS Asset Investment Manager (AIM) decision support tool.

The AIM Demand Model, models the components of demand at DMA level, such as leakage, household (HH) usage, HH wastage and non-household (NHH) consumption. A range of proactive interventions along with their associated costs and benefits are modelled.

AIM utilises an inbuilt optimisation engine to identify the optimal way to deliver the required scenarios, i.e. to determine optimal investment strategies under given constraints. It can be relied upon to give mathematically exact answers that are fully repeatable and reliable.

There are several iterations of the AIM Demand model for WRMP19. This is to enable a) new interventions to be considered, b) components of demand to be modelled differently to WRMP14 and c) the model inputs and assumptions to be disseminated across the business and challenged. It is anticipated that the assumptions and data (numbers and sources) will be revised between iterations and that the list of possible proactive interventions will be narrowed down (screening process).

This report relates to the general methodology applied for the fourth iteration of the AIM Demand Model for WRMP19, i.e. Sprint 4.

AIM

AIM is a fast and intuitive risk-based decision support tool, targeting investment under multiple serviceability and budgetary constraints. It is an asset management environment that has been designed specifically to solve large scale asset and infrastructure investment decision problems at any level of granularity and uses mathematical optimisation to optimise investment and risk in a fast, transparent, and repeatable manner.

AIM is a bottom-up investment planning tool, which allows the user to aggregate proactive investment needs, reactive costs, risks and investment benefits at any level, including asset, cohort, superstring, and geographical area.

Purpose and Structure of Report

This report provides a description of the methodology applied to develop and run the AIM application for the Demand Management options for WRMP19 Sprint 4.

Section 2 provides a description of the structure of the AIM model. This is followed by sections that describe the scenarios run in the model and the additional steps carried out after the AIM demand model is run. A summary is provided in Section 5.

Structure of AIM Model

AIM Structure

AIM is split into two main components; Editor and Risk View. The Editor section is used to construct the model and contains the data, risk map, risk model equations, intervention cost and benefits. It also contains programmes and scenarios, which allows the user to formulate investment questions (range of constraints and an objective) for the optimiser to solve. The Risk View section allows the user to view solutions (outputs) from the optimised scenarios. This can be high level costs and model component values, or broken down to a grouped or asset level. The figure below provides an overview of the structure of AIM v3.0.

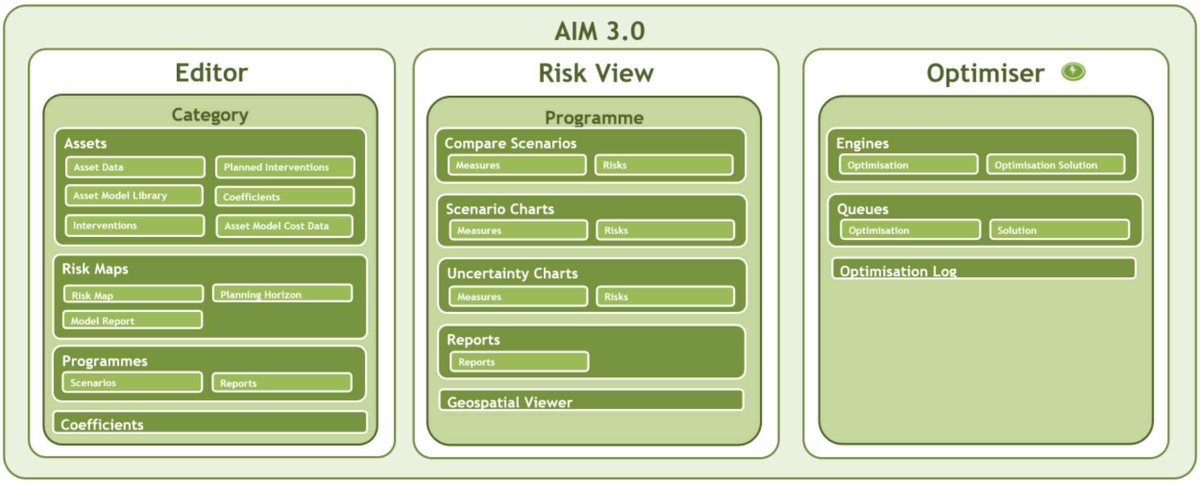


Figure 2.1 AIM Structure

Approach to Model Construction

ICS has worked closely with Thames Water over the last year to:

- Identify the components of demand to be modelled
- Identify, obtain and process DMA attribute data, i.e. data required for use within the models
- Identify the proactive interventions to be considered for WRMP19
- Model the components of demand
- Model the intervention costs
- Capture/model the intervention benefits
- Create and optimise demand reduction scenarios
- Validate optimised scenario outputs
- Present outputs to the business to enable them to be challenged and amended for subsequent runs of the model
- Update the AIM model to incorporate feedback/new data/assumptions/interventions etc
- Provide outputs from optimised scenarios for EBSD
- Ensure alignment of capital maintenance and WRMP

The work has entailed workshops with various teams within the business, e.g. metering, water efficiency etc, to obtain data, assumptions and to disseminate optimised scenario results.

Teams across the business have been heavily involved in the construction of the model to ensure buy-in to the outputs and deliverability of their targets over future AMPs.

Asset Data

AIM contains a set of base data (attributes) relating to water demand. This includes characteristics such as number of properties by property type (detached, semi-detached etc.) and meter status (measured, unmeasured, current PMP), length of distribution mains, modelled levels of leakage, intervention cost and benefit data etc. These attributes are used in the risk model equations, intervention cost models and intervention benefit models (post intervention models).

The base data is at DMA (lowest level of granularity).

AIM Coefficients

AIM Coefficients are used to capture values to be used as multipliers, scalars or variables and any uncertainty around the values. For coefficients with 'normal' distributions, the mean is used as the expected value (used in the standard model runs) and the standard deviation represents uncertainty (used in uncertainty optimisations). For coefficients with 'uniform' distributions, the mid-point of the min and max is used as the expected value and the min and max represents uncertainty around the mid-point.

AIM contains coefficients for the demand model, including assumed costs and benefits of proactive interventions and levels of usage/wastage. These mainly represent variables that are used across multiple models within AIM.

Risk Map

AIM uses "Risk Maps" to link cause and effect. Risk Maps are graphical representations of all the components that are needed to make investment decisions, such as asset type, deterioration relationships, service impact relationships (i.e. linking asset to service failure), interventions costs and impacts, and benefits (i.e. WTP) values.

Assets are linked to risks and service measures through risk nodes and risk links. Each risk node in the map represents a mathematical relationship.

The following Risk Map has been developed for WRMP19 Demand Model Sprint 4.

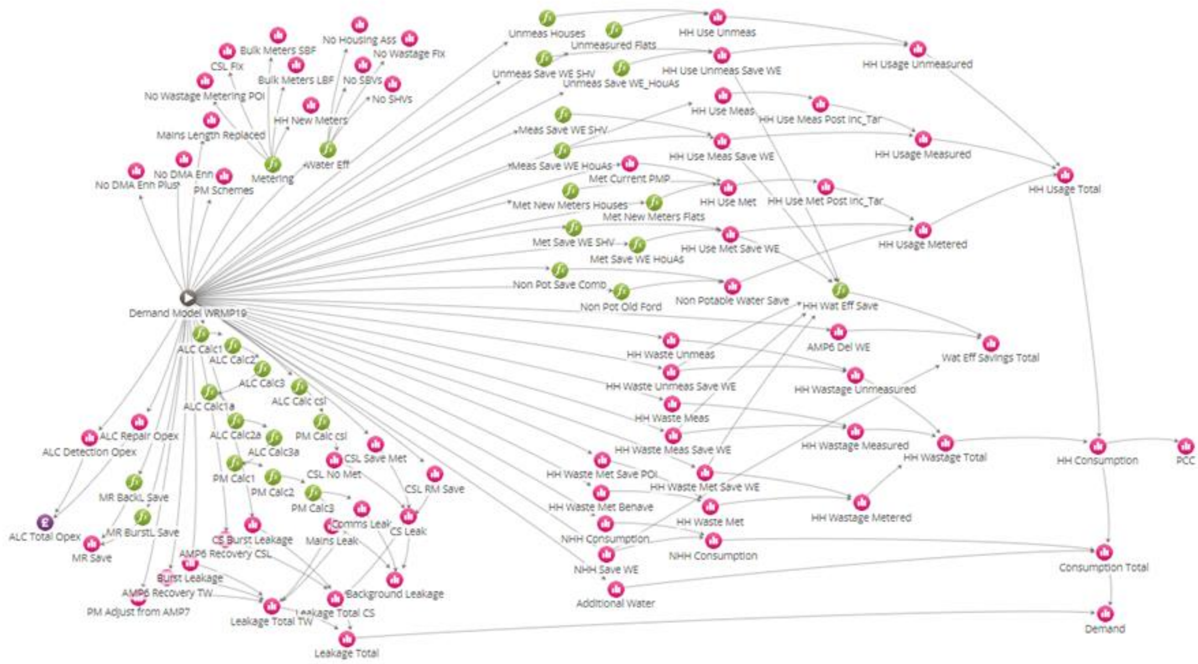


Figure 2.2 Demand Model Sprint 4 Risk Map

The risk map shows a grey node "Demand Model". This is an Asset node that represents each DMA in Thames Water. This is linked to:

- Nodes representing the quantities of each proactive intervention implemented, e.g. number of household meters installed, km of mains replaced (top left corner)
- Nodes detailing the level of leakage and Active Leakage Control (ALC) (bottom left corner).
- Nodes detailing the components of consumption, e.g. household usage and wastage and non-household consumption (right side)

The leakage and consumption components are summed to provide the level of demand.

Household PCC is also calculated.

Each node contains a pre-intervention model and can also, where applicable, contain a post intervention model.

Risk Models

There are a number of inbuilt variables that are used in the risk models and post intervention models in AIM.

YEAR	References the year, e.g. 2017
DYEAR	References the year in the planning horizon, e.g. 2 and is reset to zero in the year of the intervention for the 'intervened on assets'
THIS	Returns the value of the risk model at a point in time

Risk models are entered for each node on the risk map. They calculate the value for the demand component through time, including any deterioration, e.g. leakage.

The demand model can be split into the following main components:

- Household Usage
- Household Wastage
- Non-household Consumption
- Additional Water
- Leakage
- ALC Baseline Opex
- Intervention Quantities

Household Usage Models

Household (HH) usage has been split into:

- Measured HH usage – properties currently metered
- Unmeasured HH usage – properties currently without a meter
- Metered HH usage – properties where a meter is installed as part of a proactive intervention in the future or which are part of the current PMP, i.e. meter installed but not used for billing purposes

HH measured usage is calculated based on the number of currently metered (and billed) properties in the DMA, which is split by property type, e.g. detached, semi-detached, terraced, unknown, dwellings in large/small blocks of flats. This is multiplied by the average measured usage per property for the DMA.

HH unmeasured usage is calculated based on the number of unmeasured properties in the DMA, which is split by property type, e.g. detached, semi-detached, terraced, unknown, dwellings in large/small blocks of flats and further split by ethnicity, e.g. Asian, non-Asian, unknown. This is multiplied by the average unmeasured usage per property value, which is dependent on the property type, ethnicity and WRZ

Metered usage is to account for the property usage associated with newly metered properties, i.e. those properties where a meter is installed as part of a proactive intervention. This also accounts for those households which are part of the current PMP programme, i.e. a meter has been installed, but is not used for billing purposes.

Household Wastage Models

Household (HH) wastage has been split into:

- Measured HH wastage – properties currently metered
- Unmeasured HH wastage – properties currently without a meter
- Metered HH wastage – properties where a meter is installed as part of a proactive intervention in the future or which are part of the current PMP, i.e. meter installed but not used for billing purposes

The litres per property per day wastage values are assumed to be the same for unmeasured, measured and newly metered properties. However, they do differ by property type and location, i.e. London/Thames Valley. The total wastage numbers are based on the l/prop/d values and the mix of properties within the DMA.

Non-Household Consumption Model

NHH consumption is calculated based on the number of NHH properties in the DMA, which is split by NHH property type, e.g. agricultural, Business and social welfare, chemical and metal goods, education, health, hotels and catering, misc manufacturing, misc minor, retail, public admin and dip. and transport construction & other. This is multiplied by the average consumption per property for the DMA.

Additional Water Model

The additional water model is the sum of the water used in the DMA for operational purposes and the water taken that was unbilled.

Leakage Models

Leakage has been split into:

- Background leakage:
    - Distribution Mains leakage
    - Thames Water Communication pipe leakage
    - Customer Side leakage (supply pipes)
- Bursts based leakage
    - Thames Water burst leakage
    - Customer Side burst leakage

The five leakage models are based on the predicted levels of leakage in the AIM distribution mains model for PR19. This is calculated by the DMA leakage statistical models for background leakage and burst based leakage. The DMA total background leakage value is split into the three components based on a methodology agreed and documented for PR19 distribution mains AIM model.

The leakage values can be scaled to ensure the starting total leakage matches a) the annual leakage value in the water balance/annual return or b) the expected leakage value at the end of the AMP (target).

There is no leakage deterioration in the model as it is assumed that leakage will be held constant through the capital maintenance programme.

Weather uncertainty has also been included in the model. This is based on the distribution mains PR19 AIM model and is 2.6%. This will only be utilised if uncertainty scenarios are run in AIM.

Active Leakage Control (ALC) Opex Models

Base level ALC Opex is split into:

- ALC detection opex
- ALC repair opex

The base level ALC detection opex is based on the average number of detection hours in the last 4 AR years. This is multiplied by the hourly detection cost in London/Thames Valley.

The base level ALC repair opex is based on the average number of equivalent supply pipe bursts (ESPBs) in the last 4 AR years. This is multiplied by an average repair cost.

Both detection hours and repairs are assumed to exponentially deteriorate through time at 1.26%.

Quantity Models

Quantity models are provided for the number of:

- HH meters installed (metering interventions)
- Bulk meters installed (metering interventions) split by LBF and SBF
- CSL fixes (metering interventions)
- Wastage fixes (metering interventions)
- Smarter Home Visits (water efficiency)
- Wastage fixes (water efficiency)
- Housing association fixes (water efficiency)
- Smarter Business Visits (water efficiency)
- Pressure Management schemes
- DMA Enhancement schemes
- Km of mains replaced
- Leakage Savings (Mains Replacement)

The quantity models provide a count of the number of assets intervened on. This is set to zero to begin with and is only populated with a value following a proactive intervention.

Interventions in AIM

Potential options for proactive interventions for the Demand model were defined by Thames Water. These are grouped into the following areas:

1. Metering: household metering of combinations of various property types, e.g. houses, dwellings in flats and bulk meters on flats and different technologies (AMI, AMR, dumb)
2. Water Efficiency: household and non-household options including, Smarter Home Visits, Smarter Business Visits, Wastage Fixes, Housing Association Fixes
3. Mains Replacement: replacement of distribution mains and communication pipes for various proportions of DMAs, e.g. 25%, 50%, 75% and 100%
4. Pressure Management: potential DMA pressure management schemes
5. Non-Potable Water: combined options at potential new build opportunities in London – mapped to DMAs
6. DMA Enhancement: two options related to a different type of ALC activity aimed at improving the operation of DMAs
7. Incentives and Tariffs: Introduction of incentives/ tariff on measured and newly metered properties.

Several of the water efficiency interventions have a repeat frequency associated with them, e.g. they occur every 7 years in the same DMA. These are:

- Housing Association Fix – repeat every 7 years
- Smarter Home Visit – repeat every 7 years
- Wastage Fix – repeat every 7 years
- Smarter Business Visit – repeat every year

The costs and benefits associated with these interventions are repeated throughout the planning horizon.

Strategy Trains

The table above details the independent interventions. These are single interventions that can be applied to a DMA once in the planning horizon.

AIM also has a concept of strategy trains. These are combinations of interventions that occur at specified time intervals along the planning horizon. The interventions included in the strategy train and the time period between the interventions is specified by the user. For example, Metering followed by Water Efficiency after 1 year, followed by Mains Replacement after 5 years.

Strategy trains are needed to ensure that there are enough intervention options available to the optimiser in AIM, over the planning horizon, e.g. 25 years and to also reflect the business strategy of Thames Water over time.

AIM optimises when to start the strategy train and then carries out all interventions within the train at the user specified intervals.

ICS worked with Thames Water to identify rules and orders of interventions. For example, pressure management would precede full DMA mains replacement by at least 10 years.

Quantity of Interventions per DMA

The interventions are applied at DMA level and involve either the DMA entity or objects within the DMA having something applied. For example, pressure management occurs on the "DMA", whilst mains replacement is applied to pipes within the DMA and metering/water efficiency is applied to properties within the DMA. The quantities for each intervention reflect this, for example km replaced, number of properties metered, number of DMAs pressure managed.

Intervention Costs

The costs associated with each intervention are made up of one or multiple cost models. These cost models represent the elements associated with the intervention. For example, the costs associated with metering have been split into four components a) meter installation, b) meter reading, c) supply pipe replacement and d) meter replacement. These have been split down further based on the property group, e.g. houses, dwellings in flats and bulks.

The cost models are based on EES v9.3 models or alternative cost models that have been signed off by the business.

Intervention Benefits (Post Intervention Models)

The benefits from the interventions are entered as Post Intervention Models on the risk node in the risk map for which they are applicable.

<u>Metering</u>

HH metering interventions can reduce a) usage, b) wastage and c) customer side leakage. Metering houses / dwellings in flats reduces all three, whilst bulk metering provides only a customer side leakage reduction.

The usage reductions are based on behavioural change of customers. This behavioural change is linked to the two-year "metering journey". There is an initial reduction in usage following the initial engagement with the customer through the installation of the meter. However, the complete behavioural change (reduction) is only fully realised once the customer is billed based on their meter readings, i.e. the year after the meter is installed.

The usage reductions have been assumed to be:

- 10% of complete reductions in year of intervention
- 100% of complete reductions in year after intervention

Metering also reduces customer side leakage (CSL). This is due to the installation of household or bulk meters providing information on the volume of water which highlights points of interest (POIs), i.e. high volumes per building. The points of interest are investigated and classed as either CSL, wastage or not proven. If they are found to be CSL they are fixed and the associated savings recorded.

The CSL savings from metering are captured in the risk map/model as negative values (i.e. represents savings).

In addition to POIs which result in CSL fixes, some POIs were found to be due to wastage and Thames Water also fixes these. The wastage savings from metering are captured in the risk map/model as negative values (i.e. represents savings).

Water Efficiency

Benefits for water efficiency interventions were provided by Thames Water and are shown in AIM as negative values, thereby representing the savings. All water efficiency interventions linearly decay over 7 years.

AIM has been set up to assume a repeat frequency for some water efficiency interventions, i.e. return to same DMA and perform the same activity, this could be to the same properties as visited previously or different properties within the DMA.

Mains Replacement

Full DMA Replacement benefits use the same calculations as the DMA Replacement intervention in the Distribution Mains AIM model. The three partial mains replacement interventions 25% to 75% are based on the replacement of the most to least cost beneficial (leakage only) pipes within the DMA. For example, Partial DMA Replacement 25%, replaces 25% of the DMA length with the lowest leakage cost benefit ratio (i.e. most leakage benefit for least cost).

These values have been derived from running the AIM distribution mains model assuming all pipes are replaced. The costs and leakage benefits from this scenario have been aggregated to superstring level and used to define the 3 partial DMA replacement groups.

Pressure Management

The theoretical DMA pressure management intervention reduces a) distribution mains leakage, b) Thames Water comms leakage and c) customer side leakage. The percentage reduction in all three leakage components is based on the percentage reduction in pressure the scheme achieves. For example, a 10% reduction in pressure provides a 10% reduction in all leakage components.

Non-Potable Water

For the non-potable water intervention option, a summary of yearly usage savings and costs were provided by DMA along with a grouping of DMAs into opportunity groups. The benefits per DMA varied over the 25 years as the developments were built. There is an initial phase where the demand savings grow on an annual basis, and at some point over the 25 years the savings become constant each year.

Scenarios

Overview

A number of scenarios can be applied to the economic model to support the business in answering a variety of questions. Questions such as:

- What happens to demand and its' components when we do zero proactive investment?
- What level of proactive investment is required to achieve a given level of demand/consumption/leakage? Or
- What level of proactive investment is required to minimise whole life cost across the asset base?

To answer each question a scenario is created which defines the target of the optimisation, i.e. objective. These include:

- Risk based
    - Related to the service measure nodes on the risk map, e.g. minimise consumption
- Financial based
    - Related to the financial nodes on the risk map, e.g. minimise ALC opex
- Built-in-objectives (either minimise or maximise) over the planning horizon
    - Investment: includes the capex and opex costs of the interventions
    - Whole life cost (WLC): includes the financial nodes on the risk map with the intervention capex and opex models
    - Note: Whole life benefit (WLB) and Whole life net benefit (WLNB) scenarios cannot be run as there are no willingness to pay (social valuations) included in the model

Scenarios can also be run in AIM to determine the optimal level of investment and intervention mix, based on a number of constraints. These constraints may include:

- Budget constraints
    - Example 1: I have a fixed budget of £X, where should I spend my money?
    - Example 2: My budget has been cut, what is the effect?
- Serviceability constraints
    - Example 1: How much will it cost to keep "a" constant for "b" years?
    - Example 2: How much will it cost to reduce "a" to "a1" over "b" years?
- Asset count based constraints
    - Example 1: I want to replace 30 assets, which ones should I replace?

Starting Values

The AIM demand model has been run for the 'Reactive Only Maintenance' scenario to generate starting levels of risk, i.e. consumption, leakage etc. This scenario provides the starting values for each node on the risk map, and also their value throughout the planning horizon.

The table below shows the AIM starting value for key nodes on the risk map and also the corresponding value from Annual Return 2016 ("DWRMP19 Appendix N - Metering 011217_2.docx").

Table 3.1 Comparison of AIM Starting Values and AR16 Values for Demand Components

Demand Component	AIM 2016	AR 2016
Demand Total	2,546.9	2,599.79
Leakage Total	591.77	642.50
Consumption Total	1,955.2	1,957.29
Additional Water	44.39	49.18
NHH Consumption	505.92	505.90
HH Consumption	1,404.90	
Unmeasured HH Consumption	1,005.75	1,007.26
HH Usage Unmeasured	936.59	
HH Wastage Unmeasured	69.17	
Measured HH Consumption	399.12	394.95
HH Usage Measured	363.31	
HH Wastage Measured	35.81	

The starting values of demand differ between AIM and Annual Return 2016 by 53MLD. This difference is due to the level of leakage which is modelled in the AIM demand model. The AR 2016 value is the company level of leakage. The leakage modelled in the AIM demand model is only distribution mains related leakage (mains, communication pipes and customer side). It excludes other sources of leakage that go into the company value, e.g. trunk mains leakage.

AMP6 Scenario

A scenario was run with constraints set for AMP6 only, i.e. 2017-2019 inclusive. This was required to ensure that the end of AMP6 targets set by the business were achievable with the specified mix of interventions/restrictions on interventions.

The constraints consisted of:

- WRZ total demand constraints to ensure the business reached total demand target set for the start of AMP7
- Water efficiency savings of at least 9MLD
- A maximum of 155,000 new household meters could be installed

The figure below shows the output from the optimised scenario, in terms of the cost per year split by the interventions.

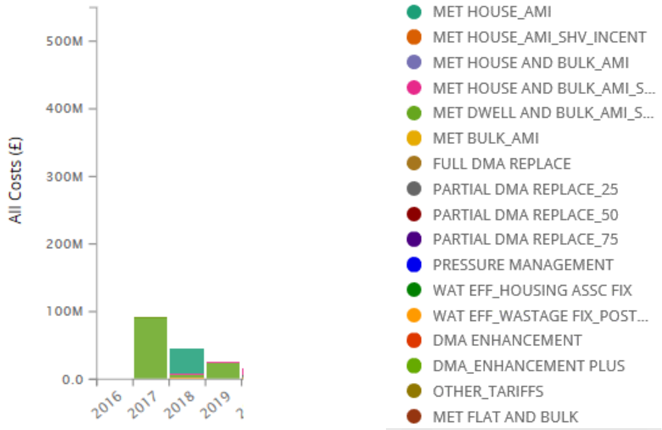


Figure 3.1 AMP6 Scenario Outputs - Cost by Intervention

The AMP6 constraints were included in all demand reduction scenarios to ensure the end of AMP6 targets were met. The same mix of interventions may not be selected in all demand reduction scenarios. This is due to AIM also considering the AMP7-9 targets (constraints). The strategy trains come into action more noticeably over longer time periods, where a combination of interventions on the same DMA throughout the 3+ AMPs needs to be applied.

WRMP19 Demand Reduction Scenarios

A number of demand reduction scenarios were run for each WRZ. These seek to reduce demand in a WRZ to a specified level. These are minimum investment scenarios, i.e. the least proactive cost over the planning horizon. These scenarios consisted of

- WRZ demand reductions at end of AMP7,8 and 9
- Water efficiency savings increasing at end of each AMP (in relation to end of AMP6 value)
- Minimum and maximum numbers of household and bulk meters to install
- AMP6 constraints to ensure required end of AMP6 target levels of leakage, water efficiency savings and meters installed were met
- Minimum numbers of different kinds water efficiency interventions e.g. smarter home visits and wastage fixes

Each scenario was designed to deliver demand targets under different operational strategies to allow Thames Water to assess the impact and costs of delivering different levels of demand reduction under different operational strategies.

It is possible for AIM to exceed the demand reduction targets, this could be due to a) the need to find further demand reductions in future years (overall demand reductions for AMP7-9), b) the strategy trains available and time period between interventions within them, c) other constraints such as minimum number of meters or d) a combination.

A high-level summary report was produced for each scenario, that details the costs and benefits per year for each intervention. This report helps the business to interpret the AIM demand model scenario results which are complex and complicated due to the use of strategy trains. An example of the report is shown below.

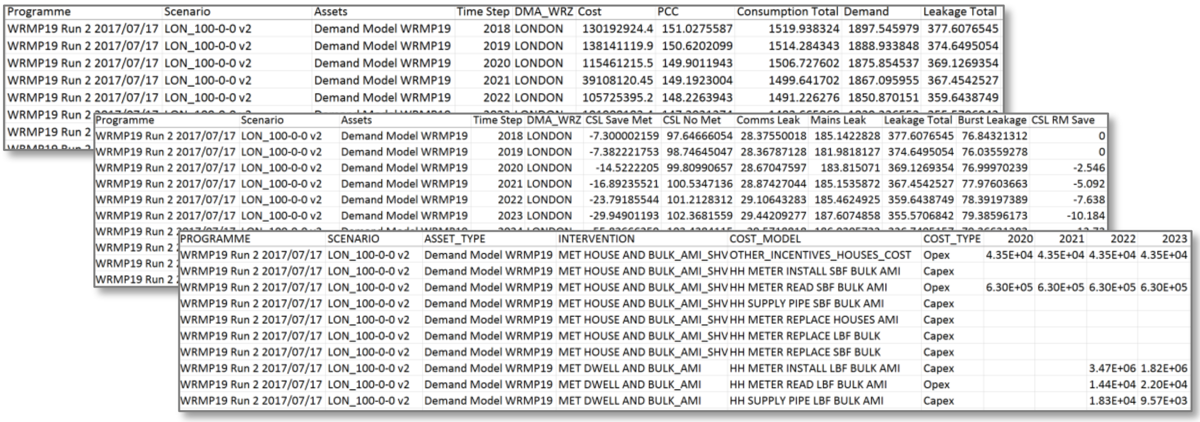
WRMP19 DEMAND OPTION SUMMARY - LONDON | 100-50-25

		AMP6			AMP7					AMP8					AMP9				
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
	Usage Savings (MLd) (benefit decay)	0.00	-0.05	-0.19	-0.32	-0.55	-0.81	-1.10	-1.46	-1.44	-1.06	-1.30	-0.85	-0.92	-0.87	-0.64	-0.81	-1.10	-1.47
Current Measured																			
Quantities	No SHV (000's) (year of intervention)	2.9	8.3	0.0	14.2	3.4	3.3	10.7	1.7	0.0	0.0	2.9	8.5	0.0	14.2	3.4	3.3	10.7	1.7
	No SHV (000's) (cumulative)	2.9	11.3	11.3	25.5	28.9	32.1	42.9	44.6	44.6	44.6	47.5	56.0	56.0	70.3	73.6	76.9	87.6	89.4
Cost	SHV Cost (£m)	£0.19	£0.53	£0.00	£0.91	£0.22	£0.21	£0.68	£0.11	£0.00	£0.00	£0.19	£0.54	£0.00	£0.91	£0.22	£0.21	£0.68	£0.11
Consumption Savings	Usage Savings (MLd) (cumulative)	0.03	0.12	0.10	0.24	0.24	0.23	0.30	0.25	0.18	0.13	0.11	0.17	0.13	0.24	0.24	0.23	0.30	0.25
	Usage Savings (MLd) (year of intervention)	0.03	0.09	0.00	0.16	0.04	0.04	0.12	0.02	0.00	0.00	0.03	0.09	0.00	0.16	0.04	0.04	0.12	0.02
	Usage Savings (MLd) (benefit decay)	0.00	-0.00	-0.02	-0.04	-0.08	-0.13	-0.18	-0.24	-0.28	-0.24	-0.29	-0.17	-0.17	-0.17	-0.10	-0.13	-0.18	-0.24
Unmeasured																			
Quantities	No SHV (000's) (year of intervention)	0.6	0.6	0.0	16.6	3.4	2.7	13.1	2.5	0.0	0.0	0.6	0.6	0.0	16.6	3.4	2.7	13.1	2.5
	No SHV (000's) (cumulative)	0.6	1.2	1.2	17.8	21.2	23.9	37.1	39.5	39.5	39.5	40.1	40.8	40.8	57.4	60.8	63.5	76.6	79.1
Cost	SHV Cost (£m)	£0.04	£0.04	£0.00	£1.06	£0.22	£0.17	£0.84	£0.16	£0.00	£0.00	£0.04	£0.04	£0.00	£1.06	£0.22	£0.17	£0.84	£0.16
Consumption Savings	Usage Savings (MLd) (cumulative)	0.01	0.03	0.02	0.43	0.46	0.45	0.69	0.62	0.48	0.34	0.22	0.16	0.09	0.44	0.46	0.45	0.69	0.62
	Usage Savings (MLd) (year of intervention)	0.01	0.02	0.00	0.42	0.09	0.07	0.33	0.06	0.00	0.00	0.01	0.02	0.00	0.42	0.09	0.07	0.33	0.06
	Usage Savings (MLd) (benefit decay)	0.00	-0.00	-0.01	-0.01	-0.07	-0.15	-0.24	-0.37	-0.49	-0.61	-0.75	-0.42	-0.40	-0.39	-0.14	-0.15	-0.24	-0.37
All Properties																			
Quantities	No SHV (000's) (year of intervention)	13.0	25.4	0.0	48.2	11.8	13.1	36.7	6.5	0.0	0.0	13.0	25.7	0.0	48.2	11.8	13.1	36.7	6.5
	No SHV (000's) (cumulative)	13.0	38.4	38.4	86.7	98.5	111.6	148.3	154.8	154.8	154.8	167.8	193.5	193.5	241.7	253.5	266.6	303.4	309.8
Cost	SHV Cost (£m)	£0.83	£1.62	£0.00	£3.08	£0.75	£0.84	£2.35	£0.41	£0.00	£0.00	£0.83	£1.64	£0.00	£3.08	£0.75	£0.84	£2.35	£0.41
Consumption Savings	Usage Savings (MLd) (cumulative)	0.40	1.06	0.90	1.95	1.93	1.92	2.42	2.02	1.49	1.06	1.04	1.45	1.08	1.98	1.93	1.92	2.42	2.02
	Usage Savings (MLd) (year of intervention)	0.40	0.72	0.00	1.22	0.31	0.37	0.92	0.16	0.00	0.00	0.40	0.72	0.00	1.22	0.31	0.37	0.92	0.16
	Usage Savings (MLd) (benefit decay)	0.00	-0.06	-0.22	-0.38	-0.71	-1.08	-1.51	-2.08	-2.21	-1.91	-2.34	-1.43	-1.49	-1.44	-0.87	-1.09	-1.52	-2.08
Wastage Fix																			
Quantities	No Fixes (000's) (year of intervention)	0.0	7.7	9.4	0.0	12.4	3.1	3.1	10.1	2.1	0.0	0.0	7.7	9.5	0.0	12.4	3.1	3.1	10.1
	No Fixes (000's) (cumulative)	0.0	7.7	17.2	17.2	29.5	32.7	35.8	45.8	47.9	47.9	47.9	55.6	65.1	65.1	77.5	80.6	83.7	93.8
Cost	Wastage Fix Cost (£m)	£0.00	£0.77	£0.94	£0.00	£1.24	£0.31	£0.31	£1.01	£0.21	£0.00	£0.00	£0.77	£0.95	£0.00	£1.24	£0.31	£0.31	£1.01
Consumption Savings	Wastage Savings (MLd) (cumulative)	0.00	1.64	3.40	2.88	4.99	4.76	4.42	5.47	4.52	3.31	2.38	3.09	4.30	3.32	5.06	4.77	4.43	5.48
	Wastage Savings (MLd) (year of intervention)	0.00	1.64	2.00	0.00	2.63	0.67	0.66	2.13	0.44	0.00	0.00	1.64	2.01	0.00	2.63	0.67	0.66	2.13
	Wastage Savings (MLd) (benefit decay)	0.00	0.00	-0.23	-0.75	-1.27	-2.17	-3.16	-4.24	-5.63	-5.20	-4.14	-5.07	-3.23	-3.55	-3.78	-2.61	-3.16	-4.25
Housing Association Fix																			
Quantities	No Fixes (000's) (year of intervention)	0.0	0.0	3.7	1.4	0.0	4.4	1.5	0.8	0.3	0.2	0.0	0.0	3.7	1.4	0.0	4.4	1.5	0.8
	No Fixes (000's) (cumulative)	0.0	0.0	3.7	5.1	5.1	9.5	11.0	11.8	12.1	12.3	12.3	12.3	16.0	17.4	17.4	21.8	23.3	24.1
Cost	Housing Association Cost (£m)	£0.00	£0.00	£0.09	£0.03	£0.00	£0.10	£0.04	£0.02	£0.01	£0.00	£0.00	£0.00	£0.09	£0.03	£0.00	£0.10	£0.04	£0.02
Consumption Savings	Usage Savings (MLd) (cumulative)	0.00	0.00	0.06	0.07	0.06	0.11	0.12	0.10	0.08	0.06	0.04	0.03	0.07	0.07	0.06	0.11	0.12	0.10
	Usage Savings (MLd) (year of intervention)	0.00	0.00	0.06	0.02	0.00	0.07	0.02	0.01	0.00	0.00	0.00	0.00	0.06	0.02	0.00	0.07	0.02	0.01
	Usage Savings (MLd) (benefit decay)	0.00	0.00	0.00	-0.01	-0.02	-0.03	-0.05	-0.07	-0.10	-0.13	-0.09	-0.08	-0.10	-0.05	-0.04	-0.04	-0.05	-0.07
Smarter Business Visit																			
Quantities	No SBV (000's) (year of intervention)	1.6	2.5	2.7	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	No SBV (000's) (cumulative)	1.6	4.1	6.8	9.9	13.2	16.5	19.8	23.1	26.4	29.7	33.1	36.4	39.7	43.0	46.3	49.6	53.0	56.3
Cost	SBV Cost (£m)	£0.66	£1.03	£1.12	£1.25	£1.35	£1.36	£1.36	£1.36	£1.36	£1.36	£1.36	£1.36	£1.36	£1.36	£1.36	£1.36	£1.36	£1.36
NHH Consumption Savinç	NHH Consumption Savings (cumulative)	2.52	5.56	8.26	10.60	12.55	13.96	14.83	15.15	15.28	15.34	15.37	15.37	15.37	15.37	15.37	15.37	15.37	15.37
	NHH Consumption Savings (year of intervention)	2.52	3.40	3.55	3.70	3.83	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84
	NHH Consumption Savings (benefit decay)	0.00	-0.36	-1.21	-2.56	-4.44	-6.86	-9.84	-13.36	-17.08	-20.85	-24.67	-28.51	-32.36	-36.20	-40.04	-43.88	-47.73	-51.57
Water Efficiency Sub Totals																			
	Opex (£m) (Annual)	£1.49	£3.42	£2.15	£4.36	£3.34	£2.61	£4.05	£2.80	£1.57	£1.36	£2.19	£3.77	£2.40	£4.47	£3.35	£2.62	£4.05	£2.80
	Usage Savings (MLd) (cumulative)	0.40	1.06	0.95	2.02	1.99	2.03	2.53	2.12	1.57	1.12	1.08	1.47	1.15	2.05	1.99	2.04	2.53	2.12
	Wastage Savings (MLd) (cumulative)	0.00	1.64	3.40	2.88	4.99	4.76	4.42	5.47	4.52	3.31	2.38	3.09	4.30	3.32	5.06	4.77	4.43	5.48
	NHH Consumption Savings (MLd) (cumulative)	2.52	5.56	8.26	10.60	12.55	13.96	14.83	15.15	15.28	15.34	15.37	15.37	15.37	15.37	15.37	15.37	15.37	15.37
	Total Demand Savings (MLd) (cumulative)	2.92	8.26	12.62	15.51	19.53	20.76	21.78	22.74	21.37	19.77	18.82	19.93	20.82	20.75	22.42	22.17	22.33	22.97
Non Potable Water																			
Old Ford																			
Cost	Old Ford (£m)	£0.00	£0.00	£0.00	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29
Consumption Savings	Consumption Savings (MLd) (annual)	0.00	0.00	0.00	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Combined Option																			
Cost	Combined Option (£m)	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
Consumption Savings	Consumption Savings (MLd) (annual)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other																			
Incentives																			
Cost	Incentives (£m)	£0.01	£0.04	£0.04	£0.08	£0.09	£0.11	£0.14	£0.14	£0.14	£0.14	£0.14	£0.14	£0.14	£0.14	£0.14	£0.14	£0.14	£0.14
Consumption Savings	Usage Savings (MLd) (annual)	0.12	0.29	0.28	0.48	0.54	0.60	0.74	0.76	0.75	0.75	0.75	0.75	0.75	0.94	1.03	1.03	1.03	1.03
Tariffs																			
Cost	Tariffs (£m)	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.02	£0.02	£0.02	£0.02	£0.02
Consumption Savings	Usage Savings (MLd) (annual)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.29	0.29	0.29	0.29
Totals																			
Cost	Capex (£m) (Annual)	£193.78	£124.08	£134.51	£104.15	£26.75	£91.07	£85.45	£340.31	£0.00	£0.00	£33.86	£6.65	£588.81	£5.28	£0.00	£11.56	£11.08	£141.37
	Opex (£m) (Annual)	£3.50	£6.03	£4.04	£11.33	£12.13	£13.86	£15.17	£27.93	£19.91	£19.68	£20.98	£22.11	£48.24	£38.08	£36.98	£36.25	£37.69	£44.46
	Combined Capex/Opex (Non-Pot) (£m) (Annual)	£0.00	£0.00	£0.00	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29	£0.29
	ALC Baseline Opex Savings (£m) (cumulative)	-£1.57	-£2.31	-£3.45	-£3.50	-£3.54	-£4.02	-£4.07	-£4.79	-£4.85	-£4.91	-£5.14	-£5.21	-£5.95	-£6.03	-£6.11	-£6.19	-£6.27	-£7.42
Demand Savings	Consumption Savings (MLd) (cumulative)	4.44	11.88	17.53	25.10	32.20	40.60	48.11	67.89	74.94	80.33	79.38	80.51	103.09	113.58	125.91	125.67	125.82	126.46
	Leakage Savings (MLd) (cumulative)	13.13	24.61	32.25	42.38	48.52	60.81	69.71	103.46	104.40	105.49	108.25	111.68	158.17	162.10	163.58	165.18	166.88	181.95
	Total Demand Savings (MLd) (cumulative)	17.57	36.49	49.78	67.48	80.72	101.41	117.82	171.35	179.34	185.83	187.63	192.19	261.26	275.69	289.49	290.84	292.70	308.41
	Consumption Savings (MLd) (year of intervention)	4.44	7.30	5.88	9.26	8.76	10.41	9.51	21.69	5.24	4.80	5.19	7.17	28.55	6.42	8.29	6.46	6.97	7.67
	Leakage Savings (MLd) (year of intervention)	13.13	11.34	7.38	7.39	3.51	9.58	5.83	30.78	0.01	0.00	1.86	2.30	46.19	2.37	0.00	0.10	0.15	16.94
	Total Demand Savings (MLd) (year of intervention)	17.57	18.64	13.26	16.65	12.28	19.99	15.34	52.47	5.24	4.80	7.05	9.48	74.74	8.80	8.29	6.56	7.11	24.61
	Consumption Savings (MLd) (2 year metering journey)	0.00	1.34	3.25	1.85	3.52	6.58	7.02	10.95	18.39	20.57	0.00	0.00	0.02	20.36	30.81	0.00	0.00	0.00
	Consumption Savings (MLd) (decay of benefits)	0.00	-0.42	-1.66	-3.69	-6.44	-10.15	-14.56	-19.75	-25.01	-28.10	-31.24	-35.10	-37.18	-41.24	-44.74	-47.62	-52.46	-57.97
	Leakage Savings (MLd) (decay of benefits)	0.00	0.00	0.00	0.00	0.00	-0.01	-0.04	-0.08	-0.11	-0.15	-0.19	-0.23	-0.36	-0.50	-0.73	-0.97	-1.22	-1.48

Figure 3.2 Example of Summary Report

Additional Steps After the AIM Demand Model

The optimised demand reduction scenarios have been summarised and provided in the relevant format to be input into EBSD by Thames Water. An example of this data is shown in the figure below.



Programme	Scenario	Assets	Time Step	DMA_WRZ	Cost	PCC	Consumption Total	Demand	Leakage Total
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2018	LONDON	130192924.4	151.0275587	1519.938324	1897.545979	377.6076545
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2019	LONDON	138141119.9	150.6202099	1514.284343	1888.933848	374.6495054
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2020	LONDON	115461215.5	149.9011943	1506.727602	1875.854537	369.1269354
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2021	LONDON	39108120.45	149.1923004	1499.641702	1867.095955	367.4542527
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2022	LONDON	105725395.2	148.2263943	1491.226276	1850.870151	359.6438749

Programme	Scenario	Assets	Time Step	DMA_WRZ	CSL Save Met	CSL No Met	Comms Leak	Mains Leak	Leakage Total	Burst Leakage	CSL RM Save
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2018	LONDON	-7.300002159	97.64666054	28.37550018	185.1422828	377.6076545	76.84321312	0
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2019	LONDON	-7.382221753	98.74645047	28.36787128	181.9818127	374.6495054	76.03559278	0
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2020	LONDON	-14.5222205	99.80990657	28.67047597	183.815071	369.1269354	76.99970239	-2.546
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2021	LONDON	-16.89235521	100.5347136	28.87427044	185.1535872	367.4542527	77.97603663	-5.092
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2022	LONDON	-23.79185544	101.2128312	29.10643283	185.4624925	359.6438749	78.39197389	-7.638
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	2023	LONDON	-29.94901193	102.3681559	29.44209277	187.6074858	355.5706842	79.38596173	-10.184

PROGRAMME	SCENARIO	ASSET_TYPE	INTERVENTION	COST_MODEL	COST_TYPE	2020	2021	2022	2023
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET HOUSE AND BULK_AMI_SHV	OTHER_INCENTIVES_HOUSES_COST	Opex	4.35E+04	4.35E+04	4.35E+04	4.35E+04
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET HOUSE AND BULK_AMI_SHV	HH METER INSTALL SBF BULK AMI	Capex				
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET HOUSE AND BULK_AMI_SHV	HH METER READ SBF BULK AMI	Opex	6.30E+05	6.30E+05	6.30E+05	6.30E+05
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET HOUSE AND BULK_AMI_SHV	HH SUPPLY PIPE SBF BULK AMI	Capex				
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET HOUSE AND BULK_AMI_SHV	HH METER REPLACE HOUSES AMI	Capex				
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET HOUSE AND BULK_AMI_SHV	HH METER REPLACE LBF BULK	Capex				
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET HOUSE AND BULK_AMI_SHV	HH METER REPLACE SBF BULK	Capex				
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET DWELL AND BULK_AMI	HH METER INSTALL LBF BULK AMI	Capex			3.47E+06	1.82E+06
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET DWELL AND BULK_AMI	HH METER READ LBF BULK AMI	Opex			1.44E+04	2.20E+04
WRMP19 Run 2 2017/07/17	LON_100-0-0 v2	Demand Model WRMP19	MET DWELL AND BULK_AMI	HH SUPPLY PIPE LBF BULK AMI	Capex			1.83E+04	9.57E+03

Figure 4.1 Example of AIM Demand Model Output for EBSD

EBSD will optimise the demand options provided by the demand reduction scenarios with supply options to determine the most optimal programme to achieve the required demand reduction. This optimal programme will involve the selection of one of the demand options for each WRZ.

This selected option will provide the business with details on the number, cost and benefits of each intervention and will form the plan for AMP7 onwards.

It is important to note that the AIM demand model only solves for enhancement (WRMP) and not leakage deterioration (capital maintenance). As part of the planning process, it is important to align the mains replacements identified in the Demand Model within the Distribution Mains Model to ensure that the benefits of mains replacement to deliver demand savings over and above deterioration can be represented, and vice versa.

The process developed ensures the most cost/beneficial mains replacement programme is selected for both capital maintenance and WRMP purposes. A summary of the process is detailed in the figure below.

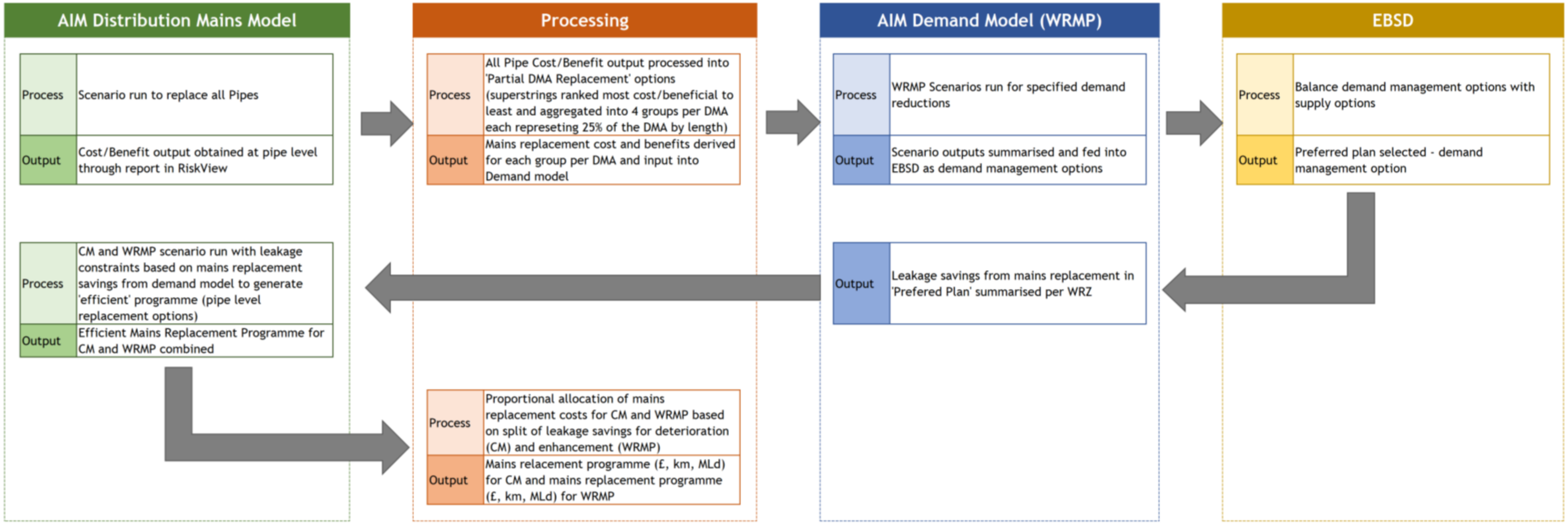


Figure 4.2 **AIM Demand Model and AIM Distribution Mains Model (WRMP and CM) Alignment Process**

Summary

Summary

An Investment Planning Model for demand management options has been developed by ICS for Thames Water to support WRMP19.

A number of cost benefit and demand reduction scenarios have been applied in the model. The investment model is captured in an investment optimisation software application, AIM, and provides a risk based and forward-looking investment planning tool for Thames Water.

The data and risk models underpinning the investment planning tool have been developed over the course of the last year. The model is currently in its fourth iteration. This has enabled to business to review the outputs from previous iterations and challenge/update any data, assumptions, models and interventions.

The optimised demand reduction scenarios have been summarised and provided in the relevant format to be input into EBSD by Thames Water. A high-level summary report has also been produced, that details the costs and benefits per year for each intervention.

EBSD will select an optimal demand option (scenario). The mains replacement element of this scenario is modified to consider efficiencies that can be achieved through pipe level replacement and to align the capital maintenance and WRMP programme.

Document Control

Version History

Version	Date	Comments
1.0	26/09/2018	
2.0	01/10/2018	Updated AR16 leakage value

Distribution

Version	Owner	Proof read by	Issued to
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2.0	William Bloomfield	Kar Yee Dearing	Marissa Van Donkelaar, Bradford Howe (Thames Water)