Our Business Plan for 2020 – 2025

Appendix 6: Wholesale Technical Support Document

September 2018

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Document Amendment History

Version	Status	Date	Amendment to this version
6	Final	02/09/2018	

	Wholesale technical support document			
	Originator		Reviewer	
	Name	Signature	Name	Signature
Section 1: Introduction	Bex Carlisle		Karinn Locke	
Section 2: Method of approach for developing the totex plan	Bex Carlisle		Karinn Locke	
Section 3: Water resources management plan investment programme	Mumin Islam		Ellie Powers	
Section 4: Environmental enhancements programme	Alister Leggatt		Ellie Powers	
Section 5: Non-infrastructure assets	Gerald Doocey		Karinn Locke	
Section 6: Infrastructure assets	Patrick Campbell		Karinn Locke	
Section 7: Business improvement expenditure	Bex Carlisle & David Clifton		Karinn Locke & Mark Hunter	
Section 8: Methodology and assurance	Allan Winkworth		Patrick Campbell	

Section 9: Summary of the Plan	Bex Carlisle		Karinn Locke	
Section 10: List of supporting information	Gina Huxley-Richards		Bex Carlisle	

		Signature	Title	Date
Approver	Mike Pocock		Director of Asset Strategy	31/08/18

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Executive summary

Customers are at the heart of everything that we do, especially investment planning. Since completing our previous business plan, we have continued to engage with and monitor customer and stakeholder needs and preferences on a daily basis. See chapter 3 of the business plan for more detail. The information that we have compiled, along with the results of recent customer and stakeholder consultations, has resulted in four Outcomes supported by totex initiatives for the period 2020/21-2024/25 (AMP7):

Outcome 1: Supplying high quality water you can trust

Customers told us that they want high quality water and that they expect Affinity Water to supply high quality water. We plan to deliver this through our proposed investments in catchment management, lead pipe replacements and by constructing four new nitrate removal plants.

Outcome 2: Making sure you have enough water while leaving more water in the environment

This Outcome reflects our ambition to deliver environmental enhancements above and beyond those delivered between 2015/16-19/20 (AMP6) while continuing to manage the significant triple challenge of sustainability reductions, population growth and climate change. If no action is taken then we estimate that demand for water will outstrip available supply plus headroom by 242Ml/d by 2079/80 across our communities. We have included investment to deliver an additional 36.31Ml/d of sustainability reductions and 24Ml/d of leakage reductions (15%). We also aim to reduce PCC to 129 l/h/d by 2025. However, the cost of replacing lost water is increasing as the 'low hanging fruit' diminishes. Since AMP6 the cost of implementing each Ml of sustainability reduction while maintaining resilience has risen from £0.4m to £1.6m. This is due to an increase in the number and length of network reinforcements and the complexity of solutions required in each case.

Outcome 3: Providing a great service that you value

This Outcome is inherent in every investment that we propose. Customers said that they want water to be affordable, so we will deliver our baseline maintenance plan for £42.4 million less than in AMP6. This is despite a projected 8.5% increase in population between 2015/16-24/25. We have incorporated ambitious efficiency targets into our expenditure proposals and we have included a programme of innovative investment projects to support our vision.

Outcome 4: Minimising disruption to you and your community

This Outcome incorporates a step change in our supply interruption performance. We propose a shift from average interruptions beyond three hours from 6 minutes/household in 2019/20 to 3 minutes/household by 2024/25. We will also invest in our assets to maintain their health and suppress burst and unplanned outage rates at target levels. We will work efficiently and improve investment targeting to keep baseline maintenance costs affordable.

This wholesale technical support document provides a comprehensive summary of the technical aspects that support the Totex Plan for the wholesale business as described in chapter 6 of the business plan. It stands on its own merit and is a record of the data, analysis and results that were used in building the totex requirements to meet Outcomes.

Sub-portfolio	Totex (£m)	Key outputs	Outcomes
Environment	£93.89m	25 investigations and options appraisals on the impact of our abstractions on water bodies A further 36.31Ml of sustainability reductions Six catchment investigations and 17 catchment improvement schemes Improvements to 157km of river Delivering biodiversity obligations at our landholdings	Providing a great service that you value Supplying high quality water you can trust Making sure you have enough water while leaving more water in the environment
Non Infrastructure	£414.69m	Replacement of 11Ml of storage assets and disconnection of 18 disused storage assets Nitrates removal treatment at four sites Full, flexible utilisation of our large Anglian Water import under average and peak conditions Production plant maintenance Reducing PCC to 129 l/h/d by 2025 Eight resilience and environment community pilot schemes 10% reduction in forecast energy consumption and a 40% reduced reliance of grid energy by 2030 Planning for the regional reservoir 117,000 meter replacements	Providing a great service that you value Minimising disruption to you and your community Making sure you have enough water while leaving more water in the environment Supplying high quality water you can trust
Infrastructure	£294.98m	Trunk main renewals Delivering 3 minute supply interruption target 210km of distribution main renewals Reducing customer exposure to lead Redistributing 17Ml of surplus water in the Wey community and maintaining supply resilience A further 80000 new connections A further 15% leakage reductions	Providing a great service that you value Supplying high quality water you can trust Making sure you have enough water while leaving more water in the environment Minimising disruption to you and your community
Business Improvement	£49.54m	Continued business planning IT maintenance	Minimising disruption to you and your community Providing a great service that you value Making sure customers you have enough water while leaving more water in the environment Supplying high quality water you can trust
Wholesale operating costs	£519.88m	Business support and continuity	
Total:	£1372.98m		

Contents

List of figures

List of tables

Abbreviations

Acronym	Definition
ABC	Activity Based Costing
ACL	Active Leakage Control
ACO	Asset Care Optimisation
ACP	Asset Care Planning
ADH	Asset Dependency Hierarchy
AGA	Above Ground Assets
AI	Artificial Intelligence
AIM	Abstraction Incentive Mechanism
AMA	Asset Management Assessment
AMP6	2015/16-2019/20
AMP7	2020/21-2024/25
AMR	Automatic Meter Reading
ANGL	Anglian Water shared resource
APM	Application Performance Management
ARM	Asset Risk Manager (module)
AT	Asset Type
AWL	Affinity Water Limited
AWS	Amazon Web Services
B2B	Business to Business
BAG	(Environment Agency) Benefits Assessment Guidance
BARI	South East Water shared resource
BGA	Below ground Assets
BI	Business Intelligence
BIM	Building Information Management
BSP	Business System Planning
Capex	Capital Expenditure
CAS	Client Assistance Schedule
CCG	Customer Challenge Group
CCW	Consumer Council for Water
CDF	Cumulative Distribution Function
CDM	Community Delivery Model
CESMM	Civil Engineering Standard Method of Measurement
CF	Consequence Factor
CLA	Critical Link Analysis
CMDB	Configuration Management Database
C-MEX	Customer Measure Experience
CMOS	Central Market Operating System
CO2e	Carbon Dioxide equivalent
COPI	Construction Output Price Indices
CP	Communication Pipe
CPPPI	Cost Per Property Per Incident
CR	Criticality
CRC	Carbon Reduction Commitment
CRC	Carbon Reduction Commitment

Acronym	Definition
CRI	Compliance Risk Index
CRM	Customer Relationship Management
CST	Customer Service Technician
Ctrack	Vehicle Tracking system
DAF	Dissolved Air Flotation
DBEIS	Department for Business, Energy & Industrial Strategy
DEAI	Southern Water shared resource
DECC	Department of Energy & Climate Change
DEFRA	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
DG2	Director General 2
DG3	Director General 3
DI	Distribution Input
DLO	Direct Labour
DLP	Data Loss Protection
D-Mex	Developer Measure of Experience
DMP	Distribution Mains Pipes
DO	Deployable Output
DOMS	Distribution, Operation and Maintenance Strategy
DR	Disaster Recovery
DrWPA	Drinking Water Protected Areas
DWI	Drinking Water Inspectorate
DWS	Drinking Water Directive Standards
DWSP	Drinking Water Safety Plan
DYAA	Dry Year Annual Average
EA	Environment Agency
EBSD	Economic Balance Supply Demand
EE	Environmental Enhancements
EGHS	South East Water shared resource
EGI	Equipment Group Identifier
EIM	Enterprise Information Management
ELL	Economic Level of Leakage
EMT	Executive Management Team
ERP	Emergency Response Plan
ERP	Enterprise Resource Planning
ETL	Extract, Transform Load
ETL	Extract Transform and Load
EUC	End User Computing
EWAMS	Enterprise Works and Asset Management Solution
FAC	Financial Account Certificates
FIS	Field Information System
FMEA	Failure Modes Effect Analysis
FT	Field Technician
FTE	Full Time Equivalent
FY	Financial Year
GAC	Granular Activated Carbon

Acronym	Definition
GES/P	Good Ecological Status/Potential
GIS	Geographical Information Systems
GMEAV	Gross Modern Equivalent Value
GSS	Guaranteed Standards Scheme
HMWT	Hertfordshire and Middlesex Wildlife Trust
HR	Human Resources
HRA	Habitats Regulation Assessment
HS2	High-Speed railway 2
HSE	Health and Safety Executive
IaC	Infrastructure as Code
ICA	Instrumentation, Control and Automation
ICFS	Instrumentation and Control Flow Switch
INNS	Invasive Non-Native Species
IoT	Internet of Things
ISO	International Standards Organisation
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITSM	IT Service Management
JML	Joiners, Movers and Leavers
KPI	Key Performance Indicator
LF	Likelihood Factor
LiDAR	Light Detection and Ranging
LIMS	Laboratory Information Management System
LNR	Local Natural Reserve
LoS	Level of Service
LOX	Liquid Oxygen
LT	Leakage Technician
LWS	Local Wildlife Site
M&R	Maintenance and Repair
MCC	Motor Control Centre
MCoW	Marginal Cost of Water
MDM	Master Data Management
MDPs	Master Development Plans
MDS	Market Reporting Solution
MIPSA 2	Mains Infrastructure Preferred Supplier Agreement
ML	Machine Learning
MNI	Maintenance Non-Infrastructure
MoSCoW	Must do', 'Should do', 'Could do' or 'Won't do'
MRDB	Meter Read Database
MSCW	Must have, Should have, Could have, Won't have
MST	Maintenance Scheduled Tasks
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
MZC	Mean Zonal Compliance
NCC	National Computing Centre
NEP	National Environment Program

Acronym	Definition
NERC	Natural Environment and Rural Communities Act 2006
NI	Non-Infrastructure
NPS	National Pollinator Strategy
NPV	Net Present Value
NRSWA	New Roads and Street Works Act 1991
NTU	Nephelometric Turbidity Units
OCC	Operational Call Centre
ODBC	Open Database Connectivity
ODI	Output Delivery Incentives
OEM	Original Equipment Manufacturer
OHSAS	Occupation Health and Safety Assessment Series
OLAP	On-Line Analytical Processing
OLTP	On-Line Transactional Processing
ONS	Office for National Statistics
Opex	Operational Expenditure
OS	Operating System
OT	Operational Technology
P/I/XaaS	Platform/Infrastructure/Everything as a Service
PA	Pesticide Applicator
PACL	Poly Aluminium Chloride
PC	Performance Commitment
PCC	Per Capita Consumption
PCV	Permissible Concentration Value
PDF	Probability Density Distribution
PE	Polyethylene
PES	Payment for Ecosystem Services
PI	Per Incident
PIMM(s)	Production Investment Maintenance Meeting(s)
PIONEER	Pro-active Investment OptimisatioN by Evaluating Expenditure and Risk
PLaN	Pressure Losses across Network
(Non)PLCP	(Non) Pipe Level Conditional Probability
PoC	Proof of Concept
POD	Probability of Default
POLWARN	Pollution Warning
PR	Process
PRV	Pressure Reducing Valve
PS	Process Stream
PSPM	Pumping Station Performance Monitor
PVC	Polyvinyl Chloride
PwC	PricewaterhouseCoopers
R&D	Research and Development
R&M	Research and Maintenance
RAG	Red Amber Green
RAPID	Review of Asset Performance following Infrastructure Disruption
RBD	River Basin District
RBMP	River Basin Management Plans

Acronym	Definition
RGF	Rapid Gravity Filter
RI	Renewal Item
RPA	Robotic Process Automation
RPI	Retail Price Index
RW	Raw Water
SA	Situational Awareness
SAMP	Strategic Asset Management Plan
SCCM	System Centre Configuration Manager
SD	Software Defined
SDM	Service Delivery Map
SEA	Strategic Environmental Assessment
SELL	Sustainable Level of leakage
SgZ	Safeguard Zones
SIM	Service Incentive Mechanism
SM	Service Measure
SOA	Service Orientated Architecture
SOSI	Source Output Sustainability Index
SP	Sub-Process
SPN	Structured Plant Number
SPoF	Single Point of Failure
SRC	Statutory, Regulatory and Compliance
SSF	Slow Sand Filter
SSSI	Sites of Specific Scientific Interest
STPR	Social Time Preference Rate
TBCA	Time Before Customers are Affected
TCO	Total Cost of Ownership
TCO	Total Cost of Ownership
TCs	Tata Consultancy Services
TM	Trunk Main
TMA	Traffic Management Act 2004
TMSR	Trunk Mains and Service Reservoir
TOGAF	To Open Group Architecture Framework
Totex	Total Expenditure
TTRS	Time to Restore Supply
TWT	Treated Water Tank
UKWIR	UK Water Industry Research
UTA	User Acceptance Testing
UTO	Utilities Other (systems specific code)
VPN	Virtual Private Network
VSD	Variable Speed Drive
VUI	Voice User Interface
WACC	Weighted Average Cost of Capital
WAFU	Water Available for Use
WAN	Wide Area Network
WASC	Water and Sewerage Company
WEF	World Economic Forum

Acronym	Definition
WFD	Water Framework Directive
WINEP3	Water Industry National Environment Programme
WISER	Water Industry Strategic Environmental Requirements
WMIS	Work Management Information System
WP	Work Package
WQ	Water Quality
WRE	Water Resources East
(r)(d)WRMP	(revised) (draft) Water Resource Management Plan
WRPG	Water Resource Planning Guide
WRSE	Water Resources in the South East
WS	Wholesale
WSA	WS Atkins
WSP	Water Saving Program
WSZ	Water Supply Zone
WTP	Willingness to Pay
WTWs	Water Treatment Works
WWTW	Waste Water Treatment Works

1 Introduction

1.1 Overview

The purpose of this appendix is to be a first point of reference for any element of the Totex Plan for the wholesale business (hereby referred to as the Totex Plan) that needs to be further understood. Reference is made to specially commissioned reports, studies and existing documents as well as the methods and processes we have employed to derive our forecasts; this is done in a fully auditable manner. This appendix does not duplicate these sources of information and the reader is pointed to these when required. The appendix supports chapter 6 of the business plan and complements the revised draft Water Resources Management Plan (rdWRMP).

This appendix satisfies the overall governance process for the preparation of the Totex Plan. It is approved by the Director of Asset Strategy and is intended for external use, subject to security and commercial confidentiality. The appendix is also closely aligned with internal and external audit findings used throughout the investment planning process. We have addressed issues raised through the audit process and incorporated any necessary changes into our approach.

The sole focus of this appendix is the totex requirements of the wholesale business (water resources and network plus price controls). For details of the Retail Plan please refer to chapter 6 of the main business plan.

In our AMP6 business plan, we committed to a step change in the way that we operate and this earned us enhanced status. Our proposed AMP7 Plan is built on the foundations of the AMP6 Plan.

1.2 Expenditure categories

Proposed expenditure falls into two main categories: -

- **Maintenance, 69%** – baseline expenditure required to deliver current levels of service. This includes maintaining and replacing our assets, producing and distributing water to current customers, continuing to meet existing regulatory and legal requirements and delivering current performance commitments (PCs) and Outcomes.

- **Enhancement, 31%** – expenditure required to improve or expand service. This includes maintaining a positive supply demand balance, satisfying new regulatory and legal requirements and building resilience above and beyond current levels. All enhancement expenditure is supported by customers or has a clear regulatory or statutory driver.

This document presents our maintenance and enhancement expenditure plans.

1.3 AMP6 vs AMP7

AMP7 totex is increasing by 15% (£175.58m) compared with AMP6 and this is driven by the doubling of enhancement expenditure. This is due to an increase in the scope of enhancement work required to meet our environmental obligations combined with a rise in the number, size and complexity of schemes needed to maintain a positive supply demand balance. For example, the size of our catchment management pesticides programme has expanded from metaldehyde only in AMP6 to include total pesticides in AMP7.

The transition from a maintenance focused Totex Plan towards an enhancement focused Plan is summarised in Figure 1-1.

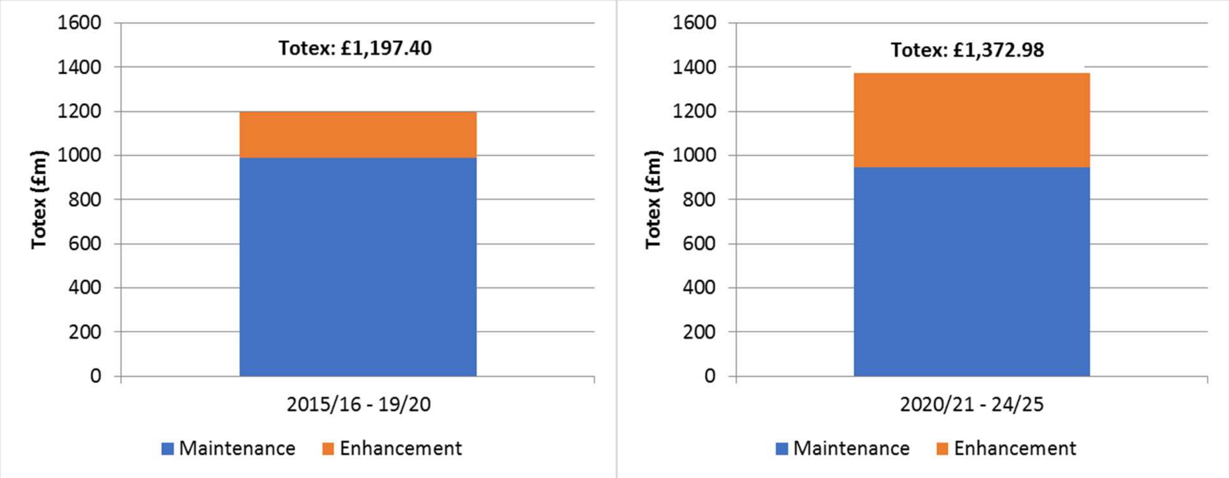

Figure 1-1 Transition from a maintenance focused plan to an enhancement focused plan

1.4 Business plan tables

Totex described in this appendix maps to the following table submissions:

- WS1: wholesale water operating and capital expenditure by business unit
- WS2: wholesale water operating and capital enhancement expenditure by purpose

The reader will be able to find the analysis that leads to the figures in the table submission in this document.

1.5 Numbers and costs

All numbers in tables have be thoroughly checked for accuracy. However, in some instances totals may differ from the sum of individual lines due to rounding, which has been maintained at two decimal places for readability purposes.

1.6 Layout

This appendix describes the process and methodologies used to develop our AMP7 Totex Plan, which has been endorsed by customers through consultation and also takes into account regulatory and stakeholder concerns.

We have set out the document by expenditure sub-portfolio:

- Environmental
- Non-infrastructure
- Infrastructure
- Business improvement

Where a single programme contains several expenditure elements it has been placed in the most relevant sub-portfolio.

The sub-portfolios and programmes contain a mixture of maintenance and enhancement expenditure. For clarity, we have used icons to identify which expenditure items are maintenance and which are enhancement. These items appear throughout the document:

Maintenance expenditure

Enhancement expenditure

The body of the document is set out as described below:

Section Name	Description
1: Introduction	An introduction to the contents and structure of the appendix.
2: Method of approach for developing the Totex Plan	A summary of our approach to estimating expenditure for AMP7.
3: Water resources management plan investment programme	The purpose of this section is to give an overview of the elements of the AMP7 investment programme that arises from our near and long-term plans to balance supply and demand for water. These investments originate from our rdWRMP, which underpins our overall expenditure planning.
4: Environmental enhancements programme	The expenditure described in this section supports our commitments 'supplying high quality water that customers can trust' and 'making sure you have enough water while leaving more in the environment'. This latter outcome reflects our ambition to deliver environmental enhancements above and beyond those delivered in AMP6 while continuing to manage the significant triple challenge of sustainability reductions, population growth and climate change. The expenditure programmes detailed in this section are: • Abstraction impact assessment • Reductions in our abstractions (sustainability reductions) • Catchment management • River enhancement • Biodiversity
5: Non-infrastructure assets	The expenditure described in this section supports our commitments to 'making sure you have enough water while leaving more water in the environment', 'supplying high quality water you can trust' and 'minimising disruption to you and your community'. The expenditure programmes detailed in this section are: • Storage • Pesticides • Nitrate treatment • Conditioning treatment • Contribution for the shared reservoir in Brett Community • Treatment investment • Reducing customer consumption • Resilience and environment community pilot schemes • Upper Thames regional reservoir • Lab equipment

	• Vehicles • Energy strategy • Meter replacement
6: Infrastructure assets	The expenditure described in this section supports our commitments to 'making sure you have enough water while leaving more water in the environment', 'supplying high quality water you can trust' and 'minimising disruption to you and your community'. The expenditure programmes detailed in this section are: • Trunk mains • Distribution mains • Replacement and refurbishment of lead communication and supply and communications pipes • Supply 2040 • Developer services • Maintaining adequate pressure • Leakage • Interruptions to supply • National infrastructure contributions
7: Business improvement expenditure	The expenditure described in this section supports all our Outcomes. It also adds value to, and underpins, our entire Totex Plan. The expenditure detailed in this section is: • Business planning • IT • Spend to save
8: Methodology and assurance	This section describes the methodology we followed to prepare our Totex plan and the assurance processes we have in place. It includes: • Historical expenditure and performance • Costs and estimates • Portfolio optimisation • Service Delivery Map and network management • Resilience • Ongoing asset management
9: Summary of the plan	In this section we summarise the key expenditure areas. The expenditure is split by regulatory category, Outcome and community area. It is also mapped to relevant business plan table submissions.
10: List of supporting information	List of the information and reports that support this document.

2 Method of approach for developing the Totex Plan

2.1 Developing and optimising the Totex Plan

2.1.1 Sources of expenditure requirements

Our Totex Plan originates from four sources:

- **WRMP, 18%** – The WRMP process produces enhancement expenditure required to maintain the supply demand balance. Our Economic Balance of Supply Demand (EBSD) model identifies least cost whole-life solutions to ensure that supply demand deficits are met in all zones and in all years of the planning period. Multi-criteria analysis has been used to shortlist the portfolios of expenditure identified through the EBSD optimisation process. The method is consistent with the modelling exercise carried out by Water Resources in the South East (WRSE) regional group.

- **PIONEER, 11%** – We have continued to utilise and improve our capital maintenance investment optimiser PIONEER (Pro - active Investment OptimisatioN by Evaluating Expenditure and Risk). The optimiser uses our asset data, deterioration curves, consequences and costs calculated per asset. It uses this to determine the optimal investment required to meet customer needs. The assets considered in the optimisation process are production and network assets, e.g. pumps, buildings, telemetry, distribution mains, communication pipes and trunk mains.

- **Business cases, 33%** – Not all expenditure needs can be derived from the WRMP or PIONEER. Robust peer-reviewed business cases were also prepared to define the need, optioneering and selection decisions for large or bespoke maintenance and enhancement expenditure items. Business cases ensure least-cost whole-life solutions are selected by using a net present value (NPV) assessment over a minimum 20-year period. The business cases also document risks, assumptions, dependencies and constraints associated with the preferred solutions. They have been subject to a high degree of challenge and scrutiny both internally and from our external auditors.

- **Deep dives, 38%** – We conducted deep dive sessions with business leaders to agree opex budgets. The deep dives incorporate incremental opex figures from business cases; deliverability allowances for stretching new PCs such as leakage; and ambitious efficiency targets. Where necessary, funding to unlock these efficiencies is included in our capital maintenance plan.

2.1.2 Developing the Totex Plan

The process by which the Totex Plan was developed is summarised in Figure 2-1.

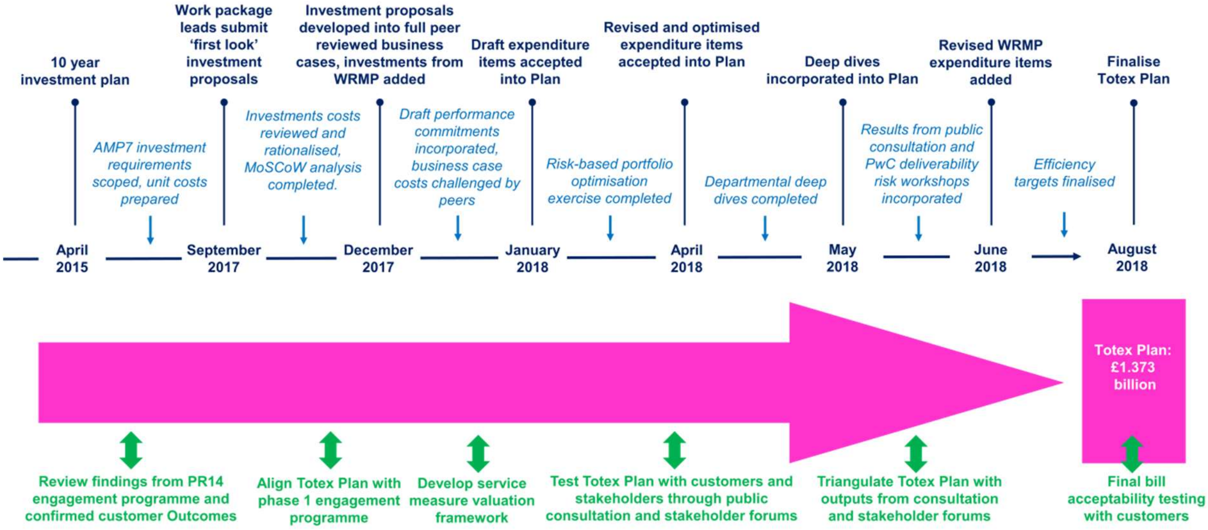

Figure 2-1 Totex plan development

2.1.2.1 April 2015 – September 2017

The starting point for our proposed Totex Plan was the ten-year plan (2015/16-2024/5) developed during the previous price review (PR14). In 2017, we updated the scope of our ten-year plan, by reviewing customer and stakeholder expectations and financial assumptions. We also identified new risks and opportunities. This scoping work formed the structure within which the Totex Plan was developed.

Our ongoing asset data processes provided us with improved information to update our standardised unit costs. These costs have been used in Pioneer and EBSD modelling as well as business cases and the results of the deep dive sessions. Where cost data was unavailable due to the bespoke nature of the subject matter, we obtained quotations from a selection of suppliers or worked with specialist consultants to develop unit cost models.

In September 2017, work package leads produced 'first look' totex proposals which made the case for maintenance and enhancement expenditure items. These were combined with baseline departmental running cost adjustments to produce a first draft totex plan.

2.1.2.2 September – December 2017

The totex proposals were reviewed and challenged by internal stakeholders and sponsors, including our PR19 Steering Committee (SteerCo). This involved a presentation of expenditure proposals to internal stakeholders followed by a challenge and answer session. A whole-life costs assessment was also completed. The drivers and level of necessity associated with each proposal were then mapped and MoSCoW analysis was performed to differentiate the Must Do proposals from the Should Do's, Could Do's and Won't Do's. Findings from phase 1 of our customer engagement programme were communicated to work package leads and sponsors and weaved into investment decision making. In this way, the need, efficiency, optioneering, methodological approach and preferred solution selection decisions were tested and aligned with customer and stakeholder preferences and the Plan was rationalised.

By early December 2017 the team had developed the proposals into full, peer-reviewed business cases. At this time the draft WRMP[1] (dWRMP) was submitted to the Secretary of State, and the schemes required under the 'preferred plan' scenario were incorporated into the Totex Plan

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2.1.2.3 December 2017 – January 2018

In December 2017, Ofwat published its Final Methodology for the PR19 Price Review[2]. Results from the customer engagement programme were used to develop Outcomes and PCs, and expenditure items were updated to reflect delivery of these. Expenditure proposals from business cases were presented to stakeholders from around the business and costs and efficiency targets were rigorously scrutinised, challenged and improved.

PCs were used to develop a comprehensive Service Measures Framework. The framework ensures that service to customers is central to maintenance investment planning. See section 8 for more information.

2.1.2.4 January – April 2018

In January 2018, the business combined all expenditure items into a draft Totex Plan. This Plan was tested in terms of risk (of failing to deliver Outcomes) and affordability through a risk-based optimisation exercise. Optimisation and balancing of the Plan was completed in a holistic manner to ensure the optimum spread of expenditure. The draft Plan and the dWRMP were then tested with customers and stakeholders through public consultation and stakeholder forums.

2.1.2.5 April – June 2018

Between April and June further insights from the customer and stakeholder engagement programme became available, including findings from the public consultations. The resulting triangulation prompted the expansion of our Totex Plan to include provision for even more stretching environmental, drought resilience and demand reduction investments, in line with customer and stakeholder needs and expectations. A series of deep dive session were held with business leaders to test departmental budget allocations in light of the changes. The deliverability risks associated with the revised Totex Plan were also tested through risk workshops, and mitigating actions identified and incorporated into the Plan. This provides assurance that the Plan fulfils customer commitments and legal and regulatory obligations.

2.1.2.6 June – August 2018

Additional work to refine scoping and costing of the items within the Totex Plan was completed and ambitious efficiency targets were incorporated into departmental budgets to ensure value for money. A benefits analysis was performed to ensure alignment between totex and customer needs. This process allowed expenditure to be balanced across business areas, with regard to customer priorities, while ensuring affordability and deliverability. Bill profiles associated with the optimised Totex Plan were tested with customers and the Plan was then finalised.

Throughout the development process, the Totex Plan has received a high degree of challenge and scrutiny from customers, Board members and stakeholders (both internal and external). It has been subject to a rigorous external audit process. The development of expenditure items is explored in further detail in this appendix document.

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[1] *dWRMP December 2017*
[2] *Final Methodology for the PR19 Price Review*

3 Water resources management plan investment programme

3.1 Overview

The purpose of this section is to give an overview of the AMP7 investment programme arising from our near and long-term plans to balance supply and demand for water, as outlined in our rdWRMP. The WRMP has been developed to support our commitment to meet the water supply needs of our customers and stakeholders over the 60-year planning period from 2020/21 to 2079/80. It is a live document that is reviewed annually and updated every five years through public consultation with stakeholders and customers.

Key features of our revised draft plan include:

- completion of our metering programme by 2024/25.
- greater resilience of supply through more robust assessment of our supply capacity going beyond historic drought conditions
- innovative demand management option, including fast data, resulting in a demand reduction of 17 Ml/d by 2024/25
- temporary change to allocation of shared resource to Anglian Water (ANGL), South East Water (EGHS and BARI), and Southern Water (DEAI)
- long term water resource development to allow a new import from the Thames catchment by 2037. The date is sensitive to small changes in supply/demand balance, but this is the earliest date achievable and we expect work to contribute to the scheme to commence during AMP7
- a further 15% reduction in leakage equivalent to 24 Ml/d by 2024/25
- water quality treatment of some of our bulk supply imports so these can be used in all zones
- further sustainability reductions of 36.31 Ml/d average by 2024/25 to meet Water Framework Directive (WFD) objectives and prevent deterioration of water bodies
- further protection of the quality of our water resources through our catchment management programme

Our published dWRMP provides further details on the methodology and approach used[3].

3.2 Methodology

We carried out a public consultation on our dWRMP between March and May 2018 to seek the views of stakeholders and customers on the draft investment proposals contained within it. In our Statement of Response due autumn 2018, we will consider each response together with other feedback that we have received on our proposals. We will revise our dWRMP accordingly in response to customer and stakeholder views, including feedback on technical analysis from the Environment Agency, Ofwat and other stakeholders.

Figure 3-1 depicts how we have developed our WRMP strategy and shows the key factors and components of our WRMP.

[3] *Published WRMP*

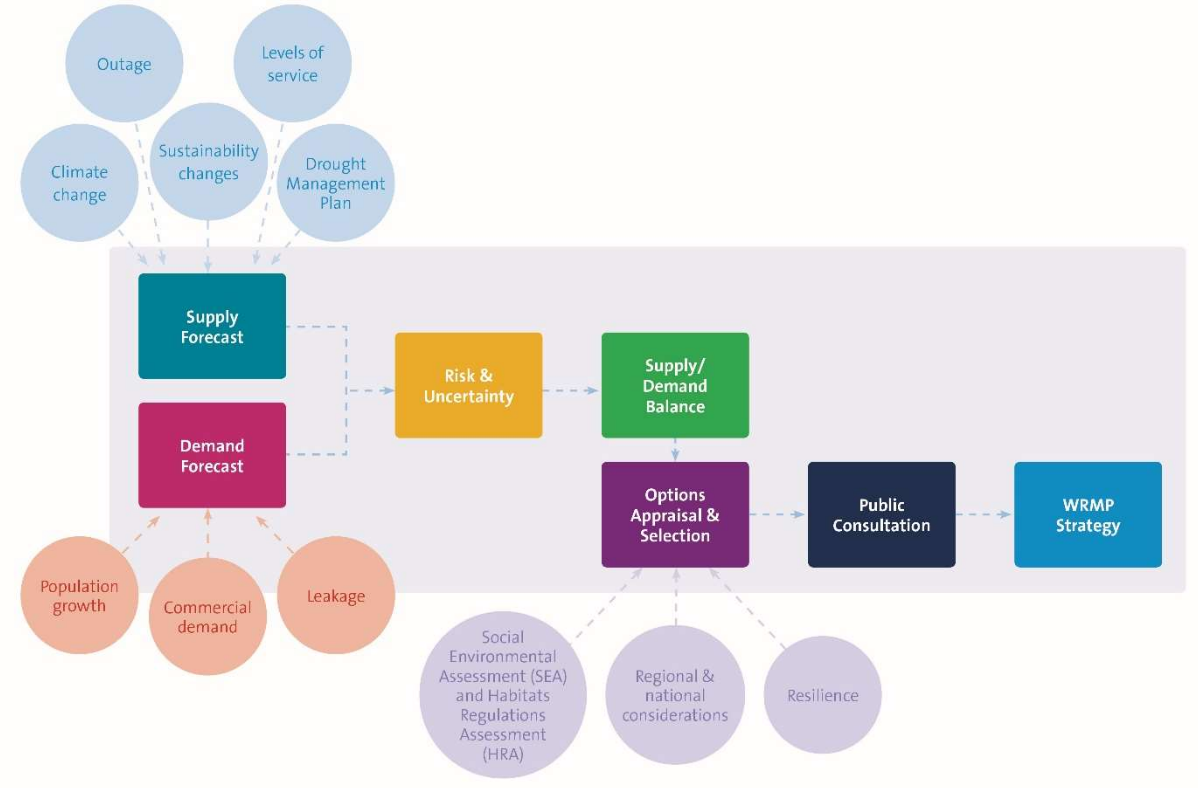

Figure 3-1 Key components of our WRMP

We calculate a baseline supply/demand balance which reflects the baseline water resources situation now and into the future without any interventions. Our supply forecast includes an assessment of factors such as climate change, outage and sustainability reductions. Our levels of service (LoS) for drought actions influence our available supply under drought conditions, which is set out in detail in our Drought Management Plan[4]. Our demand forecast considers population growth, changes in non-household demand and assessments of leakage. There is a degree of uncertainty in our estimates and therefore an allowance is made to mitigate this uncertainty, known as headroom. Consideration of all these components makes our baseline supply/demand balance as illustrated in Figure 3-1.

We are forecasting future deficits in our supply area, i.e. demand is likely to be greater than supply or the volume of water available for use in the future without action. We have therefore undertaken an options appraisal to identify solutions to resolve the deficits to ensure we balance our supply and demand over a 60-year period, up to 2079/80.

Our feasible options to balance supply and demand include schemes to reduce leakage, install smart meters and encourage more efficient use of water with minimal wastage as well as the impact on the development of new supply side options. These are consistent with Government aspirations to reduce per capita water consumption.

We have also identified a number of schemes to provide additional water resources from groundwater, surface water and transfers from neighbouring water companies and third parties within and in close proximity to our boundaries. Each of these options has been defined and priced in accordance with the methodology set out in planning guidelines[5].

[4] Drought Management Plan (due to be published 2018/19)
[5] Water Resources Planning Guideline – The technical methods and instructions, (June 2012)

For each option we have undertaken a Strategic Environmental Assessment (SEA) and, where necessary, a Habitats Regulation Assessment (HRA), to consider whether the option remains feasible should there be environmental concerns.

We have taken an active role in the WRSE project working with the Environment Agency and five other water companies to assess strategic water supply opportunities across the South East of England. The WRSE supply / demand modelling process, encompassing potential options and cross border supplies from all the water companies, has been a crucial component in the development of our WRMP.

Figure 3-2 highlights the various work strands of our WRMP and their relationships with each other. This is how we set about preparing the plan.

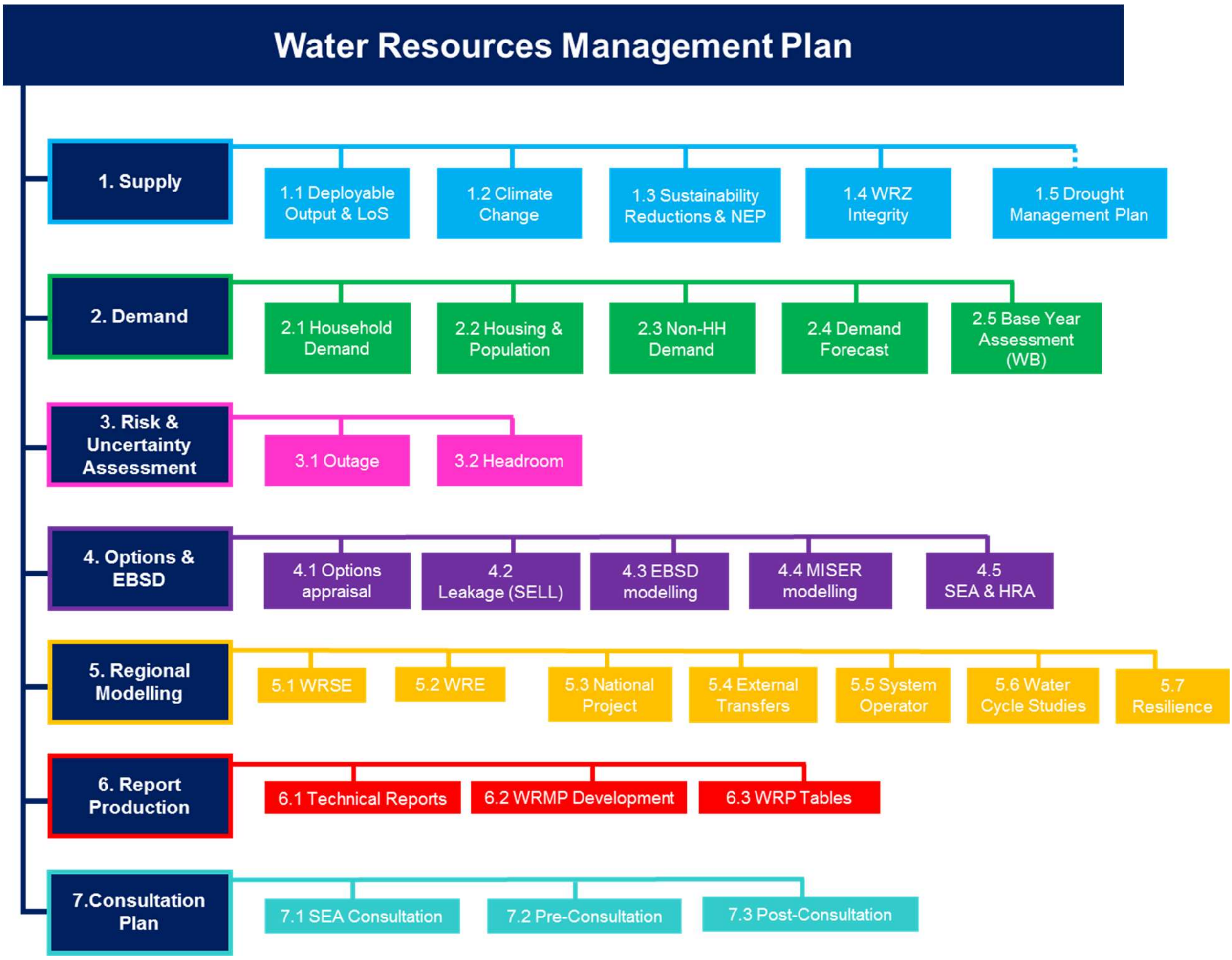

Figure 3-2 Work breakdown structure of our WRMP programme

3.2.1 Compliance

To demonstrate compliance with regulatory obligations and expectations of our key regulatory stakeholders we have followed the latest Water Resource Planning Guideline (WRPG) which was published by the Environment Agency, in collaboration with Ofwat and Defra, in April 2017. We have used the compliance checklist provided to develop and publish our Plan.

Through following the WRPG and compliance checklist we are confident that our plan takes account the relevant legislation set out in the WRPG and taken account of the advice given in the supplementary documents to the WRPG.

3.3 Supply demand programme totex summary

The following table summarises planned AMP7 investment arising from our rdWRMP and explains where to go for additional information.

Name	Description	Totex (£m)	Where to go for more information
Sustainability reductions	Abstraction reductions of **33.71 Ml/d in our Central region and 2.6 Ml/d in our East regio**n in accordance with WINEP3 by 2024 using a combination of voluntary measures under operating agreements and licence changes under s53 of the Water Resources Act. These volumes include a continuation of the River Ver Operating Agreement measures which currently expires in 2020.	58.42	4.8
Leakage reduction	Leakage reductions of **15% in AMP7** on top of the **14% in AMP6.** Further leakage reductions after 2025 to achieve 50% reduction by 2050.	35.00	6.5.1
Water Saving Programme	Completion of our water saving programme and household metering which is forecast to save **18%** per household based on evidence of achievement to date.	75.22	0
Ambitious consumption reduction measures	Further ambitious consumption reduction measures of 12.4% to achieve a normal year annual average PCC of **129** l/h/d by the end of AMP7 in 2024/25 and further reduction to 110 l/h/d by 2040, through metering, fast data, water efficiency measures, smart metering and a behavioural change programme. Long term ambition beyond AMP7 has been accelerated.	65.01	0
Strategic supply transfers	Supply 2040: Enabling 17 Ml/d of surplus water currently trapped in our Wey Community to transfer north and east to replace lost chalk groundwater options as specific options no longer supported by EA	36.67	6.5.4
New resource development	Removal of chalk abstraction development and enabling a new 8 Ml/d abstraction for the greensand aquifer	5.541	5.3.2
Preparation for a regional reservoir	Investment in AMP7 for planning and other items to enable the development of additional resource capacity in the South East in partnership with Thames Water by 2037. Costs agreed with Thames Water. Target date brought forward from 2039 in agreement with Thames Water and in response to DEFRA and NIC recommendations	18.489	5.3.10
Additional transfers	Additional transfer of water from Thames to mitigate the risk to resources from construction of HS2 which is affecting c.60 Ml/d of our resources. New transfers with our neighbours for mutual security and reduction in export to South East Water. Solutions include recommissioning existing connections and new pipe capacity both with new commercial terms.	Funded by HS2 apart from contributions	6.5.6

	New cross border supplies for mutual resilience at High Wycombe and COCF following the 2018 freeze/thaw and dry summer conditions.		
Using our imports to full capacity	Conditioning treatment of our supply from Anglian Water to ensure transfers can be used in any zone in Central Region to meet the challenge of further sustainability reductions and preserve resilience of supply to customers.	13.336	5.3.5
Regional collaboration	Commitment to staged development of WRSE as an independent regional co-ordinator by April 2020 One regional water resources plan by 2021 Integration of WRSE within a national policy framework Clear interface with other regional coordinators e.g. Water Resources East	1.55	7.2.2
Natural capital value	Working with local stakeholders and catchment partnerships to explore the natural capital value where our operations affect the local environment and identify opportunities for the provision of eco-services to local stakeholder groups and communities. BP defined programme through the mobilisation of 8 zonal pilot studies in AMP7 to assess the water environment life cycle of those communities and options for enhanced demand management measures through water recycling and studies to develop the most effective ways of achieving behavioural change for AMP8.	2	5.3.9
Catchment management	Expansion of the catchment management programme to reduce the effect of nitrate and pesticide pollution on our resources.	7.11	4.4
	Total:	**£318.35m**	

Table 3-1 Summary of revised draft plan costs (£m)

3.4 Supply demand programme highlights

3.4.1 Sustainability reductions

Our plan includes investments to reduce abstractions by a further 36.31 Ml/d at average by the end of AMP7. This is higher than our forecasts at PR14.

We planned at PR14 to continue the programme of sustainability reductions in AMP7, recognising the need to balance public water supply with protecting the environment. Our approach to further reductions in AMP7 builds on our knowledge gained from our AMP6 programme and a desire to ensure we are making reductions in locations that benefit the environment. This was consulted on in our 2018 dWRMP. WINEP3 schemes have been used for our business plan submission. As we assumed that these sustainability reductions relate to groundwater abstractions, it is a reduction at average that will have the most environmental benefit. Our revised draft Plan delivers reduction of 36.31Ml/d (average reduction in DO) by 2025. See section 4.8 for more information.

3.4.2 Supply demand balance

Our assessment of water available identifies that our Central and Southeast regions do not have sufficient water for the whole of the planning period to meet customers' need for water.

Figure 3-3 shows our baseline supply / demand balance, combining the regional balances to give the overall position that our WRMP must resolve at a zonal level for the 60-year planning period.

Figure 3-3 shows the baseline supply / demand balance for the whole company (dry year annual average). The deficit is between the blue 'water available for use (WAFU)' bars and the red 'Distribution Input plus Target Headroom' line in Figure 3-3. Our water available for use (WAFU) is calculated from our baseline deployable output (DO), which includes bulk transfers from neighbouring companies, less the impacts of climate change, sustainability reductions and outage.

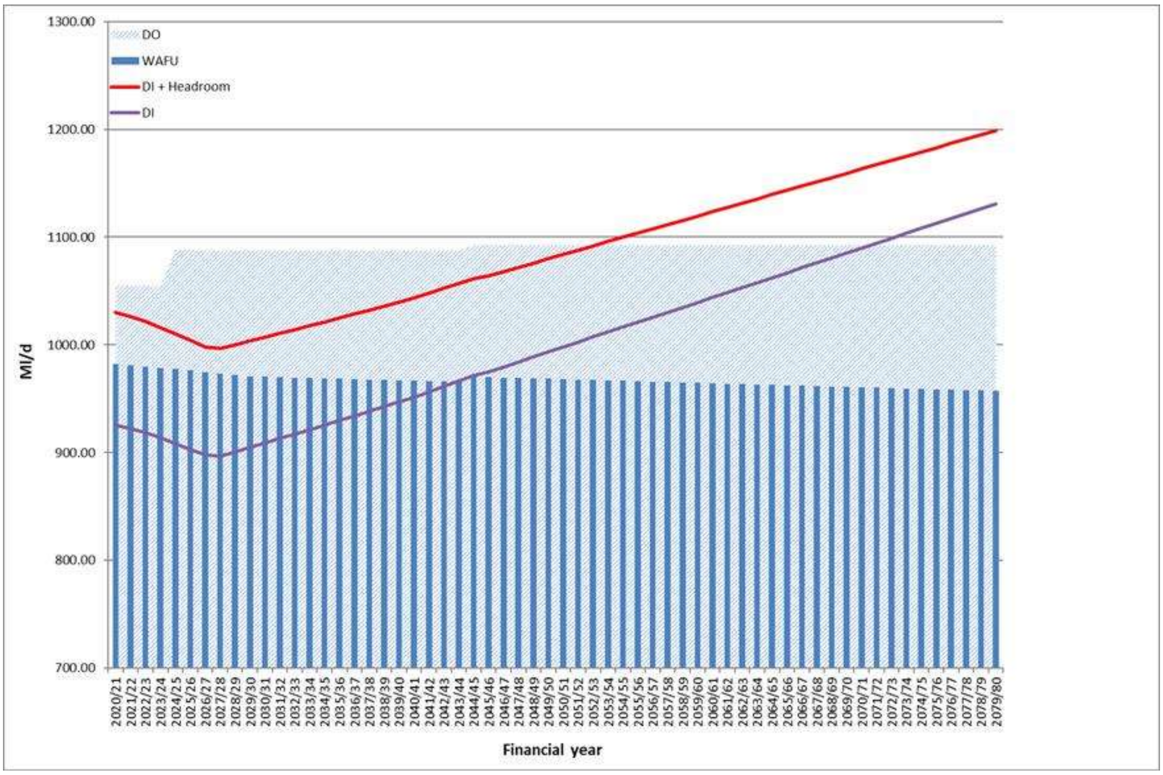

Figure 3-3 Final supply / demand balance for Affinity Water (Dry Year Annual Average)

Our baseline supply and demand assessments show that we have deficits in all of our eight water resource zones by 2069 and four of them are in deficit from the first year of our modelling. The total deficit at the end of the planning period (2079/80) for the whole company is forecast to be 241.61 Ml/d for DYAA.

In accordance with the Water Resources Planning Guidelines, we must act to remove the deficits, as there is not enough supply to meet demand, including target headroom.

3.4.3 Metering and water efficiency

During AMP6 we will selectively meter 216,000 currently unmetered domestic properties within WRZ 1, 2, 3 and 5 with a further 239,000 meters installed in WRZ 4 and 6 during AMP7. Total meter penetration in our Central Region will be 78% by the end of AMP7.

We will continue with our Water Saving Programme (WSP) which includes household level water efficiency support as well as implementing a new innovative demand management option called Fast Data at the outset of our revised draft Plan. This makes use of existing AMR meters in combination with new fast logging and live network hydraulic models to provide customers with surrogate information about their water use. Metered customers will be able to get a much more detailed picture of their water consumption than they currently receive through their six-monthly bills and we anticipate this will encourage greater water savings than our meter programme alone. As part of our initiatives for non-household premises, we will install meters on premises that do not already have them, and explore re-use schemes.

In the longer term, from 2025 - 2035 as our existing meters reach the end of their asset life, we will roll out the fixed network smart metering option with the aim to have installed smart meters at all properties where possible by the end of the programme and anticipate benefits to extend to 2050. We believe these step changes in metering are the most economical way to meet our supply and demand balance in the immediate future. The savings we are expecting to see from our water saving programme have been embedded in the demand baseline and we have explored further options to continue reducing demand beyond the WSP. See section 0 for more information.

3.4.4 Leakage programme

We will manage leakage levels in AMP7 to deliver the additional 15% reduction target. We believe this is an ambitious target that builds on our AMP6 delivery of 14% leakage reductions, which is currently the most demanding reduction target in the industry[6]. See section 6.5.1 for more information.

[6] The ELL excludes trunk mains leakage as trunk mains and service reservoir (TMSR) costs for detection & repair differ considerably to DMA cost-leakage relationships. Similarly, the policies for managing leakage on TMSR assets also differ greatly from those for DMAs. For further explanation please refer to Technical Report 4.8.1.

4 Environmental enhancements programme

4.1 Overview

This chapter describes our environmental enhancements (EE) programme for AMP7 (2020-2025). This programme has been developed to support our commitments of: making sure you have enough water, whilst leaving more water in the environment; and supplying high quality water you can trust. We have also reviewed the Water Industry Strategic Environmental Requirements (WISER), Environment Agency (EA), Drinking Water Inspectorate (DWI) and Ofwat guidance in the preparation of our plan.

We understand that our ability to continue to supply high quality drinking water to customers is dependent on having a healthy and resilient environment to abstract that water from. We submitted our WISER Report to the Environment Agency on 17th August 2018. This report sets out how WISER has informed and shaped our Plan for AMP7.

The EE programme includes investigations, options appraisals and implementation schemes to deliver our environmental regulatory expectations for the following:

- Water Framework Directive (WFD)
- Water Industry National Environment Programme (WINEP)
- Undertakings for pesticides - Drinking Water Inspectorate (DWI)
- Natural Environment and Rural Communities Act 2006 (NERC)
- Regulations 27 and 28 of Water Supply (Water Quality) Regulations 2016 (Drinking Water Safety Plans)

The EE programme will be delivered through the following key areas of investment:

- Abstraction impact assessments
  - WFD and NERC driver investigations and options appraisals
  - WFD No deterioration assessment
- Reducing our abstractions (sustainability reductions)
  - WINEP3 (green and amber reductions)
- Catchment management
  - WINEP3 water quality schemes
  - Undertakings for Pesticides
  - Drinking Water Safety Plans (DWSP)
- River Enhancement
  - WINEP3 adaptive management, river restoration and habitat enhancement
  - Monitoring and benefit assessment
- Biodiversity
  - NERC Act
  - Invasive Non-Native Species (INNS) management

4.2 Our environment programme: building on our knowledge and experience

4.2.1 Our AMP6 programme

The AMP6 National Environment Programme (NEP) is a list of environmental improvement schemes defined by the Environment Agency (EA) to ensure that water companies meet European and national targets related to water bodies. We have been working with the EA, catchment partners, stakeholders and customers for over 20 years to understand the impact of our activities on the environment. This provides us with a good understanding and strong basis for completing delivery of our AMP6 programme and preparing our PR19 submission.

Our AMP6 NEP includes investigations, options appraisals and implementation schemes relating to the environmental impact of our abstractions. The implementation schemes include sustainability reductions, 'morphological mitigation works' (river restoration and habitat enhancement), fish screening and the provision of river support. Our catchment management for water quality programme developed to deliver our regulatory expectations under Article 7 of the WFD, through the National Environment Programme for water quality (NEP WQ).

Our AMP6 programme will have:

- Delivered 42.09Ml/d reduction in average deployable output and a reduction of 39.06Ml/d in peak deployable output
- Contributed towards the improvement of 125km of globally rare chalk streams
- Investigated the impact of 69.3Ml/d of abstraction and identified options for addressing these where required
- Fulfilled our duty under Section 40 of the NERC Act including development of site specific management plans
- Identified and managed invasive non-native species (INNS) on our land holdings
- Completed 16 catchment management investigations and delivering pesticide reduction catchment management schemes with >13,000ha of eligible arable land participating
- Undertaken detailed catchment risk assessments of 116 sources to support and inform Drinking Water Safety Plans
- Assessed the effectiveness of our fish screens and appraised the need for screening 2 lakes
- Identified protected species and protected habitats across our estate through a detailed surveying programme

Our AMP6 programme has progressed well and we will continue to work with the EA and key stakeholders over the remainder of AMP6 to identify sustainable solutions to balance the demand for drinking water and the needs of the environment, to inform the requirements for AMP7.

Our PR19 EE programme includes a combination of abstraction impact assessments, abstraction reductions, catchment management, river enhancement and biodiversity works. The programme is consistent with our overall business commitment to our communities and aligns with considerations of natural capital and ecosystem services.

4.2.2 AMP7 Water industry national environment programme

The NEP has been renamed as the Water Industry National Environment Programme (WINEP) which includes both water resources and water quality. The EA have issued the WINEP tables in a number of iterations, detailing their expectations for AMP7 and assigning a level of certainty (RAG status) to each scheme. The third edition (WINEP3) has been used as the basis for our PR19 submission and costs included for all green (certain) and amber (indicative) schemes.

Our AMP7 EE programme builds on our knowledge and experience, continuing to deliver benefits to the environment, customers and communities in an efficient way.

Our AMP7 plan includes:

- Assessment of our sources against WFD no deterioration
- Investigation of the impact of our source on groundwater and surface water bodies.
- Further 33.71Ml/d sustainability reductions in Central region and 2.60Ml/d in East Region (based on average deployable output)
- Contributes towards improving 157km of river
- Six catchment investigations and 15 catchment schemes
- Our biodiversity programme, meeting our duties under Section 40 of the NERC Act

- INNS management of our land holdings.

The EA has identified 25 new investigations and options appraisals and 13 implementation schemes for our PR19 submission for the water resources element of WINEP. This work includes river restoration and habitat enhancement measures to help improve the functioning of chalk river habitats on rivers where an environmental impact of our groundwater abstraction has been identified. In addition, seven pesticide reduction schemes, eight nitrate reduction schemes as well as investigations into six emerging pollution risks have been included in the water quality element of WINEP. We will also be exploring opportunities to align these into integrated catchment schemes and developing a holistic catchment management approach. We believe this will deliver wider benefits to water quality, drought resilience and other ecosystem services which will ultimately improve the resilience of the natural environment.

We have a legislative duty and regulatory expectation for the conservation of biodiversity and control of non-native invasive species. The NERC Act imposes a duty on us to protect and where appropriate enhance priority species/habitats on our landholdings. Our AMP7 biodiversity programme will be targeted to fulfil this duty and the EA's expectations. This will focus on the individual supply areas under three separate projects with the focus on enhancing biodiversity and preventing the spread of invasive species. The EA have also identified four schemes to investigate invasive species and three schemes to investigate enhancing biodiversity on our landholdings under the WINEP.

In addition, the EA have identified through the issuing of the WINEP tables their expectations in respect of AMP7 sustainability changes (reduction in abstraction licence volume). Our dWRMP considered two different levels of sustainability reduction based on our knowledge and WINEP version 2. The EA have identified sustainability changes for the protection or improvement of internationally or nationally designated conservation sites or species; to protect or improve locally important sites (undesignated sites) or, to deliver Water Framework Directive (WFD) environmental objectives in River Basin Management Plans (RBMP). These reductions may be identified through the AMP6 NEP or review of the EA's abstraction pressures spreadsheets (EA, 2017). We have then transposed this into a sustainability reduction (reduction in deployable output) and included in our draft Water Resources Management Plan.

The third edition of WINEP, and final issue before submission of the draft business plan, was issued in March 2018. This identified a total of 33.71 Ml/d average and 21.06Ml/d (peak) reductions (green and amber level of certainty) for Central Region (community one-six). Further reductions were included for our Brett community with an amber level of certainty and no reductions for the Dour community. Further details on these schemes are shown in section 4.8 and the associated regulatory expectations in section 4.9.

4.3 Methodology

4.3.1 Programme definition and development

4.3.1.1 Abstraction impact assessments

Later resource investigations and options appraisals have been identified by the EA and their expectations listed on WINEP3. These schemes have been identified because the hydrological catchment is failing to achieve 'good ecological status/potential' (GES/P) according to the WFD. The EA therefore expects us to carry out investigations to ascertain whether abstraction is a factor in a hydrological catchment failing to achieve GES/P. Sources have also been included for investigation where it is considered there is potential for an increase in abstraction within licence to meet future growth in demand, that could represent a WFD deterioration risk. We will use the EA guidance on assessing WFD risk of deterioration to deliver this work.

Where a potential impact is identified in connection with our abstraction, an options appraisal is carried out to assess the most appropriate way forward. This is assessed against a cost benefit ratio context to understand the viability of the different options, e.g. river restoration and habitat enhancement, river support schemes or capping of abstraction licence.

The following investigations and options appraisals have been identified for AMP7 and are all given a green level of certainty in WINEP3:

- **Salary Brook -** no deterioration investigation and options appraisal scheme relating to ARDL
- **River Pant -** no deterioration investigation and options appraisal scheme, relating to HEMP source.
- **River Chelmer –** no deterioration investigation and options appraisal relating to HEMP and ARMI, THAX.
- **River Ash -** no deterioration investigation and options appraisal scheme relating to THUN and HADH source
- **River Rib –** no deterioration investigation and options appraisal scheme relating to THUN, WADE, SACO, CHIP and STAD sources
- **River Lee (Hertford to Fieldes Weir) –** investigation and options appraisal of THUN and MUSL
- **Stansted Brook -** no deterioration investigation and options appraisal scheme relating to STAN and NORS
- **Stort and Bourne Brook -** investigation and options appraisal of CAUW, STAN and NORS.
- **Upper Stort -** no deterioration investigation and options appraisal scheme relating to STAN source
- **Upper Bedford Ouse Chalk –** no deterioration groundwater investigation and options appraisal scheme of CRES, KINW, WATT, AST1, STEV, BALD, FULR and BOWR sources
- **North Essex Chalk** – no deterioration groundwater investigation and options appraisal relating to ARMI, THAX, HEMP, HIGH, LATT, SHEL, STOK, and EASB
- **Mid Chilterns Chalk** – groundwater investigation and options appraisal relating to PICC, MUDL, HOLY, AMER, CHAL and MARL
- **Mid Chilterns Chalk** – no deterioration groundwater investigation and options appraisal relating to CHES, CHAR, BERR, BRIC, BUSY, NETH, BLAF, CHOR, MILE, WALL, NORO, SPRW, STOC, WESY, GERR, KENS and GREM
- **Upper Lee Chalk** – groundwater investigation and options appraisal relating to DIGS, WHIH, and SACO.
- **Upper Lee Chalk** – no deterioration groundwater investigation and options appraisal relating to ALBE, CRES, KINW, WATT, AST1, STEV, PORT, THUN, HADH, CAUW, STAN, and NORS
- **Cam and Ely Ouse Chalk** – no deterioration groundwater investigation and options appraisal relating to WEND, NEWP, DEBD, SPRF and UTTL

For more details on these investigations/schemes and associated drivers, see Section 4.9.

4.3.1.2 Sustainability reductions

Sustainability reductions are decreases in water company deployable output due to a sustainability change (licence change) which are identified as being required to improve river flow and ecology, to meet Water Framework Directive (WFD) objectives. Abstraction licences are issued by the Environment Agency (EA) and the capability of sources to yield water is undertaken through an assessment of deployable output (DO). The methodology for assessing DO has changed for PR19, reflecting a more robust stochastic view of historic drought.

We have been working with the EA and its predecessor since 1990 to improve flows in local Chalk streams; implementing schemes in the Ver, Misbourne, Hiz, Oughton and Dour catchments from 1993 onwards. We have made significant progress in AMP6 and on completion of our programme we will have made reductions totalling 42.09Ml/d during this planning period.

We are monitoring the benefits of these reductions on groundwater levels, river flows and ecology and are presenting our findings to the EA through a series of technical workshops. We will formally report on our sustainability reductions benefit assessments in a series of reports in December 2019. The aim of this work is to help inform future decision making, to ensure best value for customers whilst supporting WFD and biodiversity objectives. We are committed to a long-term approach to water resource management to protect and enhance the environment, working collaboratively with catchment partners and key stakeholders.

Our approach to further reductions in AMP7 builds on our knowledge gained from our AMP6 programme and a desire to ensure we are making reductions in locations that benefit the environment. This was consulted on in our 2018 dWRMP. WINEP3 schemes have been used for our draft business plan submission.

WINEP3 lists 14 sources in Central region subject to sustainability changes with a *green* level of certainty and a further two sources with an *amber* level of certainty. Two sources listed in WINEP3 have been assigned both a *green* and *amber* level of certainty; BOWR and UTTL. We have accounted for them under the *green* and have sought clarification of our assumption from the EA and are still awaiting a response (as of 21/08/2018). Sources subject to sustainability reductions are located in four of our six Water Resources Zones (WRZ) in our Central region.

LoC	WINEPID	Source	River Catchment	Sustainability Reduction (1:200 drought DO)	
				Average (Ml/d)	Peak (Ml/d)
Green	HNL00065	AMER	Misbourne	2	2
	HNL00008 HNL00009	HOLY MUDL	Ver	9.01	0
	HNL00015 HNL00016	RUNL PERI	Upper Lee	10.2	11.4
	HNL00014	DIGS	Mimram	5.7	0
	EAN00010 EAN00011 EAN00012 EAN00037	WEND	Wicken Water Cam (Newport to Audley End) Wendon Brook Cam (Audley End to Stapleford)	0	0
	EAN00013/35 EAN00014 EAN00036	NEWP	Cam (US Newport) Wicken Water Cam (Audley End to Stapleford)	0.42	0
	EAN00019 EAN00023 EAN00024	DEBD	Cam (Newport to Audley End) Cam (Audley End to Stapleford) Wendon Brook	0	0
	EAN00020 EAN00021 EAN00022	BALD BOWR FULR	Ivel (US Henlow)	0	0
	EAN00025 EAN00026	SPRF	Cam (Audley End to Stapleford) Cam (Newport to Audley End)	0	0
	EAN00027 EAN00028 EAN00029 EAN00030	UTTL	Cam (Audley End to Stapleford) Wicken Water Cam (Newport to Audley End) Wendon Brook	0	0
Amb	HNL00063 HNL00066	CHES CHAR	Chess	6.38	7.66

	EAN02411	BOWR	Ivel	0	0
	EAN02412 EAN02413	UTTL	Cam (Audley End to Stapleford) Cam (Newport to Audley End)	0	0
	EAN02420	SHEL HIGM LATT STOK	Brett	2.6	2.6

Table 4-1 Summary of green and amber sustainability reductions

The *green* sustainability changes (reduction in licence) for Central region total 39.20Ml/d at average and 20.04Ml/d at peak. This equates to a reduction in deployable output (DO) of 27.33Ml/d at average and 13.40Ml/d at peak (sustainability reduction), based on our 1:200 revised drought DO. The yield from a number of these sources is already drought constrained either by existing licence conditions or borehole design. The reduction in DO is therefore less than the sustainability change on WINEP3. We have written to the EA to confirm our interpretation of the sustainability reduction volumes.

The *amber* sustainability changes for Central region total 4.55Ml/d at average and 6.60Ml/d at peak, equating to a reduction in DO of 6.38Ml/d at average and 7.66Ml/d at peak. This is based on a full cessation of the amber sources, as advised by the Area team.

The *green* and *amber* reductions for Central region therefore total 33.71Ml/d average and 21.06Ml/d peak.

In our East region, the EA have identified a sustainability change of 2.6Ml/d for four of our sources in the Brett catchment. This equates to a 2.6Ml/d sustainability reduction and costs have been included. We have had a series of correspondence with the EA over the volume to be included as there remains significant uncertainty over the volume of potential reduction. This is to be assessed through a joint investigation and options appraisal with Anglian Water, Essex and Suffolk Water and EA early in AMP7. We have included in our cost adjustment mechanism the ability for this volume and associated unit costs to increase or decrease subject to the findings of the options appraisal.

4.3.1.3 Catchment management

The catchment management for water quality aspect of this programme has been developed using a risk-based approach with an emphasis on identifying the source(s) and pathway(s) for contaminants posing a current or future risk of breaches in compliance with the Drinking Water Directive standard (DWS) at our abstractions. Our Drinking Water Safety Plan (DWSP) process highlights the risks associated with the quality of our supply to customers from source to tap. Risk assessments of all catchments supplying our abstractions are carried out as part of a five-year rolling programme or as required, where a significant land use change, such as a major brownfield site re-development, or where pollution risks, such as contaminated land are identified. Where risks are identified, a programme of investigations and catchment intervention schemes are developed and aligned with the EA under WFD and included within WINEP. The evidence from these assessments and proposed investigations and schemes are used to support the designation Drinking Water Protected Areas (DrWPA) and Safeguard Zones (SgZ) with the EA.

This scheme, and associated options, has been developed to provide the best value for our customers, as well as, aligning the requirements of the Undertakings, the DWI guidance note *'Long-term planning for the quality of drinking water supplies'* and the ‘no deterioration’ driver of the WFD delivered through WINEP.

The following schemes and investigations for AMP7 have been identified:

WINEP Water Quality Investigations:

- **WHIH; STAN; NEWP and NORM** – investigation into the source(s) and pathway(s) for nitrates affecting these groundwater abstractions
- **Lower River Colne** - investigation into the source(s) and pathway(s) for pesticides affecting our downstream River Thames surface works
- **NORM and sources -** investigation into the source(s) and pathway(s) for emerging pesticide risks (grassland and equine herbicides) affecting our NORM abstraction

WINEP WQ Drinking Water Protected Area (DrWPA) schemes (surface water abstractions):

- Two pesticide reduction catchment management schemes:
  - **Lower Thames DrWPA -** Colne (Hertfordshire) and Loddon catchments
  - **River Wey DrWPA** - Lower Wey catchment (North of Shalford)
- **ARDL reservoir and River Colne (Essex) –** WINEP WQ Total Pesticide scheme (co-funding Anglian Water delivery) affecting our shared ARDL reservoir and water treatment works

WINEP WQ Groundwater Safeguard Zone (SgZ) pesticide reduction schemes:

- **NORM and sources –** pesticide reduction catchment management schemes for 'at risk' pesticides affecting our NORM group of abstractions
- **LANE group of sources –** pesticide reduction catchment management schemes for 'at risk' pesticides affecting our LANE group of abstractions

WINEP WQ nitrate reduction schemes:

- **BROM, KIND, CHAR, SLIP, OFFS, OUGH, CHIP and KINW –** nitrate reduction catchment management schemes affecting these groundwater abstractions

In addition, a programme of catchment risk assessments for our 116 sources (source protection zone 2) to support the DWSP for AMP7 has also been identified and included within this aspect of the EE programme.

For further details on these investigations/schemes and associated drivers, see section 4.9.

4.3.1.4 River enhancement

Our river enhancement programme includes both river restoration and habitat enhancement (referred to in AMP6 as morphological works) and the provision of river support.

On the WINEP tables it is referred to as adaptive management/land management/restoration/enhancement. It is a regulatory expectation of the EA aiming to improve the local environment and deliver benefits as part of the River Basin Management Plan (RBMP) bundle of measures. Our programme of works commenced in AMP6 in conjunction with our sustainability reductions programme. The regulatory drivers are to improve habitat to support achieving 'Good Ecological Status/Potential' (GES/P) under the WFD. As these are chalk streams they are also biodiversity ‘priority’ habitats.

We plan to continue the programme of prioritised projects in collaboration with the EA, as part of our established Chalk Streams Partnership, commenced in AMP6 for the rivers Beane, Gade, Misbourne, Mimram, Upper Lea and Ver. This will ensure a holistic approach to the river restoration and habitat improvements, providing multiple benefits to each chalk stream, as well as within the wider catchment and local community. We will also undertake stakeholder engagement and the identification and prioritisation of projects on seven new rivers listed on WINEP3. These are the Rivers Bulbourne, Upper Chess, Upper and Lower Colne, Brett, Ivel and Cam. A comprehensive monitoring network will provide an evidence base, capturing the benefits of this work to inform future decision making.

River restoration and habitat enhancement projects:
- River Ivel (Upstream Henlow) and river support scheme
- River Cam (Audley End to Stapleford) and river support scheme
- River Ver (FRIA to Bricketwood)
- River Gade (Great Gaddesden to confluence with the Grand Union Canal)
- River Misbourne (Great Missenden to the M25 at DENH)
- River Beane (Walkern Mill to Stapleford)
- River Mimram (Kimpton Mill to Tewin Water)
- Upper River Lea (Luton to Luton Hoo Lake)
- Upper River Colne (Ver to BERR gauge)
- River Bulbourne (Dudswelll to Boxmoor)
- River Chess (Upstream of CHES STW)
- Lower River Colne (Chess confluence to Maple Lodge STW)
- River Brett (at confluence with Stour)
- Little Stour
- River Dour

For more details on these investigations/schemes and associated drivers, see Table 4-3.

4.3.1.4.1 River support (augmentation)

Following the completion of an AMP6 investigation and options appraisal on the River Ivel and Upper Cam, two mitigation schemes involving the provision of river support have been identified for implementation in AMP7. This will require the drilling, testing and licensing of a new river support borehole in the Ivel headwaters and a revision to an existing licence condition of our UTTL licence on the River Cam.

4.3.1.5 Biodiversity

The biodiversity programme has been developed to meet our duty under NERC Act with aspects delivered through WINEP. The previous projects, and their associated outcomes, carried out within the last ten years have been used to determine the requirements for AMP7 and deliver a robust and resilient programme of works.

We have included a programme of schemes to deliver our regulatory and legislative requirements, drawing on guidance provided by the EA on issues including invasive species management and biodiversity enhancements. This approach ensures that it encompasses a range of biodiversity activities that not only meet our regulatory obligations but also to engage with the community. This will support our vision to be the leading community focused water company and further reduce the loss of biodiversity to support meeting the UK Biodiversity 2020 and National Pollinator Strategy targets. It enables us to deliver against the EA's regulatory expectations set out in WINEP to manage and mitigate against invasive species. It also contributes to our work with partnership projects, delivering internal and external biodiversity enhancement. It ensures that we have a combination of in-house and contracted work which provides an opportunity for efficient delivery and collaborative working with internal and external stakeholders.

The programme for AMP7 will include the following:
- Tree inspections and associated remedial works
- Woodland management
- Invasive species surveying, management and control
- Land management at Wraysbury and Dungeness SSSI
- Land management of our estate
- Species and habitat monitoring
- Hertfordshire and Middlesex Wildlife Trust (HMWT) Strategic Partnership.

- Up on the Downs Strategic Partnership

For more details on these investigations/schemes and associated drivers, see Table 4-3.

4.3.2 Options appraisal and unit costs

All schemes and investigations within the EE programme were defined through their respective regulatory driver(s) and aligned to the associated customer outcome(s) and business need. Each scheme/investigation then underwent an options appraisal exploring the mitigation options and costs and resource requirements to address the need and meet the associated regulatory requirements.

Several options were developed for each scheme/investigation using a bespoke WINEP unit cost model for PR19 developed with consultants Mott McDonald. The unit cost model compiled all unit costs and staff hours for Water Resources WINEP schemes, river enhancement, catchment management and biodiversity projects based on historic proposals and quotes from schemes and investigations delivered during AMP6. The ‘project build’ tool incorporated into the model enabled the user to build up an estimate of the total project cost using pre-defined 'tasks' from drop down menus. The number of 'units' against each task was inputted, which produced a cost for each of the option developed per scheme/investigation. An audit trail was prepared for contractor and other (e.g. infrastructure and farmer incentive payment) unit costs. This also calculated the retail price iplift to 2017 if the price has been taken from before 2017. All files that provided evidence of the unit costs were subject to an internal audit to check their accuracy.

The options developed to enable the sustainability reductions were captured through an initial risk workshop, and discussion around the risks posed to supply in these zones should the AMP7 sustainability reductions come into place. The reductions were included in our dWRMP and modelled in EBSD and our bespoke model, MISER. This identified Hydraulic Demand Zones (HDZ) with supply/demand deficits and used to inform scheme requirements. Options were then developed further through engagement with stakeholders from across the company, and the current AMP6 Sustainability Reductions programme team to ensure experiences from the AMP6 programme were captured. Hydraulic modelling was undertaken to support the solutions. Further workshops were then carried out to summarise current solutions and identify any additional risks to the network. Data was gathered from the company's systems, as required, to establish site failure rates, asset condition and network configuration. These include; TRACE, telemetry, ARM, AMIS, GIS and business objects. PIONEER scheme builder, EBSD, and the unit cost model have been used for estimations of costs. With regards to trunk mains, the current PR19 mains laying summary costs were used where possible – this uses the unit cost model to determine cost per meterage of trunk main.

4.3.3 Business case and option selection

Once each of the options had been fully costed a PR19 business case document was prepared. This gave an overview of the project and the associated benefits. It also documented the project requirements, considering internal business needs, legislative requirements and regulatory expectations. This accounted for both the PR19 Driver Guidance and Guiding Principles documents associated to each project issued by the EA. For catchment management projects, the DWI Guidance Note: Long term planning for the quality of drinking water supplies, was also used to define the requirements of the projects. The scope of the project is clearly defined within this document and risks and opportunities for each option are highlighted along with the totex costs. Consideration was also given to wider benefits to the environment and society, to identify the best option for customers.

The preferred option was then selected within an estimated breakdown of annual investment required throughout the AMP7 cycle. Each preferred option was subjected to a Net Present

Value (NPV) assessment using a bespoke NPV tool and pre-defined NPV unit costs over a 20-year period. The business case also documented the risks, assumptions, dependencies and constraints associated with the preferred option. Following an initial internal screening of a business case lite version, successful projects then proceeded to be documented in Full Business Cases providing greater detail on the options appraisal process and preferred option selection and justification.

The EE programme aligns with the principles of a natural capital approach and assessment of wider ecosystem services benefits arising from knowledge gained from delivering our AMP6 programmes. We will seek to develop this further in AMP7 as we progress the individual projects.

4.4 Catchment management

4.4.1 River Thames pesticide reduction schemes

The Thames River Basin District (RBD) covers over 10,000km^2 across south east and west England upstream of our HWFS, EGHS, CHERS and WALS water treatment works (WTWs). The requirement for the River Thames pesticide reduction scheme was identified through delivery of our AMP6 NEP investigations and DrWPA scheme for metaldehyde. Investigations carried out during AMP6 concluded in March 2017 and identified several 'at risk' pesticides (metaldehyde, carbetamide and propyzamide) contributing towards deteriorating water quality at our River Thames abstractions. Priority catchments to focus future pesticide reductions schemes have been identified, in collaboration with Thames Water and South East Water, and this project has been developed to work collaboratively with farmers, regulators and other key stakeholders in these high-risk catchments. Our plan expands on the successful approaches trialled for metaldehyde in AMP6 and further develops these existing schemes, also addressing wider diffuse agricultural pollution risks to public water supply.

We work in partnership with Thames Water and South East Water who have WINEP WQ schemes in AMP6 for the River Thames DrWPA and schemes in their respective WINEP3 lists for AMP7. We collaborate to produce aligned plans and share the targeting of catchment schemes to ensure that the greatest proportion of high risk areas with the Thames River Basin are covered by catchment intervention measures. We lead on catchment schemes in the Loddon, Lower Wey and Colne catchments. We provide monitoring and technical support to Thames Water in the Lea catchment and to South East Water in the Lower Thames catchment. Thames Water and South East Water are developing parallel schemes through PR19 focusing on other high-risk catchments that have been identified. This collaborative approach is unique in the UK and enables us to maximise coverage of our schemes, share knowledge, resources, research costs and promote a partnership message.

The schemes to be implemented in these catchments will focus on key pesticides used in cereal and oilseed rape crops, that are predominantly grown in this region. The key objective of the project is to implement a payment for ecosystem services (PES) approach to incentivise adoption of best practice techniques in sustainable crop protection and empower farmers as producers of clean water through a suite of financial and other incentive mechanisms such as infrastructure grants. This will seek to incentivise farmers to go beyond compliance with their legal obligations, to adopt best practice controls where the need is greatest. The measures that will be developed and incentivised have the potential to provide additional ecosystem services benefits including: improved soil retention, greater flood resilience through improved soil organic matter and more sustainable farming. In addition to the pesticide reduction schemes the project will incorporate additional measures to support water resource protection including: pesticide amnesties for banned and out of date pesticides; pesticide applicator (PA) training courses for farmers and contractors; pesticide applicator calibration and servicing; access to capital grants for infrastructure investment focused on water quality such as bunded pesticide handling areas; specialist workshops; 1:1 farm visits and incentives based on achieving clean water targets in high risk catchments.

4.4.2 Groundwater pesticide reduction schemes

The groundwater pesticides catchment management schemes aim to address pesticide risks affecting the NORM WTW sources and the LANE group through targeted pesticide reduction schemes in high risk catchments feeding these abstractions. The NORM and LANE groups of groundwater sources abstract from groundwater susceptible to pollution from surface water due to the Karst geology in this region. NORM, ESSE, ROES, NETH, BRIC, TOLP and EAST are at risk from agricultural pesticide use in the autumn/winter under certain hydrological and hydrogeological conditions.

A series of investigations were carried out during AMP6 under the WINEP 'no deterioration' driver. These investigations required us to identify the sources and pathways of diffuse and point source pesticide pollution and identify measures required to mitigate the risk to drinking water supply. The evidence used to support decision-making on where to focus the pesticide reduction schemes was gathered through this programme of detailed catchment investigations completed in March 2017 and have formed the basis of the development of the AMP7 WINEP WQ schemes.

This project will focus on key ‘at risk’ pesticides used on the predominant crops in the region (cereal and oilseed rape). We will develop a PES mechanism to empower farmers as producers of clean water in our upstream catchments. The schemes will incentivise farmers to go beyond compliance with their legal obligations, to adopt best practice controls where the need is greatest. We will work directly with farmers and other key stakeholders to implement these measures, monitor their effectiveness and assess the ability to be replicated in larger catchment areas to prevent further deterioration in water quality. The PES approach will focus on working with farmers to improve crop protection, soil husbandry and water source protection. The measures have the potential to provide additional ecosystem services benefits including: improved soil retention, greater flood resilience through improved soil organic matter and more sustainable farming. The project will work in collaboration with a range of stakeholders including specialist agricultural delivery partners, regulators, Natural England, farmers and agronomists.

Where specific high-risk pollutant pathways have been identified (e.g. stream sinks) further studies will be carried out in the form of tracer testing to confirm their connectivity and influence on our abstractions. Based on the perceived risk, this project will seek to identify solutions to reduce the concentrations of pesticides and other pollutants entering groundwater. This targeted approach aims to achieve the greatest benefit and utilises resources effectively to represent the best value to the customer whilst providing the best environmental outcome.

In addition, these schemes will incorporate additional measures to support water resource protection including: pesticide amnesties; PA training courses for farmers and contractors; pesticide applicator calibration and servicing; access to capital grants for infrastructure investment focused on water quality (e.g. bunded pesticide handling areas); specialist workshops; 1:1 farm visits and incentives based on achieving clean water targets in high risk catchments.

4.4.3 Nitrate affected sources catchment management schemes

The nitrate affected sources catchment management scheme will investigate and identify suitable mitigation measures to reduce the rising trend in nitrate concentrations. This will be achieved through working with farmers and other potential sources of nitrate pollution to develop and implement nitrate reduction schemes. It meets the EA’s regulatory expectation under the WFD 'no deterioration' driver included on WINEP3. This series of schemes also meets the expectations set out in the Blueprint for Water Coalition's manifesto on environmental investment for PR19 and the requirements of the DWI Guidance Note: Long term planning for the quality of drinking water supplies issued September 2017.

A number of our groundwater sources in Hertfordshire, Essex and Kent are affected by long term increasing trends in nitrate concentrations. At some locations observed concentrations currently exceed the drinking water standard (DWS) and at other sources they are predicted to exceed the DWS over the next few decades. A series of investigations into eight groundwater sources were agreed with the EA and carried out during AMP6 under the WFD 'no deterioration' driver delivered through WINEP.

The outcome of these investigations, completed in March 2017 has been used to inform the investment requirements for the PR19 catchment management nitrate reduction schemes and concluded:

- KIND, BROM, KINW, CHIP, SLIP, OFFS and OUGH will observe peak nitrate concentrations between 2020 and 2040, with peak concentrations consistently exceeding the DWS.
- CHAR is predicted to observe peak nitrate concentration in the late 2030s but is not predicted to exceed the standard during the forecast period up to 2070. However, peaks above the DWS are likely during periods of exceptionally high groundwater levels similar to the 2001 and 2014 groundwater emergence events.
- Nitrate concentrations at KIND, BROM and CHIP have greater seasonal variability associated with fluctuating groundwater levels. In addition, utilising catchment management to reduce nitrate leaching for CHAR could provide greater resilience during periods of exceptionally high groundwater. Schemes will be prioritised for these sources as there is greater potential to achieve a shorter-term benefit in nitrate reductions during the peak periods. Catchment measures will be developed for the other sources, but benefits are likely to be realised over a longer period.
- It is unlikely that catchment measures for nitrate at any of these sources will be effective at preventing deterioration in the short-term due to the time-scales in which nitrate leaching from the surface reaches our groundwater abstractions. Catchment schemes will need to be implemented over a longer period (multiple AMPs) to achieve the desired water quality benefits.

The scope of activities included in our plan for the nitrate affected sources catchment management schemes will include (but are not limited to):

- Develop an effective PES mechanism for reducing in nitrate leaching to groundwater
- Undertake 1:1 specialist farm visits to support effective nutrient management plans
- Arrange workshops, training and fertiliser spreader servicing and calibration
- Develop catchment-wide nutrient management schemes for agriculture. Options include, but are not limited to:
    - Cover, catch and companion cropping
    - Nutrient management planning e.g. type and timing of fertiliser applications
    - Soil management e.g. tillage
    - Soil testing
    - Crop types/rotations
    - Precision farming techniques
    - Nutrient trading
- Incentives for farmers to change practices, take land out production, change fertiliser type/ applications
- Access to a funded capital grants scheme for infrastructure designed to reduce nitrate leaching

- Drilling of observation boreholes to monitor nitrate leaching in the soil, unsaturated zone and aquifer
- Identify and assess wider ecosystem services opportunities/benefits where appropriate. Examples include, but are not limited to:
    - Flood and drought risk management
    - Natural recharge
    - Biodiversity
    - Soil health and condition
    - Air quality
- Collaborate with academic institutions, researchers, nutrient management experts and other stakeholders to further research into reducing nitrate losses to groundwater

All pesticide and nitrate reduction catchment management schemes will be delivered in partnership with a range of stakeholders, delivery partners and ecosystem services beneficiaries including, but not limited to, the EA, Natural England, farmers and agronomists. Where specialist advice and delivery is required, consultancy service agreements will be established with specialist agricultural delivery partners for work beyond the expertise of our staff.

4.4.4 Drinking Water Safety Plans: Catchment risk assessment and mitigation

Drinking Water Safety Plans (DWSP) are a mandatory requirement under Regulations 27 and 28 of Water Supply (Water Quality) Regulations 2016. This project has been developed to deliver the “Catchment” element of the DWSP and provides the framework for investigating pollution that poses a risk to public water supply, supporting the business with operational decision-making, incident response and subsequent source/pathway investigation. Liaison meetings with the EA and other stakeholders are held regularly on matters posing actual or potential risk to water quality. This programme has been developed to meet the requirements set out in the 'DWI Guidance Note: Long term planning for the quality of drinking water supplies' issued September 2017 and the Water Safety Plan guidance document.

Our Drinking Water Safety Plan catchment management project was initially established in 2010 to undertake a detailed risk assessment of the land use within the source protection zones of our 116 groundwater sources. We have developed and refined the catchment risk assessment process through the last ten years in line with DWI guidance. This AMP7 project builds on this work completing a further risk assessment of each source as part of our 5-year rolling programme, or where an incident or major change in land use has occurred. We plan to develop a refined and dynamic risk approach which continually reviews and revises risk assessments and communicates the outputs to the business and our regulators through development of an online water safety plan assessment system.

In addition to carrying out the programme of catchment risk assessments, the scope of this project includes:

- Identifying, assessing and responding to planning applications that may pose a risk to water quality
- Responding to, investigating and acting as liaison with other stakeholders for pollution incidents notified through the Environment Agency POLWARN process
- Working with landowners, developers, consultants on mineral extraction, fracking, contaminated land remediation and communicating to relevant internal and external stakeholders to inform operational and investment decisions
- Developing action plans where significant risks or increasing trends in water quality risk based on the outputs of the catchment risk assessments

- Developing and implementing pollution prevention and mitigation guidance (e.g. following burst mains)
- Identifying and assessing future risks to water quality (e.g. new or reformulated pesticides) and developing monitoring protocols

This will support developing a greater understanding of the catchments we operate in and develop positive working relationships with landowners, developers, local authorities, regulators and our communities to mitigate the risk of present and future issues affecting our ability to supply wholesome drinking water.

It supports an increased focus on catchment management and incorporating this into the long-term planning for managing water quality in line with WFD. Article 7 of WFD stipulates a move away from end of pipe treatment solutions to managing risks and issues at the source. This option facilitates the development of catchment action plans where emerging risks are identified to further investigate catchment based solutions to support options appraisal for future catchment pollution mitigation schemes.

4.4.5 WINEP WQ investigations

The WINEP WQ Investigations seeks to investigate the source(s) and pathway(s) for pollution risks affecting a range of groundwater sources and the River Thames abstractions. This includes investigations for nitrate and emerging pesticide risks. These investigations are captured in the WINEP3 list agreed with the Environment Agency (EA) as part of our regulatory obligations to deliver catchment management under the 'no deterioration' driver of the WFD.

We have been carrying out a programme of DWSP catchment risk assessments for all groundwater sources, supporting our regulatory obligation to produce drinking water safety plans for all our sources. As part of this, a review of water quality risks and rising trends in water quality parameters, looking at all water quality results over the past ten years was undertaken. Where an emerging risk has been identified, an assessment has been undertaken to determine whether the problem is a historic contamination issue, or whether current land management practices could also be impacting on water quality at the abstraction. This work has identified a number of issues that require further investigation to understand the source of the pollution, the pathway(s) and whether catchment intervention measures could be deployed to reduce the problem at the source, rather than relying solely on water treatment and/or blending options.

The scope of this project supports the following investigations captured in WINEP3:

- WHIH; STAN; NEWP and NORM - nitrate
- Lower River Colne (affecting River Thames surface works) - pesticides
- NORM and sources - emerging pesticide risks (acid herbicides)

These investigations will include detailed research, water quality monitoring and employing techniques including (but not limited to) remote sensing (satellite imagery and LIDAR), hydrogeological and hydro-chemical modelling, catchment walkovers, land use risk assessments and 1:1 visits with farmers, landowners and businesses. The outcomes of the investigations will be reported to the EA in 2022 and will provide evidence to determine whether the catchments should be designated as Safeguard Zones (designated areas in which the use of certain substances must be carefully managed to prevent the pollution of raw water sources that are used to provide drinking water). The outcomes of the investigations will also be used to determine future investment needs, both in catchment intervention measures and future treatment/blending investment for AMP8 and beyond.

We will further develop the approach taken for the AMP NEP investigations and will work in collaboration with the range of stakeholders including: the EA, Natural England, Farming Wildlife Advisory Group, farmers, landowners, businesses, waste water providers, Local Authorities, customers, catchment partnerships and environmental groups. The project will seek to draw on expertise from specialist consultancies on activities such as remote sensing and modelling beyond the expertise of in-house employees. Where mitigation options are identified and could be effective in the short term, this option allows for implementing these measures at an earlier stage which could lead to improvements in water quality during AMP7.

4.4.6 Catchment management scheme benefits

The proposed catchment management schemes and investigation anticipate realisation of a range of benefits including, but not limited to:

- Pro-active investigation of pollution risks, impacts of development and major land use change to reduce the impact on operational expenditure arising from pollution incidents.
- development of a better understanding of our catchments where raw water is sourced and the risks posed to public water supply.
- Support of a longer-term approach of reducing diffuse and point source pollution at the source to prevent further deterioration of water quality and associated treatment needs/costs
- Support of our approach to managing pollution risks from reactive to proactive.
- Potential to realise wider ecosystem services benefits through reduction in soil/sediments losses and associated pollutants to surface and ground waters.
- Proactive engagement and development of positive collaboration with stakeholders including customers and communities, Defra, EA, Natural England, water companies, landowners, farmers, agronomists and environmental groups.
- Long term objective of reducing costs for future treatment investment and ongoing operational costs

4.5 Abstraction impact assessment

4.5.1 Surface water and groundwater resources investigation and options appraisal schemes

Water resource investigations and options appraisals relating to surface water flows and groundwater resources have been identified on WINEP3 where there is a need to establish whether there is any link between our drinking water abstractions and changes in surface water flows of nearby rivers. These investigations are to be carried out at a catchment scale with eight schemes proposed for AMP7.

Investigations and/or Options Appraisals relating to surface water flows and groundwater bodies:

- Lee Navigation (Hertford to Fieldes Weir)
- Stort and Bourne Brook
- Colne (from confluence with Ver to Gade)
- River Brett at confluence with Stour
- Colne/East Mill, Ardleigh
- Mid Chilterns Chalk
- Upper Lee Chalk
- North Essex Chalk

These rivers and groundwater bodies have been assessed as not currently supporting 'good' status under the WFD and this is believed to be linked to groundwater abstraction. Improved knowledge and understanding of our sources gained from these investigations contributes towards our customer commitment for 'making sure our customers have enough water, while leaving more water in the environment'. It also contributes towards ensuring that we meet our statutory duty of supplying water to the public and our customer outcome 'supplying high quality water that customers can trust' through our improved understanding of the subject catchments and groundwater sources.

Our approach builds on our experience from delivering the programme in the last ten years, allowing efficiencies to be realised. Work will include field work including: measurements of river flow, groundwater levels, ecological surveys and desk-based analysis including use of the relevant groundwater models. Where investigations geographically overlap, savings have been identified through sharing of resources such as monitoring and drilling new observation boreholes.

4.5.2 No deterioration investigations relating to surface water flow and groundwater resources

The aim of these investigations is to demonstrate that any increase in abstraction from recent actual rates and within our licence limits, will not cause deterioration, before any increase in abstraction occurs. For AMP7 17 'no deterioration' investigations have been included on WINEP3.

No deterioration investigations:

- Rib (from confluence with Quin to Lee Navigation)
- Ash (from confluence with Bury Green Brook to Lee)
- Stansted Brook
- Upper Stort
- Nailbourne and Little Stour
- Upper Dour
- Dour from Kearsney to Dover
- North and South Streams at Northbourne
- Chelmer (u/s Gt. Easton)
- Stutton Brook
- ARDL Reservoir
- River Stour at Cattawade northern channel
- Pant
- Mid Chilterns Chalk
- Upper Lee Chalk
- Upper Bedford Ouse Chalk
- Cam and Ely Ouse Chalk

The EA guidance on no deterioration investigations will be used in conjunction with findings from previous relevant studies. No deterioration investigations consider the overall water balance of a catchment, assessing hydrological inputs and outputs resulting in a surplus or a deficit. These investigations target areas of future growth in terms of water usage. By carrying out these no deterioration investigations ahead of any potential abstraction increases we can give confidence in our ability to supply water, and/or have time to consider alternative options if necessary.

4.5.3 Abstraction impacts assessment benefits

The abstraction impacts assessment investigation seeks to realise a range of benefits including, but not limited to:

- Greater understanding of our catchments and the resilience of our sources to different abstraction demands.

- Proactive engagement in developing positive collaboration and enhanced reputation with stakeholders including customers, communities, Defra, EA, Natural England, water companies, landowners, and local environmental groups.
- Support of a longer-term water resource management planning and drought management planning.
- Identification of sustainable abstraction regimes, balancing the need of customers and the environment.
- Development and implementation of innovative analysis techniques such as using secondary lines of evidence such as water temperature to understand recharge to rivers, and dual piezometry borehole installations.
- Well informed future planning in terms of understanding future demand and our ability to provide this.
- Information gained that can be used to support work relating to drought management.

4.6 River enhancement

4.6.1 River restoration and habitat enhancement

Many of the rivers in our supply area have been impacted by historic anthropogenic activities, resulting in over-widening, deepening of channels and a lack of longitudinal connectivity. This impacts the ecology and WFD waterbody status.

Our river restoration and habitat enhancement programme is based on the EA's expectations, as listed on WINEP3. Where there is evidence of potential impact from our abstraction on the chalk stream priority habitats, we seek to improve the flow and habitat (WFD_IMP_WRFlow and NERC_IMP1) to support good ecological status or potential under WFD. The implementation of this work will also meet the company's statutory obligations to conserve biodiversity and to control invasive non-native species (INNS) under the NERC Act.

This work also has the potential to improve the resilience of chalk streams to climate change at times of both low and high flow. This work will also create habitat improvements to increase the biodiversity of chalk streams such as fish, macroinvertebrates and macrophytes. We also recognise the wider ecosystem services benefits the river restoration and habitat enhancement schemes can deliver. These wider benefits, such as improved access for recreation, can contribute to a greater well-being for our customers and communities. Undertaking this work and comprehensively monitoring its effectiveness will provide an evidence base for PR24 and delivery of WFD objectives.

During AMP6 we have been working to improve six chalk streams (Beane, Gade, Misbourne, Mimram, Upper Lea and Ver) in Central region and the Little Stour in Southeast region. We carried out walkover surveys with the EA to identify potential projects on each river. Discussions were then held with the EA to rank projects by technical feasibility and environmental benefit. A compiled list of projects to be implemented over the next five to ten years was produced with projects being assigned to either Affinity Water, the EA or other catchment partners such as the local wildlife trusts. Stakeholder engagement has been a substantial part of the AMP6 work, ensuring we have the confidence and buy in of our stakeholders, such as landowners and local authorities, and has been key to the success of the AMP6 programme. We have also been monitoring the baseline of the rivers before any river restoration and/or habitat enhancement works have been started, and during construction and post-construction.

This data has enhanced our knowledge and understanding of these rivers and will help define AMP7 works.

The knowledge gained from AMP6 has provided confidence in identifying an achievable AMP7 programme, contributing towards the improvement of 157km of river. Our plan represents a continuation of our approach to AMP6 building upon the catchment based approach and continuing to actively work in partnership with the EA, other catchment partners, stakeholders and landowners. The positive relationships developed in AMP6 will assist in earlier implementation of projects on the six rivers where work commenced in AMP6 (Beane, Gade, Lea, Misbourne, Mimram and Ver).

This experience will also support project start up for the additional seven new rivers listed in WINEP3 (Brett, Bulbourne, Cam, Chess, Ivel, Upper Colne and Lower Colne). We will also be working in collaboration with other water companies in our Southeast region, monitoring the Little Stour and undertaking works on the River Dour, identified through our drought work. Agreement and prioritisation of projects in conjunction with stakeholder engagement will be the focus for 2020 to 2022 with implementation of restoration projects in 2022 to 2025.

Works will include:

- Weir removal or modification to improve fish passage
- Tree works to allow more light into the river channel
- Habitat enhancement
- Fencing to prevent poaching / damage to river banks
- Planform restoration including channel realignment or re-meandering

4.6.2 River support

The AMP6 Ivel NEP investigation and options appraisal identified a mitigation option for our BALD, BOWR and FULR sources through the provision of river support. Following discussion with the EA a scheme has been identified and costs included within our plan, which comprises of the installation of a dedicated river support borehole and associated infrastructure. Costs have been calculated using PIONEER, Scheme Builder and unit costs from our previous work. This scheme was included in WINEP3 with an amber level of certainty and therefore also included in our cost adjustment mechanism, should this not proceed in AMP7.

4.6.3 River enhancement benefits

A range of ecosystem services benefits can be derived through the river enhancement programme. A natural capital assessment of the benefits from these schemes will be undertaken as part of the implementation of the schemes. Benefits can include, but are not limited to:

- Contribute towards WFD objectives by improving the globally rare chalk streams in our supply area
- Develop stronger partnerships with customers and community groups through engagement on these schemes.
- Help to reconnect communities with their rivers and understand associated environmental impacts of water consumption
- Contribute to the improvement of fish passage
- Improve resilience of aquatic ecology and associated habitats
- Support riparian landowners to manage INNS
- Improve resilience of schemes delivered alongside wider catchment management activities

4.7 Biodiversity

We have responsibility for land holdings across our supply area (1470ha), including statutory designated sites, e.g. Wraysbury Lakes Site of Special Scientific Interest (SSSI), and sites of local conservation importance, e.g. STOC Lake Local Nature Reserve (LNR). Our AMP7 biodiversity programme will deliver ecological enhancement work on our landholdings. This programme will deliver against commitments and obligations in regard to biodiversity, conservation and environmental management, in line with our duty under Section 40 of the NERC Act 2006 and Section 51 for invasive species. This legislation builds upon Section 14 of The Wildlife and Countryside Act (1981). In addition, the programme will support the Biodiversity 2020 and the national pollinator strategy (NPS).

We also have responsibility for the health and safety of our staff and the public and need to ensure trees and footpaths of our landholdings are managed. Where our landholdings are accessible to the public, enhancement of biodiversity within these sites (e.g. STOC Lake) will provide wider ecosystem service benefits, such as amenity value, to our customers and communities who visit and experience these sites.

During AMP5 and AMP6, we have inspected all trees within our landholdings and utilised specialist tree mapping software to record and monitor tree health and condition, providing the conservation of trees and assurance that assets and people using the sites are safe. We have developed a strategic partnership with the Hertfordshire and Middlesex Wildlife Trust (HMWT) to manage three of our designated sites. We have also developed an ecological monitoring programme to monitor protected species and habitats on our landholdings. To date, we have identified over 50 protected species and 10 protected habitats across the environmental estate.

The biodiversity programme, will;

- Develop actions to protect, restore and enhance NERC Section 41 species and habitats which are present on land we owned or manage
- Support partnership projects which aim to enhance and protect biodiversity species and habitats within our supply area
- Investigate how landholdings can contribute to the National Pollinator Strategy and develop site management options to benefit pollinators
- Undertake tree inspections of our estate consisting of approximately 60,000 trees and necessary remedial work to promote ecological enhancement.
- Develop and build upon existing woodland management plans to manage larger habitats strategically and realise wider ecosystem services benefits
- Develop a strategy and implementation plan for invasive species surveying, management and control to reduce the risk of invasive non-native species including Himalayan balsam, giant hogweed and Japanese knotweed.
- Implement management plans for statutory designated sites within our estate including Wraysbury and Dungeness SSSIs
- Implement management plans for our non-statutory sites, including 44 sites with local wildlife site (LWS) designation
- Undertake priority species and habitat monitoring and develop specific management plans where appropriate
- Undertake a programme of work to develop and enhance landscape and heritage value of our land in the Folkestone and Dover area collaboratively with Up on the Downs partnership
- Further develop our bird box and bird ringing monitoring networks within our landholdings in collaboration with local conservation groups and the Wildlife Trust

4.8 Sustainability reductions

The purpose of a sustainability change is for the protection or improvement of internationally or nationally designated conservation sites or species; to protect or improve locally important sites (undesignated sites) or, to deliver WFD environmental objectives in River Basin Management Plans (RBMP). These reductions may be identified through the AMP6 National Environment Programme (NEP) or review of the EA's abstraction pressures spreadsheets (EA, 2017).

WFD binds the UK to delivering its requirements and does not impose any legal obligations on water companies or the EA directly. The WFD is implemented in England and Wales by the Water Environment (Water Framework (England and Wales) Regulations 2017 (WFD Regs.). The WFD requires waterbodies to achieve good ecological status (GES) or potential (GEP) and not increase river flows.

We acknowledge the ambitions of the Water Industry Strategic Environmental Requirements (WISER) and are currently delivering an ambitious AMP6 business plan and WRMP. This includes a significant reduction in abstraction, equivalent to 5% of our Central region PR14 average deployable output, leaving more water in the environment. By the end of AMP6 we will have reduced abstraction by 63.09Ml/d[7] since 1993. In combination with the abstraction reductions, we are also delivering, in partnership with the EA and other catchment partners, an extensive programme of river restoration and habitat enhancement works. We consider that the river enhancement works (section 4.6) will help improve natural resilience of the chalk streams within our supply area and contribute significantly to WFD objectives. We are monitoring the effectiveness of these works through our NEP monitoring programme. There are also strong links with our Catchment management programme.

Detailed solutions for the implementation of the sustainability reductions in AMP7 have been developed utilising information from our EBSD and Miser modelling, with engagement from stakeholders across our business. This has highlighted a number of network constraints and requirement for associated capital works, in addition to the water quality restriction associated with utilising surface water sources in areas historically supplied with groundwater. Solutions have been identified including: network reinforcement; additional pumping and transfer capabilities; strategic treated water storage and treatment requirements to enable source optimisation.

The Sustainability Reductions programme aims to deliver the following projects across our communities, thus addressing the risk to water supply while maintaining resilience throughout our network;

[7] *This is made up of 42.09Ml/d (AMP6 sustainability reduction), 8Ml/d from the River Misbourne, 13Ml/d River Ver (FRIA). A further 1.3Ml/d reduction in DO has been implemented for provision of river support (0.3Ml/d River Hiz and 1Ml/d River Oughton).*

	WRZ	Community	Project
GREEN SRs	1	Mis	HERB to BOVI network reinforcement
			BERK/ KINL resilience
			HUNT iron removal
	2	Colne	STON GAC
			New booster at OXHE (boosting 27Ml/d)
			PRV into DMA 6419
			St Albans New trunk main (8000m of 400mm)
	3	Lee	New cell BULL
			PRES reservoir PRV
			Letchworth to Royston
			BEEC reconfiguration
			DIGS treatment (pioneer costs)
			PRV replacements
			Run to waste NOMA (3300m of 250mm)
			DIGS New trunk main BFR (3750m of 400mm)
	4	Pinn	ICKE Booster pumps change (x4) (70 to 82Ml/d)
			6km of 700mm main (ICKE to HILL)
	5	Stort	UTTL turbidity and pump upgrade
	6	Wey	N/A
	7	Dour	N/A
	WRZ	Community	Project
AMBER SRs	1	Mis	CHOL chlorination plant (pioneer costs)
	8	Brett	Replacement of Galvanised Iron pipes

Table 4-2 Sustainability reduction schemes

The implementation of the sustainability reductions is reliant on the water saving programme (WSP) included in our baseline DO assessment, therefore wider costs need to be considered in the delivery of the sustainability reductions programme.

4.9 Regulatory Expectations

Table 4-3 Environmental Enhancements Regulatory Drivers Summary Table

OFWAT Classification(s)	Scheme	Asset	Driver	Issue	Scheme Details
Catchment management Drinking water quality Environmental quality – actions	LANE group pesticide reduction scheme	NETH; BRIC; EAST and BERR	WINEP WQ Safeguard Zone The Water Supply (Water Quality) Regulations	Breaches of DWS for a number of pesticides	Catchment-based pesticide reduction scheme using payment for ecosystem services approach
Catchment management Drinking water quality Environmental quality – actions	River Thames pesticide reduction scheme	EGHS; HWFS; CHERS and WALS WTW's	WINEP WQ DrWPA Safeguard Zone DWI Undertaking The Water Supply (Water Quality) Regulations	Breaches of DWS for a number of pesticides	Catchment-based pesticide reduction scheme using payment for ecosystem services approach
Catchment management Drinking water quality Environmental quality – actions	Nitrate affected sources catchment management	BROM, KIND, CHAR, SLIP, OFFY, OUGH, CHIP and KINW	WINEP WQ Safeguard Zone The Water Supply (Water Quality) Regulations	Long term and seasonal increasing trend in nitrate concentrations	Catchment-based scheme to identify source(s) of nitrate leaching to groundwater and nitrate reduction scheme using payment for ecosystem services approach
Catchment management Drinking water quality Environmental quality – actions	ARDL and River Colne (Essex) pesticide reduction scheme	ARDL	WINEP WQ DrWPA DWI Undertaking The Water Supply (Water Quality) Regulations	Breaches of DWS for a number of pesticides	Catchment-based pesticide reduction scheme delivered by Anglian Water with co-funding and support from Affinity Water

Catchment management Drinking water quality Environmental quality – actions	NORM and sources pesticide reduction scheme	NORM WTW and ESSE	WINEP WQ DrWPA Safeguard Zone The Water Supply (Water Quality) Regulations	Breaches of DWS for a number of pesticides used on arable crops	Catchment-based pesticide reduction scheme using payment for ecosystem services approach
Catchment management Drinking water quality Environmental quality – investigation	NORM and sources emerging pesticide investigation	NORM WTW and ROES	WINEP WQ DrWPA Safeguard Zone The Water Supply (Water Quality) Regulations	Increasing concentrations of grassland and equine acid herbicides (NORM) and arable pesticides (ROES)	Catchment monitoring, source apportionment and future scheme appraisal
Catchment management Drinking water quality Environmental quality – investigation	NORM nitrate investigation	NORM WTW	WINEP WQ DrWPA Safeguard Zone The Water Supply (Water Quality) Regulations	High concentrations of seasonal nitrate concentrations with risk of breaching DWS	Catchment monitoring, modelling, source apportionment and future scheme appraisal
Catchment management Drinking water quality Environmental quality – investigation	Nitrate affected sources investigation	WHIH; STAN; NEWP	WINEP WQ The Water Supply (Water Quality) Regulations	Increasing long term and seasonal trends in nitrate concentrations posing risk of future breaches of DWS	Catchment monitoring, modelling, source apportionment and future scheme appraisal
Catchment management Drinking water quality Environmental quality – investigation	Lower River Colne pesticide investigation	EGHS, CHERS and WALS WTWs	WINEP WQ DrWPA Safeguard Zone The Water Supply (Water Quality) Regulations	Seasonal concentrations of pesticides posing risk to downstream River Thames abstractions	Catchment monitoring, source apportionment and future scheme appraisal
WINEP Water resources investigations and options appraisals	Salary Brook	ARDL	WFD_NDINV_ WRHMWB	Potential impacts from abstraction causing deterioration of waterbody.	Investigation to assess abstraction and any potential risks of deterioration and options appraisal to propose mitigation measures.
WINEP Water resources investigations and options appraisals	River Pant	HEMP	WFD_NDINV_WRH MWB	To establish required mitigation measures to achieve ‘good’ ecological potential	Investigation to assess abstraction and any potential risks of deterioration.
WINEP Water resources investigations and options appraisals	River Rib	THUN, WADE, CHIP, STAD and SACO	WFD_NDINV_WRFl ow	Potential impacts from abstraction causing deterioration of waterbody.	Investigation to assess abstraction and any potential risks of deterioration.

WINEP Water resources investigations and options appraisals	River Chelmer	HEMP, ARMI and THAX	WFD_NDINV_WRFlow	To establish what extent planned abstraction and changes in the use of licences 8/37/31/*G/0042 and 8/37/35/*G/0023 might cause deterioration of flow / ecological status of the waterbody and to identify suitable options to ensure risk is removed.	Investigation to assess effects of licence changes and options appraisal to propose mitigation measures.
WINEP Water resources investigations and options appraisals	River Ash	THUN and HADH	WFD_NDINV_WRFlow	Potential impacts from abstraction causing deterioration of waterbody.	Investigation to assess abstraction and any potential risks of deterioration. Options Appraisal to outline mitigation measures if required.
WINEP Water resources investigations and options appraisals	River Lee (Hertford to Fieldes Weir)	THUN and MUSL	WFD_INV_WRFlow	Low flows causing potential impact on ecology.	Investigation to assess abstraction and any potential impacts to ecology.
WINEP Water resources investigations and options appraisals	Stansted Brook	STAN and NORS	WFD_NDINV_WRFlow	Potential impacts from abstraction causing deterioration of waterbody.	Investigation to assess abstraction and any potential risks of deterioration.
WINEP Water resources investigations and options appraisals	Stort and Bourne Brook	CAUW, STAN, and NORS	WFD_INV_WRFlow	Low flows causing potential impact on ecology.	Investigation to assess abstraction and any potential impacts to ecology.
WINEP Water resources investigations and options appraisals	Upper Bedford Ouse Chalk	CRES, KINW, WATT, AST1, BROO, BALD, BOWR and FULR	WFDGW_NDINV_GWR	Impacts to groundwater body	Investigation to better understand nature any future changes to abstraction and impacts to groundwater body. Options Appraisal to determine appropriate mitigation measures.
WINEP Water resources investigations and options appraisals	Upper Stort	STAN	WFD_NDINV_WRFlow	Potential impacts from future abstraction causing deterioration of waterbody.	Investigation to assess future abstraction and any potential impacts to ecology. Options Appraisal to identify mitigation measures
WINEP Water resources investigations and options appraisals	North and South Streams	KIND and LIGH	WFD_NDINV_WRFlow	Potential impacts from future abstraction causing deterioration of waterbody.	Investigation to assess future abstraction and any potential impacts to ecology. Options Appraisal to identify mitigation measures

WINEP Water resources investigations and options appraisals	Upper Lee Chalk	DIGS, WHIH, and SACO	WFDGW_INV_GWR	Sustainability of current abstractions	Groundwater balance investigation
WINEP Water resources investigations and options appraisals	Upper Lee Chalk	ALBE, CRES, KINW, WATT, AST1, BROO, PORT, THUN, HADH, CAUW, NORS and STAN	WFDGW_NDINV_GWR	Sustainability of future increased abstractions	Groundwater balance investigation
WINEP Water resources investigations and options appraisals	Mid Chilterns Chalk	PICC, MUDL, HOLY, AMER, CHAL and MARL	WFDGW_INV_GWR	Sustainability of current abstractions	Groundwater balance investigation
WINEP Water resources investigations and options appraisals	Mid Chilterns Chalk	CHES, CHAR, BERR, BRIC, BUSY, NETH, BLAC, CHOR, MILE, WALL, NORO, SPRW, STOC, WESY, GERR, KENS and GREM	WFDGW_NDINV_GWR	Sustainability of future increased abstractions	Groundwater balance investigation
WINEP Water resources investigations and options appraisals	Cam and Ely Ouse Chalk	WEND, NEWP, DEBD, SPRF and UTTL	WFDGW_NDINV_GWR	Sustainability of future increased abstractions	Groundwater balance investigation
WINEP Water resources investigations and options appraisals	North Essex Chalk	ARMI, THAX, HEMP, HIGH, LATT, SHEL, STOK, EASB	WFDGW_INV_GWR	Sustainability of current abstractions	Groundwater balance investigation
WINEP Water resources investigations and options appraisals	River Dour	BUCM, DOVP, CONN, PRIM, and ELMV	WFD_NDINV_WRFIow	Sustainability of future increased abstractions	Investigation to assess future abstraction and any potential impacts to ecology. Options appraisal to develop mitigation measures if appropriate.
WINEP Water resources investigations and options appraisals	Nailbourne and Little Stour	BROM, RAKN, RAKS, TAPN, TAPS, DENT, OTTI, WORL and SKEE,	WFD_NDINV_WRFIow	Sustainability of future increased abstractions	Options Appraisal only to identify mitigating measures

WINEP Water resources investigations and options appraisals	River Brett	HIGH, LATT, SHEL, STOK	WFD_INV_WRFlow	Low flows causing potential impact on ecology.	Investigation to assess abstraction and any potential impacts to ecology.
WINEP Water resources investigations and options appraisals	River Colne – Essex	ARDL	WFD_INV_WRHM WB	Impact of Ardleigh Reservoir operation on watercourses.	Investigation to assess any impacts from Ardleigh Reservoir. Options appraisal to develop mitigation measures if appropriate.
WINEP Water resources investigations and options appraisals	Stutton Brook	ESTB	WFD_NDINV_WRFl ow	Sustainability of future increased abstractions	Investigation to assess future abstraction and any potential impacts to ecology. Options appraisal to develop mitigation measures if appropriate.
WINEP Water resources investigations and options appraisals	Upper Dour	DREL and LYEO	WFD_NDINV_WRFl ow	Sustainability of future increased abstractions	Investigation to assess future abstraction and any potential impacts to ecology. Options appraisal to develop mitigation measures if appropriate.
WINEP Water resources investigations and options appraisals	Colne (From confluence with Ver to Gade)	Upper Colne – LANE Group	WFD_INV_WRFlow	Impact of LANE Group abstractions on River Colne	Options Appraisal only to identify mitigating measures
WINEP Water resources investigations and options appraisals	AP6, River Stour at Cattawade northern channel	ESTB	WFD_NDINV_WRH MWB	Sustainability of future increased abstractions	Investigation to assess future abstraction and any potential impacts to ecology. Options appraisal to develop mitigation measures if appropriate.
Biodiversity (NERC) WINEP - Land Management/ Habitat Restoration/ Physical Improvement	NERC Section 41 Species and Habitats	All sites	WINEP: NERC_IMP1	Recording protected species and habitats present on Affinity Water landholdings	Take action to protect, restore and enhance any NERC section 41 species and habitats that are present on any land owned or managed by Affinity Water.

Biodiversity (NERC) WINEP - Investigation and Options Appraisal	Support of Partnership Projects	All sites	WINEP: NERC_INV1	Working with external stakeholders to enhance biodiversity	Support partnership projects which are aiming to enhance and protect biodiversity species and habitats in catchments where the water company operates.
Biodiversity (NERC) WINEP - Investigation and Options Appraisal	National Pollinator Strategy	All sites	WINEP: NERC_INV1	Affinity Water sites not managed to benefit pollinators	Investigate how water company landholdings can contribute to the National Pollinator Strategy and develop site management options to benefit pollinators.
Biodiversity Invasive Non-Native Species (INNS) WINEP - Catchment Measure	Spread of INNS	All sites	WINEP: INNS_ND	Spread of Invasive Species to and from Affinity Water landholdings	Take action to reduce the risk of spread of INNS which may be present or may occur on any land owned or managed by Affinity Water.
Biodiversity (INNS) WINEP - Catchment Measure	Support of Partnership Projects	All sites	WINEP: INNS_ND	Working with external stakeholders to manage Invasive Species	Support multiple partnership projects which are aiming to prevent introduction and spread of invasive species in catchments where Affinity Water operate.
Biodiversity (INNS) WINEP - Investigation and Options Appraisal	Raw Water Transfer	All sites	WINEP: INNS_INV	Spread of Invasive Species through raw water transfers	New water transfers being considered under the WRMP investigated for pathway spread analysis, prevention of deterioration to waterbodies. NB: we currently do have any raw water transfers proposed but EA have requested it be retained in WINEP

Biodiversity (INNS) WINEP - Investigation and Options Appraisal	Non-native Species Plan	All sites	WINEP: INNS_INV	Spread of Invasive Species to and from Affinity Water landholdings	Produce a company-wide invasive non-native species plan (to include managing pathways of risk and site/species specific actions to prevent deterioration.
WINEP Water Resources Implementation Morphological Mitigation	Ivel (US Henlow)	BOWR, FULR and BALD	WFD_IMP_WRFlow , INNS_ND and NERC_IMP1	Linked to WR AMP6 Options Appraisal work where river restoration will be conducted in combination with river support schemes.	Implementation Scheme: Undertake river restoration to mitigate the effects of abstraction
WINEP Water Resources Implementation Morphological Mitigation	Cam (Audley End to Stapleford)	NEWP, WEND, DEBD, UTTL and SPRF	WFD_IMP_WRFlow , INNS_ND and NERC_IMP1	Linked to WR AMP6 Options Appraisal work where river restoration will be conducted in combination with river support schemes.	Implementation Scheme: Undertake river restoration to mitigate the effects of abstraction
WINEP Water Resources Implementation Morphological Mitigation	Ver (FRIA to Bricketwood)	KENS, FRIA, MUDL, HOLY	WFD_IMP_WRFlow and NERC_IMP1	Programme of river restoration projects is managed and scoped under Chalk Streams Partnership (Executive Programme Board: Environment Agency and Affinity Water). This programme started in AMP6 and should continue until all necessary projects have been delivered.	Adaptive Management: Undertake river restoration projects and monitor the benefits of the sustainability reductions.
WINEP Water Resources Implementation Morphological Mitigation	Gade (Great Gaddesden to Gade's confluence with the Grand Union Canal)	PICC, MARL	WFD_IMP_WRFlow and NERC_IMP1	Programme of river restoration projects is managed and scoped under Chalk Streams Partnership (Executive Programme Board: Environment Agency and Affinity Water). This programme started in AMP6 and should continue until all necessary projects have been delivered.	Adaptive Management: Undertake river restoration projects and monitor the benefits of the sustainability reductions.
WINEP Water Resources Implementation Morphological Mitigation	Misbourne (Great Missenden to the M25 at DENH)	GREM, AMER, CHAL and GERR	WFD_IMP_WRFlow and NERC_IMP1	Programme of river restoration projects is managed and scoped under Chalk Streams Partnership (Executive Programme Board: Environment Agency and Affinity Water). This programme started in AMP6 and should continue until all necessary projects have been delivered.	Adaptive Management: Undertake river restoration projects and monitor the benefits of the sustainability reductions.
WINEP Water Resources Implementation Morphological Mitigation	Lee (from Luton to Luton Hoo Lakes)	PERI, RUNL, CRES	WFD_IMP_WRFlow and NERC_IMP1	Programme of river restoration projects is managed and scoped under Chalk Streams Partnership (Executive Programme Board: Environment Agency and Affinity Water). This programme started in AMP6 and should continue until all necessary projects have been delivered.	Adaptive Management: Undertake river restoration projects and monitor the benefits prior to sustainability reductions.

WINEP Water Resources Implementation Morphological Mitigation	Beane (Walkern Mill to Stapleford)	SACO, AST1 and WHIH	WFD_IMP_WRFlow and NERC_IMP1	Programme of river restoration projects is managed and scoped under Chalk Streams Partnership (Executive Programme Board: Environment Agency and Affinity Water). This programme started in AMP6 and should continue until all necessary projects have been delivered.	Adaptive Management: Undertake river restoration projects and monitor the benefits of the sustainability reductions.
WINEP Water Resources Implementation Morphological Mitigation	Mimram (Kimpton Mill to Tewin Water)	CODI, FULL, DIGS and SCHO	WFD_IMP_WRFlow and NERC_IMP1	Programme of river restoration projects is managed and scoped under Chalk Streams Partnership (Executive Programme Board: Environment Agency and Affinity Water). This programme started in AMP6 and should continue until all necessary projects have been delivered.	Adaptive Management: Undertake river restoration projects and monitor the benefits of the sustainability reductions.
WINEP Water Resources Implementation Morphological Mitigation	Upper Colne (Ver to Berrygrove gauge)	NETH, BRIC, EAST and BERR	WFD_IMP_WRFlow and NERC_IMP1	Abstraction mitigation under the AMP5 investigation and options appraisal	Adaptive Management: Undertake river restoration projects and monitor the benefits.
WINEP Water Resources Implementation Morphological Mitigation	Bulbourne (Dudswelll to Boxmoor)	BERK	WFD_IMP_WRFlow and NERC_IMP1	Abstraction mitigation under the AMP6 investigation and options appraisal	Adaptive Management: Undertake river restoration projects and monitor the benefits.
WINEP Water Resources Implementation Morphological Mitigation	Chess (Upstream of CHES STW)	CHES and CHAR	WFD_IMP_WRFlow and NERC_IMP1	Investigation ongoing and the solution unknown. The solution that will go through implementation will be determined through the investigation and options appraisal. River restoration works (if recommended) would be undertaken in partnership with Thames Water.	Adaptive Management: Undertake river restoration projects and monitor the benefits.
WINEP Water Resources Implementation Morphological Mitigation	Brett (AP4, River Brett at confluence with Stour)	HIGH, LATT, SHELL, STOK	WFD_IMP_WRFlow	To implement the conclusions of preceding Inv/OA in collaboration with Essex & Suffolk Water and Anglian: this is likely to involve habitat restoration/compensation discharge to mitigate for reduction in flows, but could involve a sustainability reduction.	Adaptive Management: Undertake river restoration projects and monitor the benefits

WINEP Water Resources Implementation Morphological Mitigation	Colne (Confluence with Chess to Maple Lodge STW)	BATC, STOC, WESY and SPRW	WFD_IMP_WRFlow and NERC_IMP1	EA consider flow deficit in this water body is probable reason for declining fish population. Sustainability reductions agreed in the upper catchments will restore flows towards good hydrological regime but won't be sufficient to reach flow compliance in the catchment. The ecological evidence suggest that especially sensitive flow area is upstream of the Maple Lodge STW. This water body is complex and we would like to work with Affinity Water to improve the ecological resilience of this water body, with Affinity Water focusing on the section upstream of the Maple Lodge STW.	Adaptive Management: Undertake river restoration projects and monitor the benefits.
WINEP Restoring Sustainable Abstraction	Misbourne	AMER	WFD_IMP_WRFLOW	Level of certainty – Green	Sustainability reduction Average and peak
WINEP Restoring Sustainable Abstraction	Ver	HOLY and MUDL	WFD_IMP_WRFLOW	Level of certainty – Green	Sustainability reduction - Peak
WINEP Restoring Sustainable Abstraction	Upper Lee	RUNL and PERI	WFD_IMP_WRFLOW	Level of certainty – Green	Sustainability reduction – Average and peak
WINEP Restoring Sustainable Abstraction	Mimram	DIGS	WFD_IMP_WRFLOW	Level of certainty – Green	Sustainability reduction – Average
WINEP Restoring Sustainable Abstraction	Wicken Water Cam (Newport to Audley End) Wendon Brook Cam (Audley End to Stapleford)	WEND	WFD_ND_WRFLOW	Level of certainty – Green	Capping of licence to recent actual
WINEP Restoring Sustainable Abstraction	Cam (US Newport) Wicken Water Cam (Audley End to Stapleford)	NEWP	WFD_ND_WRFLOW	Level of certainty – Green	Sustainability reduction – Average
WINEP Restoring Sustainable Abstraction	Cam (Newport to Audley End) Cam (Audley End to Stapleford) Wendon Brook	DEBD	WFD_ND_WRFLOW	Level of certainty – Green	Capping of licence to recent actual

WINEP Restoring Sustainable Abstraction	Ivel (US Henlow)	BALD BOWR FULR	WFD_ND_WRFLOW	Level of certainty – Green	Capping of licence to recent actual
WINEP Restoring Sustainable Abstraction	Cam (Audley End to Stapleford) Cam (Newport to Audley End)	SPRF	WFD_ND_WRFLOW	Level of certainty – Green	Capping of licence to recent actual
WINEP Restoring Sustainable Abstraction	Cam (Audley End to Stapleford) Wicken Water Cam (Newport to Audley End) Wendon Brook	UTTL	WFD_ND_WRFLOW	Level of certainty – Green	Capping of licence to recent actual
WINEP Restoring Sustainable Abstraction	Chess	CHES CHAR	WFD_IMP_WRFLOW	Level of certainty – Amber	Sustainability reduction Average and peak
WINEP Restoring Sustainable Abstraction	Ivel	BOWR	WFD_IMP_WRFLOW	Level of certainty – Amber	River support scheme
WINEP Restoring Sustainable Abstraction	Cam (Audley End to Stapleford) Cam (Newport to Audley End)	UTTL	WFD_IMP_WRFLOW	Level of certainty – Amber	Revision to licence trigger for river support provision
WINEP Restoring Sustainable Abstraction	Brett	SHEL HIGM LATT STOK	WFD_IMP_WRFLOW	Level of certainty – Amber	Sustainability reduction Average and peak

4.10 Environmental enhancements totex summary

The table below summarises the AMP7 costs of the Environmental Enhancements Programme.

Table 4-4 Overview of AMP7 costs

Programme	Description	Key deliverables	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
Abstraction impact assessments	Water resource investigations and options appraisals relating to surface water flows and groundwater resources	• 8 investigations and/or options appraisals relating to surface water flows and groundwater bodies • 17 no deterioration investigations relating to surface water flow and groundwater resources	6.33	0.00	0.00	6.33
Reducing our abstractions (Sustainability Reductions)	Enabling the local implementation of sustainable abstraction reductions at sites classified as 'amber' and 'green' on WINEP3	• Green sustainability reductions; 27.33Ml/d (average) / 13.40Ml/d (peak) • Amber sustainability reductions; 8.98Ml/d (average) / 10.26Ml/d (peak)	58.42	0.00	0.00	58.42
Catchment Management	Working collaboratively with farmers, regulators, water companies and other key stakeholders to identify, investigate and mitigate the risk of raw water pollution through catchment management in high-risk catchments	• River Thames pesticide reduction schemes • Groundwater pesticide reduction schemes • Nitrate affected sources catchment management schemes • Detailed risk assessment of the land use within the Source Protection Zones of our 116 groundwater sources • 6 WINEP WQ catchment management investigations	7.11	0.00	0.00	7.11

Programme	Description	Key deliverables	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
River enhancement	Where there is evidence of potential impact from our abstraction on chalk stream priority habitats, we seek to improve the flow and habitat to support good ecological status or potential under WFD.	157km of river improvements through sustainability reductions and river restoration and habitat enhancement work, including: • Weir removal or modification to improve fish passage • Tree works to allow more light into the river channel • Habitat enhancements • Fencing to prevent poaching / damage to river banks • Planform restoration including channel realignment or re-meandering • installation of a dedicated river support borehole and associated infrastructure	19.04	0.00	0.00	19.04
Biodiversity	We have responsibility for managing land holdings across our supply area (1470ha), including statutory designated sites, Site of Special Scientific Interest (SSSI), and sites of local conservation importance	• Protect, restore and enhance NERC Section 41 species and habitats within our supply area • Contribute to the National Pollinator Strategy • Promote ecological enhancement by undertaking tree inspections and necessary remedial work • Survey, manage and control invasive species • Undertake priority species and habitat monitoring and develop specific management plans where appropriate • Participate in a partnership with Up on the Downs	3.00	0.00	0.00	3.00
					Total:	**93.89**

4.11 Supporting documentation

Table 4-5 Document references

Scheme Name	Business Case Name	Supporting Documents/ Technical Reports
All	N/A	Water Industry Strategic Environmental Requirements (WISER) Report (August 2018)
Catchment management for water quality	River Thames Pesticides CM	PR19 Business Case Full CM River Thames Pesticides v3
		National Environment Programme Water Quality Schemes: River Thames DrWPA Investigation Report
		Unit Costs PR19 - Lower Wey DrWPA
		Unit Costs PR19 - River Thames DrWPA
		EA PR19 Driver Guidance: DrWPA Final
		Guidance Note: Long term planning for the quality of drinking water supplies Drinking Water Inspectorate Guidance to water companies
Catchment management for water quality	Groundwater Pesticides CM	PR19 Business Case Full CM Groundwater Pesticides v2
		National Environment Programme Water Quality Schemes: Groundwater Pesticides Investigation Report
		Unit Costs PR19 - NORM DrWPA
		Unit Costs PR19 - LANE Group DrWPA
		EA PR19 Driver Guidance: DrWPA Final
		EA PR19 Driver Guidance: Groundwater Pressures Final
		Guidance Note: Long term planning for the quality of drinking water supplies Drinking Water Inspectorate Guidance to water companies
		Mapping of karst features and identification of preferential pollutant pathways
Catchment management for water quality	Nitrate Affected Sources CM	PR19 Business Case Full CM Nitrate Affected Sources v2
		National Environment Programme Water Quality Schemes: Nitrate Affected Sources Investigation Report
		Unit Costs PR19 - SBRO Nitrate
		Unit Costs PR19 - CHAR Nitrate
		Unit Costs PR19 – CHIP Nitrate
		Unit Costs PR19 - KINW Nitrate
		Unit Costs PR19 - SKIN Nitrate
		Unit Costs PR19 - OFFS and OUGH Nitrate
		Unit Costs PR19 - SLIP Nitrate
		EA PR19 Driver Guidance: Groundwater Pressures Final
		Guidance Note: Long term planning for the quality of drinking water supplies Drinking Water Inspectorate Guidance to water companies
		Mapping of karst features and identification of preferential pollutant pathways
		Nitrate and Pesticide Modelling Synthesis Report
		PR19 Business Case Full CM WINEP Investigations v2

Scheme Name	Business Case Name	Supporting Documents/ Technical Reports
All	N/A	Water Industry Strategic Environmental Requirements (WISER) Report (August 2018)
Catchment management for water quality	WINEP WQ investigations CM	Unit Costs PR19 - WHIH Nitrate
		Unit Costs PR19 - CLAN Coliform
		Unit Costs PR19 - DREL Coliform
		Unit Costs PR19 - Lower River Colne Pesticides
		Unit Costs PR19 - NEWP Nitrate
		Unit Costs PR19 - NORM and Sources emerging pesticides
		Unit Costs PR19 - NORM Nitrate
		Unit Costs PR19 - STAN Nitrate
		EA PR19 Driver Guidance: Groundwater Pressures Final
		Guidance Note: Long term planning for the quality of drinking water supplies Drinking Water Inspectorate Guidance to water companies
		EA PR19 Driver Guidance: DrWPA Final
		Nitrate and Pesticide Modelling Synthesis Report
		AM739 - DWSP Catchment Survey and Risk Assessment Methodology v1
		PR19 risk scoring matrix
		PR19 Site Selection Catchment (AW)
		PR19 Emerging Trends (AL)
Catchment management for water quality	Drinking Water Safety Plan CM	PR19 Business Case Full DWSP v2
		Unit Costs PR19 - DWSP
		Guidance Note: Long term planning for the quality of drinking water supplies Drinking Water Inspectorate Guidance to water companies
		Drinking water quality management from catchment to consumer. Chapter 4 - Developing a catchment Water Safety Plan
		AM739 - DWSP Catchment Survey and Risk Assessment Methodology v2
NEP Investigations and Options Appraisals	NEP Investigations and Options Appraisals	Unit Costs PR19 – Colne Essex and Ardleigh Reservoir
		Unit Costs PR19 – River Pant
		Unit Costs PR19 – River Chelmer
		Unit Costs PR19 – Cam and Ely Ouse Chalk
		Unit Costs PR19 – River Ash
		Unit Costs PR19 – Nailbourne and Little Stour
		Unit Costs PR19 – Upper Dour
		Unit Costs PR19 – Dour
		Unit Costs PR19 – North and South Streams
		Unit Costs PR19 – Mid Chilterns Chalk
		Unit Costs PR19 – Upper Bedford Ouse Chalk
		Unit Costs PR19 –Upper Stort
		Unit Costs PR19 – Rib (Quinn to Lee)

Scheme Name	Business Case Name	Supporting Documents/ Technical Reports
All	N/A	Water Industry Strategic Environmental Requirements (WISER) Report (August 2018)
		Unit Costs PR19 – Stansted Brook
		Unit Costs PR19 – Stort and Bourne Brook
		Unit Costs PR19 – Upper Lee Chalk and Lee (Hertford to Fieldes Weir)
		Unit Costs PR19 – Upper Colne
		Unit Costs PR19 – North Essex Chalk and Stutton Brook
		Unit Costs PR19 – Brett at confluence with Stour
		PR19 Business Case Full NEP Investigation and Options Appraisal
		Environment Agency Guidance: Guidance on water resources investigations into the risk of WFD waterbody deterioration
Biodiversity Programme	Biodiversity Programme	PR19 Business Case Full - Biodiversity Programme
		PR19 Unit Costing - Central Region
		PR19 Unit Costing - East Region
		PR19 Unit Costing - Southeast Region
		Summary of Evidence of Costs
		PR19 Driver Guidance: Invasive Non-Native Species (INNS)
		Biodiversity WINEP3 Schemes
		Summary of Total Costs
River Enhancement programme	Morphological Mitigation	Beane Morphological Costs - Unit Costs PR19 - Water Resources and NEP v03
		Bulbourne Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Cam Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Chess Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Gade Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Ivel Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Mimram Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Misbourne Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02

Scheme Name	Business Case Name	Supporting Documents/ Technical Reports
All	N/A	Water Industry Strategic Environmental Requirements (WISER) Report (August 2018)
		Colne Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Upper Colne Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Lea Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Ver Morphological Costs - Unit Costs PR19 - Water Resources and NEP v02
		Beane Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Bulbourne Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Cam Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Chess Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Gade Monitoring Costs - Unit Costs PR19 - Water Resources and NEP Dftv02
		Ivel Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Mimram Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Misbourne Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Colne Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Upper Colne Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Lea Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		Ver Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02

Scheme Name	Business Case Name	Supporting Documents/ Technical Reports
All	N/A	Water Industry Strategic Environmental Requirements (WISER) Report (August 2018)
		Brett Morphological Costs - Unit Costs PR19 - Water Resources and NEP v03
		Brett Monitoring Costs - Unit Costs PR19 - Water Resources and NEP v02
		PR19_Morphological_Projects_ALL_RIVERS_JE
		WINEP2_Affinity_Morphology
Sustainability Reductions	AMP 7 Sustainability Reductions	PR 19 mains laying costs summary
		dWRMP Technical report 1.4 Sustainability Reductions
		PR19 – Sustainability Reductions Costs Green PLAN V2
		PR19 – Sustainability Reductions Costs Amber PLAN V2

5 Non-infrastructure assets

5.1 Overview

Our non-infrastructure asset base comprises of approximately 70,000 assets covering operational sites. This includes reservoirs, water towers, boosters and WTW.

This section describes the tools and processes that deliver asset lifecycle management and explains how they support the investment planning cycle.

It also describes the specific expenditure for production assets, derived from

- Asset optimisation tool (PIONEER)
- Issues recorded in our Asset Risk Module (ARM), and
- Master Development Plans.

Finally, it details additional non-infrastructure investment requirements refined through the business case development process. This includes enhancement investments, originally identified through the WRMP process, and required to maintain the supply demand balance.

5.2 Asset maintenance and investment planning process

5.2.1 Purpose and scope

PIONEER is our primary planning tool and is used in conjunction with master development plans (MDP) - long term plans for strategic sites, and our asset risk module (ARM) - used for continual management of risks.

This section summarises the process for investment planning of non-infrastructure production assets and the improvements in our approach since PR14. There are approximately 70,000 physical assets on our production sites, covering everything from monitoring equipment to major civil structures.

Our process builds the deterioration functions and models the likelihood and impact of asset failure should it occur, for each of our assets. It forecasts future Maintenance Non-Infrastructure (MNI) investment which is essential to maintain the service levels required by customers and to meet our statutory obligations.

The process is fully integrated with other asset investment groups in our optimisation tool (PIONEER). Optimisation, concepts and benefits are described in further detail in section 8. The risk framework used here, and in PIONEER, incorporates our service outcome measures, PCs and ODI targets.

We apply asset management best practice, including the Framework for Expenditure Decision Making[8] which embraces the Common Framework[9], where we follow the most advanced techniques as identified in the Common Framework Review of Current Practice[10], (1a - service modelling with repairable and non-repairable failure modes), updated as appropriate by UKWIR and other industry research. Several processes and data have been enhanced since PR14. Section 5.2.4 gives more detail on the key steps in this process.

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[8] *UKWIR, Framework for Expenditure Decision Making. Ref 14/RG/05/40*
[9] *UKWIR, Capital Maintenance Planning a Common Framework. Ref 02/RG/05*
[10] *UKWIR, Capital Maintenance Planning Common Framework: Review of Current Practice, Ref: 05/RG/05/14.*

In section 5.2.7 the asset care process and how it is used to feedback issues and learning to the investment planning process is documented. The results from this analysis and the optimisation process can be found in section 8.3.

5.2.2 Characteristics of our production assets

The medium life asset groups (pumping, water treatment and other mechanical and electrical plant) represent a significant proportion (37%) of our asset value and this is where replacement proves the most effective investment option, driven by the need to maintain outcomes at least cost. Instrumentation, control and automation assets (ICA) account for 1% of our asset value and is expected to be short life. for 1% of our asset value and is expected to be short life. for 1% of our asset value and is expected to be short life. for 1% of our asset value and is expected to be short life. The investment for our storage assets is detailed in section 5.3.1.

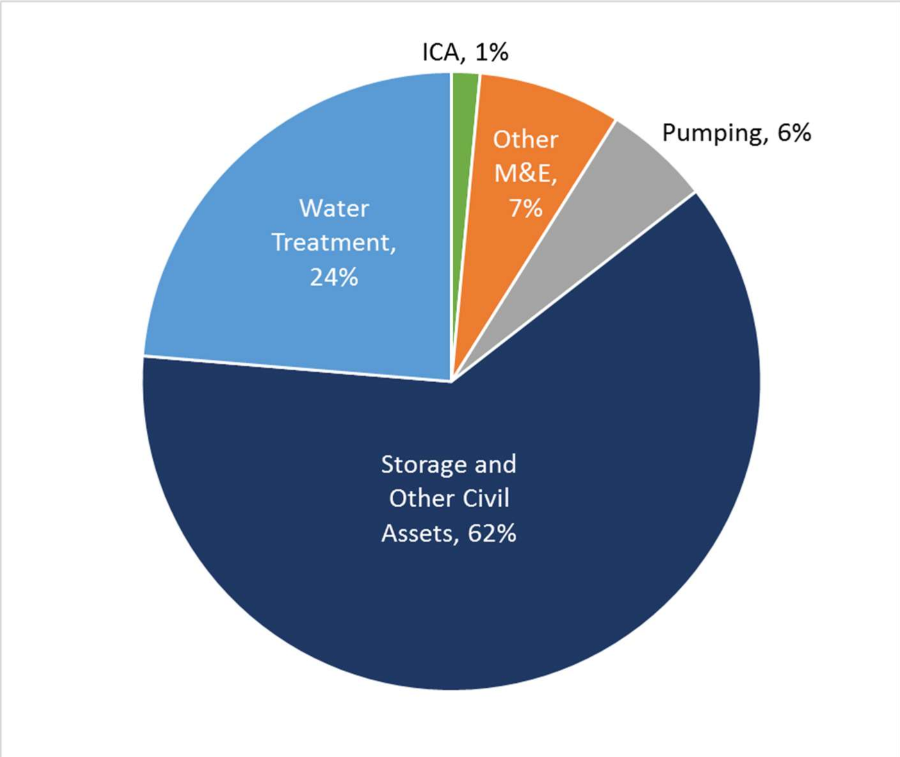

Figure 5-1 Breakdown of Asset Life Groups by GMEAV

5.2.3 Age and condition of assets at our surface works

As part of our development planning process, clusters of assets within certain processes, installed at the same time, have been inspected and identified as deteriorating. For specific details of condition and remediation see section 5.2.6.

Investments on these site-specific projects have been cross checked with the PIONEER outputs and are 'drawing down' part of the reactive capex forecast from PIONEER. PIONEER capex has been reduced accordingly.

Figure 5-2 shows sites (source works, reservoirs, towers and boosters) in the company ranked by average criticality, in terms of potential for interruptions. In our consequence modelling, should a site fail, we use the exact number of customers impacted after operational mitigation over different time-spans (0-3 hours, 6-12 hours etc.). As a broader indication of the importance of each site, we use the weighted average number of customers impacted over these time bands and the costs of mitigation, to calculate the potential impact as property minutes.

Our larger sites tend to be are situated to the left of the graph. The steepness of the curve shows that we have taken steps to mitigate against failure at many sites in the past through our SEMD programme, and trunk main hot spots programme in since 2015, but we still have some smaller strategic sites, which have few alternative means of supply. The chart shows that that 83% of our sites are mitigated by other means.

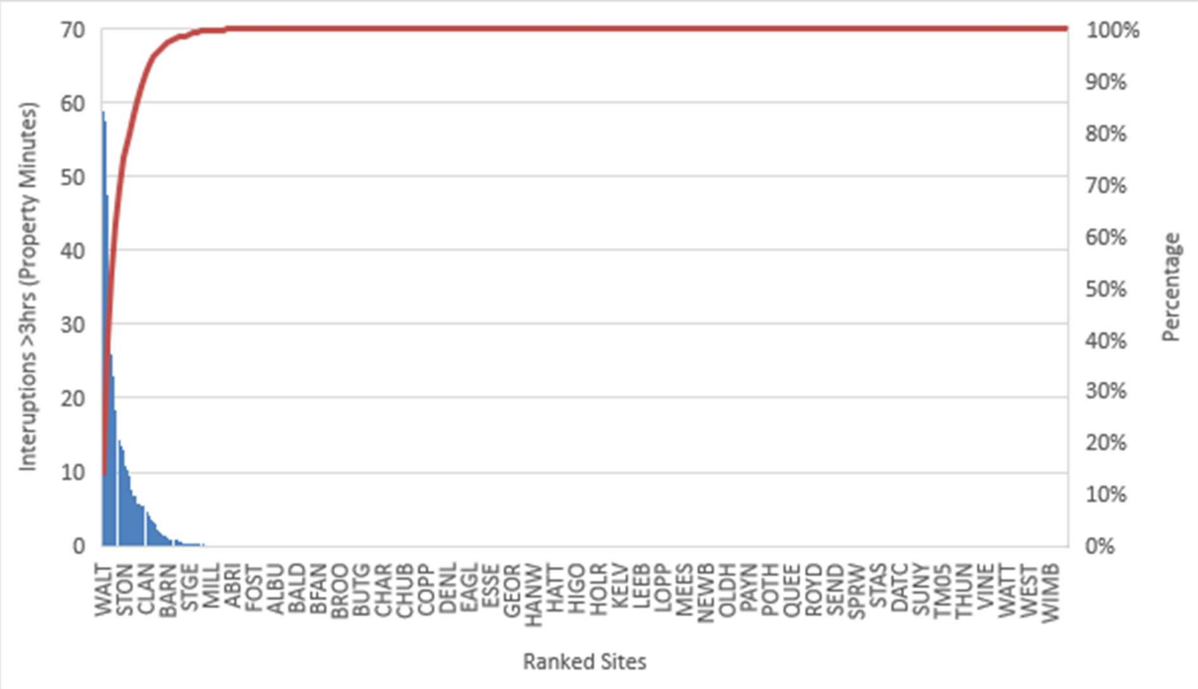

Figure 5-2 Criticality of Production Sites

5.2.4 Overall process

The overall process for forecasting production investment is summarised in the figure below. More details on each sub-process can be found in sections 5.2.5 - 5.2.6.

Process map

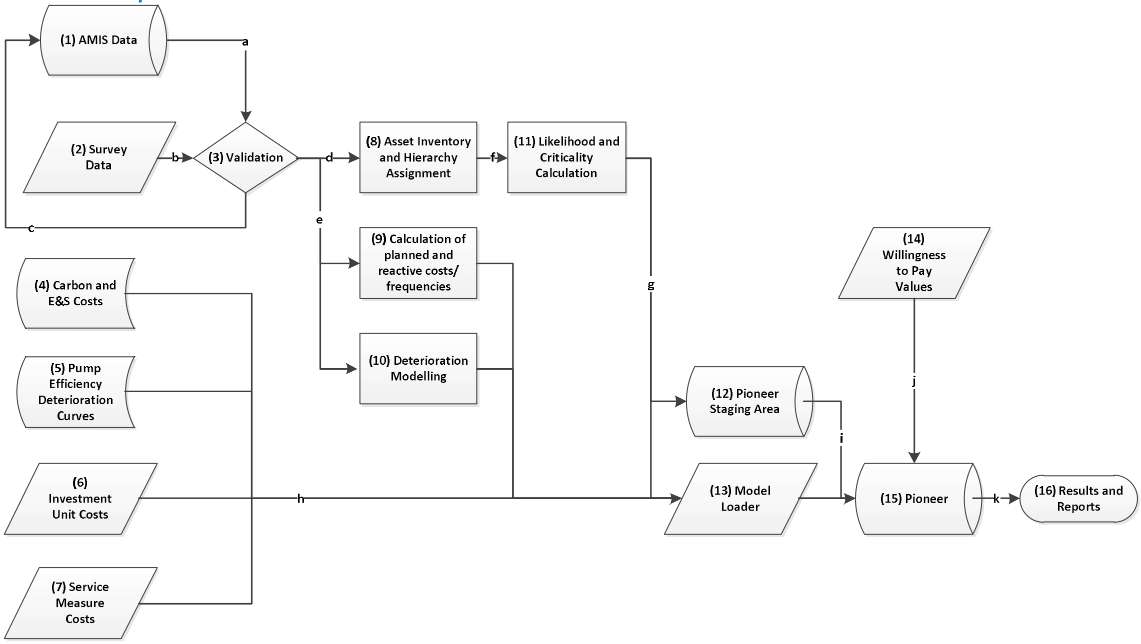

Figure 5-3 The Non-Infrastructure Production Investment Planning Process

5.2.4.1 Process commentary

1. Asset Management Information System (AMIS) Data

The key source of information for production assets is the AMIS system. This provides asset attributes such as asset unit type, size and year of installation; maintenance information such as planned and reactive maintenance events and durations; and the hierarchical tree of assets within each production site.

Since 2015, we have completed our Asset Care Planning (ACP) initiative. This has standardised maintenance practices and ensures the appropriate level of asset care is in place for all our assets. It also restructured the AMIS data into 357 Equipment Group Identifiers (EGIs) to which a risk based operational maintenance regime are applied.

2. Survey Data

All the production sites have had their data updated to the AMIS standard through the asset care optimisation (ACO) process. This has included categorisation of sites by criticality based on potential impact to customers of asset failure.

3. Validation

All survey information was challenged and reviewed in detail through the ACO process. The steps were:

- Site by site review with Production Technicians
- Asset Care Team Review
- Risk Based workshop with Production Technicians
- Peer review with Production Managers/Team Leaders
- Sign off by Technical Support Lead.

4. Carbon, Environmental and Social Costs
Our environmental consultant Jacobs restructured and updated our carbon and environmental unit costs and carbon emissions model and report[11], considering the latest research in this area and the new EGI classification system. An embedded carbon cost and carbon emission is calculated based on the material composition of each asset type, along with the change in operational emissions as a result of replacing assets with new technology.

5. Pump Efficiency Deterioration Curves
We have been active on the steering group for the Water Research Centre project CP348b[12] and have utilised the findings in our investment optimisation. The functions are utilised in PIONEER to determine the increase in energy consumption due to deterioration, though the life-cycle of all our pump sets.

The cost also accommodates the impact of change in energy use on our Carbon Reduction Commitment (CRC) costs and our future price rise forecasts (excluding RPI).

6. Investment Unit Costs
Our capital and operating costs have been extensively updated and benchmarked. The resultant cost models have been uploaded into PIONEER via the excel loaders.

7. Service Measure Costs
We have a detailed Service Measure Framework which is linked to the service outcomes customers expect:

- Supplying high quality water you can trust
- Making sure you have enough water while leaving more water in the environment
- Minimising disruption to you and your community
- Providing a great service that you value

8. Asset Inventory and Hierarchy Assignment
The asset inventory has been checked and assets mapped to one of the 357 EGIs and relevant attributes populated.

9. Calculation of Maintenance Costs and Frequencies
AMIS work event data and procurement purchase information is used to calculate the frequency and cost of both planned and reactive work events, over the lifecycle of each unit type.

The number of work events is plotted for each year of age and trended to obtain an age-based frequency and cost per unit type. These gradients and costs are loaded into PIONEER using the model loader. There is a report[13] detailing the process from our consultants Mace Ltd.
Since 2015, our maintenance data has improved through the introduction of 15,000 additional assets and a further five years of reliable data, gathered using our electronic field information system. We also benefited from a further five years of lifecycle history, which helps to more accurately define the trend for long-life assets.

10. Deterioration Modelling
The rate of failure (hazard rate) of each EGI for a given age is determined using a Weibull probability distribution function. Where sufficient lifetime failure data from AMIS is available, we calculate the statistical distribution function using an excel workbook validated against

[11] *PR19 ES Costing FBP v1.31.xlsx, Affinity Water 2017 Report v1.2*
[12] *P8688 Pumps Whole Life Cost Continuation Project – Final.pdf; WRc report C348b, December 2011.*
[13] *Mace EGI PR19 Cost Assessment Report- v2.2.pdf*

proprietary Weibull++®7 software. Where this is not the case, we carried out an expert review with the Maintenance Strategy Manager and revised our PR14 models accordingly.

Further analysis of the age ranges of surviving assets was undertaken using the maximum and mean age per EGI. This ensured that all surviving assets were within the envelope of the distribution.

11. Likelihood and Criticality Assessment
Unique likelihood and criticality values are determined for each of our 70,000 above ground assets. Likelihood values are expressed as factors and criticality values as properties affected, property minutes (in the case of the Interruptions) and an Index (in the case of CRI). They are used to estimate the impact on service if an asset fails. This is a crucial aspect of the optimisation process which, when coupled with deterioration and cost information, yields the cost to the business of an asset if it was to fail.

There have been some key enhancements to this approach since our last business plan:

- Likelihood is calculated for each asset individually
- Allowance is made for the likelihood of redundant plant failing during outage for repair or replacement i.e. during the Mean Time to Repair (MTTR)
- The property numbers impacted are scaled and weighted by time bands and the duration of mitigating actions. This has been carried out using a combination of hydraulic modelling, emergency planning and control room expertise
- The asset hierarchy is now risk based enabling automated and consistent calculation of likelihood of consequence should an asset fail.

12. PIONEER Staging Area
The Staging Area is an SQL database which stores the unit and unit attribute data described above. Microsoft SQL Server Manager is used to import the data and some basic checks for duplicates and presence of parents are carried out during this process.

13. Model Loader
As described above the Microsoft Excel loader allows model coefficients and tables of values for lookup purposes to be imported and exported from PIONEER.

14. Willingness to Pay Values
Willingness to pay values can be added or excluded.

15. PIONEER
Full verification of incoming data from the Staging Area is carried out during the PIONEER import process

16. Results and Reports
PIONEER generates numerous reports covering all costs and service measures at any level of the asset hierarchy. PIONEER and the reporting and optimisation process are more fully described in section 8.3, along with the results for the entire portfolio of investments and the comparison with historic expenditure.

5.2.5 Asset inventory and hierarchy

5.2.5.1 Data requirements

The asset inventory data structure had been developed through AMP6 to align the Asset Management Information System (AMIS) and the PIONEER optimisation package across all operational non-infrastructure assets. This was built in a new consistent architecture adopted to align with the Asset Care Plans as described in section 5.2.7 and to arrange the assets so that the likelihood of an asset type level failure can be calculated using the arrangement of processes, sub-processes and assets below it in the hierarchy.

The extracted AMIS/Asset Care data contains 69,888 physical asset records.

The transformation from the consolidated and validated AMIS database and Asset Care workbooks to the PIONEER Asset Dependency Hierarchy (ADH) format was achieved using Microsoft Excel 2010 workbooks. The key principal of the transformation was that renewable items (i.e. potential candidates for capital maintenance expenditure) within the ADH had to be recorded at the lowest level of the hierarchy, i.e. “children” with “parents”. To achieve the desired structure in the ADH we required a reconfiguration of our AMIS data structure with the addition of “dummy” or place-holder units. A comparison between the AMIS data structure and that required by PIONEER is described below by way of examples.

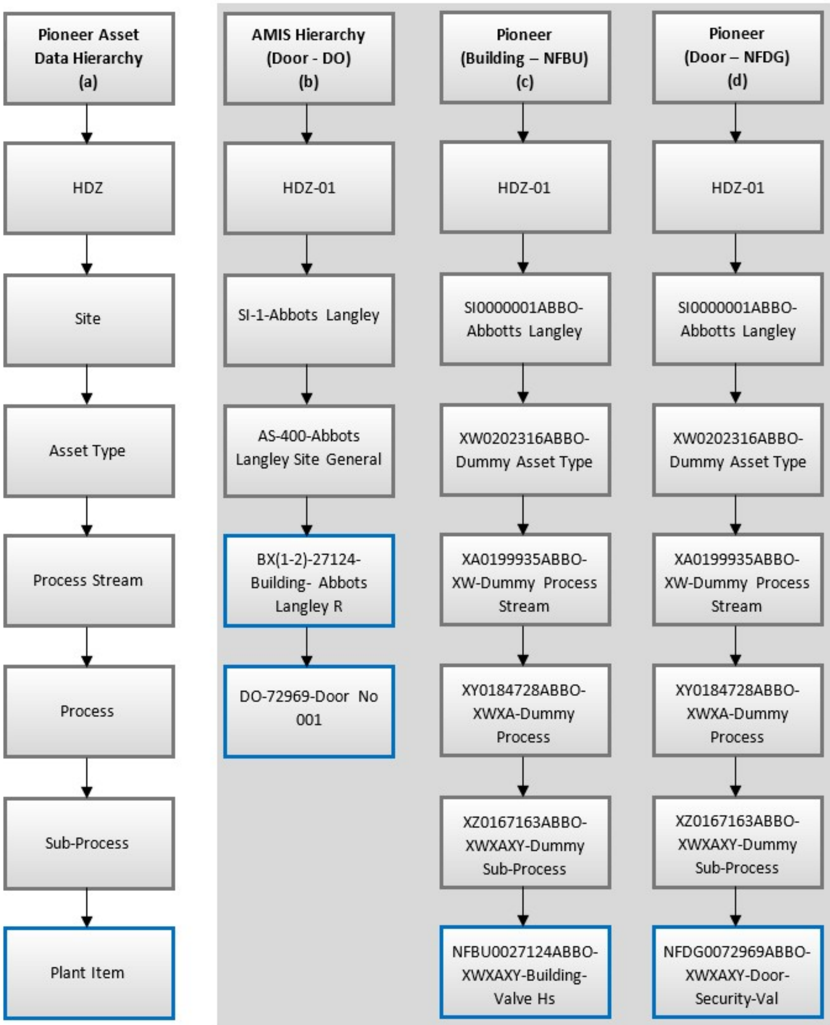

Figure 5-4 AMIS Hierarchy versus PIONEER Hierarchy

Figure 5-4 illustrates two assets at different levels in the AMIS hierarchy and how they are adjusted to move them to the plant item level (highlighted with a blue border) in the PIONEER hierarchy. This also shows the new parent structure and four-character plant item equipment group identifiers, or “EGIs”

(a) PIONEER employs an intrinsic non-infrastructure (NI) hierarchy in a number of places including Non–infrastructure Failure Modes and consequence lookups. As such the asset data from AMIS and the survey had to follow this strict hierarchy rule to enable PIONEER to identify optimal investment for each individual renewable asset at plant item level.

(b) Data from AMIS had renewable items at different levels of its hierarchy, with some acting as parents to other renewable items (RIs). To enable the application of failure likelihood and consequence to RIs in PIONEER, they all had to be at the lowest level (plant item level) in the hierarchy.

(c) Building (BX) in the AMIS hierarchy is a renewable item and as such in PIONEER must be represented at the plant item level. This change in hierarchy level creates a gap in the hierarchical tree which then needs to be gap filled with dummy parents for it to conform with the PIONEER hierarchy requirements. Note: "Dummy Asset Type" is equivalent to "Site General".

(d) Door (DO) also being an RI is a child of another renewable item (BX) which has been moved to the lowest level. Since they are both part of the same area of the site, and work together in their function, they are represented by the same hierarchical structure, so adding the dummy parents does not remove the link that the previous structure provided.

5.2.5.2 Process map

This section describes the process for the creation of the PIONEER unit asset data shown below.

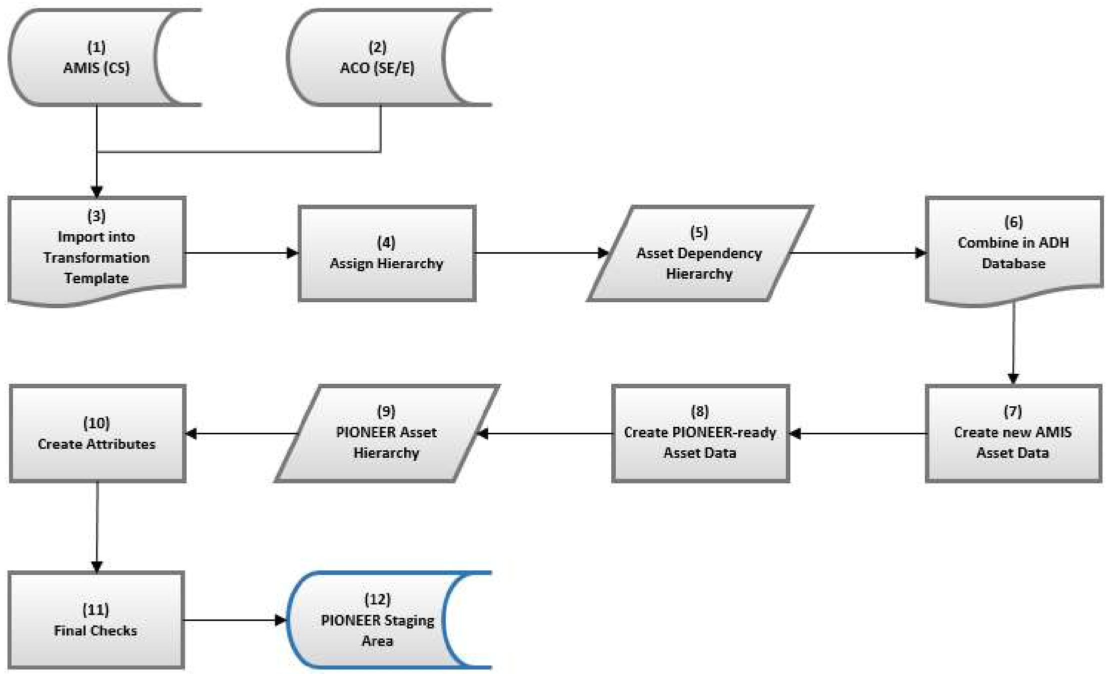

Figure 5-5 Creation of PIONEER Base Asset Data

1. AMIS Data

Our assets were extracted from the AMIS Asset Register where possible using Business Objects and compiled in an Excel workbook[14].

[14] *Site Search.xlsx*

2. Asset Care Planning (ACP) Data
Sites and assets which were in the ACP process and therefore not in AMIS at the time of data extraction, were taken directly from ACP project surveys.

Data from the ACP surveys which gathered all the production assets and maintenance regimes was challenged and reviewed in detail.

The steps were:
- Site by site review by survey manager
- Independent verification report by auditor
- Quality Assurance check by provider
- A logic check by Asset Management team
- Local coverage checks by Asset Management/production team
- Comments and challenges fed back and re-checked on completion.

3. Transformation Template
Data for each site was imported into its own template spreadsheet[15] that was created to add a consistent structure and improve the efficiency of transforming the raw list of assets to the new Asset Dependency Hierarchy, whilst reducing the potential for human error with automated recommendations and error-checking.

4. Assign Dependency Hierarchy
A new hierarchy was created for each asset by assigning parents up to Site-level with a focus on dependency and redundancy. The assets (EGI) were given an Asset Type (AT), Process Stream (PS), Process (PR) and Sub-Process (SP) parent class. The hierarchy structure is as follows:

SITEAT01-**PS**01-**PR**01-**SP**01-**EGI**01

The dependency and redundancy hierarchy follow these rules:
- By grouping assets under the same SP, they each are defined as being required for the SP to function (dependant).
- By grouping similar SP together under the same PR, each SP is a requirement for the PR (dependant).
- If one SP is in a Standby configuration, a Duty can fail without impacting the PR (redundant).

5. Asset Dependency Hierarchy (ADH)
The completed Asset Dependency Hierarchy, spanning 585 spreadsheets (one per site)

6. ADH Database
All sites were combined into one database spreadsheet[16], where checks for consistency, duplicates and errors could be carried out en-masse. The database also contained further functionality as described in points 7 and 8.

7. Create new AMIS Asset Data
To ensure all the necessary data for PIONEER was available, the full list of asset data was transformed into an AMIS-ready format. This includes AMIS Equipment ID's, Structured Plant Numbers (SPNs), as well as other fields. Assets that were found to be missing Equipment ID's (since many assets found through the ACO process were not yet added to AMIS) were given new ID's from a list of reserved numbers.

[15] *Asset Dependency Final – Database Ready*
[16] *Asset Dependency Database*

Checks were done on this output to confirm no duplication or errors existed.

8. Create PIONEER Asset Hierarchy formatted data

The data was then transformed into PIONEER-ready format, where records were created in PIONEER Staging Area format for each asset and parent, as well as the multiple attributes for each.

This process was carried out using automated methods utilising Visual Basic for Applications in Excel, creating a total of 97,096 Units and 885,743 Unit Attribute records.

9. Creation of Attributes

Attributes required in PIONEER were created as follows:

- Structured plant number (SPN): Created in Step 7 from the ADH hierarchy in Step 4.
- Description: For asset units, the description was taken directly from AMIS/ACO descriptions. For parent units, this was a concatenation of a cut-down version of the hierarchy structure down to the respective level and the description of the parent class description.
- Unit reference: This was mandatory for all assets, created by concatenating the EGI, AMIS equipment ID, site code and equipment description, capped at 40 characters.
- Unit type reference: mandatory for all assets, found by looking up the EGI in PIONEER.
- Installation date: These are mandatory for all renewable items. Data for the dates was obtained from the AMIS asset data register, and PIONEER data where the confidence was high. Any missing dates were filled using a 'smart', structured approach comparing like-unit types, sub-processes and processes, given that similar assets or processes on a site would have been installed/replaced at similar times.
- Yardstick Type: such as volume (Ml) was filled from EGI list, which outlined expected yardsticks per EGI type.
- Yardstick Value: mandatory for all renewable items, as these are used to calculate costs of interventions. Data was found from AMIS, annual return and other core systems (such as GIS). For missing data, a similar process to that used for missing dates was used.
- District: Useful for reporting purposes. Found using a lookup of site against finalised district list. The production management areas were assigned districts depending on production area.

All attributes were then checked for suitability (e.g. installation date not older than possible for the type of asset, yardstick value within possible range and correct units etc.)

10. PIONEER Staging Area

All assets and attributes were imported into the PIONEER Staging Area using Microsoft SQL Server 2017 Management Studio software program. Figure 5-6 shows the hierarchy of the production assets a total of 97,096 units that were loaded into PIONEER, along with the 885,743 attributes. the hierarchy of the production assets a total of 97,096 units that were loaded into PIONEER, along with the 885,743 attributes. the hierarchy of the production assets a total of 97,096 units that were loaded into PIONEER, along with the 885,743 attributes. the hierarchy of the production assets a total of 97,096 units that were loaded into PIONEER, along with the 885,743 attributes.

All Excel workbooks and the processes used were reviewed internally and externally audited by an independent reporter (Atkins Ltd.), and an assurance report submitted. All issues raised have been dealt with accordingly.

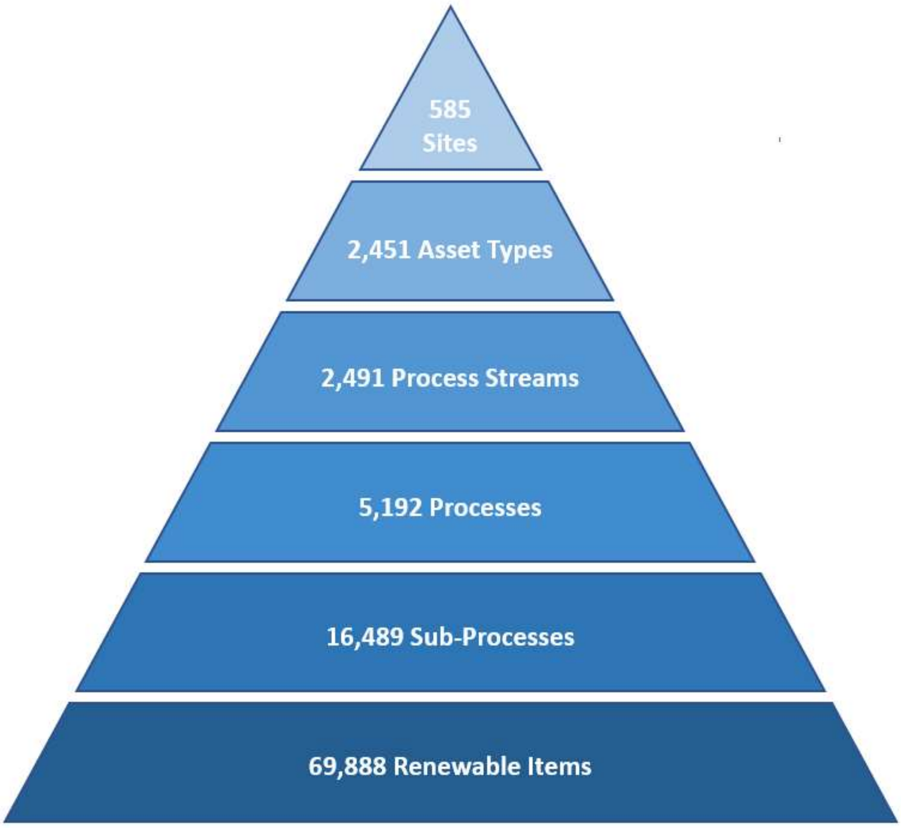

Figure 5-6 Summary of the Affinity Water Production Assets

The table below is a breakdown of the renewable items.

Renewable Items	
Number of RIs in operation	66,572
Number of RIs not in operation	3,316
Total	69,888

Table 5-1 - Number of Renewable Items

5.2.6 Asset deterioration

5.2.6.1 Overview

The forecasting of the deterioration experienced by our non-infrastructure assets is a key aspect of our approach to investment. This section outlines how we have constructed the deterioration models that are used to model asset failure for use in our business plan and business as usual.

The deterioration models cover all 357 production equipment groups (EGIs) used in the investment modelling process. An equipment group (uinit type in PIONEER) is a group of assets with the same deterioration characteristics (e.g. ICFS – instrumentation and control - flow switch). They allow us to model the likelihood of failure of assets in the group and predict the optimum time for replacement.

The scope of this analysis covers:

- Models that use new quantitative information from maintenance failure data - 72 EGIs. (Including some of the most important in terms of investment in AMP6 and

predicted investment in AMP7, for example pumps, starters and water quality instruments.)
- 176 Models based on expert review by our maintenance strategy manager and Asset Specialist or limited data, tested against the age distribution of surviving assets
- Existing models, tested against the age distribution of currently surviving assets

The deterioration of each asset class was modelled using a Weibull lifetime probability distribution function. This is used extensively in industry for reliability modelling and is applied to situations requiring replacement.

56% of our planned investment for 2020-2025 is now covered by models based on asset data. The remainder are covered using qualitative models which have been extensively compared with asset age data and reviewed by our maintenance professionals. We are therefore confident that our deterioration models represent the situation in the field.

5.2.6.2 Model updates and improvements

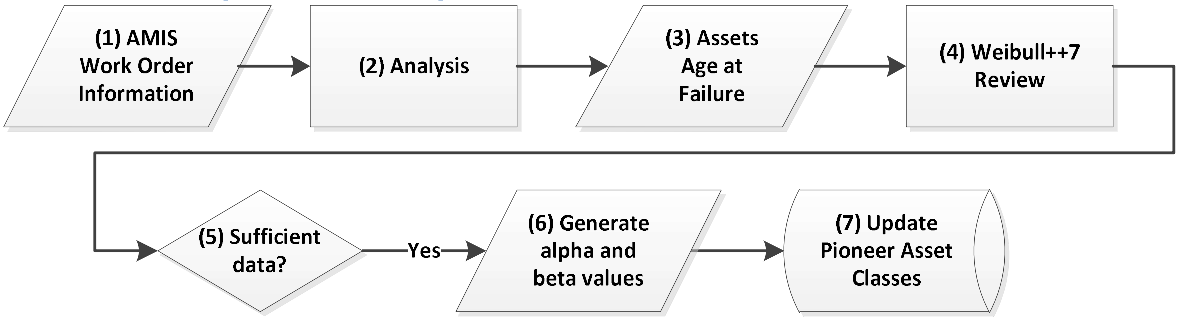

Figure 5-7 Updating Quantitative Deterioration Models

Using information from AMIS, the failure age of assets was recorded and then used to revise and improve our deterioration model library.

1. AMIS Work Order Information
Using Business Objects software, we extracted 11.5 years of maintenance work data (May 2006 to January 2017) from AMIS

2. Analysis
We Identified terminal failure of equipment from the failure mode field, confirmed with the free text (comments) field. This data identified “work orders” logged on the system by production staff.

3. Asset Age of Failure
Each work order has a description of the work carried out and an associated date. This is associated with the individual asset, so the age of the asset upon failure can be derived where this information is provided. This information was then used to produce a list of failures (and age of the asset at this point) for individual unit types (EGIs).

4. Weibull++®7 Review
For the EGIs with sufficient data, a spreadsheet model using ranked regression techniques was developed and validated against our proprietary Weibull++®7 software. The values for alpha and beta defining the shape and scale of the distributions were captured.

5. Data sufficiency Check
This quantitative failure data was used to overwrite existing asset class Weibull curves (replacing data based on previous expert knowledge) where there were four or more data points and depending on judgment on the fit of the curve (and Rho > 0.8).

In total, models of sufficient quality covering 72 EGIs were identified for use.

Where there was insufficient data each distribution was derived by our Maintenance Strategy Manager and Investment Asset Specialist based on practical experience and feedback. This was cross-checked against the actual distribution of ages of surviving assets to ensure the distribution covered the range of ages and represented the mean life.

5.2.6.3 Model outputs

6. Alpha and Beta Values
Each Weibull distribution produces shape and scale factors (alpha and beta) which enable the hazard function in PIONEER to calculate the probability of failure of any asset over time.

7. Update PIONEER Classes (EGIs)
The alpha and beta coefficients were uploaded into PIONEER using the purpose-built Excel loader.

This review has provided us with updated deterioration information for many EGIs and provided additional confidence following expert reviews.

5.2.6.4 Likelihood and criticality

So that the consequences of failure and the impact on customer outcomes can be calculated, likelihood and criticality values were determined for all our above ground assets. These are expressed as factors and are vital components of the PIONEER models. They are used to estimate the impact on service *if* an asset fails. This is a crucial aspect of the optimisation process which, when coupled with deterioration and cost information, yields the cost of an asset if it was to fail and the impact on customer service.

The calculation of the Consequence Factor (CF), Likelihood Factor (LF), and Criticality (CR) values were performed outside of PIONEER. This section provides an overview of the process.

The process for finding the likelihood and criticality of each asset in the hierarchy is summarised in the figure below.

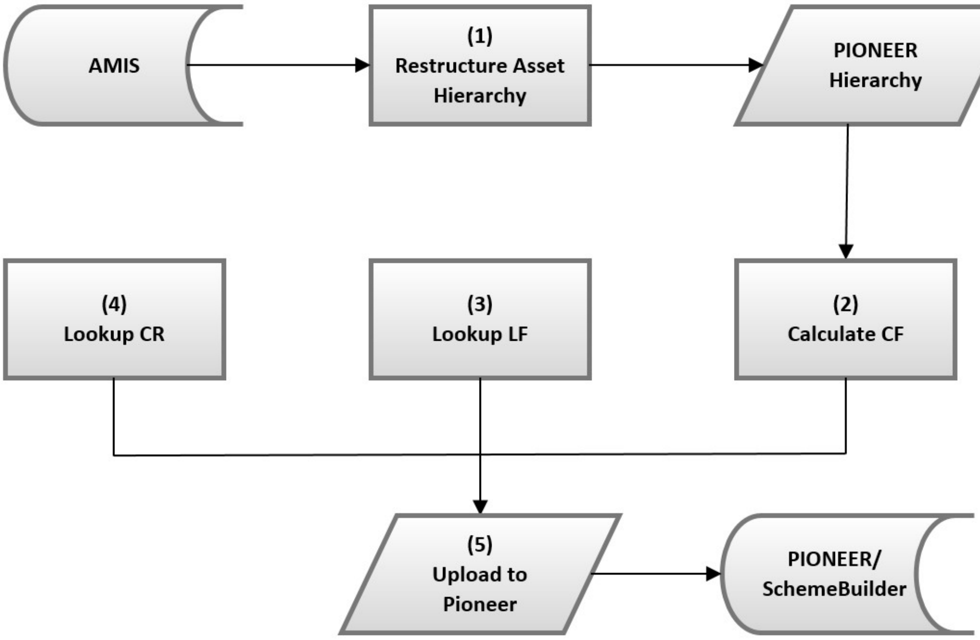

Figure 5-8 The Likelihood and Criticality Values Process

5.2.6.5 Process commentary

1. Parenting Data

To begin, a hierarchical tree from the company down to the individual asset units was required. Our AMIS database provided a good starting point for the construction of such a tree, however hierarchy parenting adjustments were necessary to our AMIS structure to fit into the PIONEER hierarchy structure. The description of this process is provided in section 5.2.5.

Following these adjustments, three values for each individual plant item unit in the asset hierarchy were calculated:

2. The Consequence Factor (CF)

This is the physical probability if an asset fails, of it affecting the site performance bearing in mind redundancy and hierarchy. This process involves retrieving the hierarchical relationship. An example hierarchy is shown in the following figure, where physical assets are blue and standby parents are orange.

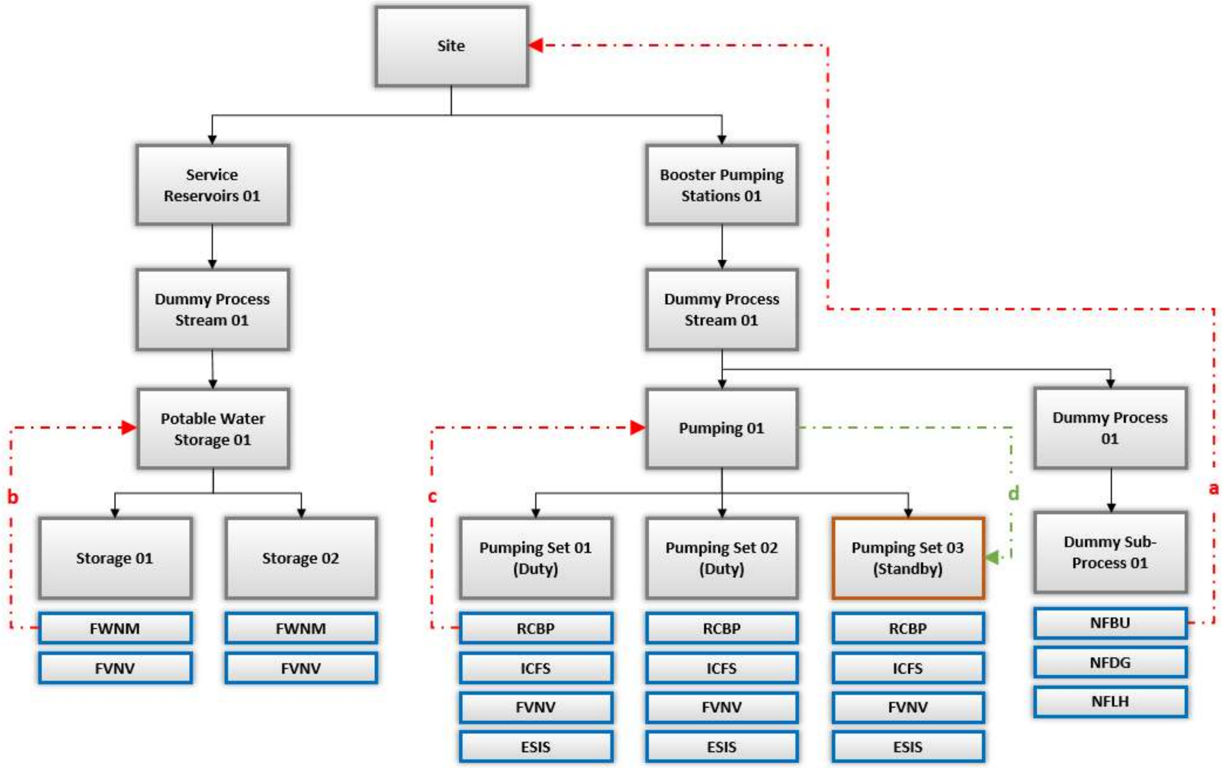

Figure 5-9 Example hierarchy

The consequence factor gives the combined probability of an asset failing up to Asset-type level. Since all assets in a sub-process (SP) are deemed as required for the SP to function, a single asset failure constitutes the entire SP failure. Therefore, consequence is considered at parent levels. The consequence of an asset failing at each hierarchical level depends on the number of links between each level and its parent level. Where there is a single connection, the consequence of failure is 1. Where there are two, the consequence of one failing would be ½=0.5. Likewise, for each level up the hierarchical tree. Each of the individual probabilities were multiplied together to get the combined probability.

For example, pathway (a) shows that there is a direct link up the tree from the NFBU (Buildings) asset, so the consequence of failure at each level would be 1, giving a total failure consequence of 1.

Pathway (b) shows that if 2 similar Sub-Processes [SP] are connected to a single process [PR], then the consequence of one failing will be 1/2 = 0.5. For each level further up the tree, there is a consequence of 1 so the total is 0.5.

One other consideration is the effect that a redundant process will have on the probability. For example, if several pumping sets feeding a common pumping process, it is most likely that one pump will be in a standby setup, as shown in pathway (c). In this case, if one duty pump fails the standby can take its place, indicated by pathway (d). By using this understanding (and the newly-formed hierarchy) we assessed the redundancy and flagged required SP's, PR's and Process Streams (PS's) as standby.

We then take account of the chance of a duty asset failing ('*mean time between failure' (MTBF))* while the failed asset is being replaced ('*mean time to repair' (MTTR))*.

Using these two values the CF is adjusted by a value determined from the MTTR and MTBF numbers – called the un-availability.

To calculate the MTBF we use data from failure Weibull curves (Hazard functions in PIONEER). Each unit has an associated Weibull curve (determined from its shape and scale parameters) to predict the probability of failure throughout its lifetime. We have estimated the MTBF to be the value at which the cumulative distribution function (CDF) is greater than 0.5, i.e. where the probability level is equal to 50% of the area under the probability density distribution (PDF).

MTTR values are estimated per unit type from expert judgement based on procurement lead times. The un-availability is given by:

$$un - availability = 1 - \frac{MTBF}{(MTBF + MTTR)}$$

We use this value to 'scale' the consequence factor determined from the hierarchical tree for all units that are in a redundant configuration.

The final calculation methodology is outlined in the following figure.

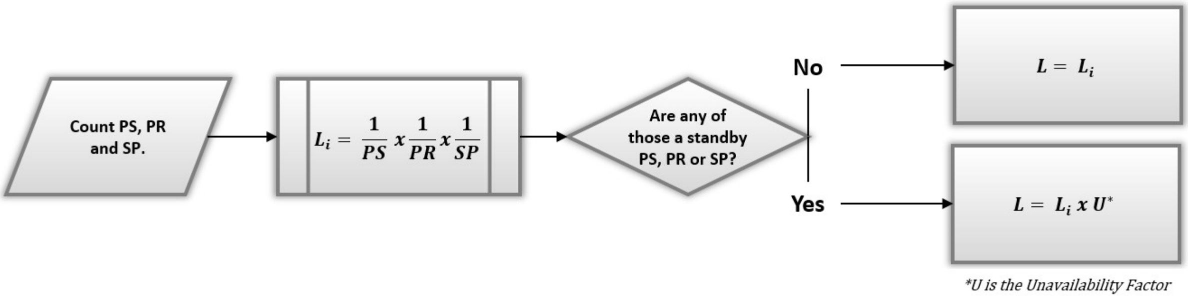

Figure 5-10 Calculation methodology

3. The likelihood factor (LF)
This is the likelihood that a particular service measure (SM) will occur if that asset fails. This process involves retrieving the likelihood of a service measure occurring. Information comes from a lookup table based on historical performance data and expert judgement.

4. The criticality (CR)
This is the number of properties affected or number of incidents if an asset fails. Information comes from InfoWorks hydraulic modelling (see section 6.4) and an update to our PR14 criticality spreadsheet[20]. The criticality considers the time taken to restore supply and the time before a customer is affected. The maximum number of properties fill the interruption time-bands depending on level of interruption.

The criticality gives the either the number of properties affected per incident (PI) or the number of incidents if a service impact occurs, depending on the unit of each SM. For example, if the unit is given as cost per property (£) per incident (CPPPI), then the criticality will return the number of properties affected by the SM, otherwise it will return 1 The costs are then multiplied against each number in PIONEER.

The approach is as follows:

- Each renewable item (at the Asset Type [AT] level) has an associated '*time before customers are affected (TBCA)*' and '*time to restore supply (TTRS)*'. An interruption to a customer can only occur if the *TTRS – TBCA* > 0.
- The difference between these numbers determines the approximate length of interruption to customers. The interruption time-bands are:
  - 0 – 3 hrs
  - 3 – 6 hrs
  - 6 – 12 hrs
  - 12 – 24 hrs
  - >24 hrs
- Each renewable item unit type has an associated likelihood per service measure (SM) – the likelihood that IF an item fails that a particular service consequence will occur. In terms of interruptions, these likelihoods fall into the five time-bands listed above. The number of properties affected (Quantity) should mirror this arrangement for each renewable item.
- The quantity values calculated from hydraulic modelling and criticality assessment, allow us to estimate the maximum number of properties affected within the interruption time bands above
- The mirroring of the likelihoods and quantities is only broken when TTRS – TBCA ≤ 0, in which case there will be no interruption to a customer. Here we replace the values in these time-bands with a zero. For example, if a unit has a value in the 0 – 3 hr likelihood time-band but there the TBCA is > 3 hrs then we replace the value in of the quantity column with zero.
- Customer minutes were derived from the property bands (over 3hrs) using duration and the number of total properties served. This is then fed into PIONEER as an attribute for interruptions to supply.

5. Upload to PIONEER

The CF, LF and CR values calculated through the described processes were imported into PIONEER's staging database, and this information is combined within PIONEER when calculating failure modes.

The CF, LF and CR values calculated and found through the described processes are imported into PIONEER's staging database, and this information is combined within PIONEER when calculating failure modes.

The cost if the asset fails is then given by:

$$\text{COST } (£) = [CF \times LF] \times C \quad \times (\text{unit cost}) \times (\text{hazard rate})$$

which can be expressed as:

$$\text{COST } (£) = Factor \times Quantity \times (\text{unit cost}) \times (\text{hazard rate})$$

Where the unit cost is the cost per incident or cost per property per incident. Hazard rate is the value taken from the Weibull curve data.

5.2.7 Asset Care Plans

5.2.7.1 Overview

Our asset care plans are specific operational maintenance activities. Care plan selection is based on the asset criticality and the specific asset type (EGI). The criticality of each asset is assessed using our standard asset risk matrix. The following metrics are used to understand an uncontrolled asset failure: The impact and likelihood of occurring on; health and safety, water quality, the environment, levels of service, asset damage, company image and total cost. Through a series of workshops involving local production staff the criticality is determined. This enables the correct care plan to be selected, and a whole site plan developed to optimise the delivery of the maintenance for all assets on the site.

This document outlines the links between the PIONEER optimisation tool and the Asset Care Planning process, which is designed to optimise our operational maintenance practices across the business.

5.2.7.2 Process maps

The Asset Care Plan process is described in the figure below:

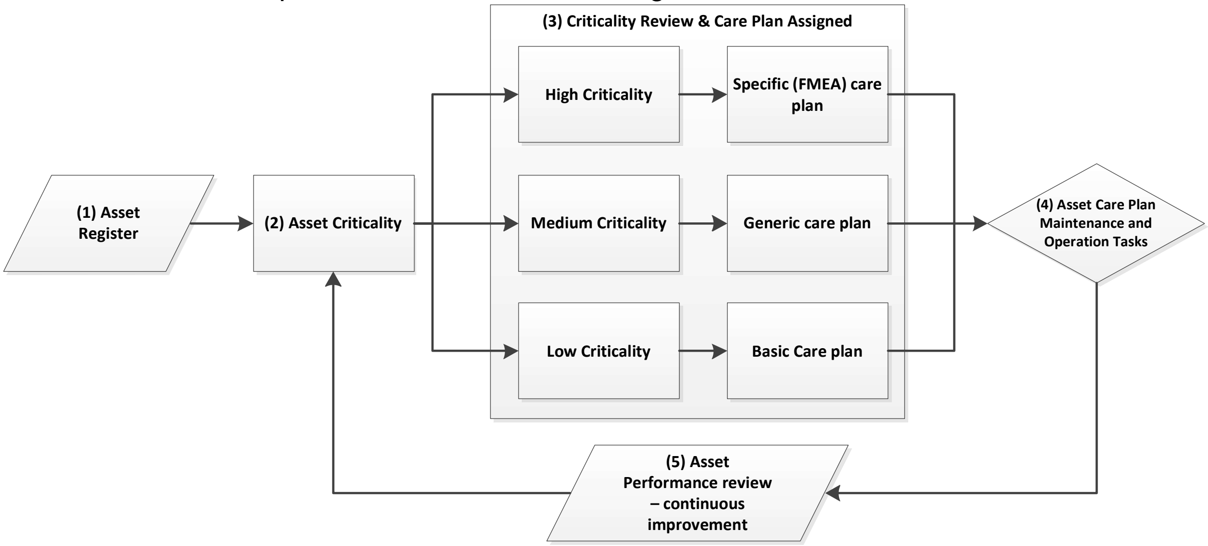

Figure 5-11 The Asset Care Process Commentary

1. AMIS register

All assets are recorded in AMIS

2. Asset criticality

The asset criticality is reviewed against our agreed risk matrix. This risk matrix assesses the impact of an asset failing against the following metrics. 1. health and safety, 2. the environment. 3. water quality. 4. levels of supply performance. 5. asset damage. 6. company image. 7. total cost of failure and a relevant asset care plan chosen based on the type of asset and criticality

3. Criticality and assigning care plans

Through the criticality review process an asset will be deemed High, Medium or Low criticality and assigned the appropriate care packages. Care packages are developed at asset type level (EGI – e.g. Chlorine Residual Monitor) – each EGI will typically have 3 levels of care (High, Medium and Low) although in some instances this may be the same care package regardless.

4. Maintenance

Maintenance is carried out by our engineering teams, with all activities systematically planned through the AMIS planning tool and delivered to the front-line teams via their field devices. All work done is recorded through the field device and uploaded into AMIS

5. Performance review
Performance of assets is continually reviewed through automated reports and monthly workshops with maintenance strategy team and maintainers.

The output of the Asset Criticality process and linkage to PIONEER

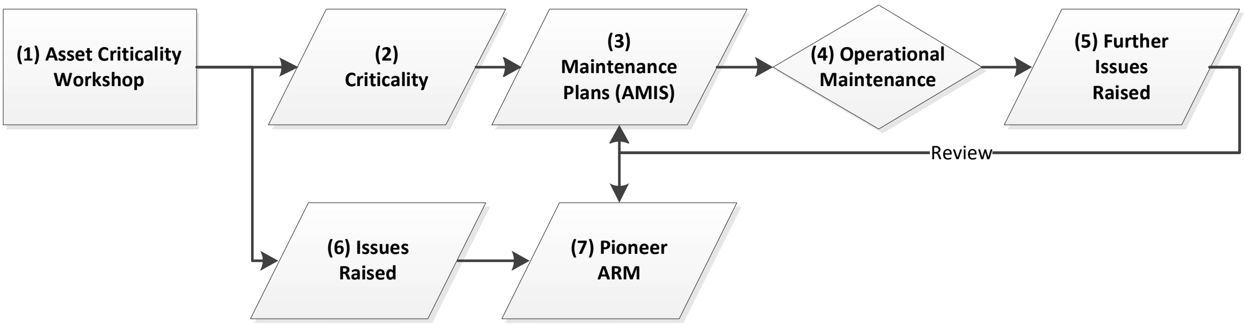

Figure 5-12 Asset Criticality and links to PIONEER

5.2.7.3 Asset criticality process

1 & 2. Asset criticality
Workshops to define the criticality of a new asset, (or where operational changes may change the criticality of an existing asset).

3. Asset care plan
Asset Care plans are developed using best practice, equipment manufacturer guidelines, our expert knowledge and include mandated actions (SRC). The criticality review determines the necessary care plan for the asset. For high criticality assets an enhanced maintenance plan is written which can be specific just for that asset. It considers any specific requirements through failure modes effect analysis (FMEA). All medium criticality assets will be assigned a generic care plan suitable for that type of asset. All low criticality assets are assigned a basic care plan that is typically a routine, non-intrusive, check to be done as part of a wider maintenance package. The care planning process is continuous, and monthly performance reports are used to review and refine plans as appropriate.

4. Maintenance
Maintenance is carried out by our engineering teams, with all activities systematically planned through the AMIS planning tool and delivered to the front-line teams via their field devices. All work done is recorded through the field device and uploaded into AMIS.

5. Further issues found during maintenance
Any additional issues (defects) found during routine maintenance are raised via the AMIS field device software and will be scheduled for resolution as appropriate.

6. Issues found
Significant issues (they may require capital intervention) are raised as risks to the PIONEER Asset Risk Module (ARM) and become part of the PIONEER optimisation process.

7. PIONEER
Asset data (age, performance and defects) is recorded in AMIS, which in turn is used by the PIONEER planning tool to select the best capital maintenance strategy.

5.3 Non-Infrastructure Investment

5.3.1 Storage

5.3.1.1 Overview

We have a total of 280 storage assets which include contact tanks, service reservoirs, surface treated water tanks and water towers. Of these assets, 196 are in operation and can hold 1,618 Ml of treated water for supply to our customers. Most are constructed from reinforced concrete and generally have a capacity below 5Ml. The remaining 84 of our storage assets have been decommissioned but are still inspected and kept safe.[17]

Our water storage assets are used to supply water to meet the hourly fluctuations in demand and provide supply resilience to customers during operational emergencies.

Water storage assets deteriorate over time and if not appropriately maintained, the risk of water quality issues originating from the structure and the potential for long term service outage increases. Overall costs of maintaining the structures increase as the remaining life of the structures diminish.

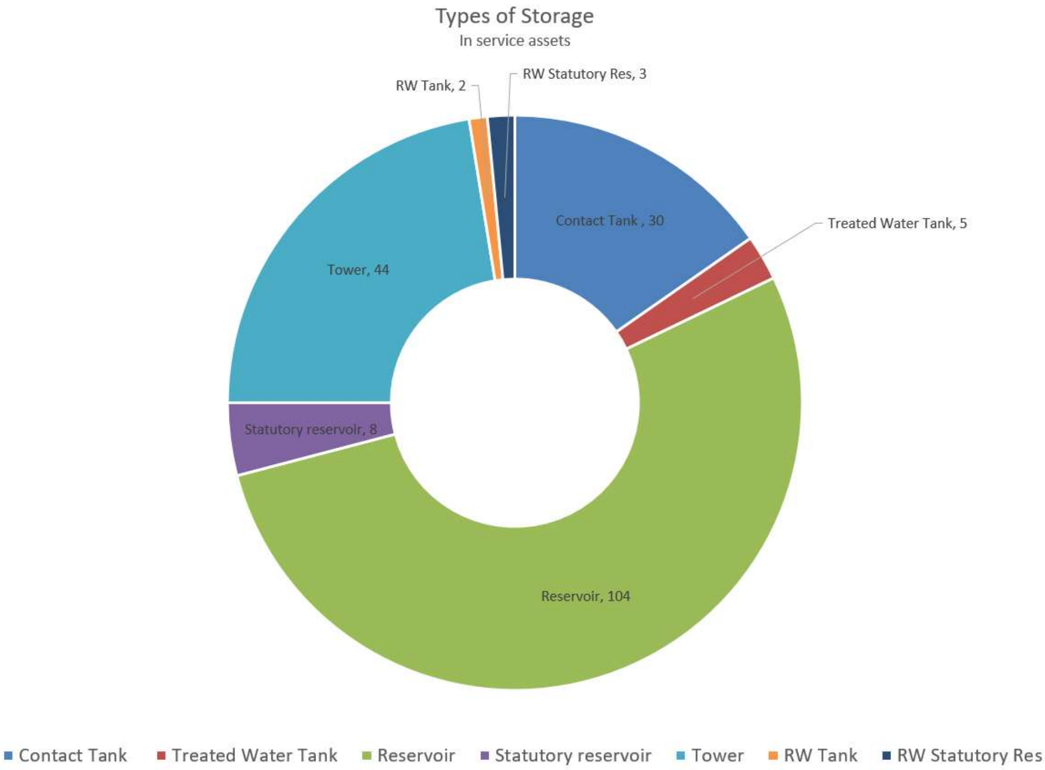

Figure 5-13 Types of Storage Assets

The figure above shows all our in-service water retaining assets. These include eight of our non-impounding service reservoirs which are designated as large raised reservoirs under The Reservoirs Act 1975. We have a further five large raised raw water reservoirs that are a mixture of impounding and non-impounding types. Obligatory statutory reservoir inspections are discharged through our programme.

[17] *Affinity Water List of Water Storage Asset.xlsx*

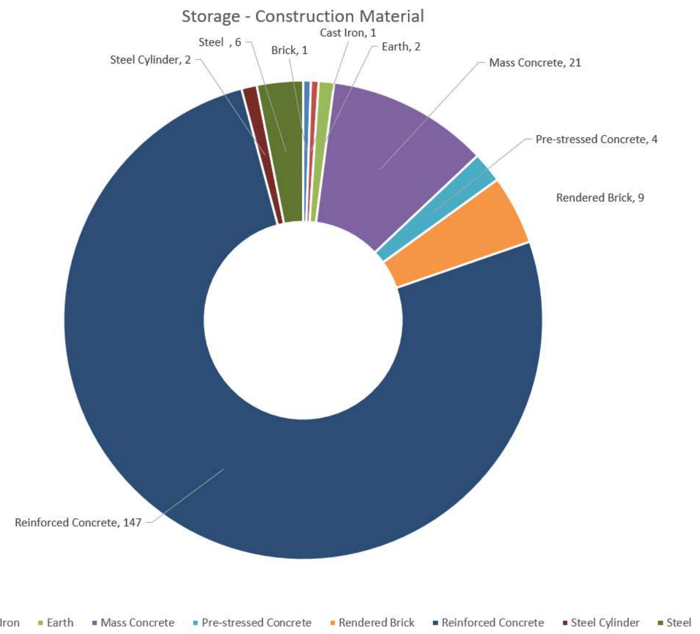

Figure 5-14 Storage Asset Construction Material

The chart above shows our storage assets construction materials. Nine of our operational structures were constructed from brick (rendered) between 1854 and 1913. Notwithstanding previous maintenance, three of these structures are now beyond economical repair and present a risk to serviceability and water quality. The remaining six assets will continue to be monitored with some planned for replacement in AMP8. The age range of our storage assets are shown on the graph below.

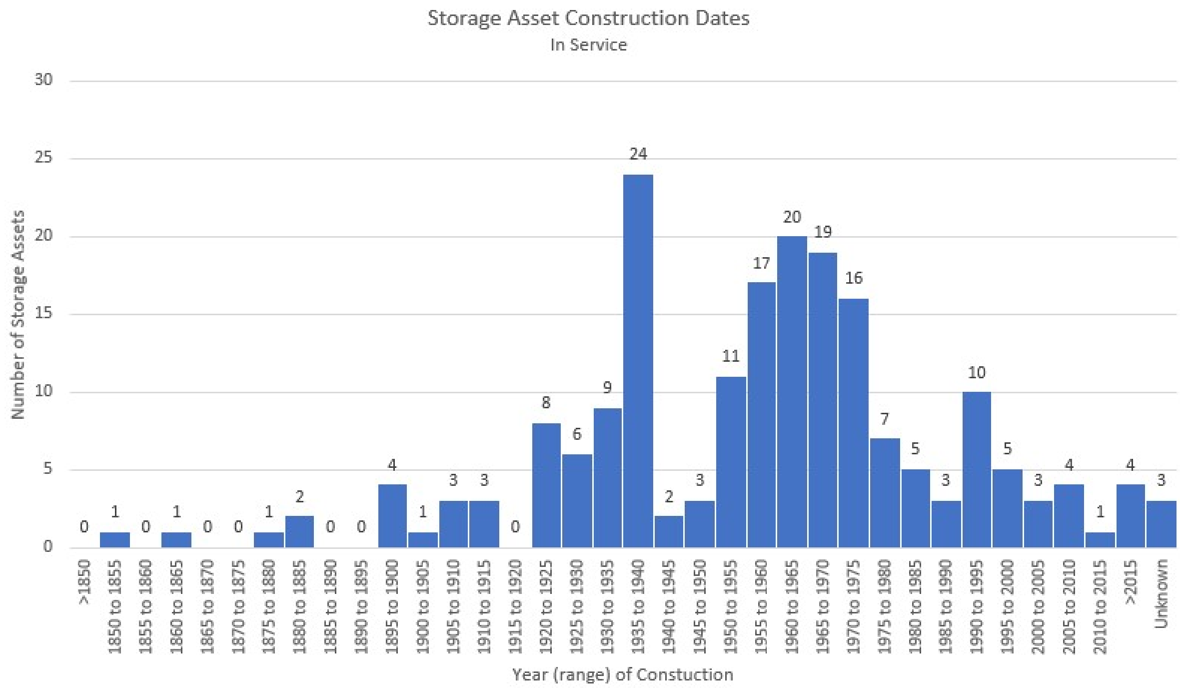

Figure 5-15 Storage construction dates

The graph below illustrates volume range of our potable water storage structures. Most of our structures have a capacity of <5Ml. This includes 44 of our water towers that have an average maximum volume of 0.86Ml. In addition to, 79 of our service reservoirs which have an average maximum volume of 1.75Ml.

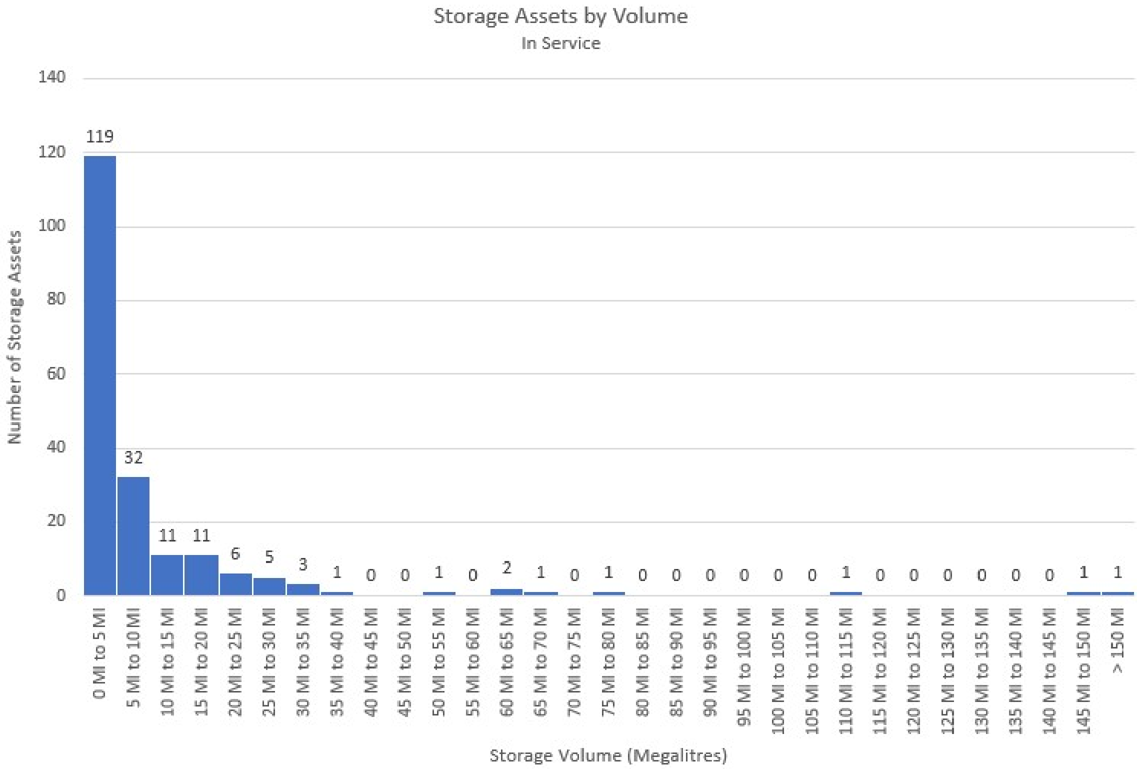

Figure 5-16 Treated water storage tanks by volume

5.3.1.2 Method of approach

The following section describes our approach and the assessment that we have carried out to forecast future capital maintenance requirements for our storage assets. The figure below illustrates our process for forecasting the capital maintenance needs for our storage assets.

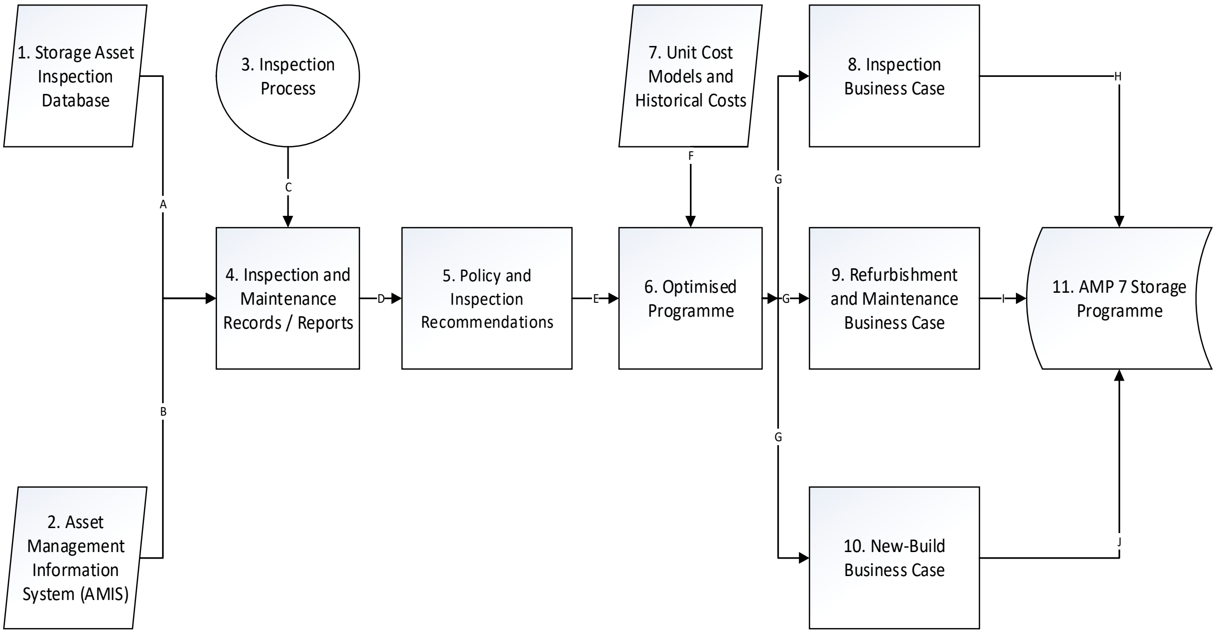

Figure 5-17 Overview of process for defining storage asset capital maintenance requirements

Information from our storage asset and AMIS data systems have been used to identify our maintenance and inspection requirements. These requirements have been assessed and prioritised in accordance with our inspection findings, policies and maintenance recommendations. Unit cost data and historical costs from past programmes of work have then been used to define programmes of work. Different options for each programme have been assessed and detailed in the storage business case[18].

5.3.1.2.1 Storage asset inspection database

Records of inspections as well as maintenance recommendations are held on our Storage Asset Inspection Database[19]. Information from this database has been used to derive the forthcoming inspections programme, the asset refurbishment scheme, minor maintenance, washout maintenance and asset replacements.

5.3.1.2.2 Inspections & maintenance

The storage inspection and maintenance programme has been a long running rolling programme. Alongside regular site maintenance checks, it is our policy to externally inspect all water retaining structures every five years and internally a period not greater than ten years[20]. Assets that have been assessed to have a greater risk to their serviceability are inspected more frequently.

Inspection findings give us greater understanding of our storage assets maintenance needs. The inspection process provides a record of asset condition, maintenance recommendations and inspection reports. These outputs are assessed to define future inspection programmes. Cost data from past inspections, maintenance and refurbishments schemes have been used to estimate the cost of future capital investment[21]. Our current schedule of rates for inspections and maintenance works has been used to develop cost estimates for unique maintenance schemes.

[18] *PR19 Storage Business Case.doc*
[19] *Affinity Water Storage Asset Inspection Database.accdb*
[20] *MAINTENANCE OF SERVICE RESERVOIRS PD027.doc*
[21] *PR19 Storage Scope & Budgetary Assessment.xlsx*

Costs for minor maintenance is expected to be similar. A quotation for completing all outstanding minor maintenance, based on day rates from a supplier, has been used to forecast costs.

5.3.1.2.3 Storage replacement

Three of our storage structures are beyond economic repair and have a higher risk of structural and water quality failures. Inspection reports and maintenance recommendations suggest that these assets are best replaced. Hydraulic analysis of these assets suggests that storage in these locations is vital to provide resilience to customers. Feasibility studies are being undertaken for the storage assets we are planning to replace[22] [23] [24]. Costs for the replacement of these assets were obtained from our Potable Water Storage Cost model[25]. This model has been used conjunction with more recent iteration of the model to make assessment of replacement costs.

5.3.1.2.4 Washout maintenance

Maintenance of storage asset washouts and related infrastructure are critical to ensure that our assets can be safely drained without causing a disruption to local customers. The condition of this infrastructure is recorded though routine inspections (described above) which has been used to prioritise a scheme of washout maintenance.

5.3.1.2.5 Process structure inspections

A programme to capture the condition and understand the maintenance needs of our pre-distribution process water retaining structures has been drawn from our AMIS system. Inspections of these assets have been prioritised according to the risks of asset failure and will be aligned with routine maintenance. The inspection of these assets will inform future investment to safeguard water treatment for customer supply.

5.3.1.2.6 Disused storage assets

Out of service storage assets require periodic inspection and maintenance, to limit our liabilities and ensure that they are safe whilst in our ownership. Recommendations from our inspection programme has informed our approach to maintenance of these structures.

18 of these our storage assets that are out of service need to be permanently disconnected from our potable distribution network. This is to eliminate any potential health and safety risk to asset users, prevent contamination of customers' water supply due to stagnating water should the current isolation method be inadvertently compromised. Preliminary design work for this undertaking is complete[26] and expected costs have been derived from activities of a similar nature.

[22] *STGE No.2 Replacement Feasibility Study*
[23] *WINH No.2 Replacement Feasibility Study*
[24] *FARC Reservoir No.1 Replacement Feasibility Study*
[25] *Potable Water Storage Cost Model.xlsx*
[26] *Disused Storage Asset Isolations Concept Design*

5.3.1.3 Summary

The following is a summary of the programme of work for our storage assets for the period 2020-2025.

Activity	Description	Scope
Inspection and Maintenance	Inspections, cleaning & disinfection of water retaining assets to understand maintenance needs.	▪ 145 Internal inspections ▪ 258 External inspections ▪ 7 Statutory (S10) inspections ▪ 65 Statutory (S12) inspections
Refurbishment	Maintenance projects to preserve storage asset life and reduce risk of failures.	▪ Refurbishment of 18 structures
New Storage (Replacement)	Replacement of storage assets at the end of their life to safeguard customer supply.	▪ Replacement of STGE Reservoir No.2 ▪ Replacement of WINH Reservoir No.2 ▪ Replacement of FARC Reservoir No.1
Process Structure Inspections	Implementation of a robust inspection regime to understand maintenance requirements.	▪ 50 Internal inspections ▪ 100 External inspections
Disused Storage Assets	Inspection and maintenance of out of service storage assets to ensure that they remain safe and the risks to customer service are minimised.	▪ Inspection and Maintenance of 77 out of service assets ▪ Isolation of 18 disused storage assets.
External Minor Repairs	Undertaking of minor external repairs identified from routine inspections.	▪ Routine maintenance of all storage assets
Washout Refurbishment	Upkeep of water retaining structure washouts and related infrastructure, so that they can be drain when required.	▪ Maintenance and repair of 110 storage asset washouts and associated infrastructure

5.3.2 Treatment investment

Non-infrastructure expenditure planning is driven by:

- Asset portfolio optimisation tool (PIONEER)
- Issues recorded in our Asset Risk Module (ARM), and
- Master Development Plans.

5.3.2.1 PIONEER

Portfolio optimisation tool that models our non-infrastructure assets. This tool is described in detail in 8.

5.3.2.2 ARM

ARM is a PIONEER tool used to record and score identified asset risks on a consistent and continuous basis. At monthly Production Investment and Maintenance Meetings (PIMMs) the asset engineer and the relevant production team assess asset and process performance, output and water quality. Risks are recorded by operational staff, asset engineers and managers from across the business. The initial recorded scores are reviewed by the asset engineer responsible for the community area.

The management strategy for new risks is identified at the PIMM. This may require immediate changes to operation, inspection and/or maintenance. If investment is identified as part of a risk strategy, this is scheduled, either for local management, or integrated into the capital investment programme.

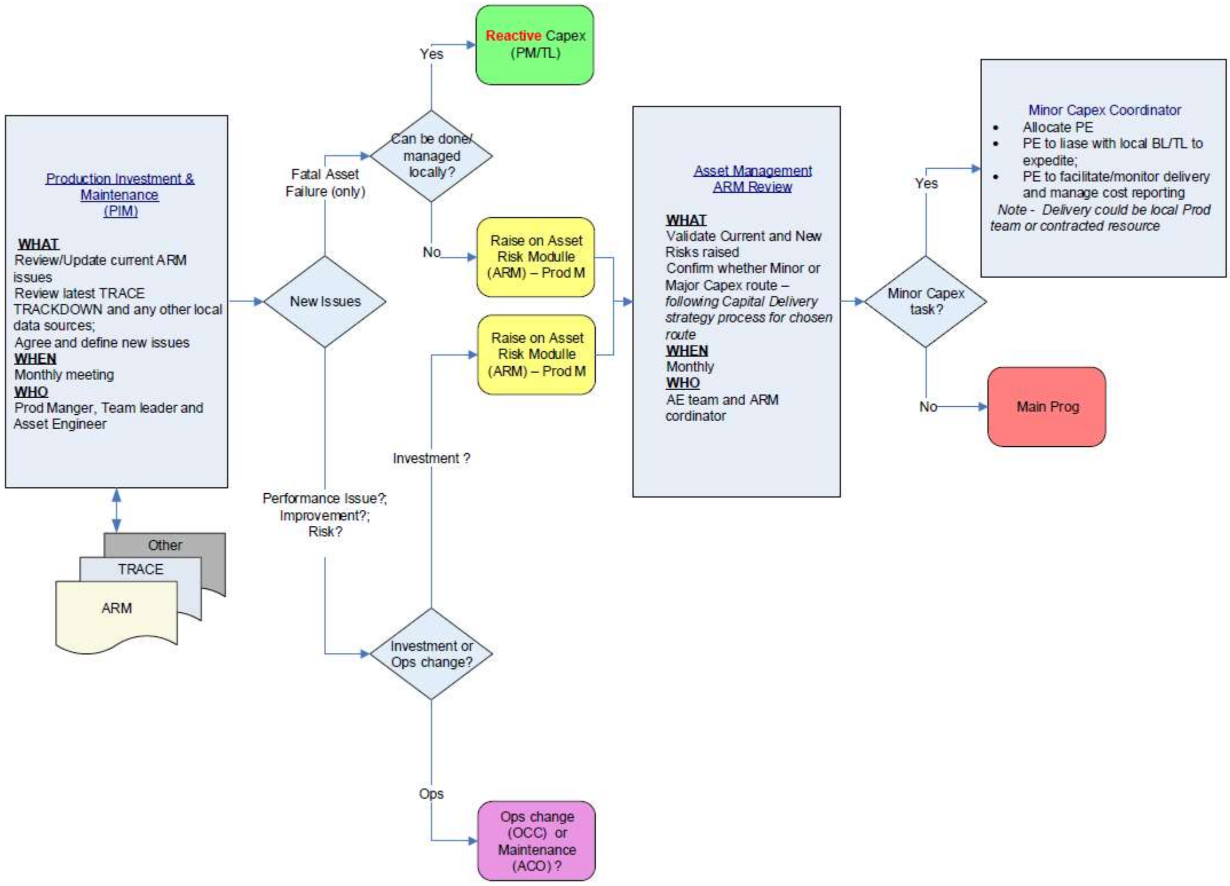

Figure 5-18 ARM - Process for assessing Asset Risks on ARM

5.3.2.3 MDPs

Master Development Plans (MDPS) are developed for our larger strategic sites. These consider a longer-term view of asset intervention (25 years horizon).

Over the past 12 months we have updated our master development plans for our strategic sites. Using expert judgement, this has identified several processes that require refurbishment or replacement to maintain continuity of service. The proposed investments have been spread over future AMPs to provide intergenerational equity.

Key investments for PR19 include: replacement of ozone treatment at HWFS that was installed in 1991 and is becoming unreliable; replacement of rapid gravity filters (RGF) at WALT that were built in the mid 1900's where the concrete is carbonating and at risk of structural failure; refurbishment of slow sand filter (SSF) structures and floors due to deterioration; upgrade to waste water treatment due to limitations in capacity.

5.3.2.4 HORC WTW

A series of resilience workshops identified that HORC Water Treatment Works (WTW) is a critical, single point of failure as it supplies 70% of our water in the Brett community. If this site is unavailable, the other source in the Bret community is not able to supply sufficient water to the whole of Brett. We are therefore increasing the resilience of our main pumping station to reduce both the duration and the scale of any outage.

Options were considered in the business case:

- Enhancement to the site consisting of; the installation of fire protection and suppression, standby equipment and spares, piping rearrangements at the site (i.e. by passes), a single raw water main to the sand filters and the motor control centre (MCC) replacement.
- Treatment at individual sources which currently feed HORC treatment works, the current raw water main going into the treatment works being ice pigged and turned into the clean water main, and decommissioning of the HORC treatment works
- Building of a new treatment works at ELMM Reservoir and a new raw water main from JUPE Booster to ELMM Booster, allowing for water from the sources normally supplying HORC, to supply new treatment at ELMM. A new trunk main with a capacity of 20Ml/d would need to be laid from the JUPE Booster to ELMM and a new treatment at ELMM of the same capacity would need to be build.
- New trunk main between SIBL Reservoir and HORC Reservoir. This option would include 52 miles of 600mm main between SIBL Reservoir and HORC Reservoir, additional boosters and surge protection. This option would also allow transfer from HORC to SIBL and would support Stort community in case of drought.
- Pumping into the Anglian Water network from Stort and taking the same volume at Brett. This option considered transferring the water from our Stort community into Anglian Water network and taking equivalent volume in Brett in case of the HORC outage. This option has not been fully investigated and needs engagement with Anglian Water. It is assumed some trunk mains need to be laid in Stort and Brett to allow for the transfer. Cost for this option needs to be determined.

Through optioneering, consultation workshops and financial evaluation, the option of enhancement of the HORC site was most cost-effective.

5.3.2.5 Single points of failure

Following our investment in the last five years, we continue to address our Single Points of Failure (SPoF) to maintain or improve our resilience. We have defined a SPoF as an asset failure leading to loss of production/availability where the residual output is insufficient to meet normal requirements. The designed resilience of our systems ensures that the two components (asset failure and subsequent loss of supply) are infrequent. However, there are a few, low likelihood, high consequence risks associated with asset failure which could lead to significant loss of supply that remain.

Our SPoF investment strategy addresses these risks whilst retaining a proportionate response that is affordable. i.e. we do not propose duplication of all assets to provide complete redundancy but a range of risk mitigation strategies (Terminate, Treat, Transfer or Tolerate) including investment to ensure the continued availability of existing contingency measures (such as standby power generation, reservoir storage and bulk transfers) and investment to reduce the consequence or likelihood of failure where there is currently no mitigation.

For our 2,500km of large diameter distribution mains we are investing to mitigate the impact of failures where more than 2,000 properties are at risk of being off supply for more than 12 hours. The numbers of properties at risk from above ground asset Single Points of Failure at treatment works are higher than this, although the likelihood is less at around one risk event per year compared to 12 risk events a year for trunk mains.

We used our risk framework as the basis for the evaluation of risk consequence and likelihood to consider the options below:

- Do nothing. This would lead to highly expensive risks as it would result in increased imports, emergency management and customer compensation payments.
- Addressing the highest ranking SPoF at sites on a priority basis.

- Addressing a broader set of SPoF including the top 15 and others that are cost effective (relatively little cost to remove risk). This would include about 40 schemes but would be a significant additional cost.

Through optioneering, consultation workshops and financial evaluation, the option of addressing the highest ranking SPoF was considered the most cost-effective option.

5.3.2.6 RUNL

RUNL treatment works is located approximately 3 km west of the town centre of Luton. It has two separate sources of water derived from different aquifers with separate treatment streams and independent abstraction licences. The chalk well has a licence of 9.55Ml/d and a deployable output (DO) of 4.50Ml/d. The greensand well has a licence of 2.73 Ml/d and a DO of 2.71Ml/d.

The water from the greensands source has high iron and ammonia content due to the natural geology and chemical processes within the lower greensand aquifer and relies on chemical oxidation to remove these compounds.

The existing greensand borehole (BH3) abstraction and treatment process was taken out of service in November 2012 due to:

- Design of the existing treatment station was outdated and not up to current standards and requirements;
- The pressurised filtration vessels were suffering corrosion damage and general deterioration and, although having two spare vessels inside the filtration building it was difficult to replace them without major structural modifications or partial demolition.
- Additionally, there was insufficient height to allow access to the top of the filters to perform maintenance.
- The four filtration units in operation had to operate continuously and offered almost no redundancy in case of a backwash failure event and, despite having two spare vessels inside the filtration building, the lack of a pipework connection to them and the building design itself made these two units unusable. To perform the backwash of one vessel the other three had to be operating full time and the operation had to be properly planned as the allowed window for this operation was too short, due to the lack of redundancy.

To add to all of the above mentioned, a decrease in pumping efficiency (decrease in the abstraction volume between 2008 and 2011), the lack of a backwash recycling system, the undersized lagoons, and the excess in man hours required to perform maintenance, it was decided to stop abstracting water from this source relying only on the chalk source.

As part of the Sustainability Reduction Programme we are delivering, the chalk source is to be shut down in 2024, so it becomes crucial to explore alternative groundwater sources to ensure security of supply to the area. As a result, the greensand borehole (BH3) needs to be put back into service to compensate for the loss of the chalk source but more importantly to restart using a license that has no restrictions by the Environment Agency in terms of abstraction and sustainability, due to the greensand aquifer being a deep aquifer with a groundwater gradient towards the southeast, being over pressurised and not contributing to surface water flows.

A new greensand borehole at RUNL is currently (summer 2018) under construction and its completion is due in early 2019. This borehole will be drilled as part of the plan to prove more output can be abstracted from this aquifer and to allow for an application with the EA to allow for an increase in abstraction from this source. Currently the greensand aquifer is not considered by the EA to be over-abstracted unlike the Chalk aquifer and as such there is a potential to increase abstraction from this source if results of the test are favourable (when borehole No.3 was drilled in 1983 a pump test showed rates of 4.5 Ml/d could be achieved). The new borehole is being drilled with sufficient diameter to allow for duty/standby pumping arrangement.

Three options were considered:

- Do Nothing - Maintain the current situation in that the site cannot be returned to service in its current condition and accepting the associated costs involved with not utilising the existing licence and site.
- Reinstatement of the existing plant - Keep the current pumping system and treatment process, reinstate abstraction while maintaining and repairing the current equipment on failure. Based on the conditions of the existing plant, this option is not a valid option.
- Design and installation of a new treatment plant to include new borehole pumps, a new chlorination process for oxidisation water prior to the filtration process and for disinfection (super and de-chlorination process, new rapid gravity filters (RGF) to remove iron, manganese and ammonia from the water and all the required instrumentation and pipework; new backwash system with recycling backwash water system and sludge treatment to reduce the amount of water going to waste; new contact tank and dechlorination process to ensure enough disinfection and residual chlorine levels for water distribution; new lift pumps to ensure enough pressure for distribution; new run-to-waste facilities; new treatment building.

Through optioneering and stakeholder workshops, the option of a new treatment plant was chosen.

This investment is for the installation of a full new treatment and pumping plant that will be required to allow the abstraction of water from the new borehole. This shall include all the required treatment and lifting processes required to treat the water abstracted from the lower greensand aquifer. All processes should be independent of the treatment processes used to treat the chalk source.

With these works the greensand source will be able to be brought back to service allowing the production of more water for distribution, alignment with stated source capacity in the WRMP, reducing the dependency on ANGL whilst becoming a more efficient treatment process not only by being able to recycle the backwash water and reducing the discharge to waste, but also by having a system that consumes less energy and maintenance.

5.3.2.7 Waste treatment

Preliminary investigations at ROYD WTW have indicated that there is a risk of discharge from the unlined lagoons on site into the local water course. As a matter of precaution, the lagoons have been taken out of service and temporary measures put in in place to allow continued operation of the site until 2020. It is essential that ROYD WTW remains in operation to meet the supply/demand balance in the Stort community, so a permanent solution for managing the wastewater produced on site is required.

Options considered included storage and removal of thickened sludge as well as multiple dewatering options. Initial optioneering has indicated that the preferred option is to provide sludge dewatering plant in addition to the existing sludge thickening process. Waste will then be removed from site as a cake for disposal off-site.

We are exploring the opportunity of using an innovative treatment process as part of the temporary solution in AMP6 which, if proven to be successful, could form part of the permanent solution in AMP7. A pilot trial with the innovative process will be run on site during 2018 to gather performance data.

5.3.2.8 Disinfection upgrades

The deterioration of ground water quality at two sites in the Lee community requires us to upgrade the disinfection process in accordance with our disinfection policy. We explored multiple options to address this risk, including catchment management, abstraction management and blending which were all ruled out as inadequately addressing the risk. Based on initial concept development, these sites will require upgrade with ultraviolet irradiation disinfection.

An additional eight sites have been identified in the Dour community as requiring upgrades to disinfection processes. These sites are OTTI, RAKS, LYEO, DREL, LIGH, CONN, DENG and DOVP. A similar optioneering process was carried out and it was concluded that these sites will also require upgrading with ultraviolet irradiation disinfection.

We have been exploring the opportunity to use an innovative UV treatment process instead of conventional designs, which reportedly has a lower energy requirement. We propose to undertake a trial with this new technology in AMP7 and, if proven to be successful, this technology could form part of the permanent solution across these sites in AMP7.

5.3.2.9 WRMP Supply Side Schemes

We have identified three WRMP supply side schemes as follows:

- The current outputs from the SPRI and SHOL sources is limited by network constraints (pipe sizes) downstream of the SPRI source. This scheme is the removal of this constraint by construction of a new main (1.19km of 300mm diameter pipe) from SPRI WTW to the existing network to allow increased abstraction from the groundwater sources and transfer to Folkestone. This scheme will provide an additional 0.97Mld during average conditions and 1.32Mld at peak for use within WRZ7.
- At SLYE, the waste stream from the membrane filtration treatment process is returned to the ground via soakaways to the benefit of the chalk aquifer. It is noted that the source is subject to reductions in abstraction at times of low flow in a nearby watercourse, the River Dour. There are other precedents in Affinity Water where the EA have allowed for this ‘returned’ water to be accounted for in assessment of the total abstracted volume (e.g. HWFS WTW). These arrangements are agreed by letter and do not involve a variation on the abstraction licence. This scheme is to obtain agreement with the EA to be documented in a letter that would be appended to the current licence to allow us to increase abstraction by 0.14Ml/d consistent with the volume of the “returned” water (around 4% of the abstraction). This option would not involve any variation in the treatment process and so no costs are involved here. The Environment Agency in a November 2016 workshop indicated that the option is feasible but requires further investigation.
- This scheme involves STAS, an existing (but disused) groundwater source within an existing licence group. There is a sequence of boreholes connected by an existing raw water main to the treatment works; SDEN; STAN; and SRAN. STAS is not within this sequence currently and the option is to re-commission the borehole to provide resilience for the licence group (the group output is limited by licence / treatment works). For example, the SDEN source has turbidity issues at higher pumping rates and the recommissioning of STAS would allow the rate at SDEN to be reduced. Test pumping is required to confirm the yield that can be achieved and water quality.

5.3.2.10 Aluminium

Aluminium is present in the raw water abstracted from the River Thames, and additionally dosed within the treatment processes at EGHA and HWFS (clarification). This is generally well controlled and the final water residual aluminium into the network is below the PCV; however, further process control is required. In addition, over time this residual aluminium has accumulated in some areas of the network and may be mobilised during changes in flow. To maintain compliance at the customers' taps we need to ensure tighter control over the final water from the treatment process, to reduce the final concentration, and to remove the accumulated build-up of aluminium from the network.

Our proposed investment includes innovative improvements to treatment, applying research developments to improve process efficiency, benefiting both turbidity and residual aluminium performance. In AMP6 we have been carrying out bench-top tests to optimise the performance of the existing clarifier assets. We will build on this research to deliver further improvements in AMP7.

The investments at HWFS will also increase total clarifier treatment capacity, by expanding the treatment capacity of the high-rate clarifiers. This will result in greater overall resilience of the site and reduced downtime if any one of the clarifier streams is taken offline. This is particularly critical as the WRMP requires that HWFS be available to produce maximum license flow to support the supply/demand balance in the Pinn community and across our Central region.

5.3.2.11 RGF House refurbishment at CHER WTW

The refurbishment of RGF1 is a requirement supported by our various Asset Management planning and investment tools. The Master Development Plan for CHER identified the need to address civil issues with the 1970 built structure and roof, whilst other risks had been captured on PIONEER ARM, including a hydraulic restriction that affects the capacity of the plant during periods of extended operation at full output. Addressing this will improve our resilience during high demand, and feed into our strategy of moving water from our surface sites northwards.

The RGF media will be due for replacement as expected after 20-25 years, and this operation will also be made safer and easier by improving the drainage of RGF1 as part of the project.
Through optioneering, the option of refurbishment to extend the life of the asset was chosen over the option of waiting until a costly full replacement is needed. The investment is also a balance of all the needs combined into a single project for efficient delivery.

5.3.2.12 RGF House refurbishment at WALT WTW

The driver for this investment is the condition of the concrete structure, which has deteriorated to the point of spalling due to deep carbonation. This was noted by a detailed independent study carried out in 2007, after which temporary repairs were carried out to extend the asset life. There is a need to address the condition of both RGF houses, and the options considered were

- to replace both,
- to refurbish both,
- to replace one and refurbish one.

RGF1 and 2 are of different ages, being built in 1939 and 1957 respectively, and this contributed to the preferred option of replacing the older house and refurbishing house 2. It is also considered to be the optimal use of capital to manage the overall risks to supply and health and safety.

This solution would also enable easier completion whilst maintaining operation of the plant, compared with refurbishing both, by phasing the work for least disruption.

Addressing this will also improve our resilience during high demand, and feed into our strategy of moving water from our surface sites northwards.

5.3.2.13 Slow sand filters at two WTWs

Slow Sand Filtration is employed at CHER and WALT WTW, with the filters constructed in 1972 and 1990 respectively. As stated above, both sites are strategically important in the company's long-term plan and the Master Development Plans have identified the optimal approach to managing the assets over 25 years.

The slow sand filters at the two sites are in varying conditions, showing signs of ageing that include wall cracks and degradation of porous concrete floors. There are also opportunities to improve hydraulic constraints and waste water recovery, improving the capacity and reducing waste. Essential refurbishment has been identified on specific filters to ensure the risks are managed and investment is targeted to the areas it is most needed.

5.3.2.14 Waste water recovery at DENG WTW

The need to review waste stream management at DENG WTW has arisen due to the forthcoming closure of the Dungeness power station sea outfall in 2023, which is currently used to dispose of one of the waste streams at DENG WTW. There is also an opportunity to improve the second waste stream that discharges into the local environment, at the same time, by treating the waste water from both streams. This will increase the treated water output by improving recovery of waste water, and/or reducing the amount of water abstracted, together with the associated environmental benefit.

A new waste water treatment plant will enable compliance with backwash water recycling and give the company full control over the waste produced.

5.3.2.15 Waste water recovery at LANE

The need for this investment at LANE is primarily to ensure compliance with the Environment Agency (EA) discharge licences. Currently the secondary membranes are not able to cope with periods of high turbidity in the raw water sources, causing constriction of LANE's deployable output (DO).

To improve the performance of the secondary membranes at LANE WTW during periods of high turbidity in the raw water supply sources, a new Poly Aluminium Chloride (PACL) dosing system and additional waste water storage solution are required.

5.3.2.16 Water tower refurbishment at DENG WTW

The DENG site booster pumps and water tower are aged and degrading assets. The booster pumps are prone to failures due to their condition and create a high risk of losing DENG WTW full output.

The water tower poses increasing health and safety risks due to its deterioration, and requires an increased level of maintenance with additional, and expensive, mitigation associated with working at height.

The four old booster pumps are to be replaced with three new booster pumps with VSDs which would allow for more control over the network flow, increase pump efficiency, lower operating costs and give increased reliability to site by reducing risk of customer supply interruptions. This option would also allow for the water tower to be bypassed when needed for maintenance and inspection purposes.

5.3.2.17 Waste water recovery at WALT

The capacity of the existing waste water treatment system is a significant restriction on site output, as during peak conditions the sand washing operation has to be suspended when backwashing the RGF filters. Additionally, lack of capacity in the waste balancing tank and supernatant channel also affect output, and risks overflows towards the River Thames. An aged polyelectrolyte dosing system contributes to the need to upgrade the waste water recovery process, giving better control, more efficient dosing, better quality of sludge, and reduced environmental and health and safety risks.

A number of options were considered in the business case for the waste water plant at WALT:

- Carry out replacement work of the current assets in order to ensure a reliable and safe waste water recovery in the next 20 years whilst reducing operation and maintenance costs. This option consists of extending the sand trap pumps area, installation of a new thickening process using Lamella clarifier, replacement of the polyelectrolyte dosing system, replacement of the supernatant channel, installation of a dewatering stage using centrifuges and disposal of the sludge off site.
- Do nothing/Status quo i.e. continue to use the current lagoon until the end of AMP7.
- Carry out replacement and refurbishment work of the current assets in order to ensure a reliable and safe waste water recovery in the next 20 years whilst reducing operation and maintenance costs. This option consists of extending the sand trap pumps area, installation of a new thickener (like for like), replacement of the polyelectrolyte dosing system, replacement of the supernatant channel and addition of a new lagoon as well as refurbishment of the existing lagoon

Through optioneering, consultation workshops and financial evaluation, the option of installing a Lamella thickener and a dewatering stage using centrifuges was considered the most cost-effective option.

5.3.2.18 Granular activated carbon (GAC) replacement/ regeneration

To maintain compliance with the pesticides levels in our final water, we require to regenerate and or replace the GAC media in our GAC contactors.

Our results have shown that regeneration and replacement frequencies vary from 3-6 years based on the nature of the raw water being treated. The regeneration programme for the period 2020-2025 is based on ensuring that our final water will not fail the pesticides PCV.

5.3.2.19 Dewatering at HWFS WTW

By improving the quality of our dewatering plant and storage, we will improve the sludge quality and get the associated benefits in efficiency and reduced waste. HWFS is a key site, and this project is key to maintaining reliability during high sludge producing periods, as well as reducing any potential environmental impact.

5.3.2.20 Turbidity and water recovery at NORM

NORM WTW, and in particular the NORM and ESSE borehole sources, are heavily affected by surface water runoff due to the karstic characteristics of the geology in this catchment. The existing clarification process is not capable of treating the full range of influent turbidity. The wastewater treatment processes on site are not adequate to treat the volume of wastewater that is produced, so presently the water cannot be recovered and recycled.

Both of these treatment limitations result in reduced capability of the site to treat full licensed flow at all times. In AMP7 and the future we will be heavily reliant on NORM WTW to support the supply/demand in the Lee Community as the sustainability reductions come into effect, and therefore need to maximise output from this site.

Based on successful operation of a similar process at HWFS WTW, and due to severe space constraints on the site, initial optioneering has identified a preferred option of high-rate clarification for the turbidity treatment.

The proposed wastewater treatment process comprises a lamella sludge thickening tank and a centrifuge – both selected to reduce footprint required, due to the severe space constraints on site.

5.3.2.21 Ozone refurbishment at three WTWs

The ozone plants at our three large WTW in the Wey community were built in the late 1990’s and require investment to avoid any water quality failures in future. To maintain the safe operation of the plants, we will invest to address the following issues:

- Pipework leaks in the ozone generation plants
- Power Supply Units are failing and not supported
- Gas flow control is poor particularly at the low ozone dose end. This leads to excessive LOX consumption
- The generators have not been cleaned for over 2 years and have lost efficiency
- There are a number of items identified during the survey in 2014 that require replacement
- Some of the Planned Preventive Maintenance has been missed in the last 5 years and this leads to issues with safe plant operation

A number of options were considered in the business case for the ozone plants.

- Refurbishment of all three ozone plants to maintain them to ensure treatment capacity and water quality over the next decades
- Do nothing/Status Quo i.e. continue reactive maintenance of ozone treatment assets until the end of AMP7.
- Replacement of the ozone plants (like for like) consisting of replacing the existing plant with similar plants.

Through optioneering, consultation workshops and financial evaluation, the option of refurbishment of the three ozone plants was considered the most cost-effective option.

5.3.2.22 Ozone refurbishment at HWFS WTW

We will invest in the ozone plant at our largest WTW. The ozone plant, built in 1991, is ageing and seeing increased failures. In order to maintain the safe operation of the plant, we will invest to address the following issues:

- Asset issues with the current ozone generators (e.g. gas leaks, poor efficiency)
- The air preparation plant fails at least monthly and the desiccant dryers are at the end of their life
- The pre-ozone gas injection is inefficient (approximately 60-70% transfer) and expensive (e.g. expensive energy costs to operate the turbines and short life of the turbines)
- The inter-ozonation diffusers are inefficient (approximately 60-70% transfer) and require regular replacement. Through their inefficiency, they also lead to ozone gas leaks in the area.
- At least one of the 4 interozone tanks has shown damage to the concrete structure and re-enforcement

A number of options were considered in the business case for the ozone plant.

- Refurbishment of main ozone plant and Installation of LOX plant for preozonation consisting of refurbishment work on the current assets to maintain them and install a separate preozonation plant to ensure treatment capacity and water quality over the next decades
- Do nothing/Status Quo i.e. continue reactive maintenance of ozone treatment assets until the end of AMP7.
- Replacement of the ozone plant (like for like) consisting of replacing the existing plant with a similar plant, to ensure treatment capacity and water quality over the next decades. This would also require the demolition of the existing plant.

Through optioneering, consultation workshops and financial evaluation, the option of refurbishment of the main ozone plant and installation of a separate preozonation plant was considered the most cost-effective option.

5.3.2.23 Waste water recovery at EGHA WTW

A new fourth sludge thickener at this strategically important site will enable the waste water system to cope with the increased requirements during certain scenarios. The main driver is to address the issue of capacity to treat all sludge coming from the clarifiers and filters under full site flow, particularly during the summer algae season, and at times of high silt loading. In addition, by improving the consistency of sludge thickening, we will remove the need to disposal to landfill at additional cost. Finally, routine maintenance of the thickeners currently reduces the site production capacity.

5.3.2.24 Waste water recovery at CHER WTW

The current waste water stream at CHER WTW

- is in risk of breaching environmental regulations
- is in risk of infiltration of the gravel well field on the site
- has the potential for recirculation of cryptosporidium to the head of the works.

We therefore need to invest in our waste system at CHER to ensure waste water is adequately treated on the site.

Through consultation workshops and financial evaluation, the most cost-effective option is to build a new waste water treatment plant including Lamella clarification and centrifuges, with a smaller footprint and more effective treatment. The new plant will ensure we meet our regulatory and environmental obligations and recover maximum waste water from the Rapid Gravity Filters and Membrane stages.

5.3.2.25 Reservoir cleaning at WALT WTW

WALT Settling Reservoir No. 2 has not had any silt removed since 1969. The previous reservoir cleaning project on both WALT settling reservoirs only included the main cleaning works related to Settling Reservoir No. 1 whilst the project also replaced both reservoir outlet valves.

The cleaning project for settling reservoir No.2 should be implemented to ensure we restore our resilience by maximising the total raw water storage capacity, and to guarantee low turbidity in the raw water (<10 NTU) towards downstream treatment process units.

5.3.3 Nitrate treatment

Results from our catchment modelling and water quality trend forecasting have demonstrated that increasing nitrate trends are directly linked to groundwater recharge. In light of the water quality forecasts, we carried out a detailed review of the historic data at all our sites deemed to be at risk from nitrates, and quantified the relative risk of each source reaching the operational trigger at which we turn off the supply.

Four sites (OUGH, STAN, BROM and KIND) have been identified as 'at high risk' of reaching our trigger in 2020-2040. Our WRMP indicates that we will be reliant on the water from these four sites to meet the supply/demand balance in the Lee, Stort and Dour communities. Therefore, it is essential that an investment is made so that we can continue to supply the full licensed flow from each site.

We explored multiple approaches to addressing this risk, including catchment management, abstraction management and blending which were all ruled out as inadequately addressing the risk in the required timescale. In AMP6, and during the course of our optioneering work, we have worked closely with a number of technology suppliers including developers of a novel nitrate treatment process. We assessed the relative merits and risks of each treatment process.

The treatment to be provided is ion exchange at all four sites. This is the industry best practice approach for nitrate removal and is a technology with which we are already familiar having several sites with ion exchange plants currently in operation.

5.3.4 Pesticides

Six of our strategic water treatment works and our bulk treated water imports are at risk from some pesticides. We applied for and were granted by DWI legal Undertakings which require us to deliver a long-term plan to mitigate these risks.

Our analysis shows that metaldehyde is the pesticide that presents the highest risk, due to our lack of treatment capability, and that other high risk pesticides pose a residual risk or can be adequately managed by our existing treatment processes. The catchments where we abstract water from are heavily influenced by agricultural activities and as such we observe seasonal risks associated with pesticides used in arable crops. Our greatest risks are associated with metaldehyde, propyzamide and carbetamide. During AMP6 we have increased our pesticide removal capacity at a treatment works in the Pinn community to help mitigate the risk of pesticides and will install a new pesticide removal treatment plant in the Lee community. We have also investigated innovative schemes which could be used to reduce the concentration of metaldehyde using novel processes. To reduce the likelihood and severity of metaldehyde in river water we have developed catchment management programmes.

Our analysis shows that metaldehyde is the pesticide that presents the highest risk, and that other high risk pesticides can be adequately managed by our existing treatment processes. The catchments where we abstract water from are heavily influenced by agricultural activities and as such we observe seasonal risks associated with pesticides used in arable crops.

As of 2017, we have metaldehyde-reduction schemes covering approximately 600km^2 of upstream catchment from our surface works. In the period 2020-25 we will expand our catchment management programme still further and make operational changes to improve pesticide removal rates using our existing treatment assets.

In November 2017 Defra indicated that they are receptive to using their regulatory powers to introduce restrictions on metaldehyde to assist water companies in meeting the pesticide drinking water standards. This will have a significant benefit on the raw water quality in the River Thames and, in combination with catchment management, will reduce the metaldehyde load in our abstracted water substantially.

We will therefore invest in tracking and monitoring the effectiveness of the metaldehyde restriction and other pesticides by installing a~~n~~ monitor up-stream of our abstraction sites on the River Thames. We have had preliminary discussions with Thames Water about data sharing arrangement whereby they would install a second monitor on a point lower down the Thames catchment as both companies would have access to the live data at both points. We have successfully delivered a project at NORM WTW in AMP6 to install an online GC-MS instrument which provides results of the metaldehyde concentration at three separate points on the treatment works within 36 minutes of sample collection. We will use the learning from this project to improve the design and utilisation of a second instrument on the River Thames. This will enable some enhanced treatment control and potentially the use of limited abstraction management It will provide near real time data on metaldehyde and other pesticides load in the river and enable enhanced treatment control and some use of abstraction management.

5.3.5 Conditioning treatment

We are licenced to import 91 Ml/d average of potable water from Anglian Waters' ANGL water treatment works (WTW). Operational restrictions mean that we can currently import no more than 50 Ml/d on average. In our rdWRMP, we need up to 81 Ml/d of water from ANGL under peak conditions from 2024 to meet the supply/demand balance. Under all modelled scenarios we will need to move ANGL water into areas that have historically been, and are currently, fed by groundwater to resolve local supply/demand imbalances caused by sustainable abstraction reductions.

The chemical composition of ANGL water is different to that of our own groundwater. There are historic incident records of customer discolouration events and taste and odour complaints when ANGL water is used in groundwater fed areas after only two weeks. Investment is therefore required to mitigate the discolouration, taste and odour risk[27]. If no action is taken then there is a very high probability that customer water quality will deteriorate; firstly, in localities where sustainable abstraction reductions must be implemented and then throughout the central region, in line with our long-term water resource plans, which involve utilising imported water companywide.

Through our on-going Drinking Water Safety Plan (DWSP) risk assessments we have identified the following risks for water imported from ANGL WTW:

- Discolouration, due to corrosion of galvanised iron supply and communication pipes;
- Taste and odour, due to customer perception of the difference between residual disinfectant being used by Anglian Water and by ourselves; and
- Pesticides (in particular metaldehyde), largely due to agricultural diffuse pollution.

5.3.6 Laboratory equipment

Our laboratory in Staines is UKAS accredited and handles approximately 60,000 samples, performing 600,000 individual analyses a year to meet our regulatory requirements and provide operational data which assists us in providing a wholesome supply of drinking water. Our investment proposal is risk based, with a starting point of expected asset life[28]. Most the current analytical equipment has relatively short life assets, requiring frequent replacement. In addition to these, we have several high value technical analytical assets that are crucial to the operation of the laboratory and proactive replacement is required to ensure business continuity. We considered the following three options:

[27] *AFW- Cost adjustment claim AFW005*
[28] *10 Year Rolling Replacement Calendar Oct 13.xlsx*

- Do nothing - As instruments cease to function, testing will gradually need to be subcontracted to other laboratories at a greater cost and increased reporting period than at present.
- Replacement on breakdown- When instruments cease to function, testing will also need to be subcontracted to other laboratories at a greater cost and increased reporting period than at present
- Replacement, based on above strategy - Instruments will be replaced in a controlled fashion, providing continuous supply of resources to enable the provision of test data to allow the business to fulfil its regulatory and operational requirements.

The risk-based replacement option will avoid disruptive loss/delay of data. This is also the strategy that has been adopted for the last five years and has proven to be successful.

5.3.7 Contributions for our shared reservoir in Brett Community

Our Brett Region receives treated water that is abstracted from the River Colne in Colchester and stored and treated at the ARDL Reservoir and Treatment Works. This is a joint facility with Anglian Water. Costs relating to capital maintenance and quality enhancements are generally shared equally, but in some instances, are proportional to use.

These works and reservoir assets are not included in our non-infrastructure modelling and portfolio optimisation processes. Instead we have worked with Anglian Water to develop the needs for the plant and the costs of implementation. Anglian Water has provided the scheme cost estimates which we have verified and are satisfied can meet the outcomes to be delivered.

The needs and issues that will be addressed in the capital investment plan for ARD are summarised as follows:

Investment area	Driver	Activities	Cost (£)
Water Resources	WINEP2	Investigations under the Eel regulations, WFD study for the Colne, invasive species transfers study.	199,000
Water Resources	Reservoirs Act	Inspections and remedial works for the Dam. Dam break risk analysis.	308,000
Water Resources	Catchment management	Investigations into the use of phosphate in the catchment	27,000
Raw Water Distribution	Maintenance	Dealing with mussels, instrumentation and general maintenance	127,000
Treatment	Maintenance	General minor	799,000
Treatment	Maintenance (specific)	Works include: DAF scraper renewal, salt saturator renewal, GAC regeneration, filter refurbishment, fire protection, GAC outlet weir refurbishment.	1,840,000
		Total	**3,300,000**
		Total for Affinity Water (50%)	**1,650,000**

5.3.8 Reducing customer consumption

Part of our solution to maintaining a positive supply demand balance is to work with customers to reduce their water use in the short term, and over longer time frames, when consumption can creep up. Our WRMP assumes an overall reduction in customer use from 155 litres per person per day in 2018 to 129 litres per person per day by 2025. This programme encompasses everything that we will be doing with customers to reduce our per capita consumption (PCC). The following projects have been selected through the WRMP planning process:

5.3.8.1 Fast data

We know that customers are more likely to reduce their consumption when presented with improved usage data then they are when offered more financial gains. We therefore plan to focus on improving the way that we communicate consumption information to individual users. This makes use of existing AMR meters in combination with new fast logging and live network hydraulic models to provide customers with surrogate information about their water use. Metered customers will be able to get a much more detailed picture of their water consumption than they currently receive through their six-monthly bills and we anticipate this will encourage greater water savings than our meter programme alone. In this way customers will receive comparative data to help them understand their own consumption in the context of community and regional usage. The project is anticipated to save 17 Ml/d by 2025.

5.3.8.2 Water reuse schemes

This project involves the implementation of a rainwater harvesting system in the Terminal and Hangar Buildings of a large commercial airport. We will work with Retailers and with the commercial customer to install free standing rainwater tanks at optimal collection points across site, and water re-use for toilet flushing only. This project anticipates 2.3 Ml/d saving by 2025

5.3.8.3 National water efficiency campaign

We will work with Government, regulators, water companies and other partners to influence water consumption behaviour at a regional and national level that would generate savings outside of our direct control. The aim is for us to lead a partnership which builds on the efficiency campaign work that we have done with Hubbub. The project targets a 13 Ml/d saving by 2025.

5.3.8.4 Unmeasured non-household metering and water audits

There are approximately 8,600 non-household customers that pay via an unmetered bill. It is assumed that 78% of the 8,600 can be metered, with the rest being infeasible due to shared supplies and difficulties in metering some properties. We will work with Retailers and non-household customers to install meters and reduce water use through water audits. We anticipate a saving of 0.75 Ml/d from the metering and 6Ml/d from the water audits by 2025.

5.3.8.5 Water saving programme

We will continue to deliver our ten-year Water Saving Programme (WSP); an initiative selected by our PR14 WRMP. The programme involves the installation of water meters at household customer properties in our Central Region which encourages customers to value the water they use and in doing so reduces demand. The purpose of the programme is to help to maintain a water balance surplus.

We will install 240,000 meters by the end of AMP7. This will bring total meter penetration in our Central Region up to 78% by the end of AMP7. The use of smart meters will allow quarterly drive by meter reading to take place, providing economies of scale and reducing our operational meter reading costs. The meters will also provide enhanced consumption data which we will share with customers to help drive further water savings.

In the longer term, we will roll out smart meters to all properties that we can meter as and when our existing meters reach the end of their asset life. We anticipate that the benefits will extend to 2050.

In addition, we will offer household level water efficiency support in the form of home water audits. This, in conjunction with the schemes described above, will further reduce customer consumption. Upon completion of the WSP in 2025 we anticipate achieving an 18% reduction in consumption per household. This figure is based on evidence of our achievements to date.

5.3.9 Resilience and environment community pilot schemes

We will carry out eight pilot schemes that will enable us to improve the resilience of our catchment. There will be one scheme per community, working in partnership with local businesses and Environmental groups. This is an innovative solution to increase the quality and quantity of water in our catchments. If the pilot schemes are successful, then we plan to expand them further in AMP8. See chapter 4 of the main business plan for more information.

5.3.10 Upper Thames regional reservoir

Our rdWRMP makes the case for investment in new resource development as part of a regional scheme that might benefit multiple water companies in the south east. The need for a regional strategic import to our supply area is also something that is promoted through WRSE group modelling. The preferred strategy is to seek to secure additional reliable water by transferring water from a new regional reservoir in the Upper Thames catchment promoted in partnership with our neighbours as part of WRSE, which could support new abstractions in the Lower River Thames reaches.

The scheme will support our plans to meet a severe drought (1:200-year event) and will be timed to meet our long-term supply demand balance in conjunction with the uncertainty of savings inherent in our forecast savings from our demand management options.

This scheme has a 15 year 'lead in time'. We have co-ordinated with neighbouring companies, who are also planning for the need in AMP10, and we recognise that there will be development costs incurred in AMP7 to support the later procurement and civil construction phases of the project. Following on from recent discussions with neighbouring companies, the earliest date that the scheme could be commissioned would be 2037.

The decision for the location was the result of over a decade of planning from Thames Water. A number of options were considered:

- Do nothing – This would lead to a supply-demand deficit that would leave large amounts of customers without an available water supply
- Regional reservoir – This would ensure access to up to 100Ml/d additional water that would lead to increased resilience relating to customers' water supply
- Severn Thames Transfer UTRD – This option is not supported by neighbouring companies, so this would not be cost efficient to progress as one company
- Anglian Water Import – Although this is based on sharing a supply boundary with this company and therefore transfers should be over a relatively small distance, accurate costs have not been readily available, and this option is extremely new which means it is untested and uncertain
- Severn Trent direct import - This option consists of a pipeline over 100km in length that would cross from Severn Trent, through Anglian Water's supply region and into ours. The pipeline would need to cross the M1 (possibly on multiple locations) and may interact with existing infrastructure elsewhere. In addition, there are also water quality concerns with this option.

- Grand Union Canal - By its nature the water in the Grand Union canal would require significant treatment to mitigate the raw water risks. In addition, this option would deliver water to an area where it is not needed the most. These options also have had very little in the way of drought assessments, so uncertainty exists around how they would perform under extreme droughts

Through thorough discussions and assessments in the last ten years, the option of constructing a new storage reservoir at Abingdon is considered the least cost whole-life option. The expenditure planned for AMP7 is to develop more detailed plans for this option, including the exploration of direct procurement, in partnership with Thames Water.

5.3.11 Energy strategy

We expect to consume circa. £95m worth of electrical energy in AMP6. This amounts to an annual energy spend of circa £19m, a significant portion of our operating costs. Our annual energy bill comprises of 50% base load costs and 50% pass through costs. The Cornwall Pricing Guide[29] estimates that there will be a significant rise in pass through costs in the next 5 years and beyond. This means that if energy consumption remains the same and no action is taken, energy costs will increase to £117m in AMP7 (an additional £22m) and to £133m in AMP8 as shown in Figure 5-19 below.

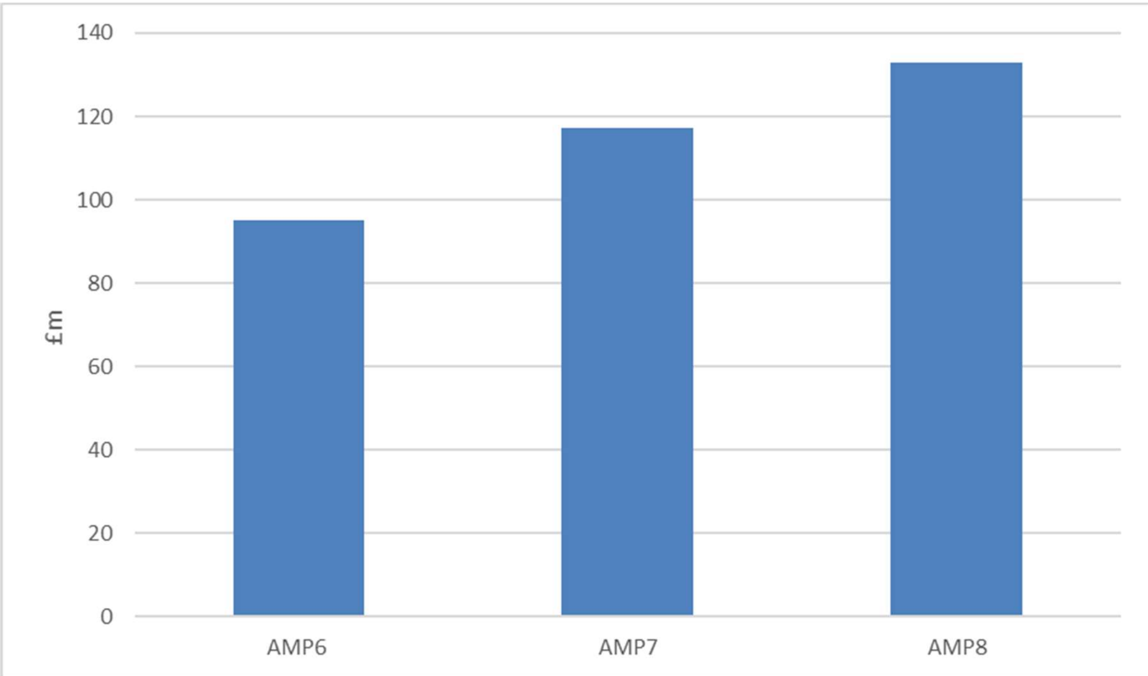

Figure 5-19 Energy Cost Profile

This demonstrates a clear need to change our strategy to ensure our running costs remain efficient for customers while supporting the broader community by reducing our carbon footprint.

Optimisation studies and industry experts have validated an energy efficiency saving potential of circa. 10% which will mitigate £11.7m of the forecast AMP7 energy cost. This will be deliver through a combination of continuous improvement, visualisation/capability enhancement and capital maintenance.

[29] *Cornwall Pricing Guide*

Our ambition is to completely neutralise the forecast cost increases, but this requires more radical change. Through engaging with industry experts and participating in collaborative projects we, like others in the sector, recognise that investing in alternative energy is a must. Working with our external energy consultant we have reviewed a range of technologies. These included gas engines, wind (tethered and static), solar, solar/battery and micro-hydro. Given factors such as cost, environment, energy density, geography and resilience we concluded that progressing with solar/battery and gas engines represents the most effective solution. This solution will enable us to neutralise operational energy cost increases during AMP7 and reduce our reliance on grid supply by 40% by 2030. To enable this, start-up capex of £19.7m is required, and this will payback in full during AMP8.

Costs for alternative energy have been based on actual £/MW provided and verified by our external energy consultant and peer reviewed. Potential sites have been surveyed and reviewed for suitability with definitive site locations to be determined at implementation stage. Our Energy 2030 Strategy[30] details our broader ambition and plans over the next 10 years.

5.3.12 Vehicles

We lease the majority of our fleet. The exceptions to this policy are the technically specific vehicles, typically weighing above 3.5 tonnes, which we purchase. These vehicles are either unavailable for hire, or generally kept much longer than a hire company are prepared to quote for, hence the need to purchase. Examples include large vehicles specifically configured for network maintenance activities and vehicles modified for emergency access to flooded sites. Our analysis includes £100,000 for the purchase of undetermined speciality vehicles. A cost benefit analysis has been performed for the entire fleet, and the costs for lease against purchase have been seen to be comparable for standard vehicle types. The decision to choose the lease option is twofold: there is a greater cost certainty when leasing; purchasing of vehicles greatly increases the exposure to the risk of residual value. This is increased due to the volatility that has been seen in the vehicle market in the last decade. We have also included for the disposals of current vehicles.

5.3.13 Meter replacement

We currently have approximately 900,000 revenue meters at household and non-household properties. They provide revenue information for measured customers. The number of meters will increase by 240,000 in AMP7 in line with the completion of the Water Saving Programme. Each year we expect ~ 1-2% to fail. Meters have a life span of between 14 and 20 years. New AMR meters have a battery life of at least 15 years depending how we use them. Meters will be replaced on a reactive failure basis.

[30] *Energy Strategy*

5.4 Non-infrastructure assets totex summary

The following is a summary of proposed totex for non-infrastructure in AMP7.

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
Storage						
Inspection & Maintenance	Inspections, cleaning & disinfection of water retaining assets to understand maintenance needs.	• 145 Internal inspections • 258 External inspections • 7 Statutory (S10) inspections • 65 Statutory (S12) inspections	19.63	1.37	0.00	21.00
Refurbishment	Maintenance projects to preserve storage asset life and reduce risk of failures.	• Refurbishment of 18 structures				
New Storage (Replacement)	Replacement of storage assets at the end of their life to safeguard customer supply.	• Replacement of STGE No.2 • Replacement of WINH Reservoir No.2 • Replacement of FARC Reservoir No.1				
Process Structure Inspections	Implementation of a robust inspection regime to understand maintenance requirements.	• 50 Internal inspections • 100 External inspections				
Disused Storage Assets	Inspection and maintenance of out of service storage assets to ensure that they remain safe and the risks to customer service are minimised.	• Inspection & Maintenance of 77 out of service assets • Isolation of 18 disused storage assets.				
External Minor Repairs	Undertaking of minor external repairs identified from routine inspections.	• Routine maintenance of all storage assets				
Washout Refurbishment	Upkeep of water retaining structure washouts and related infrastructure, so that they can drain when required.	• Maintenance & repair of 110 storage asset washouts and associated infrastructure				
					Storage sub-total:	21.00
Treatment Investment						
HORC	Improving site resilience	• fire protection and suppression	3.30	0.00	0.00	3.30

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
		• stand by equipment and parts • piping rearrangements at the site				
Single Points of Failure	Improving resilience	• addressing the highest ranking single points of failure	5.00	0.00	0.00	5.00
RUNGS	Re-instatement of the green sands source	• new borehole pump • new chlorination process for oxidisation water prior to the filtration process and for disinfection (super and de-chlorination process • new Rapid Gravity Filters • new backwash system with recycling backwash water system and sludge treatment to reduce the amount of water going to waste • new contact tank and dechlorination process • new lift pumps to ensure enough pressure for distribution • new run-to-waste facilities; new treatment building.	5.54	0.00	0.00	5.54
Waste Water Treatment ROYD	Installation of waste water treatment plant	• Provide sludge dewatering plant in addition to the existing sludge thickening process. • Waste will then be removed from site as a cake for disposal off-site.	1.00	0.00	0.00	1.00
Disinfection upgrade	to use an innovative UV treatment process	• Install UV treatment at eight sites	4.18	0.00	0.00	4.18
WRMP Supply side schemes	Supply schemes to increase abstraction to satisfy customer demand	• Licence investigations and (potential) variations	0.60	0.00	0.00	0.60
Aluminium	Improvements to process efficiency and increase in clarification capacity	• Use of innovative clarifier dosing control • targeted network cleaning for the parts of the network most greatly affected by aluminium deposition	2.96	3.90	0.00	6.86
RGF House CHER	Refurbishment of RGF1 house	• Civil refurbishment	0.46	0.00	0.00	0.46

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
		• Media replacement				
RGF House WALT	Refurbishment of one RGF House and replacement of one RGF House	• Civil replacement • Civil refurbishment • Media replacement	6.86	0.00	0.00	6.86
Slow Sand filters	Refurbishment and removal of hydraulic restrictions	• Floor replacement • Media replacement • Additional outlet pipework	5.40	0.00	0.00	5.40
Waste Water Recovery DENG	Installation of new waste water treatment plant	• Installation of new plant • Improvement in waste water recovery	2.04	0.00	0.00	2.04
Waste Water Recovery LANE	Installation of improved waste water treatment plant	• New PACL dosing system • Third waste water storage tank will aid with waste water storage requirements	2.20	0.00	0.00	2.20
Water Tower DENG	Refurbishment of booster pumps and water tower	• Replacement of current four boosters by three VSD boosters • Refurbishment of water tower	0.48	0.00	0.00	0.48
Waste Water Recovery WALT	Installation of an improved waste water recovery plant	• Building of a Lamella settling tank • New polyelectrolyte dosing • New centrifuges • All associated pipework	1.10	0.00	0.00	1.10
GAC Regeneration	Regeneration of carbon media	• Regeneration of specified number of filters • Media regeneration • Media replacement	7.15	0.00	0.00	7.15
Dewatering at HWFS	Installation of an improved storage area	• Installation of an improved storage area	1.15	0.00	0.00	1.15
Turbidity and Waste Water Recovery at NORM	New waste water treatment to increase overall site capacity	• Installation of a Lamella sludge thickening tank • Installation of a Centrifuge	3.85	0.00	0.00	3.85

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
Ozone refurbishment at three WWTW	Refurbishment of three ozone plants on surface works	• Pipework repairs in the ozone generation plants • New Power Supply Units • Improved Gas flow control • Cleaning of generators • Replacement of obsolete items	1.90	0.00	0.00	1.90
Waste Water Upgrade at EGHA	Increased waste water treatment capacity	• Building of a fourth thickener	0.90	0.00	0.00	0.90
Ozone Refurbishment at HWFS	Replacement of Preozonation and refurbishment of Interozonation Processes	• Installation of a LOX preozonation self-contained unit • Replacement of two ozone generators for interozonation • Refurbishment of concrete in interozonation tanks	4.80	0.00	0.00	4.80
Waste Water Recovery at CHER	Installation of an improved waste water recovery plant	• Building of a Lamella settling tank • New polyelectrolyte dosing • New centrifuges • Installation of new pipework	1.80	0.00	0.00	1.80
Reservoir Cleaning at WALT	Removal of silt from settling reservoir	• Improved water quality and storage capacity in one of the two settling reservoirs at WALT	1.58	0.00	0.00	1.58
Capital Maintenance	Reactive and proactive capital maintenance	• Please see section 8 for additional information and deliverables	85.16	0.00	0.00	85.16
					Treatment investment sub-total:	153.31
Nitrate treatment						
Nitrate Treatment	Mitigating the risk of site shut down due to nitrate concentrations	• Installation of four ion exchange plants	9.96	0.00	0.00	9.96
					Nitrate treatment sub-total:	9.96
Pesticides						
Pesticides	On line pesticides Monitor	• Purchase on-line pesticides monitor	1.20	0.00	0.00	1.20

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
		• Installation of monitor				
					Pesticides sub-total:	1.20
Reducing customer consumption						
Reducing customer consumption	Activities to reduce customer consumption to 126 l/d by 2025	• Providing customers with relevant consumption data • Implementing water efficiency schemes • Implementing water reuse schemes • A national water efficiency campaign • Metering unmeasured non-household water users • Water saving programme	134.36	5.87	0.00	140.23
					Reducing customer consumption sub-total:	140.23
Environment community pilot schemes						
	Pilots to increase the quality and quantity of water in our catchments	• 8 pilot schemes, one per community	2.00	0.00	0.00	2.00
					Environment community pilot schemes sub-total:	2.00
Upper Thames regional reservoir						
Upper Thames regional reservoir	Developing a new shared water resource	• Exploring direct procurement in partnership with Thames Water	18.49	0.00	0.00	18.49
					Upper Thames regional reservoir sub-total:	18.49
Laboratory equipment						
Laboratory equipment	Purchasing and installation of specified equipment for the laboratory		1.83	0.00	0.00	1.83
					Laboratory equipment sub-total:	1.83
Vehicles						
Plant	Purchasing of specific vehicles		0.35	0.00	0.00	0.35
					Vehicles sub-total:	0.35

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
Contributions for our shared reservoir in Brett Community						
Contributions for our shared reservoir in Brett Community	Contribution to capital expenditure for our shared WTW		1.65	0.00	0.00	1.65
Contributions for our shared reservoir in Brett Community sub-total:						1.65
Conditioning treatment						
Conditioning treatment	Removing the 50Ml/d restriction on average import of water from ANGL reservoir	Installation of a new WTW to address: • discolouration • taste and odour • pesticide monitoring	11.22	2.12	0.00	13.34
Contributions for our shared reservoir in Brett Community sub-total:						13.34
Energy strategy						
Energy strategy	Investment to mitigate the risk of rising energy prices and secure resilient long-term supplies	• install solar/battery and gas engines • realise an energy usage efficiency saving of circa 10%	19.70	0.00	0.00	19.70
Energy strategy sub-total:						19.70
Meter replacement						
Meter replacement	Replacing existing water meters on a reactive basis	• 117,000 meter replacements	22.00	0.00	0.00	22.00
Meter replacements sub-total:						22.00
Ongoing asset management						
Ongoing asset management	Activities described in section 8.6	Activities described in section 8.6	9.65	0.00	0.00	9.65
Ongoing asset management sub-total:						9.65
Non-infrastructure total:						**414.69**

6 Infrastructure assets

6.1 Overview

The purpose of this section is to outline the processes and analysis that was performed to obtain the PR19 capital maintenance programme for infrastructure assets. Most of this analysis has been integrated into the PIONEER optimisation process and follows the UKWIR Framework for Expenditure Decision Making incorporating the Common Framework. The analysis required for the remainder of the expenditure is also described.

This section covers the ongoing renewal and maintenance of the following asset groups
- Distribution mains
- Trunk mains

It details the additional infrastructure costs associated with meeting our targets for
- Leakage
- Interruptions to supply

It also covers other specific major programmes of work to be carried out in AMP7
- Lead pipe replacement
- Supply 2040
- Maintaining adequate pressure
- National infrastructure contributions
- Developer Services

6.2 Distribution mains

6.2.1 Overview

Our distribution mains network makes up 13,966 km of our supply infrastructure. This infrastructure transfers water around our district supply areas, from the strategic trunk mains network. Communication pipes are the final connection between the network and customers. Failure of distribution mains and communication pipes affect customers directly in a number of ways: through supply interruption, flooding and traffic disruption. Investment in these assets ensures that the disruption is minimised.

Generally, less than 300mm in diameter, over 75% of our distribution mains are below 125mm nominal diameter (Figure 6-1) with two-thirds of the asset stock still ferrous and an increasing percentage of polyethylene pipes (Figure 6-2), following our recent mains renewal programme.

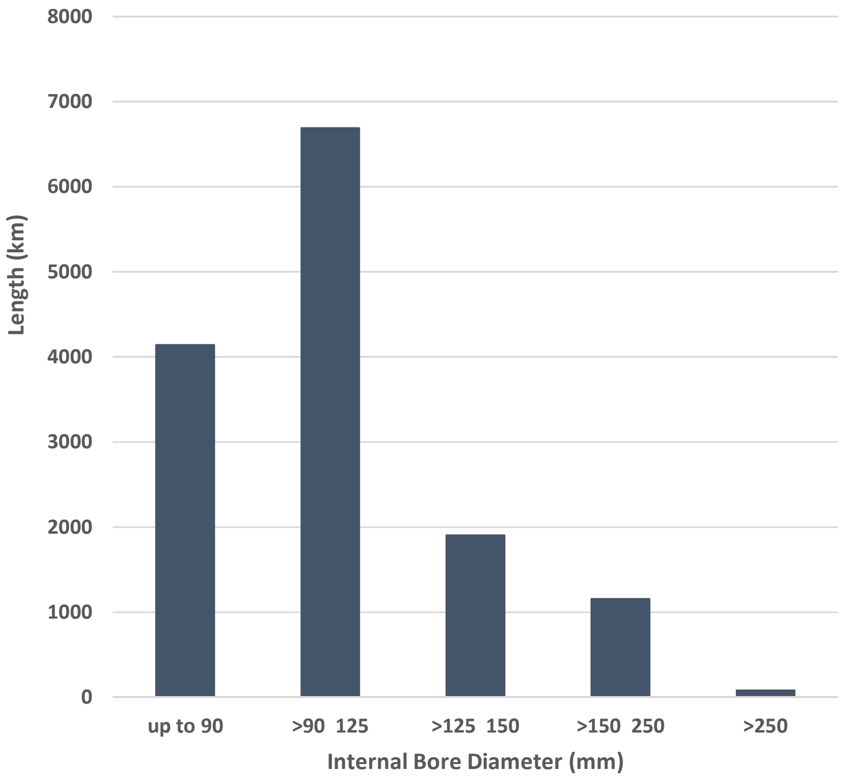

Figure 6-1 Length of Distribution Main Pipes Network by Diameter

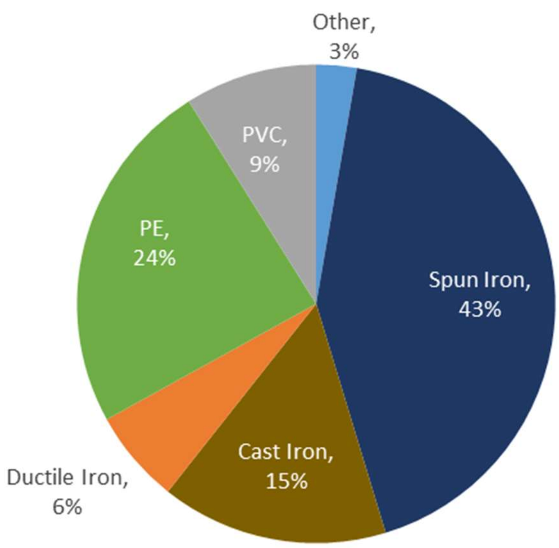

Figure 6-2 Distribution Main Pipes Network Percentage Material by Length

The age profile of distribution mains shows a large increase in pipe laying post 2nd World War and continuing into the late 20th Century following the growth in London and the South East.

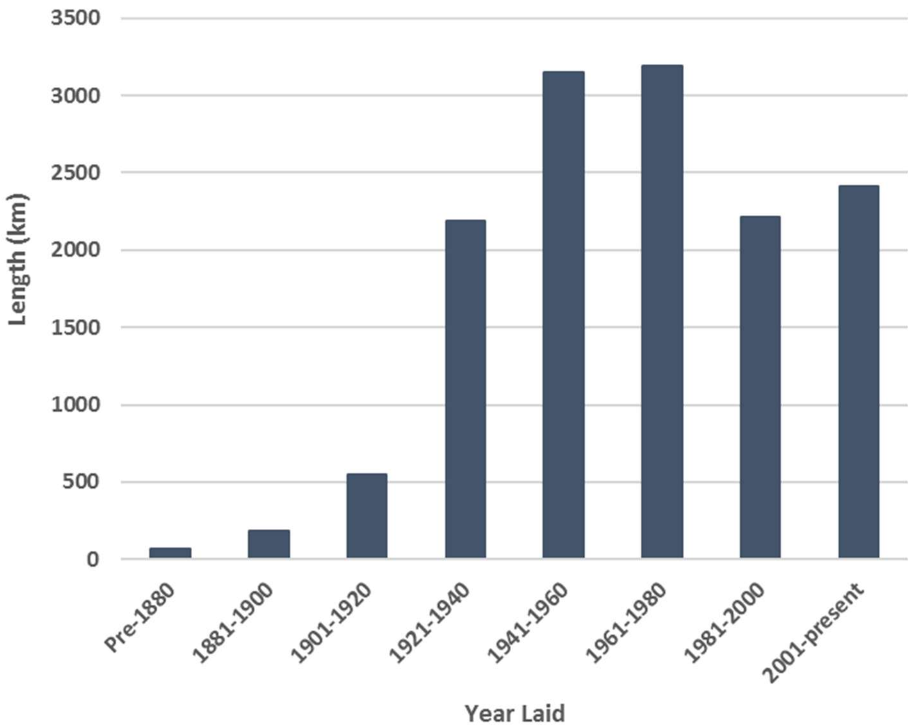

Figure 6-3 Age profile for distribution mains

The following section describes the analysis and modelling performed to provide forecasts for our investment portfolio optimiser PIONEER. The most relevant step in this analysis considers the number of failures predicted for each of the pipe assets. This modelling process uses the survival analysis theory approach and examines each of our material cohorts separately to produce a deterioration curve (or burst rate model) for every pipe in our network. The adopted methodology, following the Common Framework approach, used historical failure data to estimate the modelled failures in our network.

6.2.2 Distribution mains modelled failures

The predicted number of failures on our distribution mains network is based on a statistical burst model and a pragmatic geospatial approach. This failure data was then used within our portfolio optimisation tool PIONEER to determine lengths of renewal against business priorities. Our approach to the forecasting of communication pipe failures is also presented here. Pipe elements were grouped together to achieve pseudo schemes, resulting in a more realistic representation of our historical delivery of mains renewal and ensured that the benefits of mains renewals programme are not overstated.

The distribution mains failure model applies a survival analysis theory approach to achieve a forward-looking prediction of pipe elements based on historical failure. Primarily, the analysis uses both the physical attributes of the pipe elements and their laying conditions to determine the effect on the burst rates, using these attributes to calibrate multiplicative models (Non-Pipe Level Conditional Probability "Non-PLCP" calibration) that will be used to forecast future burst rates. In a second stage, it considers the PLCP calibration, a statistical adjustment considering the recent failure history of each distribution pipe, reflecting the observed correlation between failures in successive years. This approach applies the principles of the Common Framework for Capital Maintenance Planning by drawing on historic data analysis to allow models to be developed which can predict future burst performance.

This section describes what information was used, how the various elements of the process linked together and what outputs were produced for use in our portfolio optimisation process.

6.2.2.1 Process map

The following diagram illustrates the principal elements of the process and should be read in conjunction with its associated commentary.

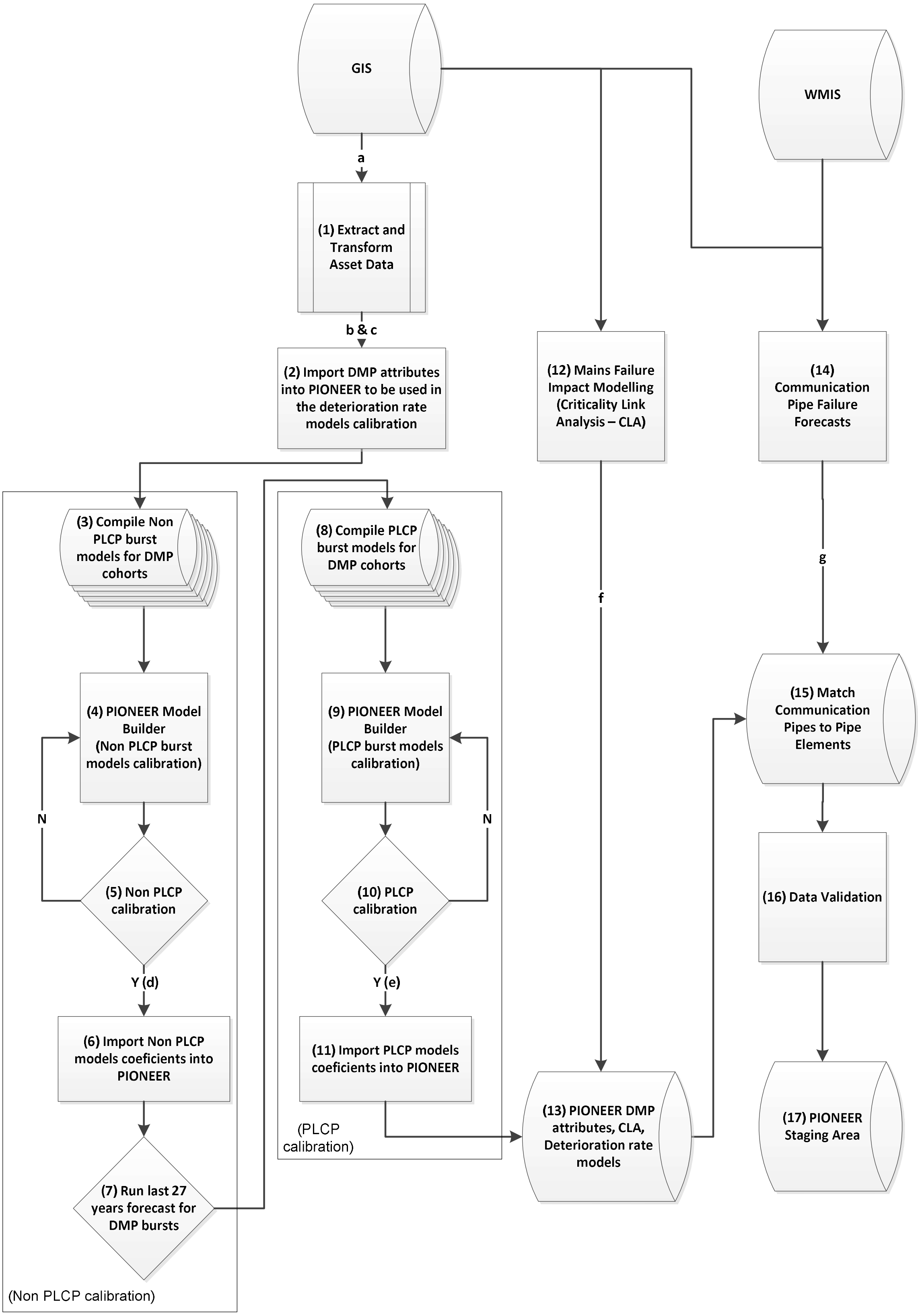

Figure 6-4 Distribution Mains Capital Maintenance Process

6.2.2.2 *Commentary*

This section provides a brief description of the process elements illustrated above.

1. Extraction and transformation of asset data

A set of the distribution main pipes (DMPs) physical attributes and performance indicators were extracted from GIS: DMA, length, material, diameter, date laid and burst occurrences (from 01/04/1990 to 01/04/2017), between other relevant attributes. This was done for all the current "In Use" and "Abandoned" mains. Each DMP unit was identified by its unique "SystemID", which was used as the pipe identifier throughout the whole calculation process. The unit's identification also considered the prefix "DMP" (Distribution Mains Pipe) and the suffix "ABN" in case of abandoned pipe.

a] Physical attributes of pipe elements as per GIS;

b] and **c]** Physical attributes data and bursts data by pipe element and DMA, treated and formatted to be loaded into PIONEER.

2. Import DMP attributes into PIONEER to be used in the deterioration rate models' calibration

At this stage, all DMP units were loaded into PIONEER with the necessary attributes for burst modelling calibration. The loading process takes into account the infrastructure hierarchy.

3. Compile Non PLCP burst models for DMP cohorts

In order to obtain more adequate and accurate results in the burst modelling process, pipe and burst data were considered to be combined into 17 different groups of pipes (Cohorts), taking into account material similarities, different periods of date laid, or different ground conditions for ferrous pipes.

To account for the maximum quantity of available data, each cohort model calibration was performed on the whole data set (considering both abandoned and in use DMP units). These groups are identified in the table below.

Material Group	DMP cohort		Soil	Installation date band	Length (km)		
					Active	Abandoned*	Total
Other	1	Barrier Pipe	All Ground	No restriction	127	0	127
	2	AC			215	67	281
Ductile Iron	3	New Ductile Iron - A	Aggressive Ground	≥1990	76	2	77
	4	New Ductile Iron - B	Benign Ground		247	5	252
	5	Old Ductile Iron - A	Aggressive Ground	<1990	60	15	75
	6	Old Ductile Iron - B	Benign Ground		502	33	535
PE	7	HPPE	All Ground	No restriction	3363	25	3389
PVC	8	PVC	All Ground		1249	87	1336
Cast Iron	9	New Cast Iron - A	Aggressive Ground	≥1920, <1936	647	412	1059
	10	New Cast Iron - B	Benign Ground		701	135	836
	11	Old Cast Iron - A	Aggressive Ground	<1920	125	72	197
	12	Old Cast Iron - B	Benign Ground		670	106	776
Other	13	Other	All Ground	No restriction	40	18	58
Spun Iron	14	New Spun Iron - A	Aggressive Ground	≥1960	219	118	337
	15	New Spun Iron - B	Benign Ground		2169	438	2606
	16	Old Spun Iron - A	Aggressive Ground	≥1936, <1960	595	445	1041
	17	Old Spun Iron - B	Benign Ground		2963	659	3621
Total					13966	2638	16605

Table 6-1 The Modelled Distribution Main Pipe Cohorts
**Includes abandoned mains for calibration*

4. and 5. PIONEER Model Builder (Non PLCP burst model calibration)
At this stage, the Non PLCP burst models in PIONEER were calibrated for each cohort using PIONEER Model Builder. This application considered both the DMP attributes and burst records from PIONEER, calibrating each parameter (attributes selected for calibration presented in Table

6.2) to achieve the best fit between observed and modelled burst rates, within the selected period for calibration (any period between 1990 and 2017).

(cohort)	1 - Barrier Pipe	2 - AC	3 - New Ductile Iron - A	4 - New Ductile Iron - B	5 - Old Ductile Iron - A	6 - Old Ductile Iron - B	7 - HPPE	8 - PVC	9 - New Cast Iron - A	10 - New Cast Iron - B	11 - Old Cast Iron - A	12 - Old Cast Iron - B	13 - Other	14 - New Spun Iron - A	15 - New Spun Iron - B	16 - Old Spun Iron - A	17 - Old Spun Iron - B
(parameter for calibration)																	
Age	n	y	y	y	y	Y	y	y	y	n	y	y	y	y	y	y	y
Length	y	y	y	y	y	n	n	y	n	y	y	y	n	y	y	n	y
Nominal Diameter	y	y	y	y	y	Y	y	y	y	y	y	y	y	y	y	y	y
Ground Mov.	y	y	y	y	y	Y	y	y	y	y	y	y	y	y	y	y	y
In London Flag	y	y	n	y	y	Y	y	y	y	y	y	y	y	y	y	y	y
Soil Corrosivity	n	y	y	y	y	Y	n	n	y	y	y	y	y	y	y	y	y
Surface Type	y	y	y	y	y	Y	y	y	y	y	y	y	y	y	y	y	y
Urbanicity	y	y	y	y	y	Y	y	y	y	y	y	y	y	y	y	y	y

Table 6-2 Calibrated parameters per Distribution Main Pipe Cohort

Once the parameters were all set for calibration in the PIONEER Model Builder, the calibration took place within the “R” statistical analysis package.

d] Non PLCP model’s calibrated attribute coefficients per cohort.

6. and 7. Import Non-PLCP model coefficients into PIONEER and Run

Once the calibration process reached the best possible set of results for the parameters in analysis (per cohort), the coefficients were loaded into PIONEER, populating the Non PLCP models.

At this stage, the Non-PLCP calibration was finished, and a modelled forecast was prepared for the last 20-years period (observed data period), to be used in the PLCP calibration. The figure below shows the modelled burst profile against observed data. Variations to the modelled data can be attributed to weather outliers.

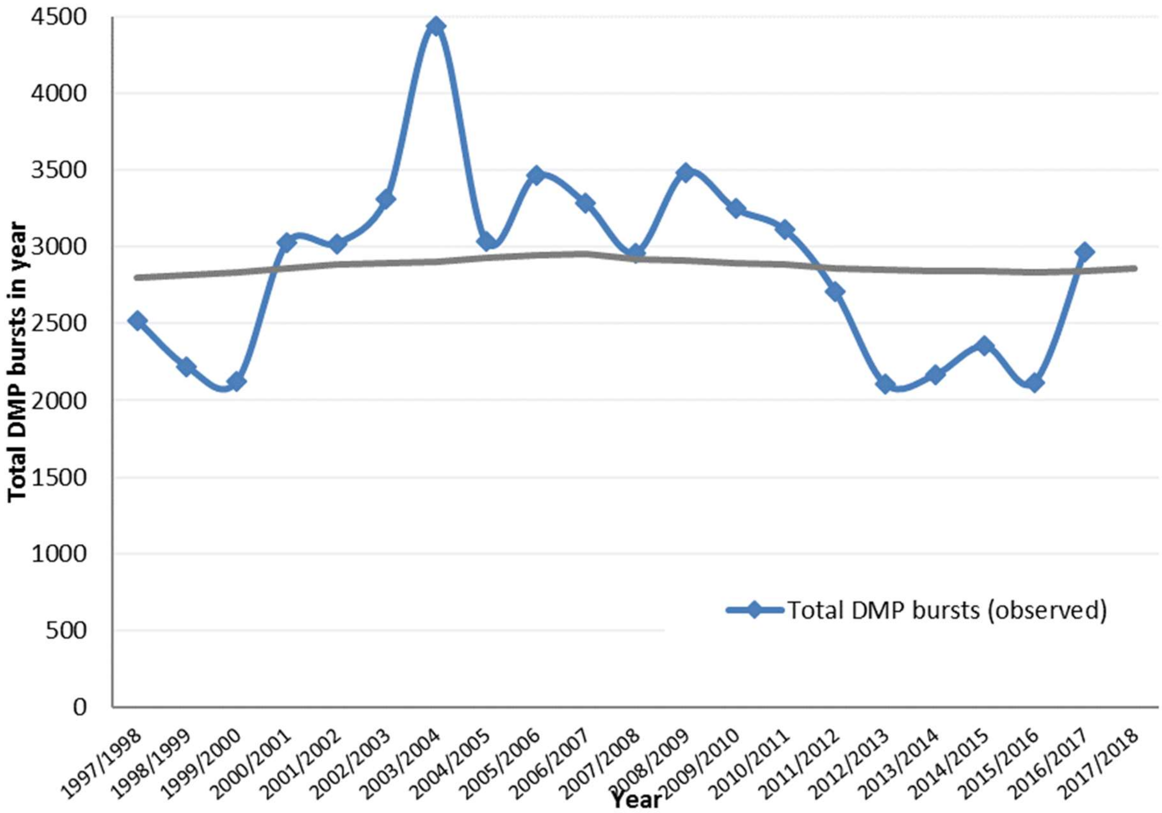

Figure 6-3 Last 20 years DMP modelled burst forecast against observed data

8. Compile PLCP burst models for DMP cohorts
As adopted in 3, the same 17 DMP cohorts were considered for the PLCP calibration. This way, 17 PLCP models were compiled in PIONEER to account for that calibration.

9. and 10. PIONEER Model Builder (PLCP burst model's calibration)
This analysis consisted in a refinement of the Non PLCP analysis results, taking into account the recent failure history of each individual DMP. The PLCP burst models' calibration also took place in "R", through the PIONEER Model Builder.

This calibration considered, for each Cohort, the correlation between failures in successive years, establishing, for a given reference year, a relationship between the previous 10 years and the following two years, both for modelled and observed burst data.

e] Calibrated coefficients adopted for PLCP models.

11. Import PLCP model coefficients into PIONEER
Once the calibration process was completed for all cohorts, the coefficients were loaded into PIONEER, populating the PLCP models.

At this stage, the PLCP calibration was finished, and the PIONEER (Non-PLCP and PLCP) burst models were able to produce the burst rate forecast for all DMP units, based on the physical attributes, laying conditions and recent burst history of each pipe.

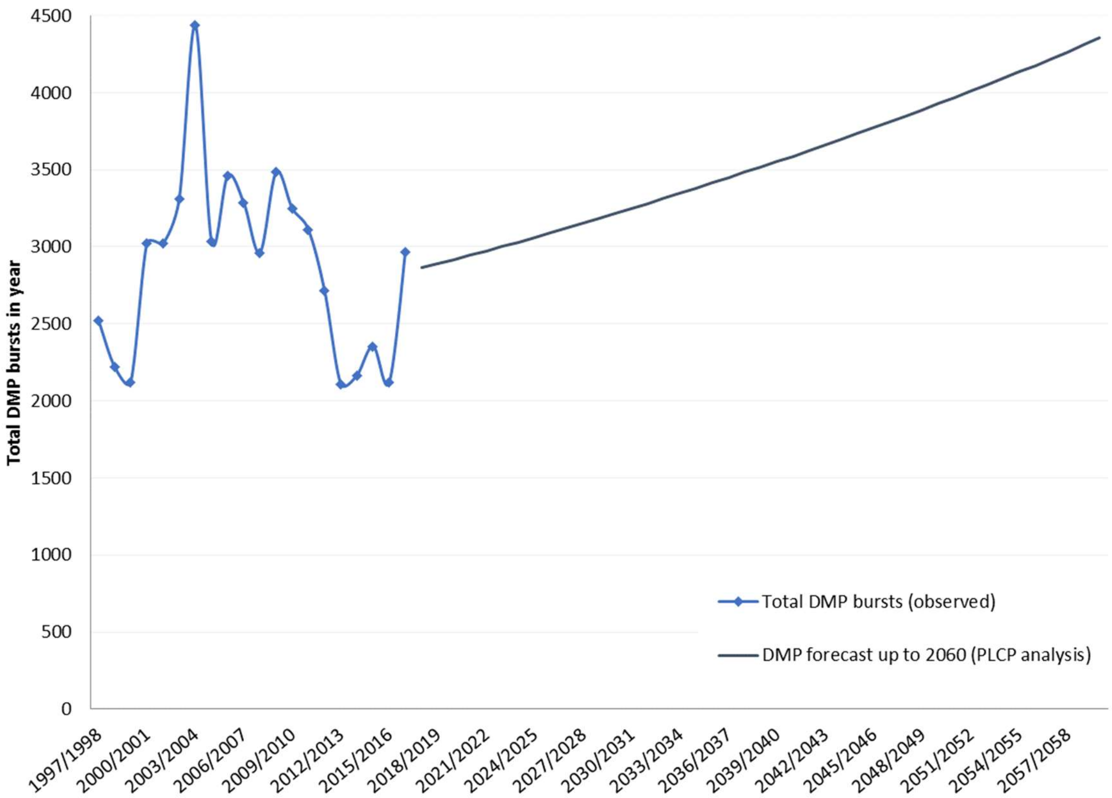

Figure 6-4 Modelled PLCP burst forecast for DMP up to 2060

12. Mains failure impact modelling.
To calculate the number of customers impacted by a failure, the DMP elements were combined into suitable isolation groups. This reduced the computation requirements by grouping pipes with identical consequences together. Criticality Link analysis (CLA) was performed on each of these sections using the InfoWorks software (see section 8.4 for more information). The results of this analysis forecasted the number of customers affected by a shutdown of each group and the number of customers that would be isolated in that group. This was then mapped backed to each of the pipe elements.

The CLA analysis simulates the effect on properties in terms of interruptions to supply taking into account:

- The hydraulics of the DMA after isolation
- the potential to mitigate properties at risk by opening boundary valves

f] Pipe element isolation attributes providing numbers of properties affected by pipe element failures.

13. PIONEER DMP attributes, CLA, Deterioration rate models
At this stage, the CLA attributes for DMPs were loaded into PIONEER. Optimisation runs could already be performed without considering the Communication Pipes failures.

14. Communication pipes failure forecasting.
Communication pipe (CP) failure was calculated using the AECOM CARAFE model (see section 8.2.4) These results were derived as a set of coefficients for a cubic equation, for each of the five communication pipe material groups for each distribution main pipe element (communication pipes were modelled as attributes of their host pipes and not as separate units).

g] CP failure coefficients were loaded into PIONEER for each of the five CP material groups.

15. Match Communication Pipes to Pipe Elements
The completed data set for each pipe element included attributes, failure forecasts and communication pipe information (which were held and modelled as attributes of the distribution main pipes).

16. Data validation
As part of the import into the PIONEER Staging Area, the SQL Management Studio was used to perform data validation, error checking and correct parenting confirmations, preventing erroneous data to be loaded into PIONEER.

17. PIONEER Transformation
The PIONEER Staging Area transforms the data into a form compatible with the main PIONEER tool and import process.

6.2.2.3 Sources of data and inputs
The principal data sources for the process was the Geographic Information System (GIS) containing physical details of the underground asset base and its environment together with organisational data such as water resource zones, district metered areas (DMA) etc. It also contains the failure (burst) records of all water mains. This system is our master record for underground assets and is being updated and improved continuously.

6.2.3 Distribution pipe grouping process
6.2.3.1 Overview
The pipe grouping process considers the balance between an “ideal” investment, where only the pipe units in the worst condition or with the best cost/benefit ratio are selected for intervention (resulting in a significant dispersion of pipes), with a more realistic approach, considering the selection of an additional percentage of random pipes for intervention.

This process (represented below) is notable in that it uses the concept of ‘logical infill’, used to account for the realities of scheme selection. During design of mains renewal schemes, pipes are selected based on their estimated condition, with those with the worst burst rate being normally selected for intervention. However, with the practicalities of accessing pipes in the ground, it is necessary and cost-effective to also include other sections of pipe, adjacent or lie between the poor performing mains, these are known as logical infill pipes. Logical infill is incorporated into the grouping process to ensure that the benefits of pipe replacement are not overestimated, as well as capturing the benefits of infill replacement.

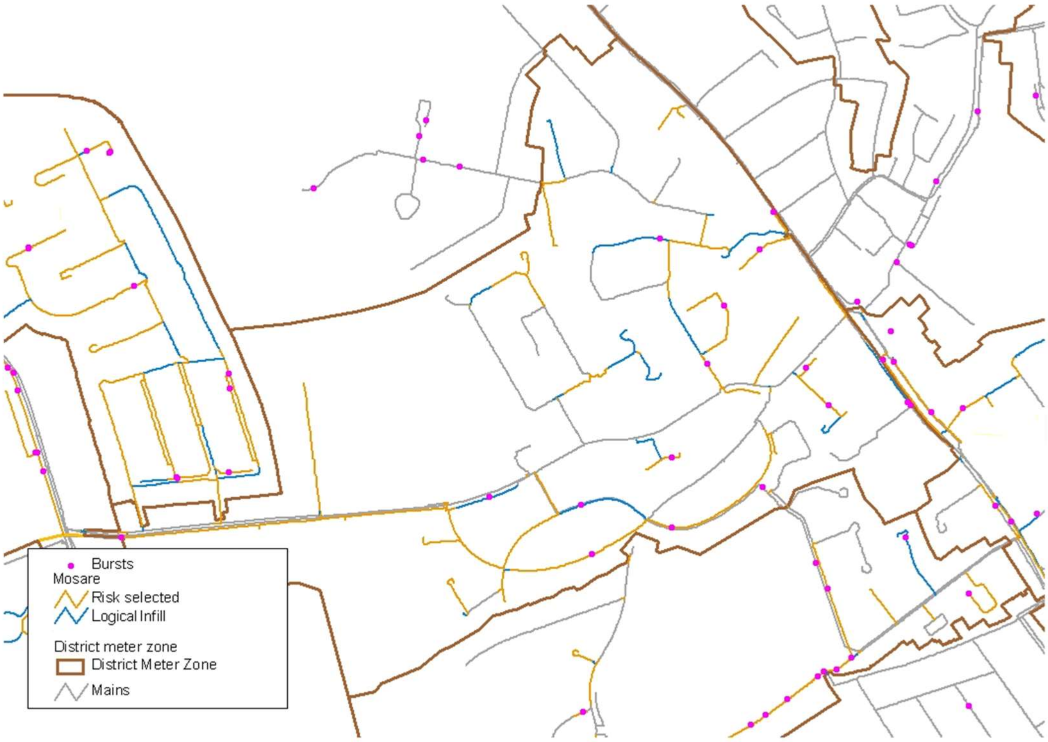

Figure 6-5 An Example of the Grouping Process Output

The pipe grouping process takes individual distribution pipes in our network and uses their attributes to create groups into pseudo renewal schemes. Its purpose is to approximate the scheme creation process used by mains renewals design teams on a day-to-day basis, considering all pipes within the company. These schemes are required for the portfolio optimisation process and give realistic costs and benefits for any investment scenario.

The following diagram illustrates the principal elements of the process and should be read in conjunction with its associated commentary.

6.2.3.2 Process map

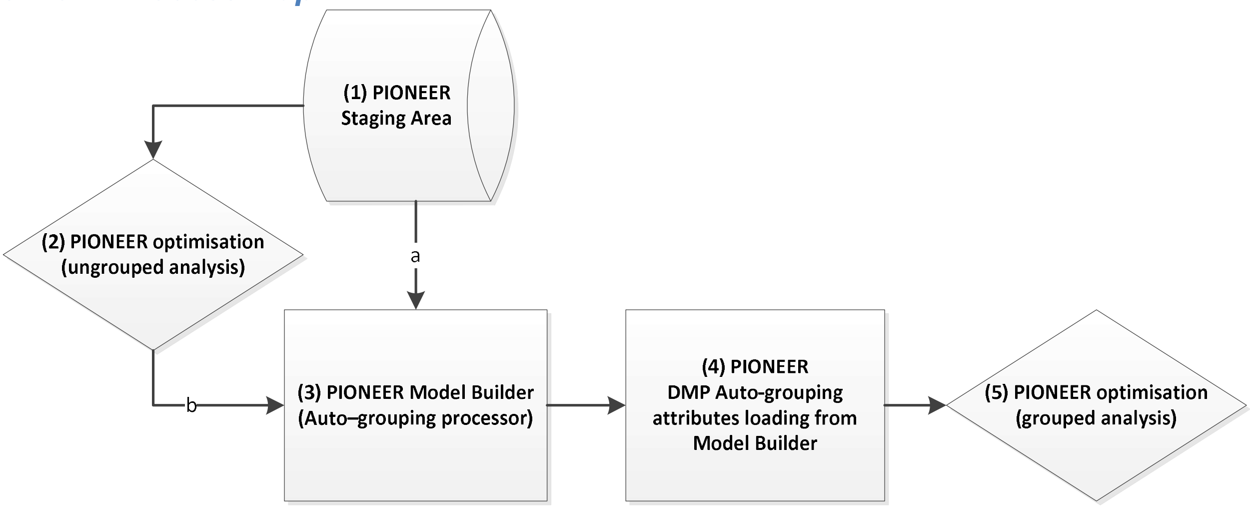

Figure 6-6 Distribution Mains' Grouping Process

6.2.3.3 Commentary

1. PIONEER Staging Area

Individual pipe attributes, including the Pipe ID, length and DMA, were used in the grouping process. The mains scheduled to be renewed in AMP6 were also flagged so that they could be subject of intervention before AMP7 and, therefore, not be included in the grouping process.

a] Pipe attributes were combined and imported into the PIONEER Model Builder auto-grouping processor

2. PIONEER optimisation – ungrouped analysis

Taking into account the burst models created for each cohort, intervention unit costs per asset and specific performance targets agreed for the investment plan, a preliminary optimisation run, without considering any grouping conditions, was performed in PIONEER. At this stage PIONEER returned for intervention the DMP units in the worst condition or with the best cost/benefit ratio.

b] The DMP units selected for intervention were identified and loaded into the Auto-grouping processor as “Ranked pipes for intervention”, with the remaining pipes being considered as “Randomised pipes for intervention”.

3. PIONEER Model Builder – Auto grouping processor

The grouping followed several steps within a basic cycling procedure through all DMAs, then through the pipes within each DMA.

Considering the ratio between Ranked/Randomised units to populate each group (elected to be approximately 2/3 Ranked + 1/3 Randomised) and the total group length (chosen to be approximately 1000m), the groups were generated in the following way:

- each group could only exist in one DMA;
- in each DMA, the groups were created starting with the highest priority Ranked pipes until its maximum length within the group (2/3≈666m) was reached;
- additional pipes (Randomised pipes) within the DMA were randomly added to the group until the total group length (≈1000m) was reached;
- subsequent groups were created until no more pipes (Ranked or Randomised) were available for selection within the DMA;
- process was repeated until complete for all DMAs.

As result of the grouping process, for each DMA, the first generated groups included the ranked/randomised ratio of 2/3 to 1/3, followed by one group with a smaller percentage of ranked mains (remaining ranked mains within the DMA). The rest of the groups comprising only of randomised pipes.

4. PIONEER - DMP Auto grouping attributes loading from Model Builder

For each pipe, the resulting “Intervention Group ID” and an “Intervention grouping reason” (assuming values of “Burst rate” or “Random”) were populated to assign Unit Attributes within PIONEER.

5. PIONEER optimisation – grouped analysis

Once the DMP grouping attributes were loaded into PIONEER, a new optimisation run was produced taking into account the groups. This run considered the same burst conditions, intervention costs per asset and specific performance targets assumed in the 1st optimisation run. However, considering an optimisation over the created set of pipe groups instead of individual pipes, PIONEER returned for intervention a more realistic collection of pseudo renewal schemes, to be used for investment.

6.2.4 Communication pipes investment

6.2.4.1 Overview, purpose and scope

To help maintain the communication pipes' levels of serviceability in our network, and determine the costs associated to its maintenance, a comprehensive study to forecast the CP failures was developed. This study took into account a comprehensive understanding on the deterioration and maintenance of the existing CP stock, with the development of a set of failure models based on evolutions of those developed for PR09 and PR14. For PR19, most of the strategy evaluation was undertaken within the PIONEER optimiser package.

A methodology was derived to characterise our communication pipes and to model their deterioration and service failure. A number of key parameters affecting deterioration were combined to form pipe "classes". Within each of these, all pipes were assumed to behave on average in the same manner. The approach used was the same to all material types and was applied on a class-by-class basis, allowing for different modes and rates of deterioration.

The key principles employed for this analysis are compatible with the UKWIR Common Framework, assessing service risk, based upon an analysis of asset data, in conjunction with recorded failure data. To achieve this goal, a mathematical model was developed to replicate the likelihood of current failure events and to forecast future levels of failure up to the year 2060. This methodology also takes into account the effects of intervention (i.e. repair or replacement) on successive assets and their behaviour.

The outputs were provided at distribution main level in a format suitable to be loaded into PIONEER, where investment strategies could be tested. A detailed report[31] was produced and provides full detail of the modelling process.

6.2.4.2 Process map

The diagram below (Figure 6-7) illustrates the CP failure modelling process:

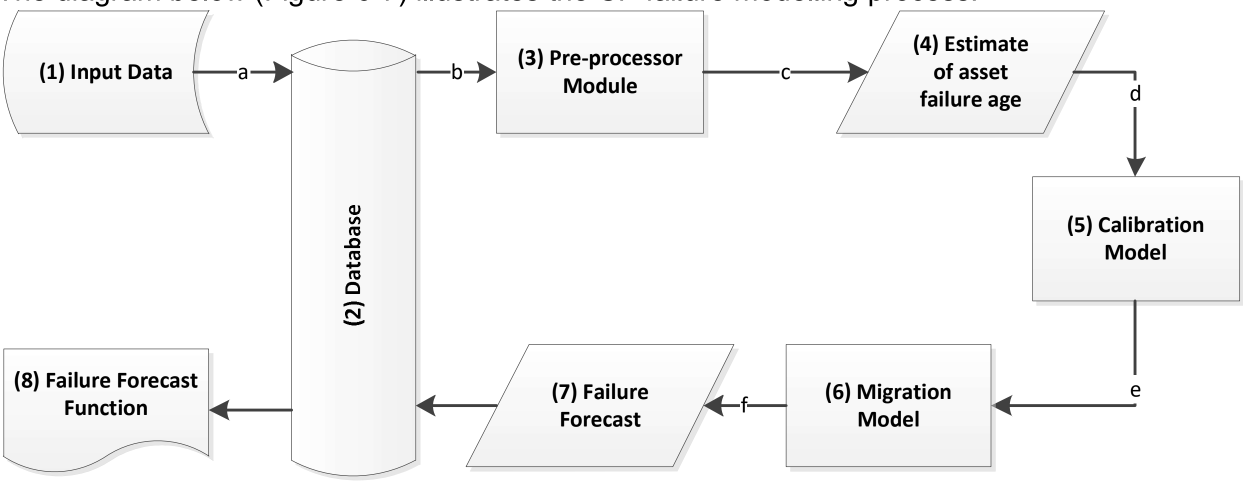

Figure 6-7 The Communication Pipe Deterioration Modelling Process

6.2.4.3 Commentary

Commentary on the above process diagram is provided below using references to the appropriate annotations.

[31] *Affinity Water PR19 Communication Pipes – Reliability Modelling*

1. and a] Input Data
The following data was extracted from our information systems:

- Logical connections from property points to the closest distribution main, tagged with
  - The SystemID of the distribution main to which they are connected
  - Whether they cross a road centreline, to determine whether they are short-side or long-side connections
  - Whether they are in a designated street under the Traffic Management Act
- Communication pipe repair/replacement jobs from Work Management Information System (WMIS)
- Stop tap job data from the Field Information System (FIS)
- Table of relationships between distribution mains and PIONEER distribution mains groups (DMP)
- Ordnance Survey MasterMap

Additionally, some data from the exercise undertaken for PR14 was used,

- PR14 notional asset stock.
- GIS polygons for material usage rules. These were originally constructed using information from research and surveys undertaken for AMP2 and AMP3, and revised using information from property connection records digitised at PR09 and PR14. For each polygon there are ranges of dates for which different pipe materials are known to have been used.

The analysis covers all three regions, however as with PR14, the data for Central was used to calibrate the reliability model, which was then applied to the combined asset stock from the two regions.

This data was transferred to an access database

2. Access Database
Data base used to store the input data and organise output data from the modelling process.
b] Data for processing is extracted from the database

3. Pre-Processor Module
This step assigned each communication pipe to a “group” that represents when it was first commissioned and which area it lies in. To account for the uncertainty of the installation dates/materials in these groups, each was then further subdivided into a discrete distribution that holds the probability that the group member was installed on a particular year and had a particular material(s). Records of restoration (repair or replacement) between years 2000 and 2017 were analysed and assigned to each group.

c] Data extract.

4. Estimate of Asset Failure Age
Based on the input parameters, restoration volumes were summarised by failure age and pipe material.

d] Failure age and volumes transferred to the calibration model

5. Calibration Model
The Calibration model took the failure age and volume data as input and fitted Weibull survival curves for each pipe material.

e] Weibull survival curves are transferred using their parameters for ease of processing.

6. Migration Model
The migration model calculates the predicted failure volumes for each group of communication pipes.

7. Failure Forecast
Failure forecasts for each group for each year (between 2017 and 2060) were collated for output to the Access Database.

f] Failure forecasts for storage in database. Different outputs are generated from this database for strategy level modelling in the portfolio optimisation package.

6.2.4.4 Process outputs

8. Failure Forecasts Function
Failure volumes calculated were summarised by distribution main SystemID for each material and each year between 2017 and 2060.

A third order polynomial curve was fitted for each SystemID and material. Equations for these curves were provided as input to the PIONEER Strategy model.

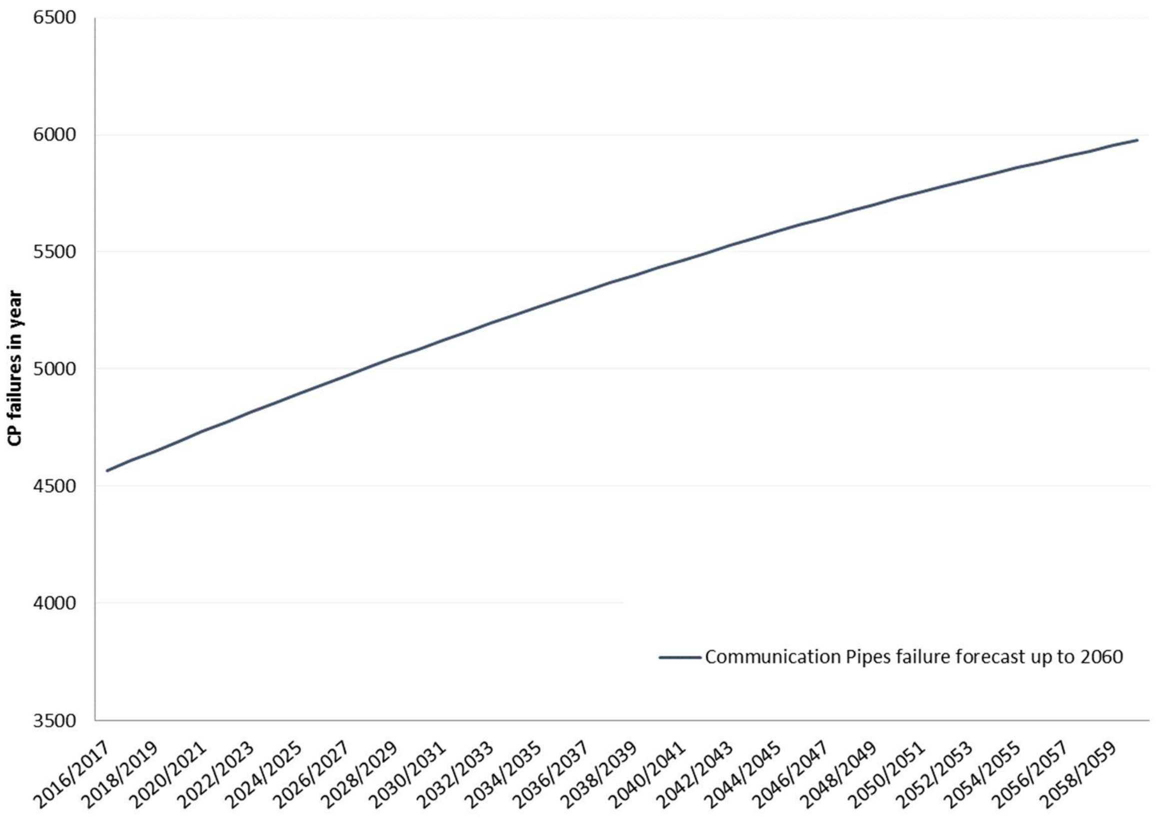

Figure 6-8 Communication Pipes failure forecast up to 2060

6.3 Trunk mains

6.3.1 Overview

Our Trunk Main (TM) network comprises in total approximately 2,977km, of potable and non-potable pipelines. This infrastructure moves the water between our sources and treatment facilities (non-potable TM), or between treatment facilities or storage reservoirs and our distribution main network (potable TM).

Any failure on these mains is likely to cause a significant disruption to customers through interruption of supply, traffic disruption or damage to property as result of flooding. Also, there is usually an elevated cost associated to TM bursts repair, management and incident clear up. Therefore, the investment in our trunk main network becomes essential not only to control and maintain an acceptable risk for the disruption to customers and communities, but also to minimise the costs resulting from those disruptions.

The vast majority of our trunk mains are between diameters of 200mm and 450mm, with over 80% composed by ferrous materials. Often located in rural areas, with low interconnectivity, these mains embody an increased probability of causing disruption. The combination of high risk of disruption with the propensity to fail either through corrosion or flaws from past manufacturing processes means that, to mitigate these risks, investment in TM renewal is required.

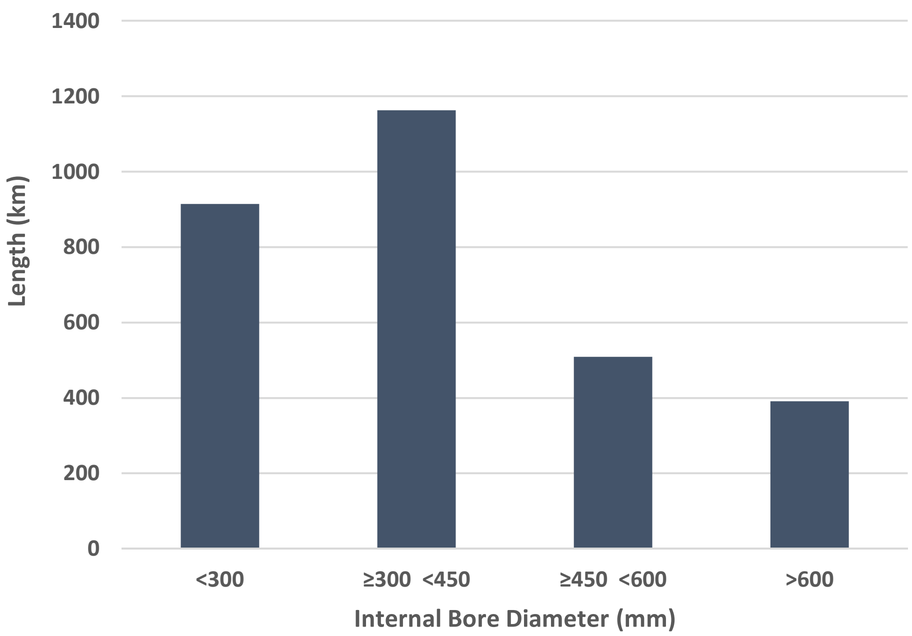

Figure 6-9 Trunk Mains Network length by Diameter

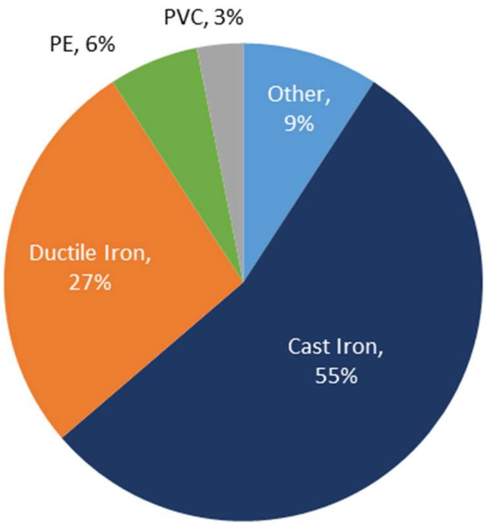

Figure 6-10 Trunk Mains Network Percentage Material by Length

The following diagram shows the age profile of trunk mains

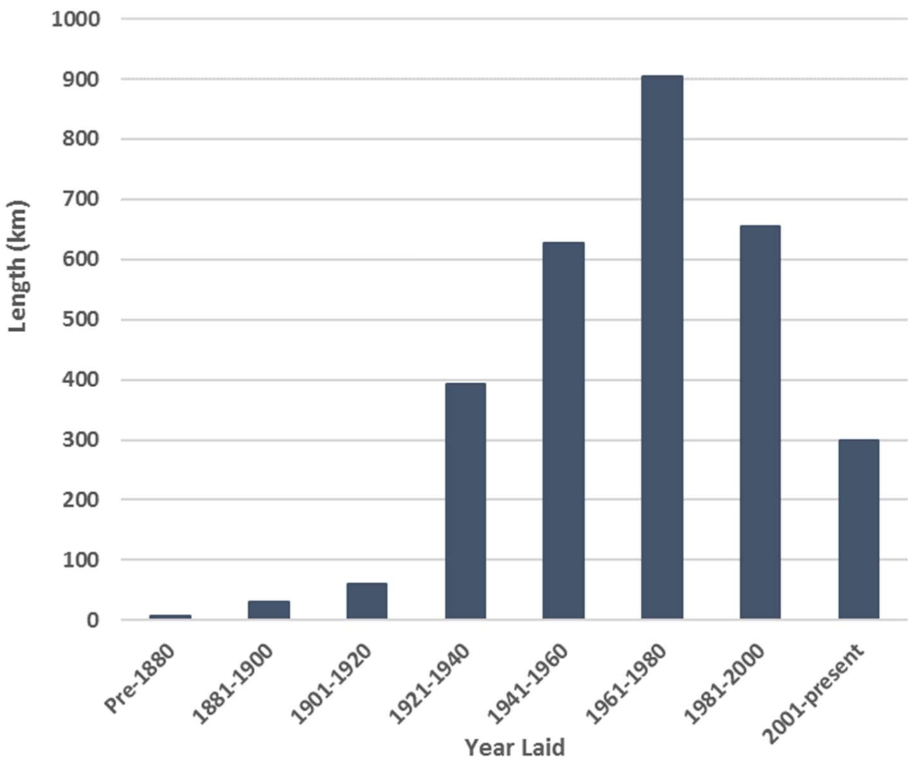

Figure 6-11 The Age Profile of the Trunk Mains Network, total length – 2977 km

In the following section, we describe the analysis, modelling and assessment we have undertaken to forecast the future capital maintenance requirements of our trunk mains. These methods follow the UKWIR Common Framework approach closely, producing investment forecasts that are robust and valid. The main source of data for this analysis was the corporate GIS database, which combines pipe and failure information over all three regions of the company.

Deterioration modelling was performed to estimate the future number of trunk main failures, which was then incorporated into the portfolio optimisation, resulting in the selection of trunk main units for renewal in section 8.2.

6.3.1.1 Overview

This section describes the process we used to forecast the likelihood and consequence of failures on our trunk main network. The principal source of information for this work was our geographic information system (GIS), containing the physical properties of the mains, their operating environment and failure history.

This process was a precursor to our portfolio investment optimisation process where potential remedial schemes were compared and matched to maximise benefits to customers at least cost. Trunk mains failures are rare events but can have significant and widespread impacts on customer service.

This process comprised three principal components: the organisation of the digital information from the GIS into practical trunk mains units able to be modelled, the forecasting of failures for those units between 2017 and 2060 and the estimation of the numbers of customers affected by those failures.

6.3.1.2 Process maps

Figure 6-12 and Figure 6-13 below illustrate the process for forecasting the capital maintenance needs of our trunk mains:

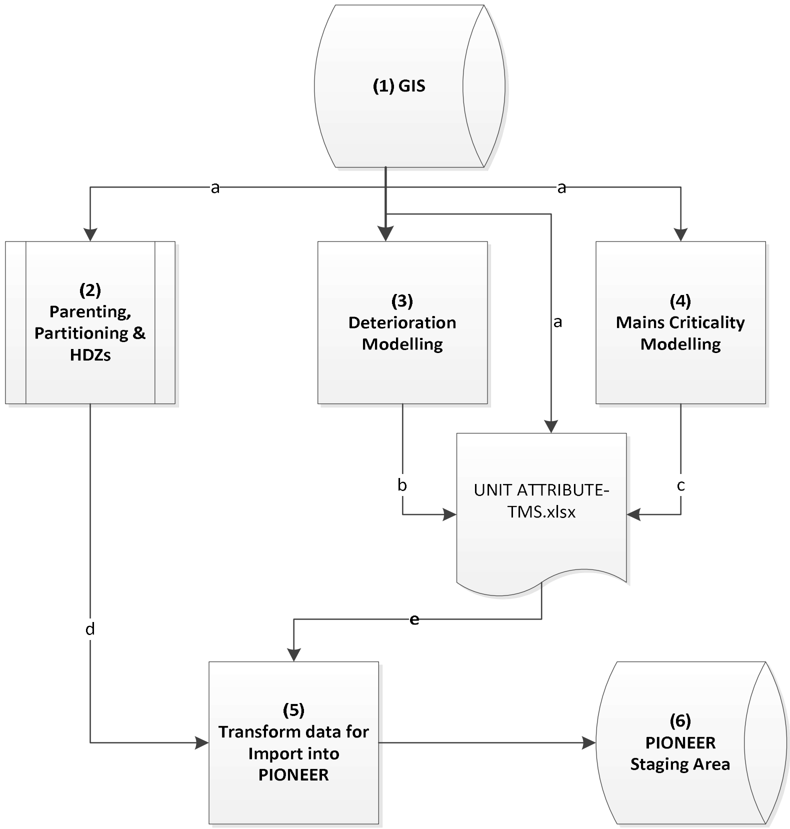

Figure 6-12 Overview of the Trunk Main Process

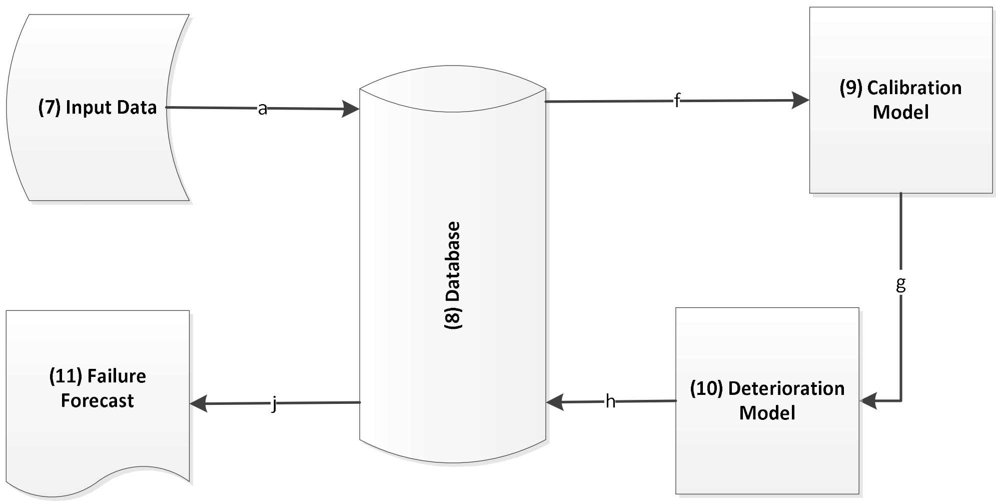

Figure 6-13 Trunk Main Deterioration Modelling Process

6.3.1.3 Commentary

This section provides commentary on the process referring to the annotations in the diagram above.

6.3.1.4 Overview

1. GIS

This was the source of all physical and environmental data used in the trunk main units burst modelling analysis.

a] Physical attribute data was used as the basis for all process elements (material, nominal diameter, length, environment, location, etc.)

2. Parenting and partitioning

Trunk mains were organised in a parent-child hierarchy. The trunk main whole units use designations to allow the results to be related back to the GIS system. A process was introduced to rationalise the number of very short pipe elements recorded in the GIS that made up the trunk main whole units (due to initial digitisation methods). This reduced the total number of assets to be modelled from 44,499 (with an average length of 83.4m) to 13,601 (with an average length of 211.8m). These assets were then subdivided down into 200m trunk main sections to allow a more granular level of assessment. 200m was used as this was decided to be the smallest practical replaceable part of a trunk main.

3. Deterioration modelling

The forecasting of trunk main pipe element failures was undertaken as a discrete process and is described in more detail below.

b] The future failure forecasts were expressed as curves for each trunk main element; these curves were expressed as coefficients of a third order polynomial.

4. Mains criticality modelling

The hydraulic consequences of pipe failure were determined using our all mains hydraulic models. The process, which is common with distribution mains, is described in section 8.3. Each pipe element was isolated in turn from the models to assess the impact of pipe failure on customer service.

To account for the flood risk associated to trunk main bursts, an additional analysis was performed to evaluate the flood impact in sensitive areas, buildings or major infrastructures, along our trunk main network.

Due to the nature of the raw water trunk mains network operation (not directly connected to the supply network), the criticality link analysis for each raw water trunk main unit considered the impact associated to the respective water treatment plant.

c] The numbers of customer properties affected by pipe failure, attributed to each trunk main section, calculated in section 8.4

d] The organised trunk main physical attributes were contained in files

e] The principal failure likelihood and impact attributes were transferred in the workbook

5. Data preparation for PIONEER

The data was prepared for loaded into the PIONEER Staging Area using SQL Management Studio ©.

Deterioration Modelling
A summary of the deterioration modelling is provided below, a more detailed technical report has also been produced[32].

7. Input Data
Data for the process was extracted from our GIS (1).

a] All pipe data was imported into the main database (8)

8. Database
This database was used to organise and manipulate the information and results from the process. Burst Records (from 01/04/1996 to 01/04/2017) spatially assigned to the appropriate trunk main in GIS.

f] The mains were put into cohorts by material group and, in the case of ferrous mains, soil corrosivity. These cohorts are summarised below in Table 6-. Burst volumes were then summarised by failure age for each cohort.

[32] *Affinity Water PR19 Trunk Mains – Reliability and Consequence Modelling*

Material Group	TM cohort		Length (km)		
			Potable TM	Non-Potable TM	Total
Other	AC1	Asbestos Cement < 300mm, All Grounds	16	7	22
	AC2	Asbestos Cement ≥ 300mm, All Grounds	102	20	121
Cast Iron	CIA1	Cast Iron < 300mm, Aggressive Ground	116	1	118
	CIA2	Cast Iron ≥300mm, Aggressive Ground	362	21	383
	CIB1	Cast Iron < 300mm, Benign Ground	433	16	448
	CIB2	Cast Iron ≥300mm, Benign Ground	612	63	675
Ductile Iron	DIA1	Ductile Iron (<1990) All Sizes Aggressive Ground	70	1	72
	DIB1	Ductile Iron (<1990) All Sizes Benign Ground	252	9	261
	DI2A1	Ductile Iron (≥1990) All sizes Aggressive Ground	117	11	128
	DI2B1	Ductile Iron (≥1990) All sizes Benign Ground	310	37	347
Other	OT1	Other All Sizes All Grounds	39	3	43
PE	PE1	Polyethylene All Sizes All Grounds	152	28	181
PVC	PVC1	PVc <300mm, All Grounds	56	1	57
	PVC2	PVc ≥300mm, All Grounds	36	0	36
Other	STA1	Steel <300mm, All Grounds	24	1	25
	STB1	Steel <300mm, All Grounds	59	2	62
Total			2756	222	2977

Table 6-5 The Modelled Trunk Main Cohorts

9. Calibration model

This module fitted Weibull survival curves for each pipe material. The calibration of the Weibull distribution was undertaken using an optimisation procedure, which was developed to determine the most likely set of deterioration curves for each respective categorisation of material and soil type.

Weibull probability distribution functions were chosen because they are widely used in industry for reliability modelling. Weibull has been typically applied to non-repairable failure modes, i.e. only to situations involving component replacement. In this case, however, drawing on experience of similar work, the analysis was developed to take account of pipe repair. A further modification to the Weibull model was necessary to take account of the fact that it is not the whole asset that has failed, but only a part of it. Combined with the segmentation of the mains, this facilitates a more realistic approach to repair or replacement.

g] Weibull distributions describing the probability of failure over time, expressed as "Weibull Parameters" for ease of processing.

10. Deterioration Model
This model used the "Weibull Parameters" for each cohort to calculate the forecasted number of failures. This was used to calculate a failure rate (bursts/km/year) for a given asset age which was then used to forecast the number of failures for each pipe asset up to 2060.

h] Import failure forecasts into the database

The forecasts were imported back into the Database (8). Different outputs were generated from this database for use within our PIONEER portfolio optimisation process (see section *Process Outputs* below).

6.3.1.5 Sources of data and inputs
All of the source data was provided by our GIS team and comprised,

- Trunk Mains data – for all mains, including abandoned pipes
- Trunk
- Mains Bursts – these were provided with the SystemID for the nearest pipe
- Soils data
- Ordnance Survey MasterMap

The data covered all three regions – Central, South East and East.

The following activities were carried out to process the data for modelling,

- For calibration of the reliability model, a composite set of mains both in use and abandoned, was extracted from the source data where the mains diameter was >199mm
- The GIS features were analysed against polygons with measures for soil corrosivity
- For use in the investment model the asset stock was reduced by removal of the abandoned mains and mains not assigned as trunk mains in our GIS system.

6.3.1.6 Process outputs
11. and i] Failure Forecasts
This was an estimate for the annual volume of trunk main bursts between 2018 and 2060, calculated from an input data set to each trunk main unit. For this purpose, a third order polynomial curve was fitted for each main, and loaded into PIONEER to be used in the portfolio optimisation process.

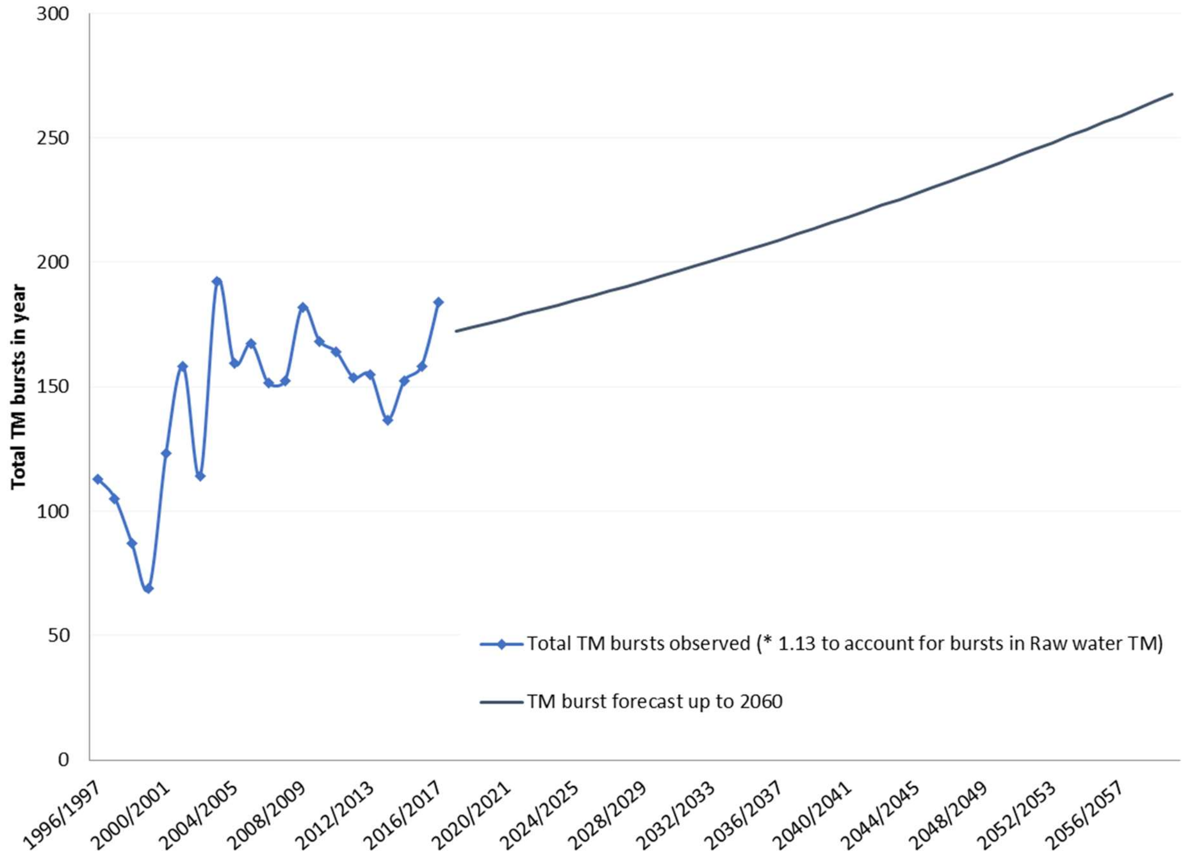

Figure 6-14 Modelled TM burst forecast up to 2060

6.4 Mains criticality modelling

6.4.1 Overview

This section presents the work we undertook to determine the hydraulic consequences of pipe failures across our network. The results of this formed important part of our processes to model distribution and trunk mains failures, by identifying “important” pipes so that potential impacts on customers could form part of the analysis.

The aim of the Mains Criticality Modelling process was to assign every pipe in our company with a ‘consequence of outage’. Consequence was defined as the number of customers affected during the isolation of, not only the pipe in question, but also the adjacent pipes which would also be ‘valved-in’ as part of the isolation for repair.

The results were obtained using the network analysis models which already existed for all of our areas in the InfoWorks WS platform. The InfoWorks WS modelling software is capable of carrying out systematic model runs to analyse and store the results of each isolated group of pipes - this modelling feature is called *Critical Link Analysis* (CLA).

6.4.2 Process map

The process map shown below uses abbreviation of names for convenience, these are:

- GIS (Geographic Information System).

- IW (InfoWorks WS network analysis software).
- IW SQL (Bespoke routines written for process in the InfoWorks WS environment).
- SMAP (StruMap geospatial analysis software).
- SMAP EXPR (Bespoke routines written for process in the StruMap environment).
- CLA (Critical Link Analysis feature with InfoWorks WS).

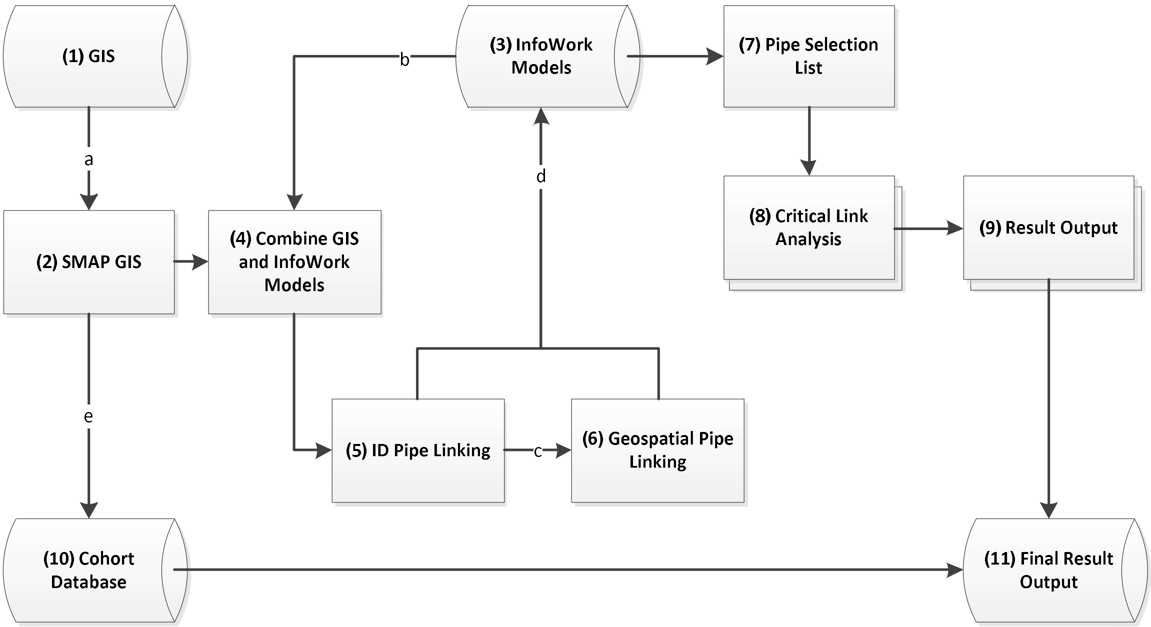

Figure 6-15 The Mains Criticality Process

6.4.3 Methodology

1. GIS

A shape-file of the GIS data was extracted including the pipe and valve layers representing network state on 31/05/2017.

a] GIS shape files loaded into StruMap software (automatically converted into nodes and spans).

2. SMAP GIS

The pipes and valves were represented in StruMap. Data cleansing routines were applied to address connectivity issues in the GIS.

Automatic CLA Cohort tracing routine written and applied to the data, this systematically invoked a trace from each pipe until dead-ends or valves were encountered. This essentially groups pipes together which belong to the same outage group. Each pipe had a new attribute added to identify which CLA Cohort it belonged to. The routine also calculated the number of valves to isolate CLA Cohort, length of mains in CLA Cohort and volume of water in CLA Cohort.

3. InfoWorks Models

InfoWorks WS model versions created from current master model for each HDZ in native 'iwm' database format.

b] Each model was exported from InfoWorks WS to csv format (comma separated values) for import into StruMap. This is a standard feature of InfoWorks WS. Each model was subsequently imported into StruMap using bespoke routines for reading data from csv files.

4. Combine GIS and InfoWorks Models
GIS representation of pipes was brought together with InfoWorks WS model representation of pipes into the same StruMap file. This allowed geospatial analysis to be performed between the two datasets.

5. ID Pipe Linking
Before the CLA runs could be carried out it was first necessary to recreate the link between GIS pipes and modelled pipes so that any results obtained from the InfoWorks model runs could be attributed back to the current GIS dataset. A bespoke routine was written and applied to link GIS pipes to model pipes where unique identifiers exist in the models. The CLA Cohort reference was then copied from GIS pipe to model pipe in StruMap.

c] Pipes not able to be linked using unique identifiers

6. Geospatial Pipe Linking
The originally robust link between these two datasets begins to deteriorate at the point of model extraction from GIS due to fundamental and unavoidable differences in maintenance methods between the two datasets. Although GIS is rigorously maintained (pipes added and abandoned etc.), the models continue their working lives with only ‘hydraulically necessary’ updates applied in a ‘manual’ way. Consequently, as models become older, the use of the GIS derived unique asset identification codes as a link between the two datasets becomes increasingly less successful.

Recreating the ‘lost’ links between pipes in the two different datasets can only then be achieved using geospatial analysis. For this reason, StruMap, a very powerful and flexible geospatial analysis program was used. Bespoke routines written and applied to geospatially link non-matched modelled pipes to GIS pipes. This linked the mid-point of a non-matched model pipe to the nearest GIS pipe where certain criteria are met (within 5m range and similar diameter). CLA Cohort reference and GIS asset ID was then copied from GIS pipe to model pipe in StruMap.

d] Bespoke routines written and applied to export text files of the link between model pipes and GIS pipes where a match was achieved. Excel and ‘lookup’ formulas were used to back-populate the model with CLA Cohort references. Manual and random checks were carried out to ensure matches had been carried through correctly from StruMap.

7. Pipe Selection List
Bespoke routines written and applied to create a ‘selection list’ of one pipe per CLA Cohort (because the results are the same for every pipe belonging to given CLA Cohort the number of CLA runs can be dramatically reduced saving many days of processing time).

8. Critical Link Analysis
Execution of CLA analysis in InfoWorks WS. This systematically analysed the consequence of closing all of the pipes belonging to each CLA Cohort in turn and generated a report of numbers of customers isolated and number of customer receiving pressure below 15m for each CLA Cohort.

CLA analyses and results were repeated with and without rezoning using divisional boundary valves for 3 different time windows (01:30 – 02:30, 07:30 – 08:30 and 13:30 – 14:30); periods of low, high and medium demand serve as sensitivity checks.

9. Result Output
Bespoke SQL routines written and applied to write CLA Cohort reference, CLA Cohort length, CLA Cohort volume and number of customers allocated to pipes in CLA Cohort to an external *.csv file.

All results combined into a MS Excel spread sheet, i.e. one line for each CLA Cohort and consequences for 3 different time windows (along with CLA Cohort length, volume and number of allocated customers).

e] Export from StruMap GIS into text file format then imported into MS Access.

10. Cohort Database
Access Database containing 2 tables:

- GIS unique asset IDs with CLA Cohort reference (367,770 records).
- CLA Cohort references, total length of pipe, total volume, number of pipes and number of valves (121,541 records).

11. Final Result Output
Data from the CLA cohort spread sheet and the cohort database are combined to create a master table of GIS pipe asset IDs along with their consequence as gained from the CLA analysis.

6.4.4 Sources of data and Inputs

The principal data sources for the process were:

- Geographic Information System (GIS) containing details of the underground asset base. This process specifically used the information relating to the pipes and the valves.
- InfoWorks WS model versions created from current master model for each HDZ in native ‘iwm’ database format. These were current operational models of various ages but have all been calibrated at some point in the past. This was used to perform the CLA analysis.

6.4.5 Process outputs

The main output of this process was the final result outputs that contained the hydraulically modelled values for each of the pipes in the GIS system. Each pipe (both trunk mains and distribution mains) were assigned the appropriate attributes and added to the PIONEER Staging Area.

The combination of deterioration and risk analysis is and input to the portfolio optimisation process outlined in section 8.2.

6.4.6 Trunk main maintenance

In addition to the trunk main renewal analysis in portfolio optimisation a bottom up approach has been adopted for trunk main maintenance.

The maintenance of our trunk main system is hugely important in ensuring customers are not interrupted unnecessarily and when this happens the disruption is kept to a minimum.

Trunk main inspections carried out over a number of years have highlighted a number of critical sections where valves and other equipment were missing (19%) and those found approximately 7% were inoperable. Maintenance of trunk main equipment is important to ensure that each section of trunk main can provide the service it was designed for. We have however some 4000 operating assets on our trunk mains so need to prioritise maintenance. This is done by categorising our trunk mains as follows

Category A: single points of failure. These will affect communities >2,000 properties if they fail. These are the trunk main sections highlighted in our AMP6 mitigations programme where work is being carried out to prevent large scale loss of supply by improving the connectivity with adjacent zones.

Category B- Strategic pipelines. Those pipelines that are considered strategic for the carrying of large volumes of water to strategic reservoirs and the loss and subsequent time of repair could invoke our SEMD measures

Category C- Strategic infrastructure crossings and high-risk roads

Category D- high burst pipes not in programme for renewal

Category E- other

Each category has now a care plan which sets out what we have to do in terms of inspection and the frequency. Works identified in each inspection are prioritised and logged for reference. Where it is decided, say, that a valve does not need replacing as there are other valves that can fulfil, the function then information as to the status is added to the GIS for reference.

The care plan sets out our aim to initially inspect all Category A to D by the end of AMP 7 with all the required remedial works carried out. Ongoing inspection will be every 3-5 years following this programme of work. All category E trunk mains will be inspected on an opportunistic basis (through normal work access) or if its category were to changes.

Our current cost of inspections (and remedial repairs) is estimated at £850k for 125kms and this has been increased to £1.5M/ year for AMP7 to now inspect and carry out redial works to 220km per year.

The total cost of this programme of work is £7,500k.

6.4.6.1 Restricted Mains

Our AMP6 mitigations programme of work ensure that any burst that affects supplies to communities >2,000 properties can be maintained through valving and connection from adjacent zones. The strategy relies on the interconnectivity of much of our system and not on redundancy and duplication of mains. We know however that we have a number of DMA connections that if opened would create poor quality water even if flushed. We have identified those high risk "restricted" mains with potential solutions such as moving boundaries so that some pipe flow could be achieved.

This was also used to assess the criticality of sites based on the number of properties that would be isolated due to a failure of the site.

6.5 Additional infrastructure expenditure

In addition to the expenditure that can and has been modelled through the PIONEER optimisation process, other areas of expenditure are required so that we can manage and operate the distribution network to meet our objectives in a safe and efficient manner. These investments are a result of a comprehensive business case development process, our resilience work (see section 8.5) and our detailed water quality analysis and DWI submission.

6.5.1 Leakage and leakage infrastructure

6.5.1.1 Leakage operations

We have adopted a leakage operations strategy that defines how we will meet the ambitious leakage targets set for AMP7. We explain our strategy in more detail in our WRMP technical paper 'Technical Report 4.8: Leakage Strategy Report.'[33]

To deliver our leakage strategy we have revised our policy on leakage detection to include the widespread use of acoustic logging. Utilising acoustic loggers to find leaks earlier in their lives will reduce overall volumes of lost water and support our teams to repair leaks before they grow larger.

The leakage strategy also makes improved use of metering techniques. Automatic meter read (AMR) meters are an essential component of our per capita consumption reduction strategy which is a primary driver. These meters will also contribute to leakage reduction. Over 25% of leakage in the areas we serve is attributable to customer side leakage so early detection of issues is crucial to achieving the industry target of 15% reduction in AMP7.

The particular AMR meters we are installing in AMP7 are capable of flagging when leaks occur on customer side pipes. They do this by measuring continuous flow over a given period and triggering an alarm for our meter readers to pick up and action.

Other elements of the strategy include the ongoing improvements to pressure managed zones and planned detection activities such as step testing.

In AMP7, never-seen-before levels of leakage reduction will be achieved by our operational teams. Active leakage control (ALC) costs derived from a bottom up approach were compared to the traditional ALC cost curves. Costs were estimated to keep leakage stable at AMP6 target levels and also considered various degrees of leakage reduction including the final agreed level of 15% for AMP7. An assumed efficiency was applied and these costs were used to calculate the Sustainable Level of Leakage (SELL) needed for the WRMP and other table submissions. A summary of the costs is set out below.

1	Pressure reduction	**£2,000,000**
2	Customer supply pipe leakage from WRMP "fast data" programme	**£1,470,000**
3	ALC find and fix costs, including customer side leakage (CSL) from ALC activities	**£49,454,000**
	Total SELL pre-efficiency cost	**£52,924,000**

Bottom up resource-based estimate to reduce leakage:

1	Base costs to meet AMP6 targets (current)	**£49,650,000**
2	Reduction costs (15% leakage reduction)	
	Additional CSL repairs	**£7,500,000**
	Additional repairs	**£31,667,000**
	Additional ALC resource	**£9,167,000**
	Total	**£97,984,000**

Efficiency applied on bottom up costs is 29%. Efficiency has been applied equally across maintenance costs and reduction (enhancement) costs. Therefore:

[33] *Leakage Strategy AMP7*

	Maintenance costs	**£36,475,000**
	Reduction (enhancement) costs	**£35,108,000**

Costs used in the SELL calculation assume a 30% efficiency applied (12% year on year).

6.5.1.2 Leakage infrastructure

We have 1878 district meters that provide 15-minute flow data to support our leakage efforts and ensure we have accurate regulatory reporting. We currently replace 25 a year when failed. We achieve this very low frequency because we have managed to only replace the internal mechanism of our older helix meters. These helix meters have been in service now for 20-27 years and the internal mechanisms are no longer manufactured so total replacement is necessary to our standards.

We have 300 of these meters and are allowing for total replacement between 2020/21 and 2024/25.

Base maintenance on PRVs comprises of yearly minor maintenance and major servicing which essentially fully refurbishes the PRV every five years. This level of maintenance will be maintained between 2020/21 and 2024/25. In addition to the minor and major servicing we replace for various reasons five PRVs/ year and have included for this rate of replacement to continue.

Our data logger stock is growing and now includes an additional 1000 loggers to aid network event detection. We replace about 260 a year and battery replacement is every five years.

To ensure that we meet our requirements for leakage reporting consistency with other companies we are required to have a coverage of 95% of properties in reporting DMAs. This involves work to increase coverage by 59,000 properties at 52 sites making 30 new DMAs.

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6.5.1.3 Network ancillaries

Network ancillaries include those assets associated with the distribution network that are replaced as a result of reactive maintenance, leakage surveys etc. They mainly comprise

- Communication pipes
- Stop taps
- Valves, hydrants, washouts

Replacement decisions are based on policy and if a unit cannot be repaired or it has been subject to a previous repair then the decision is generally to replace. It is not possible to forecast the deterioration of these assets. Instead volumes and costs for AMP7 are based on historical AMP6 rates with costs captured through the cost allocation process.

6.5.2 Interruptions to Supply

In order to meet our new PC for interruptions of three minutes per property we will enhance our current improvement programme. This programme ensures that out-of-hours performance is commensurate with in-hours performance and focusses on five key areas

- Ensuring the alignment of key skills and support 24/7
- Providing the monitoring and control support through the Network Service Desk 24/7

- Providing the necessary tools and equipment at convenient locations
- Adopting a flow restoration principle as well as speed of repair
- Aligning the supply chain to the performance targets.

The reduction of incidents of planned interruptions due to distribution mains renewal by providing overland supplies is included in mains renewal scheme costs.
We are currently progressing the improvement programme to achieve an end of AMP6 performance of 12 minutes per property for unplanned interruptions. In order to meet the new target of three minutes per property the following activity has been identified.

Activity to meet the three-minute ODI target	cost (£)
Extended operational working hours - additional resources	**5,750,000**
Ringfenced gangs on standby	**9,855,000**
Functional standby or Managers (available all hours)	**490,000**
Network Optimisation Team 24/7 support	**300,000**
Increased use of non-disruptive repair techniques	**1,200,000**
Maintained new fittings (line stops, repair clamp encapsulation collars) store	**2,500,000**
Enhanced network control desk operation to permit and control all network access	**3,750,000**
Interruption to supply and restoration training academy	**100,000**
Upgraded IT applications	**50,000**
Tanker purchase	**500,000**
Total	**24,495,000**

6.5.3 Lead pipe replacement

The water quality investment aspect of the lead programme has been developed to follow a risk-based approach focusing on reducing the risk of compliance failure. Our on-going Drinking Water Safety Plan process highlights the risks associated with the quality of our supply to customers from source to tap. These plans are part of day to day business recording when water quality risks change across our business. The water quality capital investment schemes are in line with our Companywide Long-Term Lead Strategy.

In addition to meeting the requirements of the business there are a number of mandatory regulatory requirements which we have also considered and addressed. These include:

- Water Supply (Water Quality) Regulations
- DWI Undertakings
- DWI Notices
- Water Framework Directive (WFD)

6.5.3.1 Regulatory obligations

OFWAT Classification		Scheme	Asset	Driver	Issue and needs	Scheme Details
Drinking Water Quality	Lead replacement	Long Term Lead Strategy	Lead Supply and Communication Pipes	DWI Long Term Planning Guidance Compliance with lead standards, including proposed changes to EU drinking water directive Defra Statement of Obligations	Reducing customer exposure to lead via pipework	*Companywide:* Mandatory communication pipe refurbishment or replacement (water quality results greater than 5µg/l). Communication pipe refurbishment or replacement (when customer supply pipe already replaced or refurbished). Water Quality Educational Programme. *Within highest risk Brett Community only*: Communication & supply pipe refurb/replace (water quality results greater than 5µg/l). Pilot Trial on innovative techniques. Plumbosolvency removal strategy.

Table 6-3 Water Quality Enhancements Regulatory Drivers Summary Table

On 1st February 2018, the European Commission adopted a proposal for a revised drinking water directive. Following a period of consultation, the proposal will be transmitted to the European Parliament and EU Council for negotiation and adoption before it becomes applicable. The revised drinking water directive includes a further reduction in the lead standard from 10µg/l to 5µg/l. This value shall be met, at the latest, 10 years after the new Directive comes into force. The parametric value for lead until that time remains 10µg/l.

6.5.3.2 Mitigation mechanisms

The Drinking Water standard for lead reduced in December 2013 from 25µg/l to 10µg/l. In AMP6 we developed a programme of work targeting two water supply zones, Watford and Finchley, as both were identified to have a high proportion of lead pipes. Since 2016 we commenced a programme to replace or refurbish lead communication pipes in these areas.

In addition, we commenced a programme of work to replace lead communications pipes at all infant, junior schools, nurseries, across the six Communities that comprise our Central region. We will have replaced all our lead pipework supplying junior schools and nurseries across our area of supply by 2020. This option targets public buildings in the community in a controlled and structured way to introduce an element of engagement with educational providers for other Company messages. We were issued with a Drinking Water Inspectorate (DWI) Notice for Lead for this programme in AMP6.

As part of PR19 business planning process we reviewed our long-term water quality strategy including lead and have developed our AMP7 strategy to strive towards 100% compliance with lead standards and further reduce exposure of lead from pipework to customers in the longer term, taking account of the latest health advice.

Our continuous water quality monitoring has identified the three highest risk water supply zones with respect to the current lead standard, which are Northwood, Chartridge and Underground Zone 1 in the Brett Community. Using Underground Zone 1 in the Brett Community as a pilot trial location and building upon information and techniques obtained in AMP6 on communication pipes, we are proposing to investigate innovative techniques to replace or refurbish some of the customer lead supply-side pipes in conjunction with our lead communication-side pipes. This will require work with our supply chains to develop improved ways of working which will seek to minimise disruption to customers and property owners as we undertake what has potential to be intrusive work within some premises. In addition, we will replace or refurbish our lead communication pipe where customers have replaced their supply side already in the whole Brett Community.

We will continue with our on-going companywide mandatory replacement or refurbishment of communication pipes and will enhance this requirement to include all properties where our random water quality monitoring data demonstrates that lead concentrations exceed 50% of the current drinking water standard. We will continue to review our treatment processes to optimise the effectiveness of plumbosolvency control and will participate in research on optimising plumbosolvency controls through coordinated water industry research.

In addition, we will establish a companywide educational programme, to raise the awareness of the adverse health impacts associated with lead as well as other water quality related topics. We will use a delivery partner as a platform to support liaison with health professionals, local authorities and housing associations. We will focus our safe drinking water messages on those consumers most at risk from the health impacts from lead such as pregnant mothers.

As per AMP6 we will cluster the delivery of this work to ensure that it is delivered with the minimum of disruption to our customers.

% LEAD RESULTS <10 UG/L **SEP 2012 - AUG 2017 CURRENT DATA** **Green >= 98%** **Amber >=97 <98%** **Red < 97%**	**NEW AF ZONE NO.**	**DESCRIPTION** **ZONES REQUIRING ORTHO DOSING IN BLUE FONT**
96.10	**41**	CHARTRIDGE
96.56	**75**	UNDERGROUND ZONE 1 was ZUN1
96.95	**48**	NORTHWOOD/RUISLIP
97.73	**53**	EDGWARE/MILL HILL From Jan 2015 zone split, approx 50% AF083
97.75	**51**	EAST BARNET
97.76	**54**	FINCHLEY
97.77	**56**	HARROW
97.77	**52**	PINNER/STANMORE
97.92	**50**	BARNET
97.96	**46**	WATFORD

Table 6-4 Affinity Water Highest Risk WSZ for Lead

6.5.3.3 Supporting information

Scheme Name	Investment Proposal Name	Supporting Documents/ Technical Reports	Supporting Documents File Name
CP replacement Programme	Long Term Lead Strategy	1. Company Lead Strategy 2. DWI WQ Submissions 3. DWI Long Term Planning Guidance	1. Lead Strategy 2020_2070 V2.1.docx 2. Affinity Water PR19 DWI Submissions December 17

Table 6-5 Document references and link

6.5.4 Supply 2040

The area that we supply water to is classified by Defra as being ‘severely water stressed’. Our supply area is also home to rare chalk stream habitats, which we must protect, by abstracting less from the environment where our abstractions are assessed to be ecologically damaging. However, the population is increasing and climate change is depleting our water resources. It is therefore essential that we make the most of the water resources and headroom that we’ve already got. We can do this by enhancing our supply transfer network.

We have included investment to support our Supply 2040 vision. Supply 2040 is the development of a long term strategic plan to ensure supply resilience. It is a programme of schemes will enable us to:

- transfer 17Ml/d of surplus water to areas where there is deficit
- improve interconnectivity in our Central Region
- protect and maximise existing critical resources, and
- prepare the network for a 100Ml import of water upon completion of the Upper Thames Reservoir in 2037.

Required investment is spread across a 20-year period to guarantee integrational equity. We recognise that to be successful and deliver best value to customers, we must be flexible. Therefore, our schedule of schemes is adaptive to mitigate against the risk of stranded assets. AMP7 schemes are required to maintain the supply demand balance within Communities but will have the additional benefit of improving resilience within the Central Region and, in the longer term, throughout the South East.

We have considered a broad range of options to meet needs now and in the future. We undertake extensive modelling, analysis and optioneering to select schemes that are best whole-life value for customers.

The first phase of Supply 2040 is due to start in AMP7. It contains thirteen schemes, five of which are to be delivered through the AMP7 sustainability reduction programme and eight of which are to be delivered through the Supply 2040 programme. A further twelve schemes are to be delivered in AMP8 and AMP9. AMP7 schemes due to be delivered through the Supply 2040 programme are summarised in Table 6-6 below[i34].

[34] *Supply 2040 Technical Report*

Reference	Scheme Name	Description	Delivery AMP	Cost (£m)
ST1a	EGHS to HWFS	1st stage: Install new booster to transfer 17Ml/d average (30Ml/d peak) north to Pinn	AMP7	2.08
ST2	BLAF re-lift to Ickenham	Install 700mm main from BLAF booster to IBOO; 3.6km	AMP7	12.84
ST5	ARKN	Remove a network restriction by surveying 2.5km of main and completing 50m of pipework at ARKN.	AMP7	0.8
ST6	NORM Improvement	Improve control and visibility at NORM to enable flow North and South. Software, control valve, improvements to PLC	AMP7	1.18
ST9	Booster BUGR to PRER	Install new booster to transfer 20Ml/d from BUGR to PRER	AMP7	2.06
ST10	Booster PRER to SUND	Install new booster to transfer 20Ml/d from PRER to SUND	AMP7	2.06
ST13	New storage at CHAU	New 20Ml cell at CHAU	AMP7	8.76
ST14	New storage at PRER	New 12Ml cell at PRER	AMP7	6.74

Table 6-6 Supply 2040 AMP7 schemes

6.5.5 Maintaining adequate pressure

The top causes of unwanted operational customer contact related to our operational activities are pressure / flow problems and interruptions to supply. Unwanted contacts negatively affect our Service Incentive Measure score. Customer contacts about interruptions to supply represent a customer receiving 'no water' and are generally related to incidents such as bursts. We have PCs related to interruptions to supply. Customers contacting us about pressure or flow problems do have a water supply, but it may be insufficient to meet their expectations e.g. running a washing machine and their bathroom tap at the same time.

We are legally required to provide a minimum level of service of ten metres head (1 bar) at flow rate nine litres per second at the property boundary (DG2 measure). Seven metres head (0.7 bar) at the property's boundary stop tap is the service level set at which compensation (GSS payments) are paid to customers if these levels are not met. We aim to provide all customers with 15 metres head (1.5 bar) in the distribution pipe at the point of connection that serves the property. We maintain a register of those properties which do not receive the DG2 level of pressure and progressively work through these to maintain a target level of properties on the register. This is our DG2 programme with the aim to have <200 on the register between 2020 and 2025.

In addition to the DG2 programme of works we are introducing a more encompassing PC for pressure. Whereas the DG2 programme provides a measure of how many properties receive poor pressure throughout the year it does not recognise the frequency and length of each low-pressure event. The new PC is reported in hours/property in one year, similar to our interruptions PC and measured against the 15m standard. It excludes exceptional demand similarly to DG2 and all pressures drops below 1 hour. It however now includes repeat instances such as morning and evening peak periods and extended pressure failures caused by bursts and other excludable items in the DG2 measure.

Since 2016 we have installed over 600 new critical point loggers in our network to augment our 300 DG2 loggers with the aim to have all DMAs with remote in line pressure monitoring at 15 minute intervals. This widespread coverage of pressure loggers is a key part of our strategy to improve our awareness of incidents happening in our network and response times to such incidents. The loggers will then allow us to accurately determine those properties that have been affected and for how long and whether due pipe capacity, pump failure or burst.

The information we have to date from all the loggers indicate that that we have approximately 190 sites that currently experience pressures that would fail this measure. Our current baseline figure is 13 hours/property/year. We intend to improve this by 33% to 8.7 hours/property/year. Solutions to improve pressure will vary from minor configuration improvements involving new valve arrangements, new pressure control or where necessary major pipework of pump reinforcement.

6.5.6 National infrastructure contributions

We are working on three main national infrastructure projects in our operational area that will be in construction between 2020 and 2025 and beyond. These are HS2 (currently in construction), Heathrow Expansion and the River Thames Scheme. All these national projects will require changes to our own infrastructure, mainly through diversionary work. Cost estimates for HS2 are based on detailed designs and costs from our HS2 framework contractor. Costs of works necessary for the River Thames Scheme are based on drawings developed with the EA's consultants and using our framework rates. Costs for the Heathrow Expansion are less certain and based on the diversion of a large trunk main to accommodate the works plus an estimate for more local network reconfiguration. The feasibility study for the Heathrow diversion commenced in July 2018. These works are part of national infrastructure improvements under NRSWA so subject to a 7.5% contribution, which is the cost included in our programme[35].

6.5.7 Developer Services

The provision of services to developers to provide new homes and commercial properties in accordance with local plans and our Water Resources Management Plan. A full explanation on the derivation of costs for these services is found in section 8.2.

6.6 Infrastructure cost summary

The following is a summary of the capital expenditure proposal for AMP7 for infrastructure following an options appraisal.

[35] *National Infrastructure Costs Estimate*

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
Distribution Mains						
Distribution Mains Renewal	Renewal of distribution mains and communication pipes to maintain asset health	210km of mains renewed	38.00	0.00	0.00	38.00
					Distribution Mains sub-total:	38.00
Trunk Mains						
Trunk Mains Renewal	Renewal of trunk mains to maintain asset health	Renewal of most critical trunk mains	25.24	0.00	0.00	25.24
Trunk Mains Maintenance and Mitigation	Maintenance of trunk mains apparatus to ensure trunk mains can provide the service intended	Replacement of valves, air valves, hydrants etc. Removal of restricted mains in the network to allow for rezone flexibility	8.50	0.00	0.00	8.50

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
					Trunk Mains sub-total:	33.74
Additional Infrastructure						
Lead Pipes						
Lead Pipes	Refurbishment and replacement of lead communication pipes	refurbishment or replacement of lead communication pipes where lead exceeds 50% of the PCV	9.20	0.00	0.00	9.20
Supply 2040						
Supply 2040	Implementation of the first phase of a long term strategic plan to ensure resilience	Support to our long term plan to achieve: •transfer of 17Mld surplus water to areas of deficit •improve connectivity in our central region •protect and maximise existing critical sources •prepare network for additional 100Mld from new Upper Thames regional reservoir	36.67	0.00	0.00	36.67
Developer Services						
Developer Services	Infrastructure to meet the new housing and commercial growth in our operational area	16,000 new properties per year	53.84	0.00	-33.49	20.35
Maintaining adequate Pressure						
Maintaining adequate Pressure	Maintain minimum pressure for the new PC	Reduce instances of poor pressure from 13hrs/property/year to 8.7hrs/property/year	3.75	0.00	0.00	3.75
Leakage						
Leakage operations	Operational costs to reduce leakage	Operational costs to reduce leakage	0.00	71.98	0.00	71.98

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
Leakage Infrastructure and maintenance	Manage, control and reduce leakage	Asset maintenance and operational costs to reduce leakage by 15%	14.17	0.00	0.00	14.17
Network ancillaries	Replacing vital leakage equipment	• Communication pipes • Stop taps • Valves, hydrants, washouts	40.00	0.00	0.00	40.00
Interruptions to supply						
Interruptions to supply	Delivering the supply interruptions PC	• Ensuring the alignment of key skills and support 24/7 • Providing the monitoring and control support through the Network Service Desk 24/7 • Providing the necessary tools and equipment at convenient locations • Adopting a flow restoration principle as well as speed of repair • Aligning the supply chain to the performance targets.	0.00	24.50	0.00	24.50
National Infrastructure Contributions						
National Infrastructure Contributions	Contribution to national programme	• HS2 •Heathrow extension • River Thames scheme	2.63	0.00	0.00	2.63
					Additional Infrastructure sub-total:	223.24
					Infrastructure total:	**294.98**

7 Business improvement expenditure

7.1 Overview

This section covers the areas of expenditure that are excluded from the larger programmes of work described above. This includes capital expenditure driven by systems that provide services to the larger programmes, maintaining business as usual activities or costs that are linked with other water companies' business plans through water trading agreements.

7.2 Business planning

7.2.1 Water resources feasibility

Our WRMP19 has identified the need for long term strategic water resource infrastructure investment, in the form of new treatment options, storage facilities and strategic transfers. These options are identified as being needed post-2025 but will require supporting technical studies to be carried out during AMP7. Currently little supporting feasibility, sustainability and engineering design work supports these options. They are based on WRMP dossier evidence, which is minimal but meets the requirements of the WRMP options appraisal process. Furthermore, dWRMP19 stakeholder representations point towards the need for us to move faster with the development of long term options.

The key benefits from carrying out this work as early as possible are:

- to understand the engineering challenges that may be faced in commissioning the schemes
- to understand whether new abstractions are sustainable
- where neighbouring company schemes are involved, to assess the design assumptions of the schemes, their costs and the robustness of the source option proposals
- improve option feasibility and cost ahead of WRMP24

7.2.2 Water Resources South East and Water Resources East

We have taken a leading role in the WRSE project, supported Water Resources East (WRE) and participated on the steering group of the Water UK Long Term Water Resources Plan, working with the Environment Agency and other water companies to assess strategic water supply opportunities across the regions. These activities are key to ensuring the long-term resilience and sustainability of water supplies.

We have worked with WRSE to develop plans for collaborative water resources planning. The preferred option can be described as 'One Regional Plan,' with semi-independent functionality. Work to agree the cost sharing mechanism between member companies is ongoing. Funding included in our business plan submission is therefore for Affinity Waters' share under a fair draft cost sharing scenario[36].

7.2.3 Business plan

Our estimated expenditure for business planning in AMP7 is based on our expected expenditure during AMP6. This expenditure encompasses activities that are required to complete a detailed price review and produce the PR24 business plan. Business as usual activities that also feed into business planning are excluded.

The main areas of expenditure are:

- Detailed customer engagement and consultation

[36] *WRSE file 795; Future Funding Options*

- Evaluation of our capital maintenance activities, including a review of costs and deterioration models
- Work to meet the regulatory requirements, this includes the need to fill out tables, commentaries and technical reports
- Financial modelling to assess bill impact
- Developing PCs and ODIs

We anticipate that we can make efficiency improvements when completing the PR24 submission due to the business as usual processes laid out in 8.6. We have therefore estimated that it will cost 25% less than in AMP6.

7.2.4 Water resources management plan

Our estimated expenditure includes the cost of work to meet regulatory requirements for the preparation and approval of our water resources management plan, including adhering to Water Resources Planning guidelines, submitting the Plan to the Secretary of State for Environment, engaging statutory consultees, undertaking public consultation, preparing a Statement of Response and preparing for and appearing before public inquiry.

7.2.5 Drought management planning

Our estimated expenditure for drought management planning in AMP7 is based on our expected expenditure during AMP6. We anticipate that we can make efficiency improvements when completing the next drought management plan due to lessons learned during AMP6. We have therefore applied a 30% reduction in expenditure relative to AMP6.

7.3 IT assets

7.3.1 Overview

This section describes the approach, process and expected outcomes for Information Technology for the period 2020-2025.

We see Information Technology as part of a wider utilisation of technology across all functions of our operations and a key enabler to achieve our customer outcomes. Well defined investment in technology will enable us to meet the challenges we face and become a more resilient organisation to better meet customer needs and expectations.

We will continue to build on an environment for learning and innovation, providing the basis for cultural changes, knowledge sharing and ideation. Through information systems we will provide customer insights, feeding this back to customers to aid their efforts to reduce water consumption and lower their bill. We will be paying particular interest in supporting our most vulnerable customers to ensure they receive the same high-quality service at the least cost.

7.3.2 Our Approach

We will continue to improve our data quality and business intelligence, exploiting new technologies such as Artificial Intelligence (AI) and Analytics. Our vision has moved from **stabilisation** to **simplification**. While stability is still a common theme within our architecture, the simplification of the implementation, integration and management of our systems is envisioned as the most appropriate path to achieve this, while providing a platform for enhancement and innovation.

This vision is set to continue into AMP7. The foundational technology and tools such as the cloud migration are the enablers for continuous improvement, optimisation and makes innovation an embedded behaviour. This journey gives us an ability to react and respond and make better and more informed decisions. The diagram below depicts this journey.

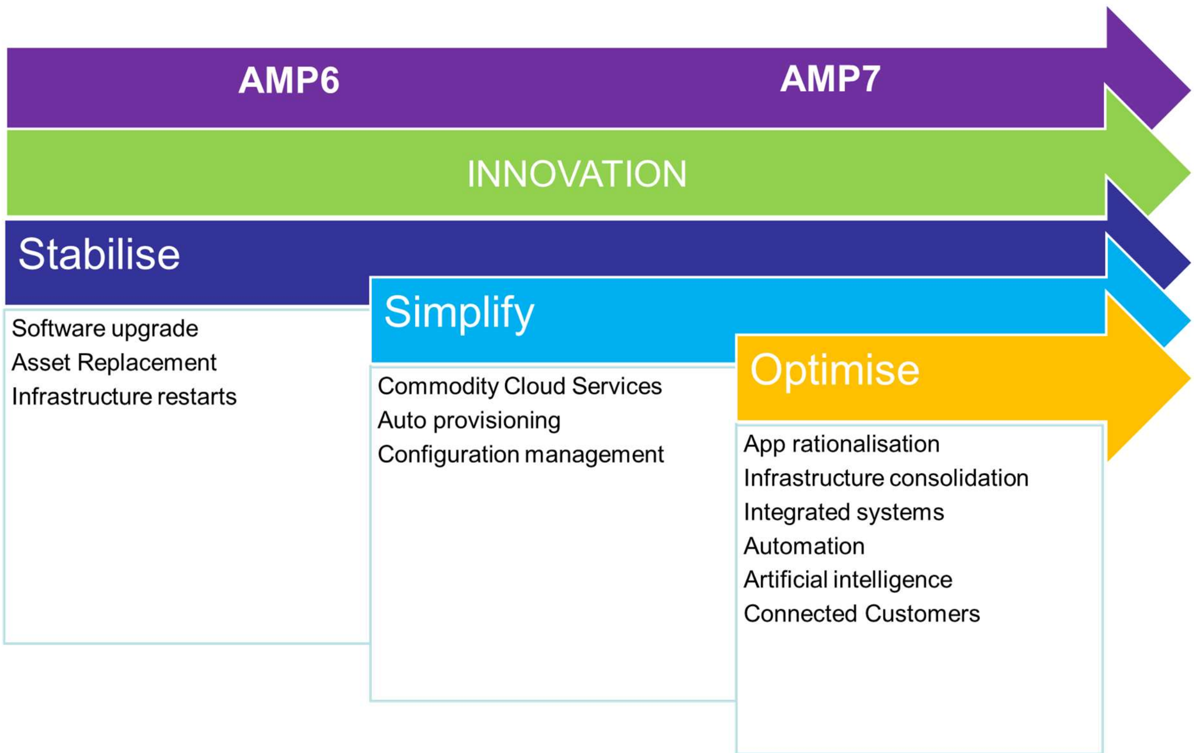


Figure 7-1 IT Journey Overview

Our IT strategies of “cloud first” and “digital first” are driving a step change in how we provision IT services and ultimately how we invest in the future.

We are currently driving our vision for simplification through the adoption of Cloud Based IT services, based on a “Cloud First” model. This approach to IT provisioning is moving the technology asset base from a capital expenditure to an operational expenditure model. This will lead to an overall totex improvement and has significant advantages over the typical capex based model.

7.3.2.1 Uncertainty

With uncertainty of IT due to the rate of change, moving to a cloud based opex model will provide the flexibility for services to evolve and change. We wish for our IT financials to no longer rely on the amortization or depreciation of IT asset investments over an extended period.

7.3.2.2 Reduce upfront costs

With the move to commodity IT services, large upfront expenditure in the IT planning process is no longer required, reducing the risk of poor investment in the event of failure.

7.3.2.3 Reduce time to start

Project planning time is significantly shortening through the elimination of rigorous and lengthy cost estimation processes associated with upfront capital expenditure.

7.3.2.4 Reduce continued capital

Cloud based services are commoditising the IT infrastructure and application estate, reducing the continued capital expenditure to maintain, even providing “evergreen” services through Software and Platform as a Service Models (SaaS and PaaS respectively)

Our “Digital First” philosophy is to change the way we deliver technology solutions and adapt to change, optimising and automating where possible. We intend to change the way we work to improve people’s lives through effortless technology.

We aim to provide our teams with:

- Technology devices appropriate to their roles within the organisation, to enable online and offline working, providing the correct information for our colleagues and partners in a timely fashion and enabling them to work in a safe environment.
- New technology solutions and innovative services, to help us compete for Talent and changing expectations / values of new workforce.
- Connected assets, exploiting emerging and mainstream technologies such as the Internet of Things (IoT) to improve operational understanding and asset care.

We aim to provide our Partners and suppliers with:

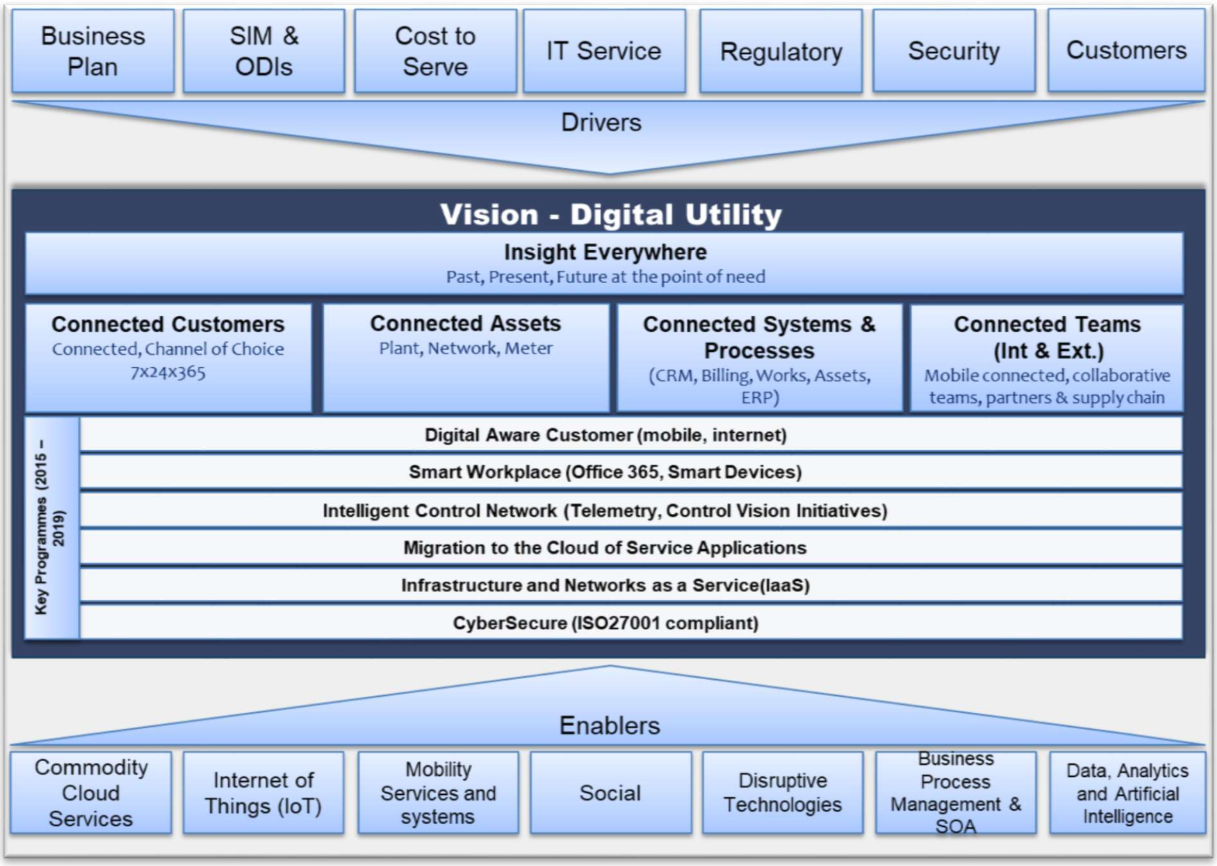
- Online solutions for operational work.
- Business to Business (B2B) integrations to streamline transactional processes and reduce operational delays.
- Data services for information sharing and improving operational and reporting procedures.

We aim to provide customers with:

- Online data and informational services, to provide insightful and relevant information to aid them to manage their water service, with particular reference to usage and affordability, again while staying safe.

- Digital and automated processes to reduce customer inquiry and on-hold times, improving levels of service, through mobility aware solutions.

The diagram below depicts our digital utility vision



Our investment is split into two categories based on IT Baseline Maintenance (also known as “Run the Business”) and IT Strategy Initiatives (“Change and Transform the Business”).

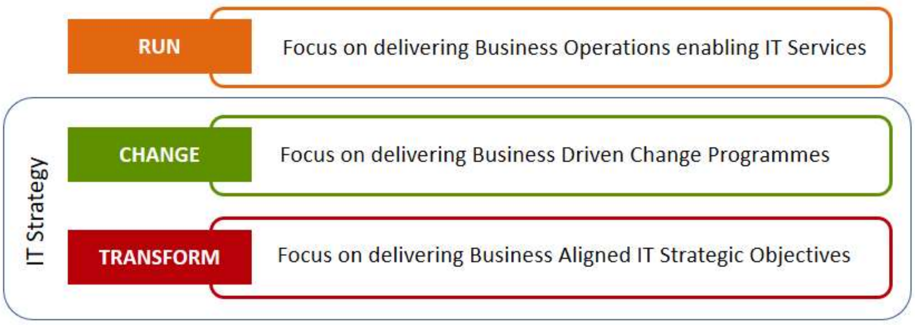


Figure 7-2 IT Spend Categories

- **IT Baseline Maintenance (Run)** - Investments required to maintain the IT service levels and asset base at levels, mitigating service impacting risks.
- **Business Change Initiatives (Change)** – Business driven changes that require technology investment, typical drivers include; strategic direction, support cost and service efficiencies, regulatory and legal compliance.

- **Business or IT Strategic Initiatives (Transform)** – Business opportunities for investments in technology that deliver positive business and IT outcomes (Cost/benefit, service, risk)

The IT Baseline Maintenance plan has been designed to provide the right level of investment to support the four key maintenance criteria of Technical Obsolescence, Security, Safety and Customer Satisfaction.

The IT Strategy Initiatives are designed to support the necessary changes to support the customer outcomes while engendering innovation, customer satisfaction and operational efficiencies. While the essential maintenance is about stability, the strategy initiatives aim is to drive the organisation forward through technology, making us more efficient and ultimately providing improved levels of service to customer at the least possible cost.

7.3.2.5 IT baseline maintenance

The IT Baseline Maintenance plan provides a Total Cost of Ownership (TCO) assessment of the investment required during the AMP7 period to maintain the serviceability of our asset base for the following assets groups:

1. IT End User Computing
2. IT Applications
3. IT Data Base Technology Register
4. IT Core Infrastructure
5. IT Networking and Telephony

The above, when aggregated, supports the portfolio of business and underpins IT services to business functions and further downstream to customers, suppliers and partners. This model aligns to our Information Technology Infrastructure Library (ITIL) based service delivery model.

7.3.2.6 IT strategy

The plan for IT strategy Initiatives has been devised to determine the optimal IT project portfolio for the period 2020-2025. The initiatives represent the projects to be undertaken to help us deliver our outcomes and operational efficiencies for the 2020-2025 period.

Awareness of various drivers and influencers needed to be appreciated during the process of proposing business cases. The below diagram outlines these key considerations.

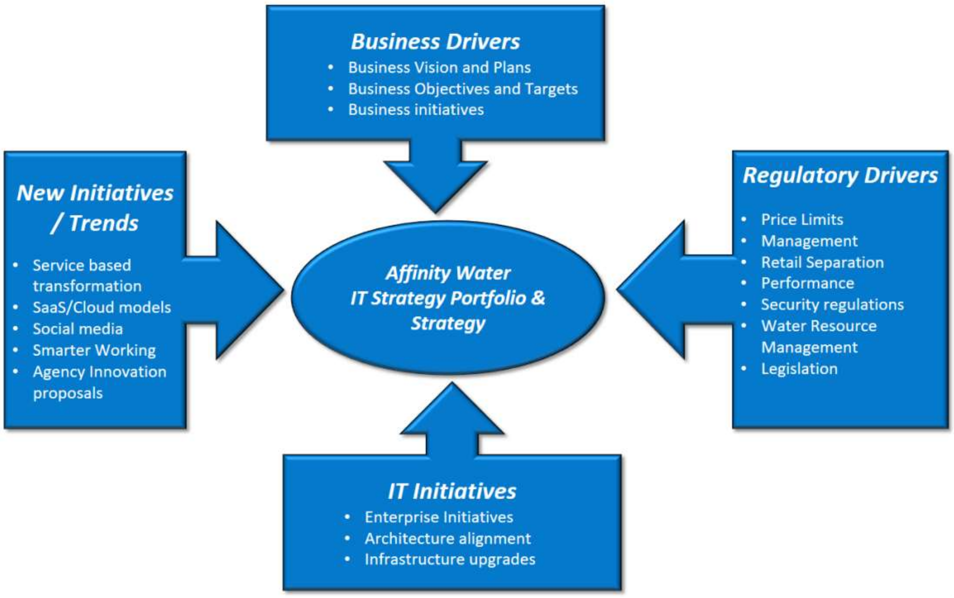


Figure 7-3 IT Strategy Drivers

7.3.2.7 Key planning principles

The following principles have been adopted and underpin the planning and development of our investment requirements.

- Build upon the PR14 submission and approach, taking an Asset cost and an IT Service based view of all proposed investments.
- Follow the UKWIR guidelines for applying common framework approach for M&G (IT) asset capital maintenance investment planning in the development of our plan
- Build on the Business System Planning[37] (BSP) work
- Build an investment portfolio aligned to our organisational goals
- Build a stable plan that enables a future culture for innovation and our digital vision

7.3.3 Process

7.3.3.1 Process steps

The process steps used to define our baseline and strategy are shown in Figure 7-4:

Figure 7-4 Approach Overview

7.3.3.1.1 Planning and preparation

- Agree AMP7 IT planning approach, deliverables and objectives
- Create the baseline IT Asset Register for each IT domain
- Create the master register for strategy initiatives

7.3.3.1.2 Analysis (historical and forward looking)

- IT AMP6 performance review (service, financial and asset)
- IT AMP6 vs AMP7 financial review (baseline)
- Define preferred AMP6 IT maintenance strategy
- IT AMP6 omitted investment review (strategy)
- IT AMP7 directorate vision and objectives capture (strategy)
- IT AMP7 business case identification, financial detail, prioritisation and risk assessment (strategy)

7.3.3.1.3 Optioneering, modelling and justification

- Redefine preferred option based on top-down review from Executive Board
- Define alternate IT maintenance planning options
- Assess opportunities for further IT efficiencies
- Model IT maintenance plan options (service, asset and cost benefits analysis)
- Combine the baseline and strategy work stream into consolidate single plan
- Review top-down assessment of IT strategy initiatives
- Define alternate IT strategy implementation options
- Define recommended AMP7 IT strategy (strategy)

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[37] *Business System Planning was the IT road mapping exercise undertaken towards the end of year 2, to determine the IT investment required for Years 3-5 of AMP6. This provided a baseline plan and ringfenced funding to deliver the agreed IT strategy and plan for AMP6.*

7.3.3.1.4 Validation, approval and outcomes – see section IT plan summary

- Finance team review of financial models and plan
- Develop supporting business case justification
- External audit and benchmark
- Measure the plan against key business objectives and principles
- Approval and preferred plan summary

Please note: This four-stage process is not entirely sequential in practice and all stages involve a degree of iterative sub processing to achieve its respective outcomes and validation.

7.3.3.2 IT AMP7 planning process overview

This diagram provides a quick reference of the process steps, key data sources and supporting documents used to develop the IT maintenance plan.

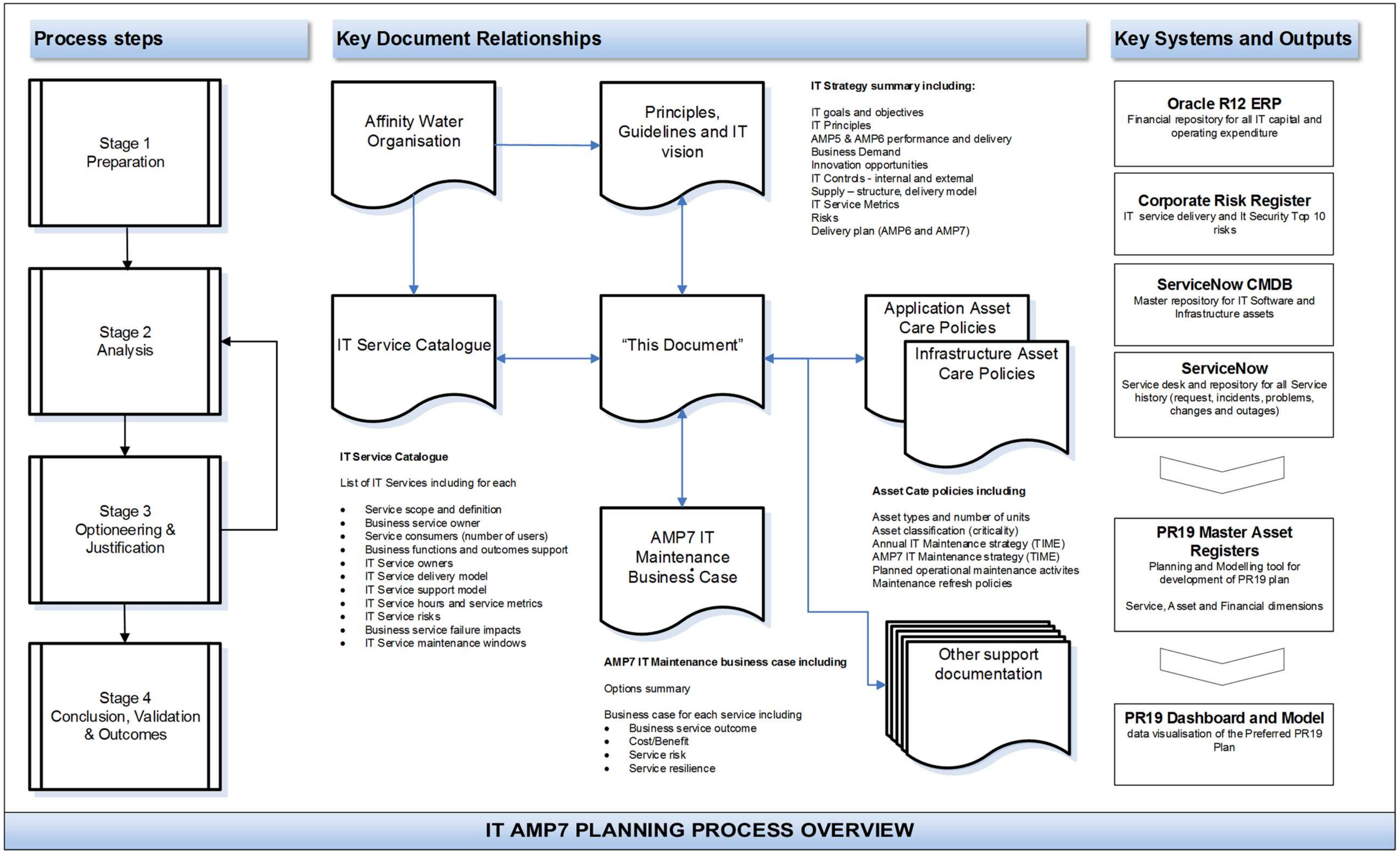

Figure 7-5 IT AMP7 Planning Process overview

This diagram provides a quick reference of the process steps, key data sources and supporting documents used to develop the IT Strategy plan.

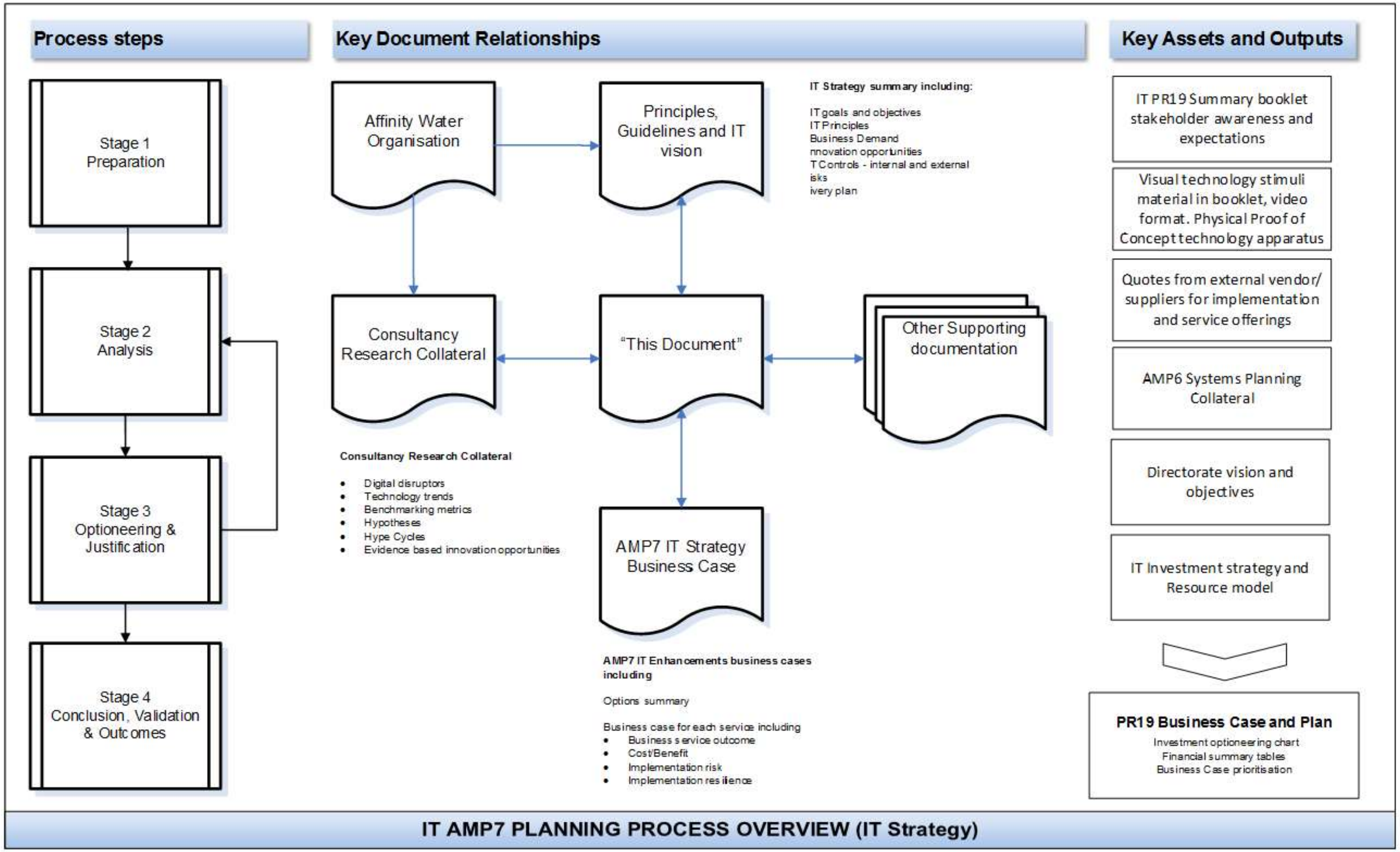

Figure 7-6 IT AMP7 Strategy Planning Process overview

7.3.3.3 Method of Approach

7.3.3.3.1 Stage one – planning and preparation

The Planning and Preparation stage sets out the delivery model for this study and enables the initial development of key artefacts, including the various IT Asset registers.

Baseline - IT assset registers creation

At the foundation of our plan are the IT asset registers used to capture and categorise each asset's details, including name, type, cost and roadmap criteria. Each individual register, segregated by asset groupings, contains its relevant asset's information and provides the financial modelling capability to devise the preferred and optional plans

The registers have been split into the following categories and align to the six layers within our architectural asset hierarchy.

Figure 7-7 IT Asset Categories

Note: Layer oone costs have been split over the layers two-six to ensure the protection of personal data.

Each asset register typically contains, as a minimum, the following data cross-referenced via separate tabs:

- **Asset data** - individual hardware and software assets and attributes (name, make/model, supplier, date commissioned, business criticality (Tier 1 & 2), number of users, locations. AMP7 capex investment costs, opex running costs, assigned to individual and groups of assets.
- **Financial summary** - provides a cost summary overview broken down by asset type, by expenditure type and by AMP year.
- **Asset maintenance policies** - refresh and replacement cycles, unit cost to replace, IT maintenance strategy (TIME38).

- **Supplementary data** - each separate register is then supplemented with other lookup information such as AWS services and costs, EUC price lists, asset warranty information, etc.

Strategy - IT strategy register creation

In addition to the IT assets register, we collated the IT strategy register. This register forms the non-maintenance initiatives designed to drive innovation, enhancement and business operational efficiencies for the 2020-2025 period.
The strategic initiatives register aims to capture descriptive and financial collateral for each business case proposed.

Stage one key (planning and preparation) outputs

- Planning objectives for IT AMP7 investment plan and work package definition
- Work package plan
- Master IT asset registers, per asset grouping
- Historical IT capital expenditure register for AMP6
- Service incident register (AMP6 start - to-date)
- First draft of the IT enhancements registers

7.3.3.4 Stage two – analysis

The purpose of this analysis stage is threefold:

- Analyse and review our AMP6 IT performance with regards to financial management and IT service delivery
- Analyse our IT asset registers for baseline maintenance, aligning to future vision and maintenance care schedules
- Analyse IT strategic initiatives, further defining a high-level business case for each

AMP6 IT Performance review

To help understand our technology journey and to ensure our analysis correlates to expected expenditure a review of the AMP6 proposed and planned investment portfolio was undertaken.

Programme delivery against PR14 plan

Within this process we review what we planned to deliver by the end of the AMP6 period against our proposed PR14 programme to validate if we have fulfilled our commitments and obligations during the present AMP period. While year 1 & 2 initiatives correlated to our proposed investment plan, at the end of year 2, based on an evolving with changes at executive level, of ownership and of technology, we realigned the programme through our Business System Planning (BSP) process.

The purpose of the BSP programme was to re-evaluate our investment programme based on the current real-world scenario with an increased emphasis of simplifying our Information Technology estate and operations.

Financial review (totex)

A bottom up financial review of the IT capital and operating costs (totex) for the AMP6 period was undertaken.

The review included a detailed sub-analysis of IT totex costs by both IT service and asset group to fully understand our cost drivers and unit cost model for IT. These were then assessed against Gartner benchmark information to evaluate our effectiveness and efficiency. The outputs were used to drive stage three financial modelling and externally benchmarking our maintenance planning and options and deriving the preferred plan.

IT service review

At the beginning of the AMP6 period we decided to revert from the outsource IT model to an in-house delivery team as we believed that the in-house IT model was cost effective and provided a better level of service for our customers in the long term.

As part of the historical review, we analysed service statistics from our ITIL based service management platform (ServiceNow), correlated to our asset registers for each IT service and supporting asset group, to understand the effectiveness of our AMP6 investment programme and applied maintenance policies.

The chart below summarises the investment outcomes and portrays a positive correlation between investment and improvements in IT service outcomes during the AMP6 period.

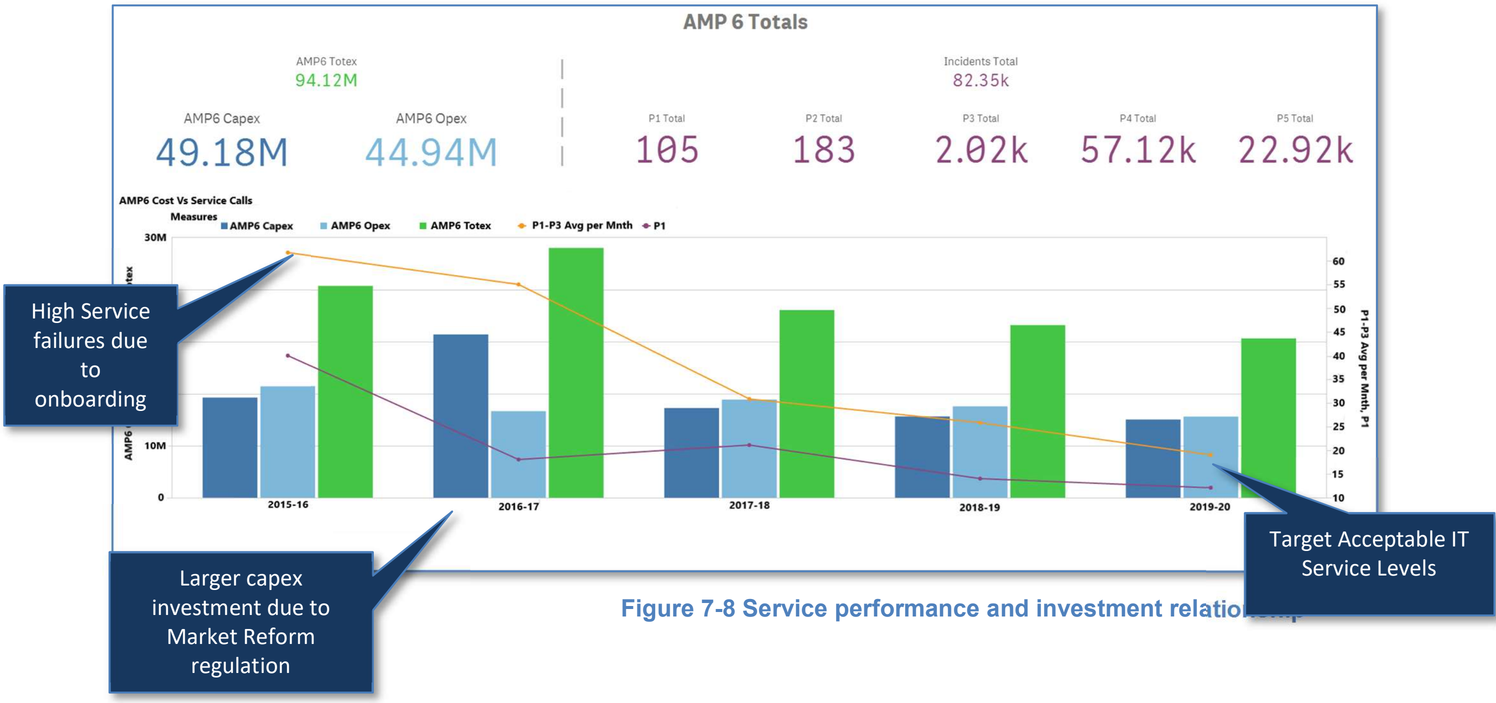

Figure 7-8 Service performance and investment relationship

The conclusion drawn from this analysis is the need to avoid a boom and bust approach to IT investments for the coming AMP7 period and define a plan that maintains a consistent level of investment that strikes the optimum balance between affordability while maintaining the IT assets at consistent levels of serviceability. This in turn provides the stability to open opportunities for innovation and operational efficiencies while assuring our simplified IT vision.

AMP7 future demand and IT maintenance strategy

As the document has demonstrated so far, the advancements in Information Technology mean that relying on stability through maintenance alone is not sufficient to achieve our goals.
Our IT AMP7 plan is designed to provide a programme of work that includes a balance of essential maintenance activities supplemented by strategic investment to drive innovation and change to in order to improve business operations and customer experience.

Stage two (analysis) key outputs

- Refined baseline asset registers
- Refined IT strategic initiatives list
- Target IT maintenance strategy for AMP7 modelling and optioneering
- Target IT strategic initiatives list for AMP7, defined costs
- IT baseline business case (draft) and EMT submission

- IT strategic business cases (draft) and EMT submission
- Totex presentation for baseline maintenance strategy
- Totex presentation for strategic initiatives list
- Initial financial models and cost breakdowns

7.3.3.5 stage three – optioneering and justification

The objective of this phase was to financially model the IT maintenance and strategic options based on differing scenarios and expected outcomes and allows for an informed executive decision to be made on the final submission.

The following scenarios have been considered for the maintenance plan:

Asset Type	Description
Option 1 Top-down financial driven	**Cost driven outcome –** based on the Total Financial model across the business a top down £ figure is provided from the executive board derived from the initial analysis from stage 2
Option 2 Stretched plan	**Cost driven outcome –** Aimed at reducing overall cost of ownership, sometime compromising on Service level. Stretching assets beyond their refresh policy to a break fix model.
Option 3 Service at least cost	**Service and Cost Driven –** Aimed at providing the correct balance between cost and service, trying to achieve acceptable levels of service for the least cost
Option 4 Fast Followers	**Service Driven –** Provide the best service outcomes, typically at higher cost, but typically drive business outcomes and innovation.

Table 7-1 Baseline maintenance Delivery approaches

The following scenarios have been considered for the strategic plan:

Asset Type	Description
Option 1 Innovators	**Leading the industry** in producing a true digital utility of the future, working with partners and fellow industry organisations to drive innovation.
Option 2 Fast Followers	**Learning from our fellow industry** companies and market trends to innovate at Affinity Water, adapting and integrating new technologies once proven.
Option 3 Future Proof	**Invest in essential strategic initiatives** for the betterment of business operations while introducing some risk/reward programmes to improve
Option 4 Secure and Optimise	**Assure current operations** and optimise where applicable, only investing in essential technology enhancements where proven.
Option 5 Nil Investment	**Opting for no capital investment** for any of the proposed IT strategic projects.

Table 7-2 Strategy Initiatives Delivery approaches

IT outperformance opportunities

During the AMP6 period we delivered some major strategic changes to the way we provision and introduce new technology as exampled below:

- **Cloud migration –** we simplified our IT architecture and reduced running costs through commodity infrastructure and leased solutions
- **In-housing of IT team –** we optimised our delivery capability and costs through internal talent, allowing us to adapt and innovate when necessary

- **New BT communications as a service contract –** we optimised our networking suppliers and support, consolidating into a single supplier and contract across the business
- **Dedicated security team –** we introduced a dedicated team to support our cyber security obligations aiming to deliver a secure safe IT environment, avoiding punitive fines and reputational damage

Our strategy for AMP7 is to continue our vision of simplification and innovation, shifting our boundaries of operational performance with the right mix of cost and risk, while learning and collaborating with others both within our industry and external to it. We see the following as key success criteria to outperform within the AMP7 period:

- **Further cloud opportunities** - shift up the stack from IaaS to SaaS, moving to evergreen managed services with unprecedented uptime and performance levels. Further reducing our technology capital investments.
- **Advanced predictive analytics** – understanding our business and customers better through data insights and informed decision. Predicting the future based on historical trends to achieve and where possible exceed our PCs.
- **Automation and artificial intelligence** –Streamlining our processes and people providing the stepping stones to shift to real-time 24/7 operations.

Our strategic initiatives plan is designed to further support this vison and thinking, providing a considered level of investment to realise these goals.

Modelling solutions

To support modelling our options, Microsoft Excel supplemented by Microsoft SharePoint Online have been utilised. These tools provide the flexibility, control and configurability to both categorise the data and to financially model based on lookups and variables.
Further supporting this modelling process our Qlik platform has been utilised to create dashboard information and "what if" scenarios, allowing us to get the right balance for the options described earlier.

The cost of change (maintenance)

To calculate the investment required for each asset we use a model based on "the cost of change", whereby each asset's cost was calculated based on the complexity of change at the point it expires (or is recommended for upgrade), based on a refresh policy lifecycle.
Key attributes to model this are:

- Date asset was commissioned
- Refresh policy – number of years till obsolete
- Capital cost of asset – cost to buy like for like assets
- Capital cost to commission asset – cost of resource to commission
- Running costs of asset per year
  - External cost to run – support contracts, rental costs (fixed and variable costs)
  - Internal cost to support (fixed and variable costs)

These attributes also allow us to perform a "straight line" depreciation value, to understand the value of the assets currently within our IT asset base.
The following diagram depicts the IT asset hierarchy and the typically impact scale for outages at the various asset group layers.

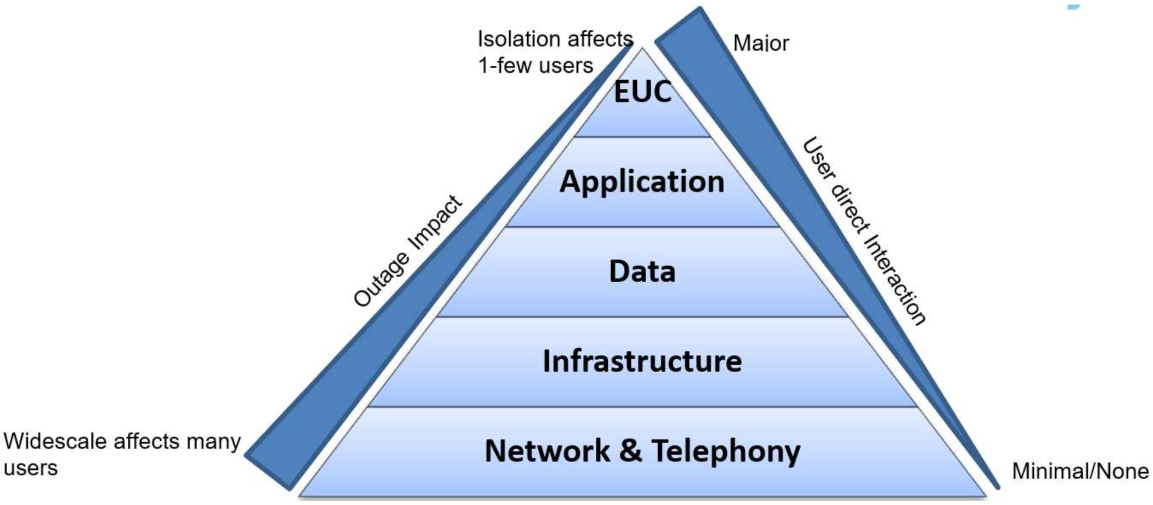

Figure 7-9 Asset Hierarchy and impact scale

Cost avoidance (non-application failures)

As described previously, the aim of the baseline investment is to reduce the number of service failures and impact on internal customers and subsequently external customers. To calculate this, we utilise a formula for "the cost of downtime", which is an IT industry standard term within IT Service Management (ITSM), although the calculation can differ between service providers.

Cost avoidance (application failures)

Application downtime is far more unpredictable than physical hardware, especially with our "resiliency in design" approach to provisioning software services. As we move further towards cloud service offerings it is expected that software downtime will be almost eliminated, with our focus moving to the network assets, connectivity of our sites and end users, being the main causes of failure.

End user computing

End User Computing (EUC) describes the physical assets used by our internal customers. This category includes the largest variety of sub assets types as well as the largest number of assets. These assets include items such as user devices: laptop, desktops, mobiles; as well as shared office equipment: TV screens, printers, video conferencing etc.
Each EUC asset's life policy contains a deterioration expectancy which provides the basis for modelling the asset health over a specific timespan. This model then supports optioneering with our assets, allowing us to test the financial consequences of increasing the refresh cycle of an asset v shortening it, against a prescribed asset failure rate and life expectancy.

Applications

Applications are at the heart of our operations and this is reflected in that the asset group accounts for the majority of the IT baseline investment. The application asset group covers:

- **Business applications** - helping manage and run the non-IT aspects of the business.
- **Core applications** - applications provided to all our user base e.g. Microsoft Office.
- **Infrastructure applications** - service and development applications, used to manage the complete IT value chain lifecycle
- **Security applications** - used to maintain and secure our technology environment from all threats.

Data
Data assets cover the database products used for our On-Line Transactional Processing (OLTP) and On-Line Analytical Processing (OLAP) systems.

Many of our database costs have been calculated within the application costs as most major database upgrades are typically performed at the point the application requires its own major upgrade. This provides the most cost-efficient capital expenditure process for the maintenance of this asset type.

Infrastructure
Building on our cloud first strategy and migration, the financial modelling has been developed with a 100% Amazon Web Services (AWS) like-for-like replacement of our current physical and VMware infrastructure. This means that each server has been matched with a like-for-like AWS elastic compute (or alternate service) equivalent, and then the least cost option has been taken as a monthly opex value.

It is the vision that our infrastructure will be 99% cloud based by the start of AMP7 and so the true costs of this will be realised during and up to the end of AMP6, providing the opportunity to optimise and mature the environment during AMP7.

Network and telephony
The final asset category is our underpinning network and telephony infrastructure. For this class of asset, the same approach is used as with EUC and infrastructure whereby each asset is modelled on a fixed lifespan replacement with a yearly break support cost.

This is supplemented with a support contract provided by our preferred partner BT, who provide us with ongoing maintenance (and implementation, where necessary) of our Wide Area Network (WAN) and connecting infrastructure (routers and switches). The BT support model covers both the IT and Operational Technology (OT) networks.

Option modelling (maintenance)
To allow us to re-model the varying options our initial base model (option 3) was calculated based on the replacement and break support values used within AMP6. This provides a go-to reference point for the other options in terms of financial costing and asset serviceability.
To calculate each investment plan, the following steps were taken:

1. Set the asset care refresh policies for each asset group within the model to levels that deliver the targeted IT service outcomes for each option.
2. Verify that the financial unit cost rates and dates of the last interventions are set to correct values within the model for each infrastructure asset group and for software assets at individual asset level.
3. Run the model to calculate the five-year investment programme.
4. Publish asset based and service based financial summaries
5. Repeat one through four for each option

The cost of change (strategy)
Whilst the baseline totex suite ensures we can keep the business running, it was crucial to look outside our existing mode of operation to ensure that we can take advantage of the digital economy to reduce our overall costs, provide higher customer satisfaction and deliver water more efficiently to customers. The portfolio of proposed initiatives produced will be key to reaching our ODI targets, improved SIM score, community commitments and improvements in employee productivity within AMP7 and beyond.

To calculate the investment required for each initiative it was imperative to formulate a standardised business case template/structure which included a detailed breakdown of the cost including; the initial capital investment i.e. year one of the AMP, the capital investment for the remaining four years of the AMP and the operational expense over the full five years. The Capex estimations were based on two main factors; the cost model for IT development and vendor costs where applicable.

7.3.3.6 Stage three (optioneering and justification) key outputs

- Refined baseline asset registers
- Refined IT strategic initiatives list
- Preferred IT maintenance strategy for AMP7 modelled with options
- Preferred IT strategic initiatives list for AMP7, defined costs
- Refined IT baseline business case draft and EMT submission
- Refined IT strategic initiatives business cases draft and EMT submission
- Totex presentation for baseline maintenance strategy
- Totex presentation for Strategic initiatives strategy
- Initial financial models and cost breakdowns
- Draft IT PR19 plan

7.3.4 Outcomes

7.3.4.1 IT assets plan summary

Following the completion of the three steps described above, the options were validated (stage 4) through stakeholder workshops and external benchmarking[39].
Our plan, which will meet our outcomes [40] , is summarised below:

7.3.4.2 Our plan – IT baseline summary

Our preferred investment option for maintenance is option 3 ‘service at least cost’ which aligns to our AMP6 and AMP7 strategy and leads us into a stable format for AMP8.

The process for deriving our maintenance strategy considered both the outputs from the future demand review and an assessment of each of our key software and infrastructure assets against the criteria listed below:

- Business fit and value
- Technical efficiency and alignment with IT architectural standards
- Costs to run and enhance, and risks of failure
- Supplier maintenance roadmap
- Delivery model changes

Our baseline investment, based on delivering the outcomes of our maintenance policies and providing balance between investment and stability, will ensure continuity of service for:

- IT End User Computing
- IT applications
- IT data base technology register
- IT core infrastructure
- IT networking and telephony

7.3.4.3 Our plan – IT strategy initiatives summary

Our preferred investment option for IT strategy is option 2 ‘fast followers’ which will achieve essential enhancements for the improvement of our operations whilst learning from our

[39] *IT Supporting information*
[40] *Meeting our Business outcomes*

industry peers and market trends. This will allow us to innovate, adapt and integrate new technologies once proven. Improving the way we interface and work with customers to reduce consumption while making sure we hit our leakage targets is a prime focus. The information systems needed by our workforce to maintain operational infrastructure more efficiently will enable our sustainability reduction programme. We will be able to provide better, more secure information to our customer base so providing clarity of service and demonstrating value for money.

Our IT strategy initiatives will be focusing on the following areas - business optimisation, data, innovation, customer and resilience:

Business Optimisation

We will be placing artificial intelligence (AI) and automation at the very heart of many of our processes and systems and are planning to leverage these technologies within AMP7 such as machine learning and automation to automate processes and reduce administrative tasks. Both robotic process automation (RPA) and AI are technologies that have the capability to drive significant, step-change efficiencies as well as generating completely new sources of value and this will offer improved accuracy, compliance and improved responsiveness. The combination of AI, automation and machine learning will drive opportunities such as customer data segmentation/personalisation and water network data management and telemetry. Usage of chatbots will also play a prevalent part in our plan, being utilised both for end customer needs as well as for internal usage, aiming to streamline service requests resulting in reduction of operational costs across the company.

Data

Data management plays a key role in meeting our company vision and customers' expectations. Our overall objective is to provide a long-term, valued service to customers, by delivering enough, high quality water and minimising service disruptions, in the most responsive and efficient way and a number of key IT initiatives focus on securing, collecting, storing, improving, analysing and organising data to meet these business commitments. Our data strategy sets out our longer-term ambition and vision on how to obtain best value from the asset, operational, financial and customer data we hold; our approach for achieving this and how it will benefit customers; how this will be embedded through the organisation, and how we measure success and drive continuous improvement.

During AMP6 we have firmly established our community-focused approach, which is based on data and insight, and we developed several innovative initiatives to meet our customers' needs, particularly around customer engagement and information:

- Our community dashboards, which provide customers with a tailored view of our performance within their local area.
- Our customer experience improvement programme – which includes the deployment of our "my account" platform for self-serve customer support and billing.
- Our 'in your area' web application, which provides customers with up-to-date information on planned and unplanned interruptions to the network.
- Our social media strategy, which supports customers by providing updates on works management for those customers affected by outages.

This has successfully helped us to support our customer information needs whilst keeping stakeholders informed about our community performance. In addition to this, we are using our Navig-8 community impact tool to provide the link between asset performance, community operation and customer feedback.

There are now compelling requirements for further improving our maturity during AMP7:

- Enhancements needed to our business processes and ways of working to meet upper quartile performance expectations and provide tangible savings.
- Increased expectations from customers and stakeholders about the service we provide and on how to save water.

Innovation

One of the key strategic themes and our aim is to extend the innovative approach from PR14. Examples include:

- Innovation award winning tools to protect workers against electrical strikes.
- 20,000 IoT loggers on our network to better understand our assets and give more real-time data analysis.
- Cloud migration of our technology estate and the launch of new multi-channel technology solutions to our customers.
- Cloud technology to deliver resilience, continuous improvement and deployments to release change both quickly and cost effectively. New works management platform allowing our field workers to have access to the right information and helping them work smarter whilst keeping customers more informed.

The next step in our business transformation is one of curious, collaborative and insight-driven strategy leading to convergence and connectivity at all levels. Our strategy is one with multiple stages, going beyond digitisation and the application of technologies towards innovation and flexibility capabilities, to deal with the demands of a highly interconnected customer-centric real-time utility provider.

Customer

We will be focusing on three main objectives:

Modernising our business: Leveraging new and emerging technologies, delivered in an agile way, co-created with our customers to ensure we are delivering more for less than the retail cost to serve.

An insight driven business: Building on early successes of data-driven insight to direct and support our customer journeys. Customer centricity validated through cross organisational data analytics.

Delivering an inclusive and personal customer experience: Proactive customer dialogue and data-driven continuous improvement including a ring-fenced dedicated investment for vulnerability and affordability endeavours.

Resilience

Our key aim is to implement technology solutions and business change that are fit-for-purpose, robust and secure ensuring the continuity of business operations. Over AMP6, IT have made significant strides forward on the architecture of the IT estate, moving from self-hosted, long lead time physical infrastructure to a cloud first approach to hosting. This is one of our unique capabilities allowing corporate resilience for change, through the flexibility of our core infrastructure assets. This approach provides the ability to adapt to emerging changes within the industry and regulations with reduced risk of failure and minimal costs.

The cloud first approach is also enabling our core assets to be resilient by design. The inherent redundancy and disaster recovery (DR) features of cloud-based Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) provides peace of mind to system availability and business continuity.

We have embarked and continue to invest in a significant data and information security (InfoSec) program. Over the last three years there has been a significant increase in our InfoSec maturity which was recorded at level three in the independent NCC assessment report of early 2017, well above the UK corporate average.

We were awarded the UK Government's Cyber Security Essentials+ certification in October 2017 and have continued to build upon the concepts of the certification by beginning the journey to fully align with the Global Information Security Management System Certification ISO27001. The target for alignment is the end of 2018.

Moving into the AMP7, we foresee risks increasing in cyber security. To reduce our risk, we are investing further in artificial intelligence (AI) cyber software, tracking activity over the IT estate to determine anomalies and potential threats.

We see further growth in AI through 'big data' analysis, machine learning and automation. Providing further innovation with regards to real-time operations, reducing mean time to repair (MTTR). This analysis and pro-active situational awareness will also provide the basis for reduced interruptions to supply and water resource management. New predictive models for asset care will evolve and mature through quality data processing, improving our planned maintenance.

Finally, our cloud first strategy will mature and start to move up the value chain, shifting from Infrastructure as a Service (IaaS) to Everything as a Service (XaaS). This will provide not only better value for money, but improved evergreen resilient IT services, mitigating risks of failure, technical obsolescence and functional capability gaps.

The table below lists our IT strategy initiatives for AMP7

Theme	Initiative
Business optimisation	Month end automation; journal management; invoice scanning; cash management; fixed asset management; budget management software; automated control technology-intelligent process automation; model office; asset unit costs system; LIMS; single enterprise works and asset management; CMOS changes; automated planning and scheduling for field; insurance claims management system; corporate risk management; corporate governance tools
Data	Data segmentation and personalisation; financial intelligence; upgrade or re-implementation of Oracle Enter; migration of Oracle SOA to Oracle SOA as a service; data management and business intelligence; enterprise information programme; ETL enhancements; radiators screens; GIS data quality and GPS location of valves; situational awareness; integration of 3rd party systems with AIC; NEDs-3;
Innovation	R&D; IoT; new Intranet; drone technology; BIM; augmented reality visualisation for field
Customer	Website enhancement; smart leak reporting; customer education; augmented reality for community; multi-channel service solution/CRM,
Resilience	Network and telephony strategy; IT assets configuration management; automation – monitoring, IASS, failover, releases; facial recognition technology; application performance monitoring; information and cyber security; works management system;

Table 7-3 IT Strategy Initiatives

7.4 Spend to save

Our Plan is underpinned by ambitious efficiency savings targeted at processes we use to deliver projects, procure goods and services and operate in our communities. We plan to realise efficiencies early in AMP7 for maximum benefit throughout the period. There is a need for upfront capital funding to 'unlock' efficiency savings to the benefit of customers and stakeholders.

7.5 Business improvement totex summary

Programme	Description	Key deliverables and activities	Capex (£m)	Incremental operating costs (£m)	Contributions (£m)	Totex (£m)
Business Improvements						
Business Planning						
Water resources feasibility	Technical studies for long-term strategic water resources infrastructure	Feasibilty studies to •understand engineering challenges •understand whether new abstractions are sustainable •improve option feasibility and cost ahead of WRMP24	5.00	0.00	0.00	5.00
Water resources South East	Assessment of water supply strategic opportunities in South East England	Affinity Water share of new regional scheme	1.55	0.00	0.00	1.55
Business Plan	Preparation of business plan	•Detailed customer engagement and consultation •Evaluation of capital maintenance activities •Completion of regulatory requirements •Financial modelling •Developing PCs and ODIs	4.60	0.00	0.00	4.60
Water Resources Management Plan	Preparation of WRMP	•Engagement •Public consultation •Statement of response •Public enquiry	7.00	0.00	0.00	7.00
Drought Management Plan	Preparation of drought management plan	activities required to prepare plan	0.25	0.00	0.00	0.25
					Business planning sub-total:	18.40
IT						

IT Infrastructure Maintenance	Baseline investment to maintain IT infrastructure	Investment required to ensurecontinuity of services for •End User Computing (EUC) •Applications •Data base technology register •Core infrastructure •Networking and telephony	8.32	0.00	0.00	8.32
IT Strategy	Essential enhancements for the improvements of our operations	IT strategy initiatives focusing on •Business optimisation •Data •Innovation •Customer •Resilience	12.00	0.00	0.00	12.00
LIMS	Expenditure required for the LIMS	Licence fee for the LIMS system	0.10	0.72	0.00	0.82
					IT sub-total:	21.14
Spend to save						
Spend to save	Upfront capital funding to unlock efficiencies	Targeted expenditure to deliver efficiency savings	10.00	0.00	0.00	10.00
					Spend to save sub-total:	10.00
					Business improvements total:	**49.54**

8 Methodology and assurance

8.1 Historical expenditure and performance

8.1.1 Overview

This section presents the historical expenditure on capital maintenance and presents this in context with the reported performance across the relevant service measures. We also present case studies, for non-infrastructure and infrastructure assets, which show examples where we have improved our effectiveness in managing our assets, improving serviceability and delivering service and value to customers.

The information presented in the following sub-sections is reported in our annual returns and, apart from bursts, represents all regions (Affinity Water Central, East and Southeast).

Our capital expenditure is mainly driven by our customer outcomes:

- Supplying high quality water you can trust.
- Making sure you have enough water, while leaving more water in the environment.
- Providing a great service that you value.
- Minimising disruption to you and your community.

Achievement against these measures is indicated by:

- Bursts
- Pressure
- Water quality compliance
- Interruptions to supply
- Leakage

8.1.2 Past serviceability and expenditure

8.1.2.1 Service measures

This sub-section presents historical data from our June/Annual returns for service measures that are directly influenced by asset performance. It is these measures that provide the impetus for maintenance and particularly capital maintenance expenditure.

8.1.2.1.1 Bursts

Our Central Region has one of the industry's highest burst rates due to the age of the network and the aggressive pipe environment. The following graph presents the trend in reported bursts since 1991. The changes from year to year are subject to significant annual variation due to largely climatic influences (Figure 8-1), but the trend over several years is influenced by the quantity and effectiveness of capital maintenance expenditure.

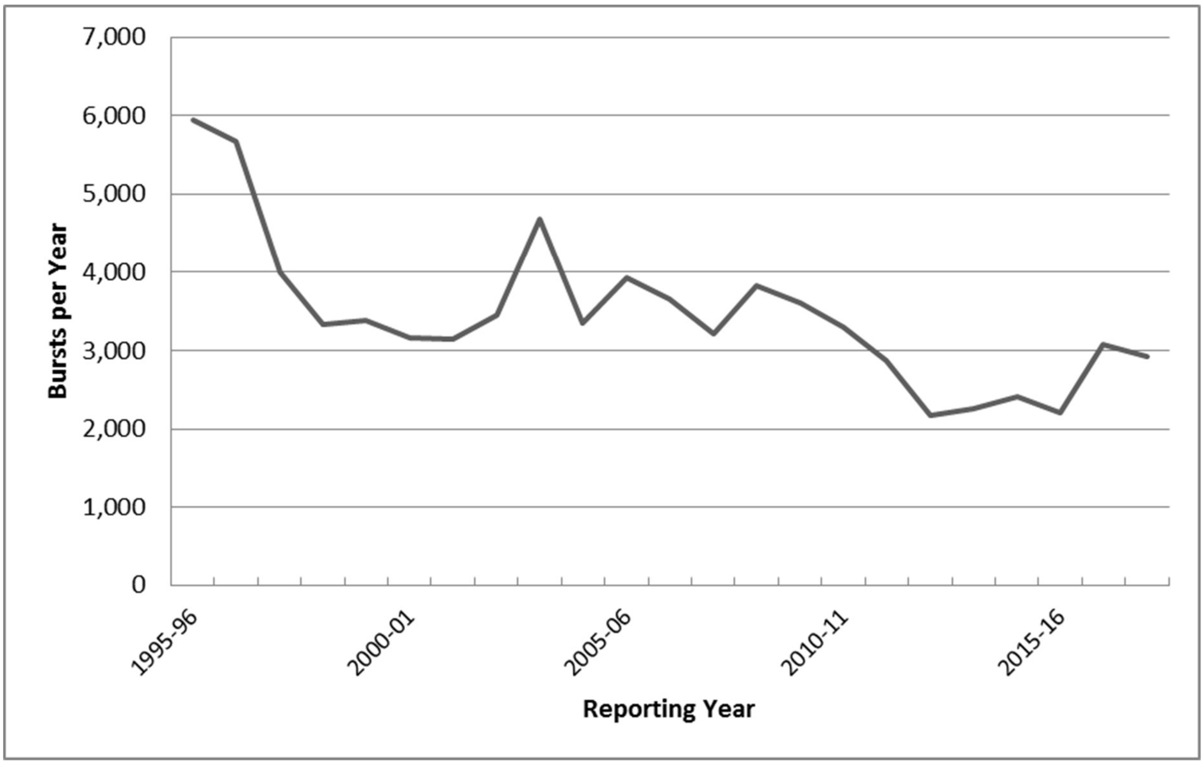

Figure 8-1 Affinity Water Central Region Reported Bursts

Against the background of very modest asset renewals during AMP1 and AMP2 our assets were seen to be deteriorating in AMP3 and AMP4, where OFWAT considered our infrastructure serviceability to be either deteriorating or marginal. This situation has since been addressed by an increased mains renewal programme for AMPs 4 and 5, with a shift in emphasis to trunk main renewal in AMP6, but still at the increased level of investment. Consecutive benign weather years (no extremes) in 2014/15 and 2016/17 helped to reduce bursts significantly below our PC target. The winter of 2016/17 was severe in relative terms, but burst levels remained below target. The winter of 2017/8 was again colder than average with an extended cold snap in March 2018 (the Beast from the East), with six consecutive days of below zero temperatures producing a burst outbreak, but the overall burst levels remained below target.

8.1.2.1.2 Pressure

Our performance with respect to pressure at customers' taps (DG2) is shown in Figure 8-2. We plan to return DG2 properties on the register to below 100 for 2018/19. For PR19 we are introducing a company specific ODI for pressure which reflects more closely our customers' issues and uses an extended network of loggers in all our DMAs.

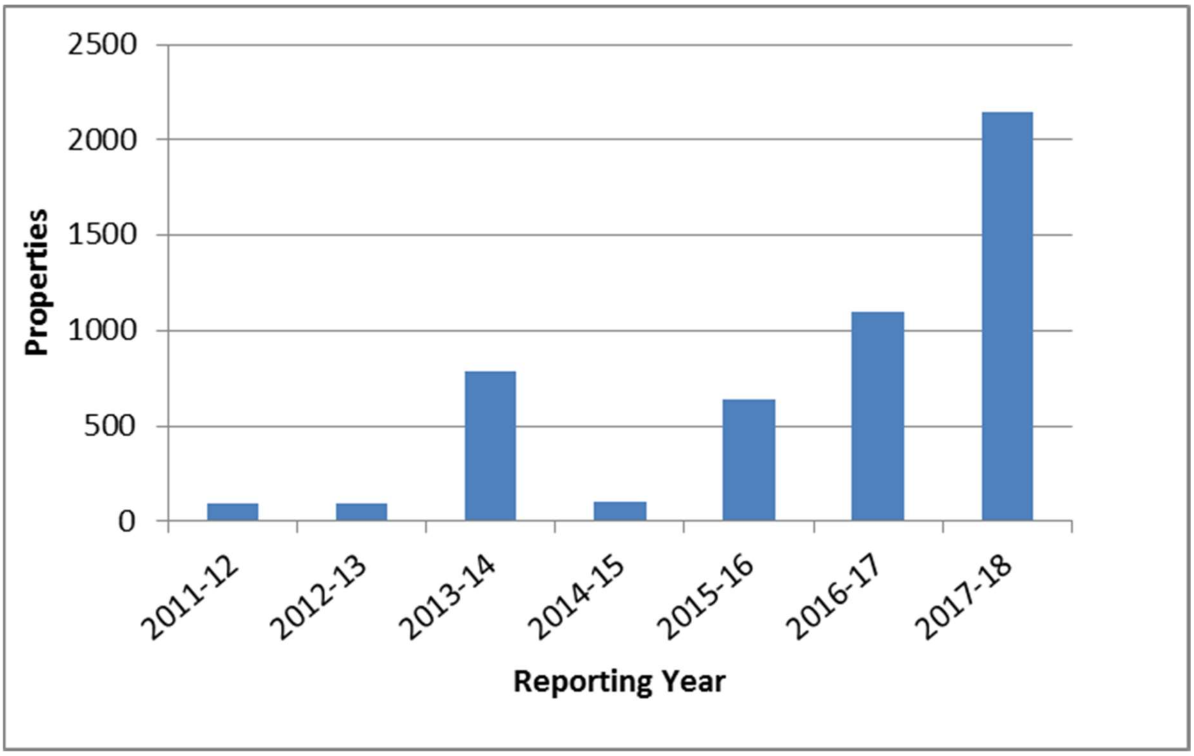

Figure 8-2 Our DG2 Performance

8.1.2.1.3 Customer interruptions

Figure 8-3 presents our performance with respect to disruption to customers' water supplies for periods greater than 12 hours over the last 14 years.

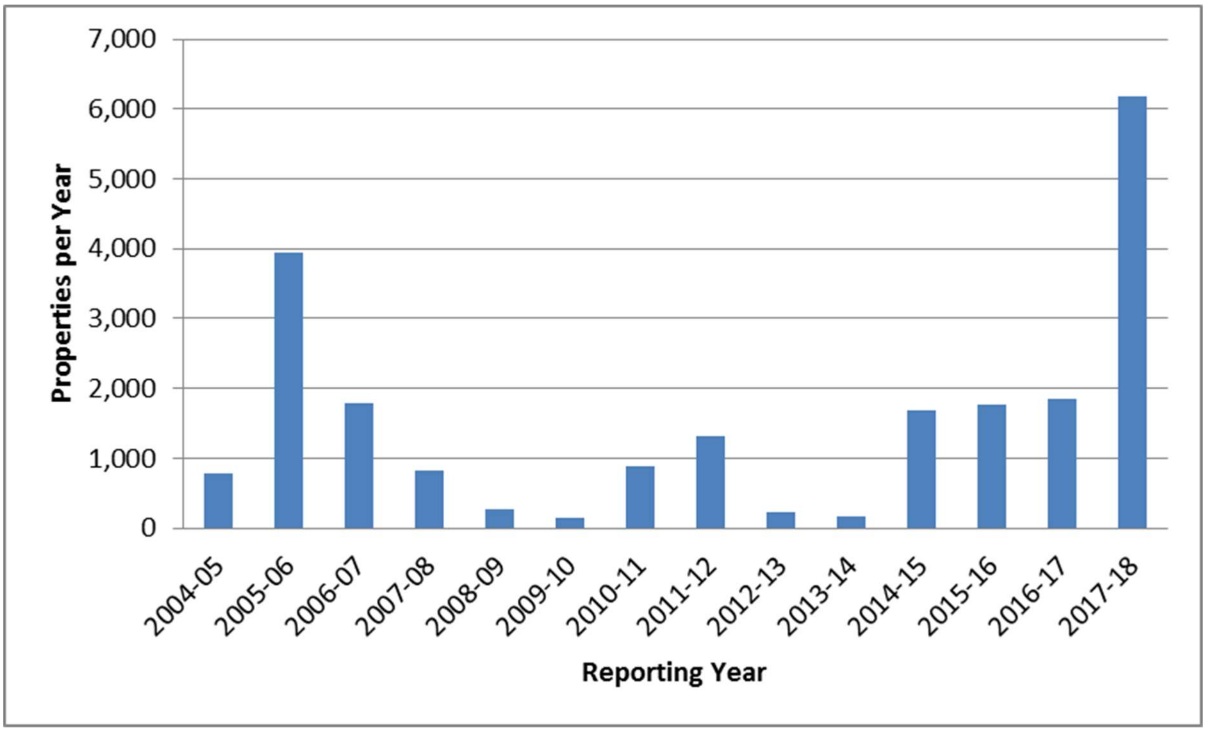

Figure 8-3 Properties Interrupted over 12 hours

This measure is highly variable from year to year and nearly always driven by major trunk mains failures that affect many customers, on the rare occasions that they occur. The following graph shows in more detail our performance for 2017/18, mapping interruptions >12hrs against significant events (defined as those >500 property hours). We can see our performance on the interruptions ODI was associated with three events all caused by trunk main failure, where issues with our response meant customers were without water for extended periods of time.

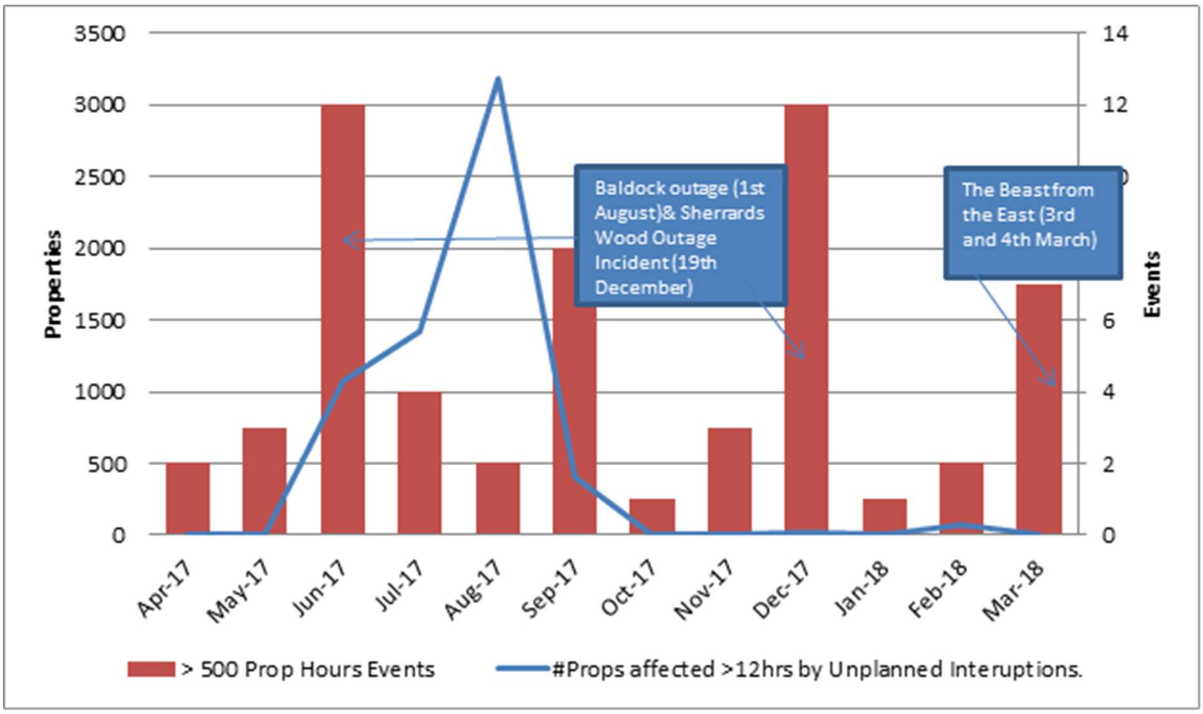

Figure 8-4 Interruptions greater than 12 hours performance

Since November 2017 we have put in place measures such as a 24/7 network desk in our control room, improved control and support of our network teams and a wider array of equipment for minimising disruption when repairing and restoring supplies during repairs.

8.1.2.1.4 Leakage

Our leakage performance is shown in Figure 8-5 below; it is particularly sensitive to climatic influences and expenditure on maintenance activity in response to active leakage control initiatives.

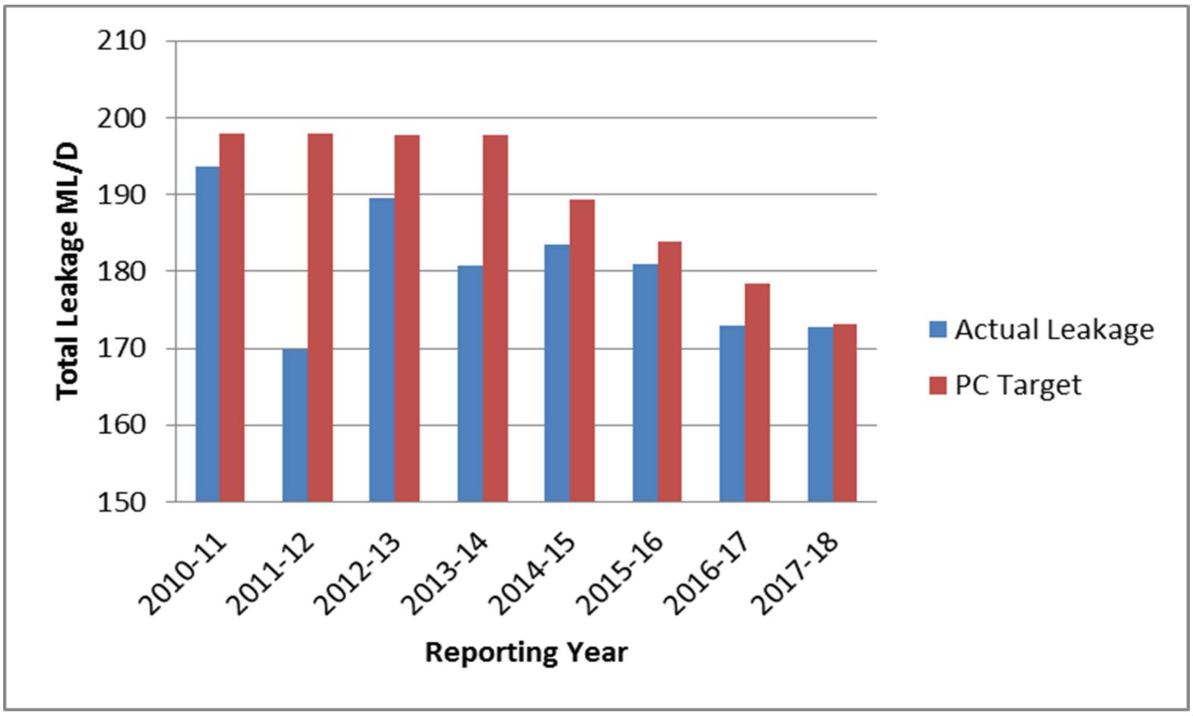

Figure 8-5 Reported Leakage against PC

We have maintained good progress against our ambitious leakage target for AMP6 and in readiness for AMP7.

8.1.2.1.5 Customers' water quality

Figure 8-6 presented below illustrates our performance in delivering water of the highest quality to our customers.

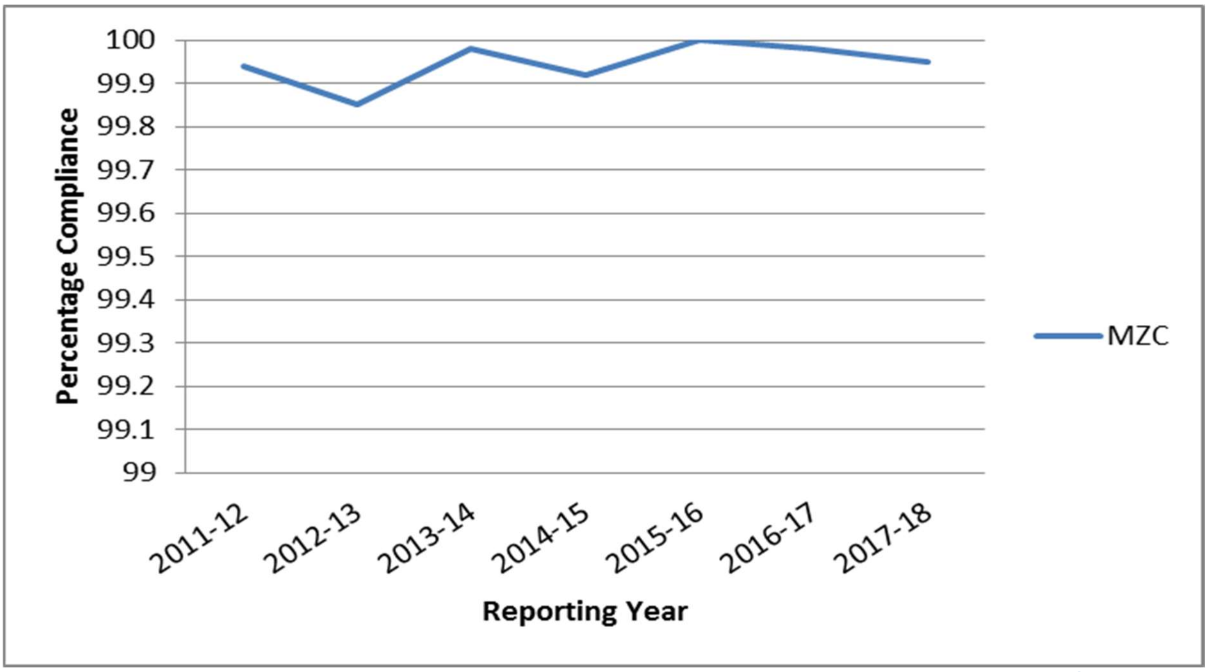

Figure 8-6 Mean Zonal Compliance

The mean zonal compliance results represent a measure of performance across a suite of 39 different measures of water quality and therefore represent a comprehensive picture of overall quality.

Below is a table of our key drinking water quality metrics (Table 8-1), which include the distribution maintenance index, a measure of the health and cleanliness of the distribution network. The measure comprises a number of aesthetic water quality parameters which customers are particularly sensitive. Performance against this measure drives our mains flushing programme.

We consistently meet the very high standards of water supply generally seen across the UK water industry. Individual measures reported by the DWI confirm the high degree of compliance; see the table below from 2015, the figures of which are taken from the DWI London report for 2018 for our company[1].

	Our Performance			Industry Average
	2014	2015	2016	2016
Overall drinking water quality – water treatment				
Process control index	>99.99%	99.99%	100%	> 99.99%
Disinfection index	>99.99%	99.99%	>99.99%	99.99%
Distribution systems				
Distribution maintenance index	99.96%	99.99%	99.99%	99.92%
Reservoir integrity index	99.98%	99.97%	99.94%	99.97%
Building water systems				
Parameters influenced by domestic water systems	99.88%	99.94%	99.81%	99.85%

Table 8-1 Drinking Water Quality Summary Data

This high degree of compliance is reflected in the numbers of times customers feel the need to contact us for general enquiries (fluoride, water hardness, water quality report or other information) or specific aesthetic complaints (appearance, taste and odour). This is highlighted in Table 8-2.

	Our Performance			Industry average
	2015	2016	2017	2017
Customer enquiries (general questions)				
Total number	1,689	1,111	992	N/A
Rate per 1,000 population	0.47	0.31	0.27	1.42
Acceptability of water to customers (Appearance, taste and odour complaints)				
Total number	3,350	3,339	2,925	N/A
Rate per 1000 population	0.92	0.92	0.78	1.35

Table 8-2 Customer Contacts

We plan to maintain this high level of service for customers, and in-line with mandatory requirements, whilst keeping outage levels at treatment plants low to maintain plant availability and 100% Source Output Sustainability Index (SOSI).

8.1.2.2 Expenditure

Figure 8-7 below illustrates the historic and forecast AMP6 capital investment levels for all our assets in 2017/18 prices. The data covers the following aspects of our investment portfolio:

Non-Infrastructure

- Process equipment replacement (ozone, pesticide, nitrate removal etc.)
- Pump replacement and capital maintenance
- Reservoir inspection and construction

Infrastructure

- Leakage and pressure management
- Mains and trunk main renewals
- Pipe ancillaries replacement (communications pipes, stop taps etc.)

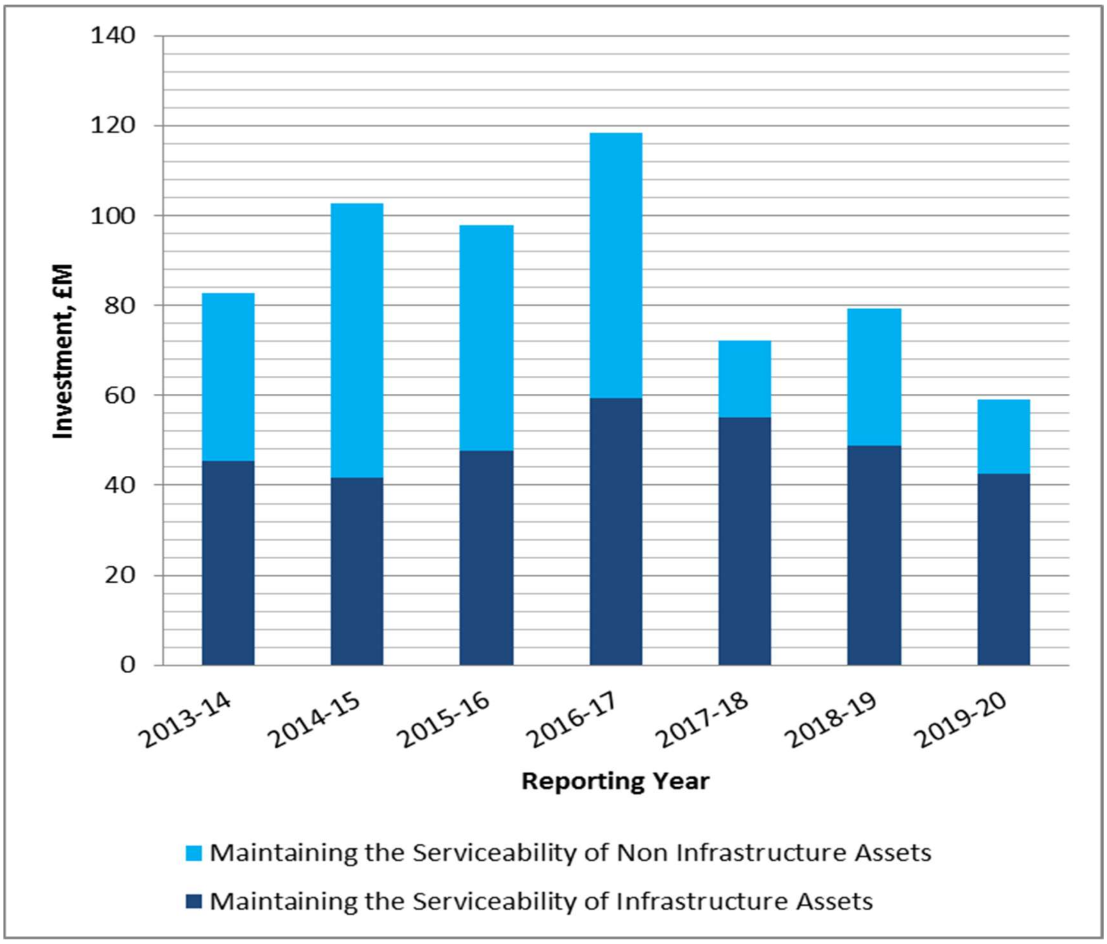

Figure 8-7 Historic and Current AMP6 Capital Maintenance Investment

8.1.2.3 Mains renewals

The burst performance for our central region illustrated in Figure 8-8 below shows the period since 2007-08 and the associated mains renewal activity over the same period; we do not have complete data sets for the East and Southeast regions however, these two regions combined, contribute to only five per cent of our bursts in any year.

The graph shows our success in reducing the numbers of mains failures until 2016/17 when severe weather increased numbers, but we remained under our PC. This is directly due to the general increase in mains renewal activity since 2006/07, together with our methods for targeting which mains to renew.

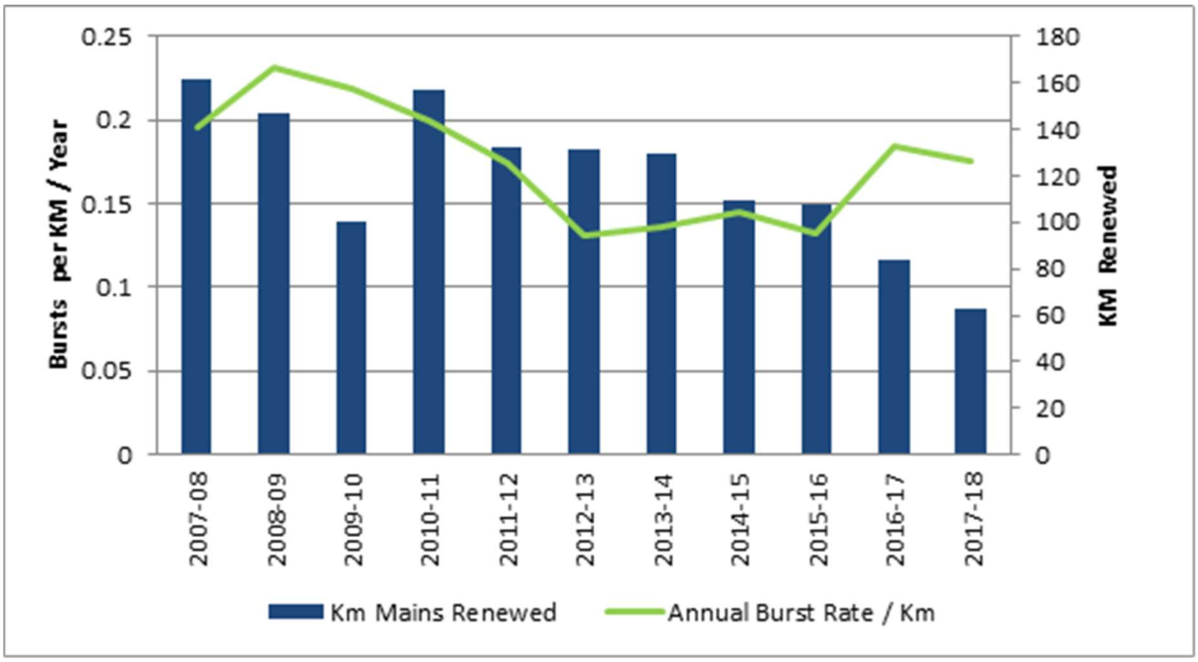

Figure 8-8 Trend in Burst Rate for Our Central Region

Our AMP6 programme of renewal was reduced to offset an increase in expenditure on trunk mains for the period.

We continuously review the performance of the mains renewal programme to assess the effects that expenditure has on bursts, network repairs and leakage. The information we collect has been used in the UKWIR research project "Assessing the impact of a burst driven mains renewal programme on leakage control effort", a project proposed us. We are now using the model produced to further establish the benefits already seen from our own previous analysis.

A review of bursts in 2016/17 following two benign years and highlighted by the winter breakout shows the following:

Pipes with bursts in the previous 5 years	Number of bursts	% of 2016/17 total
0	2,248	76%
1	458	16%
2	156	5%
3	40	1%
4	29	1%
>4	33	1%

Table 8-3 Review of 2016/17 bursts

Observations:

- 76% of pipes that burst in 2016/17 had no burst history in the previous five years making it difficult to predict bursts based on recent burst rate.

- Only 2% of pipes had experienced >3 bursts over the last five years and on 43km of pipes. Only 62 bursts occurred on these pipes with a propensity to burst. They also occurred on 27% of the cohort of pipes that had three or more historical bursts. This means that if we had accelerated the renewals programme based on burst history to try to reduce the burst rate for the year, we would only have had a 1 in 4 chance of reducing bursts by 2%.
- This means that our probabilistic approach to targeting, backed up by burst history and pipe sampling over a long period is the best solution and small adjustments to mains renewal targeting make little difference.

Our overall targeting methodology remains robust and will be used in AMP7 when a further reduced programme is planned to offset a continued increase in trunk main expenditure.

Planned and unplanned maintenance

Figure 8-9 shows our historic expenditure on infrastructure and non-infrastructure maintenance. This includes our opex expenditure on network and treatment asset maintenance, as described below: This includes our opex expenditure on network and treatment asset maintenance, as described below:

- Production sites expenditure includes (but not limited to) the planned and unplanned mechanical, electrical and ICA maintenance of treatment and storage assets, the maintenance of treatment/ chemical equipment and civil structures (reservoirs, treatment buildings)
- Network maintenance includes repairs and response to bursts, leakage detection and repairs, responding to customer queries (stop taps, water quality, leakage, pressure), isolation of mains, valve operations and recovery of supply to customers.

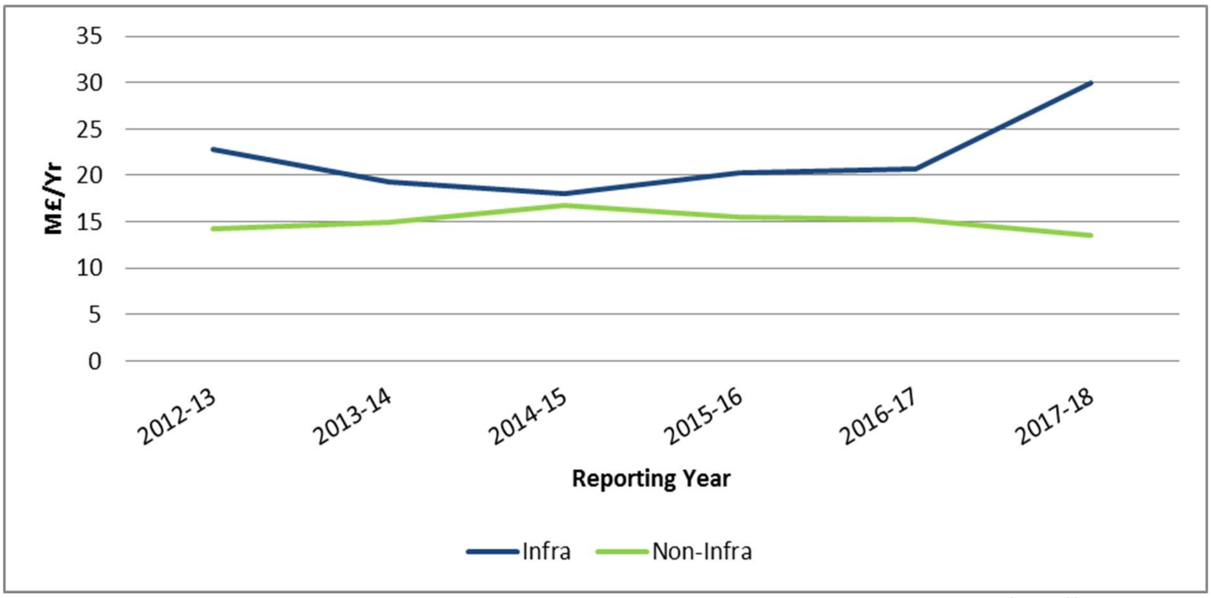

Figure 8-9 Trends in Annual Maintenance Expenditure for Affinity Water

The increase in cost over the last financial year is attributed to increased efforts required to meet our ambitious leakage target.

Expenditure on non-infrastructure assets is stable in AMP6, following a period of slight increase in 2014/15. We have improved the serviceability of our treatment and production assets through the asset care programme, which has resulted in a predictable and more stable maintenance environment where proactive work reduces reactive callouts. The graph below illustrates our improvements and a 32% reduction in reactive callouts for plant outages from a peak of around 2,350 in 2013/14, down to about 1,830 in 2017/18.

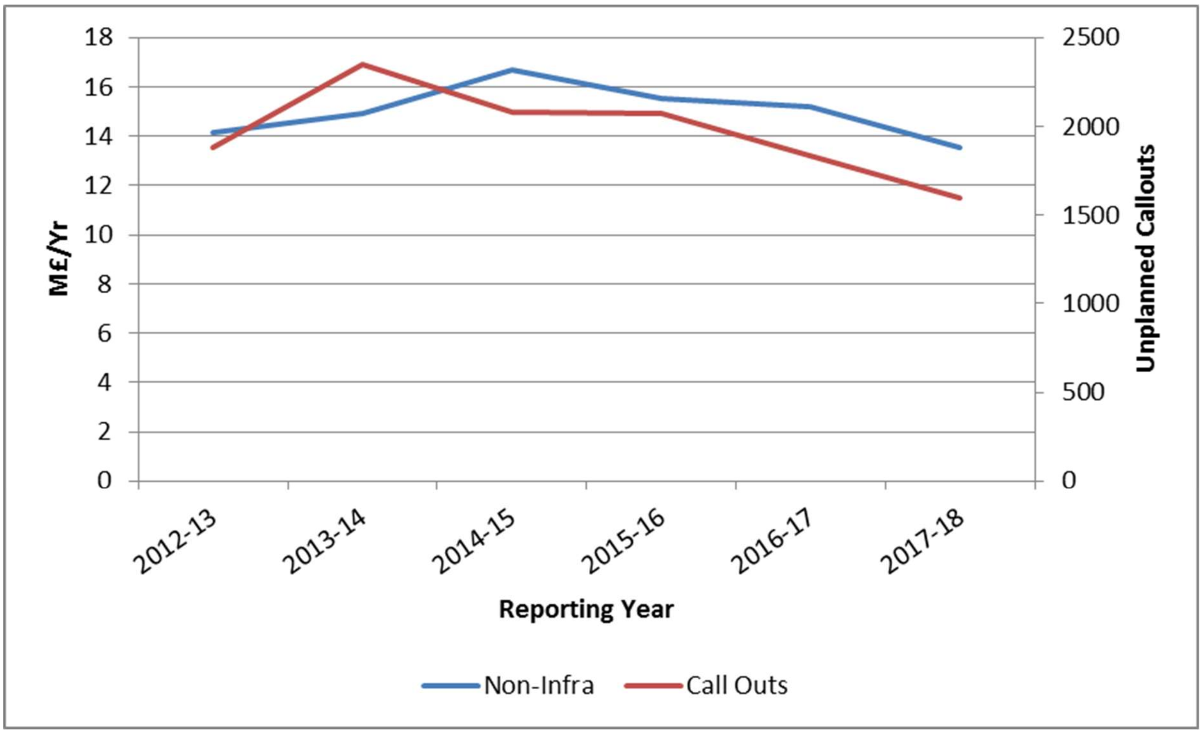

Figure 8-10 Trends in Annual Maintenance Expenditure

8.2 Costs and estimates

8.2.1 Overview

This section sets out the various methodologies applied to produce the accurate unit costs we have used in our Business Plan. We aim to meet Ofwat's key tests on costs, aligned with delivering our proposed work programmes and outcomes for customers. We describe how we have derived the unit costs that were used to forecast our future expenditure. These costs are predominately capital expenditure (capex), but also cover operating expenditure (opex) where related to investment decisions. This includes full coverage of operational maintenance costs for our production and network assets, energy, service impact, environmental and social costs.

The unit costs and cost curve coefficients were uploaded and used within our portfolio optimisation application (*Proactive Investment Optimisation by Evaluating Expenditure and Risk* - **PIONEER**) for deriving expenditure on asset interventions and schemes. The PIONEER costs are a product of unit cost models reflecting their size and single unit rates for some items. New development programme costs and various metering strategies are also covered in this section.

In cases where bottom-up cost estimates are used for specific schemes, then reference is made to the business cases that support these cost estimates. The resulting costs were all analysed and reviewed to make sure they were aligned with our existing contractual frameworks, were reasonable and covered the scope of investments, with high confidence where proposed investments are material.

A dynamic and well-structured approach has been followed in preparing and producing the costs and estimates for our Business Plan to ensure it is competitive, and meets management objectives and regulatory demands. We have:
Analysed and utilised final account project costs from AMP5 and AMP6 rebased to financial year 2017 /18 to derive unit costs where applicable.

- Carried out various benchmarking exercises to ensure that costs produced align with existing framework contracts, especially for work(s) where the contractors have changed and accessible outturn cost data largely covers historic frameworks.
- Calculated all on-costs, overheads and management fees from first principles using actual corporate finance data, whilst assuming levels of efficiency within our current operating model.
- Used applicable market rates in cases of insufficient cost data for some non-infrastructure assets.
- Used costs to build over 260 cost models, estimate over 12,000 individual unit costs and derive various cost curve formulae used to price the various elements of our Business Plan.
- Built up costs from bottom-up estimates where the unit cost methods of cost estimating are not appropriate, and aligned them to actual costs where practicable and in some cases sought new / alternative market rates.
- Have had our costs independently audited and benchmarked by Atkins Limited and PricewaterhouseCoopers (PwC) with their due diligence and risk report provided to our Board and the CCG.
- Carried out robust peer review and technical challenge sessions to continually review and revise costs through a rigorous internal assurance process with at least two levels of review to ensure consistency of approach and finalised costs.
- Undertaken the work internally through our Asset Strategy team; and overseen by our Commercial Director throughout, providing independent challenge and guidance.

The following asset groups are covered in this section:
Infrastructure

- Capex unit costs for combinations of main laying techniques, urbanicity, diameter and surface type (with and without communication pipes and overlander costs)
- Capex unit costs for ancillary assets such as air valves, district meters, ferrules, fire hydrants, sluice valves, stop tap, washouts etc.
- Capex unit costs for metering
- The costs of Developer Services mains, communication pipes and meters including contributions
- Repair and maintenance costs for network operations

Non-infrastructure

- Capex unit cost curve functions and bespoke item costs for buildings, production, telemetry, health and safety assets
- Capex unit costs for security items such as alarm systems, barriers, doors, fences and gates
- Capex unit costs for different metering strategies and programmes (universal, optant, retrofit, new and replacement)
- Energy unit costs and future price increases
- Production asset operational maintenance costs

General

- Carbon, environmental and social footprint and unit costs for infrastructure and non-infrastructure assets
- Service measure and consequential costs

Confidence and accuracy ratings are assigned to the source data used in the cost modelling. This includes a qualitative evaluation of the data to ensure that selected cost sources are within acceptable risk tolerances to guarantee accurate future cost forecasts. Examples of a high rating include company specific information/out-turn costs. A medium rating may indicate there is a perceived moderate risk of data entry issues or a smaller sample size. A low rating would indicate that the information is not company specific and may rely on several assumptions being made. It could also indicate a small sample size being used.

8.2.2 Capital expenditure infrastructure assets

8.2.2.1 Distribution mains capex unit costs

8.2.2.1.1 Overview, purpose and scope

The process adopted to derive the capex unit cost per metre for the construction and installation of distribution mains pipe (DMP) less than 300 mm diameter is explained in this section. The costs are representative capex unit rates for mains renewal schemes to be carried out by us as part of our AMP7 capital programme. A similar methodology was also used to calculate the costs associated with mains laying with communication pipes (CPs) and stop taps.

The process was completed by analysing information on projects completed in AMP5 and AMP6 and the latest applicable contractual rates. The unit rates represent an all-in cost and as such allows for all expenses which are expected to be incurred by the business in the delivery of the assets. The price base used is Financial Year (FY) 17/18.
The purpose of this section is to summarise the process implemented and highlight the key sources of data used in the creation of the unit costs.

8.2.2.1.2 Process map

The diagram below illustrates the process for determining distribution mains replacement unit costs.

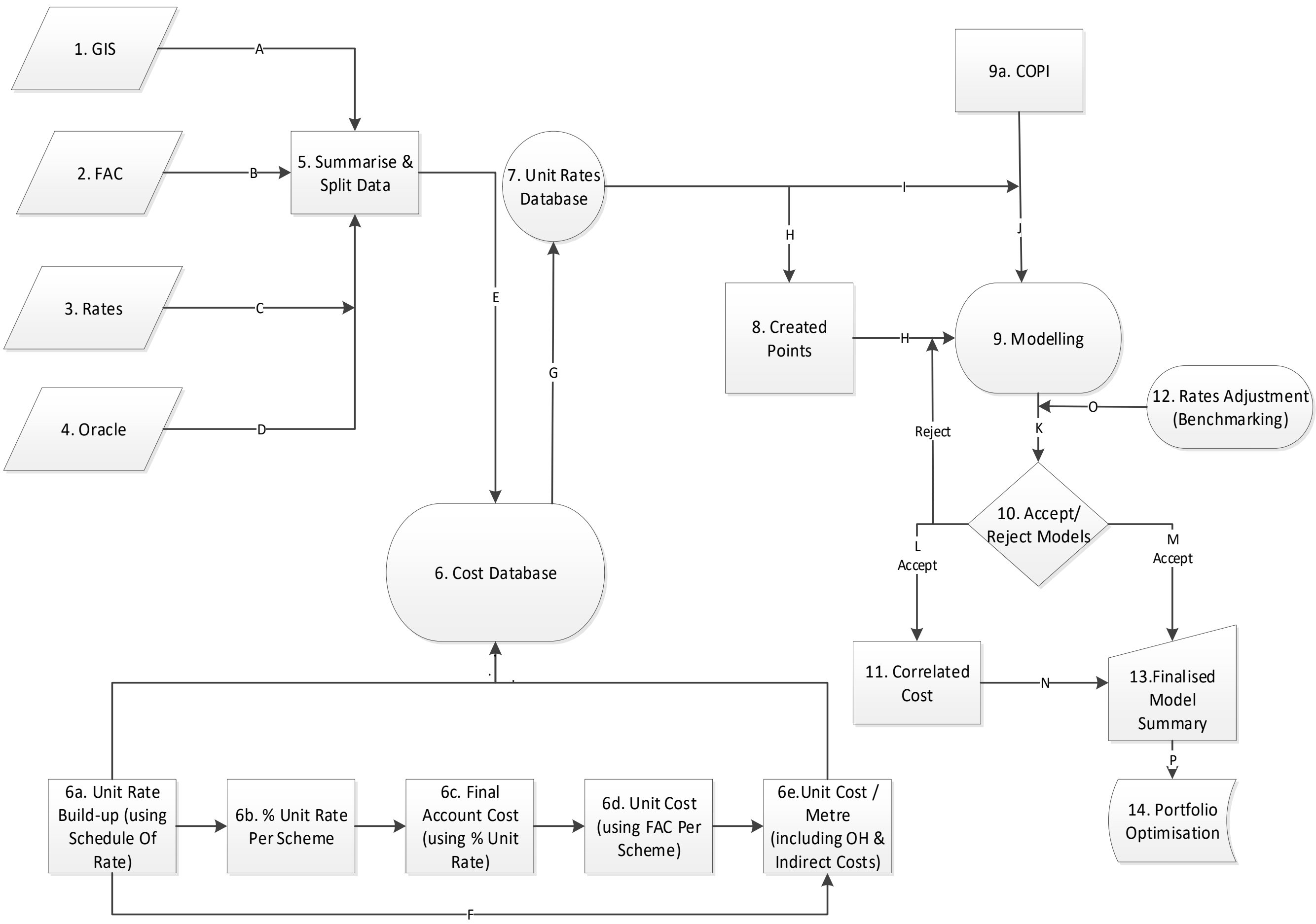

Figure 8-11 Distribution mains renewal costs model process

Source: Affinity Water

8.2.2.1.3 Commentary

This section provides commentary on the above methodology diagram (Figure 8-11) by reference to the appropriate annotations and data flow adopted. We use actual costs from completed contracts benchmarked against our recently adopted main laying contractual framework to derive applicable unit rates for our AMP7 renewal strategy[41].

1. GIS (Geographical Information System)

Physical attributes on distribution mains schemes were obtained directly from our Geographic Information System (GIS). The information comprised construction date, construction technique, length (m) of mains, nominal size of mains laid, pipeline manufacturer, pipeline material, project name, scheme number, street name, surface type, survey date and urbanicity. Information was sourced for each scheme and project which had reached final account during AMP5 and AMP6. This information was used to calculate the weighting of mains in different construction techniques, surface types, urbanicity and these weights were then applied to the various mains laying contract rates.

a] Physical attribute data transferred in the form of a GIS report workbook

2. and b] Final Account Certificates (FAC)

FACs of each completed scheme and project considered as part of the cost assessment exercise were obtained for review and processing. These were provided by our Asset Delivery Team and show agreed milestones and finalised cost for schemes and projects (collection of schemes).

3. and c] Contractual rates

Contractual framework schedule of rates for schemes and projects evaluated, were collated as part of the cost methodology. This is needed to achieve a bottom-up cost approach to initially price schemes to work-out their percentage contribution to a common project. Each scheme's contribution is then matched to the project finalised costs from the FACs to determine the scheme level final account costs.

4. and d] Oracle reports

Framework management fees and corporate overheads[42] (asset delivery, management, procurement and wholesale operations) recorded in their various cost centres were extracted from the finance Oracle reports. These costs were then compared with the finalised construction costs from FAC and project cost from the Oracle report to accurately establish our indirect and gross project costs. These overhead costs were expressed as percentage uplifts to the derived construction unit rates.

5 and 6. e, f and g] Data consolidation, summary and creation of DMP cost database

The collated data from steps 1 to 4 were validated and analysed to create variables for the formation of the distribution mains cost database. These variables include aggregated contract rates, project costs, indirect costs, scheme and project summaries. The database aims to establish various cost rates per metre based on construction technique, surface type and urbanicity for the cost models. This is used to indicate cost trends and to derive cost functions. Data manipulation techniques were used to summarise the collated data by aggregating the lengths of DMP for each combination of pipe size, material, technique and surface type for given schemes. Costs for various work(s) done within a scheme are derived by multiplying the

[41] *BGA Dataset*

[42] *BGA capex OH calculations*

applicable contract rate (from the agreed schedule of rates) with the total length of the mains for each scheme component that make up a scheme. The various scheme component derived costs were then expressed as a percentage contribution to their specific aggregated project cost (summation of scheme components cost to derive scheme and eventually project costs). The percentage contributions were then applied to the value of their project FAC to deduce the contractor's unit cost per scheme component. The contractor's unit cost is further divided by the length of mains laid per scheme component to derive the unit cost per metre. The derived scheme component costs were summed up to derive the scheme costs and eventually a project cost.

Overhead and indirect costs such as corporate overhead costs, framework management fees and several other indirect costs[43] are derived and expressed as a percentage uplift to the contractor's unit cost. They are added to the derived contractor's unit cost per metre to deduce the gross cost per metre unit rate based on actual costs. These costs form the required database and were subsequently used to create various cost models for further analysis.

7 – 9. h – k] Analysis of uplift factors, unit rate cost models, cost rebase and correlated costs

The contractor's unit cost per metre were individually transferred to their respective cost models to generate cost curves based on common construction technique, surface type and urbanicity. Some cost references were also created from a combination of derived gross cost per metre unit rates and further used to create cost models. This was only done in cases where there are non-existent corresponding actual work(s) for a desired combination construction technique, surface type and urbanicity.

Variations in environment and pipe material are accounted for in the cost models and applied to the contractor's unit costs. An adjustment was made at this stage to rebase all costs to a price base of 2017/18 using Construction Output Price Indices (COPI)[44]. Cost outliers were also identified prior and during the formation of the cost models. They were excluded from the cost plots in the models and investigated for reintegration into the cost modelling. The resulting cost curves allow estimates of consolidated costs based on any work scenarios of diameter, surface type and urbanicity.

10 - 11. and l and m] Review of unit costs and correlated costs

The contents of the DMP unit rates database were reviewed to ensure validity. The accepted cost sources formed the basis for the cost models derived, while the rejected cost sources were reviewed to consider re-integrating them into the cost assessment. Any rate identified as a skewed cost due to non-conformity to the expected cost chronology is regarded as an outlier and subjected to a repeat review at step 9. Not all required work requirements had a corresponding cost based on the accepted cost curves and coefficients derived. In this case, work(s) costs were correlated using the nearest appropriate actual work cost curves.

12 – 13 and n – o] Adjustment to latest contract rates

Owing to a recent change in the main laying framework contractor and introduction of a new framework agreement (MIPSA 2), there were insufficient outturn projects to determine unit costs based on the new contract alone. This required us to use past framework projects to work-up costs and generate initial cost estimates. We initially deduced costs based on past framework agreements, then weight the costs based on a proposed work program to derive a weighted run-rate cost. This deduced run-rate cost was then compared against the actual

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[43] *BGA capex OH calculations*

[44] *Ref to gov website ONS*

MIPSA 2 construction run-rate. Any variance observed as either a downgrade or uplift was applied to the historic costs to derive the final costs.

A benchmark analysis was carried out on our 10-year work programme using the initial cost estimates (steps 1 – 10) to calculate an overall weighted cost per metre, based on our typical mix of work. This run-rate was compared to the actual MIPSA 2 run-rate as constructed and the variance expressed in percentage was applied as an adjustment to the cost assessment from steps 10 to 13[45].

To confirm the rates were representative, the PR14 cost summary was applied to this forecast work mix to also deduce a weighted run-rate per metre. The resulting analysis showed that the weighted run-rate cost derived from the PR14 cost summary was same as the actual outturn run-rate cost from 2012/13. This proved a sufficient and effective comparison tool to align past framework rates to the current contractor rates.

14. and p] Model summary

After the introduction of the MIPSA 2 adjustment, the cost estimates were weighted by the percentage distribution of works carried out in AMP5 and AMP6. This process produces the final weighted costs for DMP's[46]. The validated final rates are summarised by size band in line with the portfolio optimisation requirements and extracted for upload to the portfolio optimisation application (PIONEER).

Data Source	Scope	Date Range	Origin	Accuracy
GIS	Information on scheme / project characteristics of completed work(s)	AMP 5 & 6 Projects	GIS	Medium-High
Contractual Rates	Schedule of rates for the installation of mains based on pipe size, material, urbanicity and technique for all contractors involved in MR schemes.	AMP 5 & 6 Projects	Supplied by Contractors (Amey, Balfour Beatty, Enterprise, Morrison)	High
Final Account Certificates	Agreed final accounts between commercial management and contractor specifying the agreed final value of a scheme / project	AMP 5 & 6 Projects	Asset Delivery and Commercial Team	High
Oracle	Provided breakdown of allocation of costs for various Infrastructure and non-infrastructure projects, framework management and overheads. Used for calculation of uplifts for indirect costs and overheads	FY16/17	Finance Department	Medium-High
Construction Output Price Indices (COPI)	Used to adjust costs to FY17/18	FY14 - 17	Office for National Statistics (ONS)	High
Payment Applications	Breakdown of payment applications and different cost categories for schemes and projects.	AMP 5 & 6	Commercial Management	High

Table 8-4 Distribution mains data sources

[45] *PIONEER output benchmark_BGA*
[46] *PR19 Final Model Summary (MR)*

8.2.2.1.4 Process outputs

P] Finalised costs from the modelling process were summarised and imported into the PIONEER portfolio optimisation process through PIONEER excel add-in functions[47].
For all cost models, a quality grade is provided to give an indication of certainty. This summary score is based on the deviation of data points from the model curve. Each model is categorised, A to E, in accordance with the table below.

Grade	Uncertainty Level
A	The 10% and 90% percentiles (80% confidence level) are within 10% of the mean removed from the mean.
B	The 10% and 90% percentiles (80% confidence level) are within 20% of the mean removed from the mean.
C	The 10% and 90% percentiles (80% confidence level) are within 30% of the mean removed from the mean.
D	The 10% and 90% percentiles (80% confidence level) are within 40% of the mean removed from the mean.
E	The 10% and 90% percentiles (80% confidence level) are within 50% of the mean removed from the mean.

Table 8-5 Data quality grade

These uncertainty values are used within the portfolio optimisation process.

8.2.2.2 Trunk mains capex unit costs

8.2.2.2.1 Overview, purpose and scope

This section describes the methodology to estimate the capex unit cost per metre for the installation of trunk mains, which most times are greater than 300 mm diameter and forms part of our AMP7 capital programme. A summary of the process adopted is explained and the key sources of data used in the creation of the unit costs highlighted.

Information on projects completed in AMP5 and AMP6 were analysed and aligned to the latest applicable contractual rates to forecast the desired costs. The derived unit rates represent an all-in cost and as such allow for all expenses which are expected to be incurred by the business in project delivery[48]. The price base is indexed to 2017/18.

8.2.2.2.2 Process map

The diagram below illustrates the process used in deriving trunk mains replacement unit costs.

[47] *MR finalised cost_PR19*
[48] *PR19 Final Model Summary (TM)*

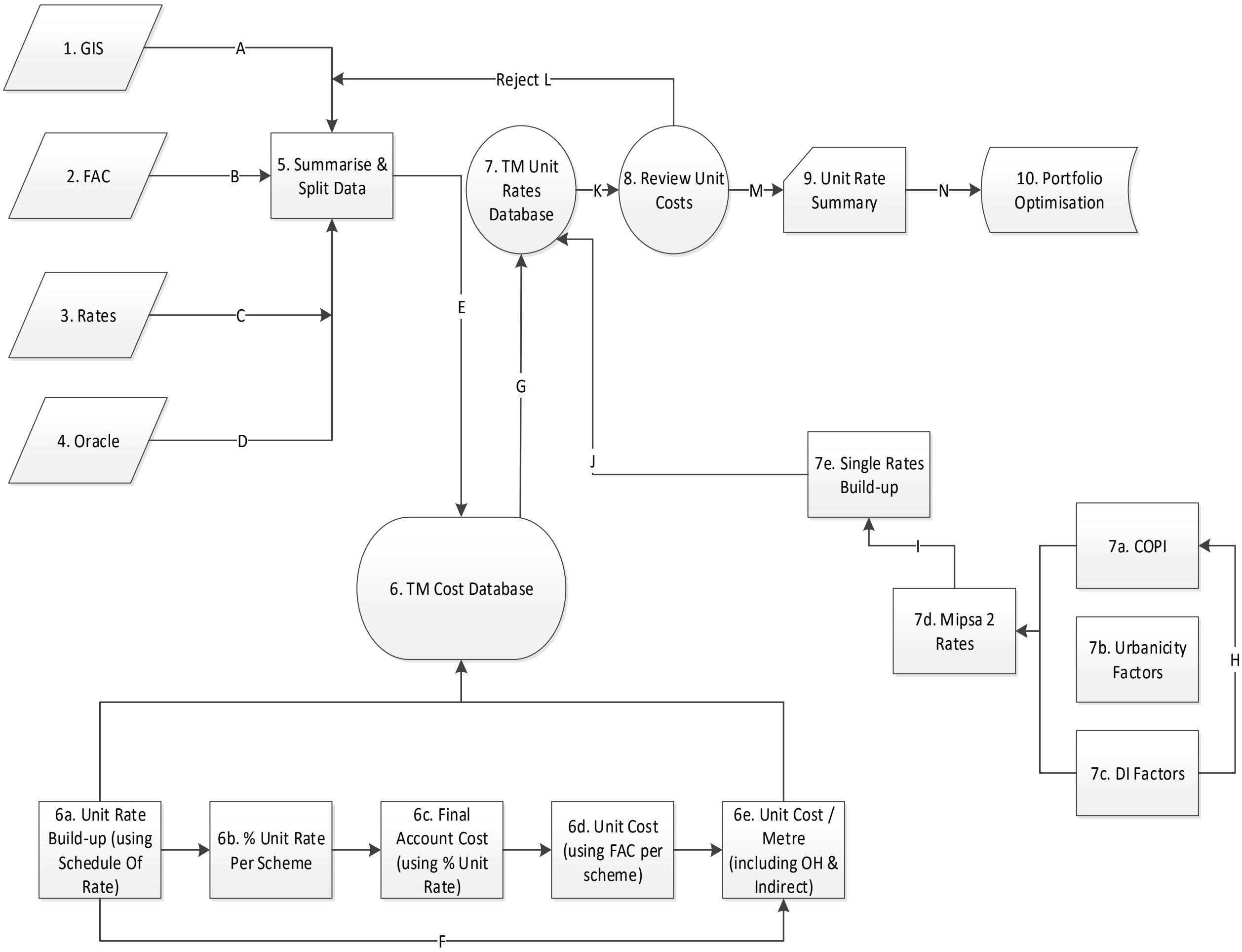

Figure 8-12 Trunk mains unit costs model process

8.2.2.2.3 Commentary

This section provides commentary on the process diagram by reference to the appropriate annotations in the diagram above.

1. and a] GIS

Physical attributes for trunk main schemes were obtained directly from our GIS system. The information comprised construction date, construction technique, length, nominal size of mains laid, pipeline manufacturer, pipeline material, project name, scheme number, street name, surface type, survey date and urbanicity.

Information was sourced for each scheme and project which had reached final account during AMP5 and AMP6. This information was used to calculate the weighting of mains in different urbanicities, surface types, construction techniques and those weights were then applied to the various main laying contract rates to obtain combined rates representative of our work mix. a] Physical attribute data transferred in the form of a GIS report workbook

2. and b] Final Account Certificates (FAC)

Details of select completed trunk mains projects were collated, reviewed and processed as part of the cost assessment exercise. Certificates were provided by the delivery team which showed agreed milestones and finalised costs for schemes and projects.

3. and c] Contractual rates

Historic and the current schedule of rates for trunk mains were obtained from the delivery team and transferred for further processing. These contractual rates are needed to apply a bottom-up approach to estimate project costs for select work(s) identified for the cost modelling. The derived project costs are compared to the actual finalised construction costs and the average variance between both sets of costs is applied to the latest schedule of rates to deduce the forecast costs.

4. and d] Oracle reports

Framework management fees and corporate overheads (asset delivery, management, procurement and wholesale operations) recorded in their various cost centres were extracted from our Oracle reports. These costs were extracted and compared with the FAC and construction cost to accurately establish our indirect and gross project costs. These overhead costs were expressed as percentage uplifts to the derived unit rates.

5, 6. and e - g] Consolidate, summarise and creation of trunk mains database

The collated data from steps 1 to 4 were validated and analysed to create the trunk mains cost database[49]. The database produced a consolidated cost adjustment factor to be used on the current schedule of rates. This factor which is based on the select completed trunk mains projects, is the established variance between the actual project unit costs and the estimated unit costs derived by a bottom-up approach using the applicable contractual rates.

Various unit costs based on construction technique, surface type and urbanicity were derived by multiplying the contract rates from the schedule of rates by the applicable scheme or sub-scheme length. The costs for each scheme or its sub-scheme were then expressed as a percentage of its total project cost. The deduced percentages were multiplied by the actual finalised project costs to derive the contractor's unit cost. This was then divided with the applicable length to derive the contractor's unit cost per metre.

Additional costs such as corporate overhead costs, framework management fees and several other indirect fees[50] are derived and expressed as a percentage uplift to the contractor's unit cost. The various uplifts are then added to the contractor's unit cost per metre to derive a gross cost per metre unit rate, based on actual costs. These costs form the required database needed for further analysis during the cost assessment.

7. h - k] Creation of uplift factors and trunk mains unit rates database

As part of producing the trunk mains unit rates database, various adjustments were analysed, derived and applied to the current schedule of rates to derive the finalised trunk main costs. These adjustments were applied between steps 5 and 6, and include COPI (inflation related), variations in environment and pipe material in relation to various diameter bands.

The costs derived from the adjusted schedule of rates were then further analysed to produce weighted costs based on the mix and type of actual work(s) carried out. The weighted costs per metre were used to produce the trunk mains unit rates database. This database stores costs for various variations in diameter, specifications, surface type and urbanicity, rebased to 2017/18.

8. and m] Review of unit costs

The contents of the trunk mains unit rates database were reviewed to ensure validity. Any rejected rates or outliers were subjected to a repeat review at step 5 [l]. Outliers are identified

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[49] *PR19 Final Model Summary (TM)*

[50] *BGA capex OH calculations*

as skewed costs due to non-conformity to the expected cost chronology or order of established contractual rates.

The verified costs formed the basis for the unit rate summary, while the rejected cost sources were reviewed in view of re-integrating them into the cost assessment or finally rejected.

9. and n] Finalisation and summary
The validated and finalised costs per metre were summarised in line with the portfolio optimisation requirements [m]. A summary file was created and used to upload the finalised costs to the portfolio optimisation package (PIONEER) via an Excel add-in function.

8.2.2.2.4 Sources of data and inputs
The sources of data used for the trunk mains cost assessment are same to those described in table 7.2, which show details of the various data sources, nature and assigned confidence level.

8.2.2.2.5 Process outputs
N] Finalised costs from the modelling process are summarised and imported into the PIONEER portfolio optimisation process through the Excel add-in functions[51].

8.2.2.3 Infrastructure (capex) ancillary costs
8.2.2.3.1 Overview, purpose and scope
A summary of the methodology and data sources used to derive the unit costs for ancillary infrastructure costs will be explained in this section. The derived unit costs represent the forecast rates for ancillary works[52] (i.e. air valves, fire hydrants, network meters, sluice valves, washouts and related chamber / pit works) in AMP7 as part of our maintenance programme. Projects and purchases completed in AMP6 and an internally audited payment schedule were used as the primary source of data for the cost assessment. The costs are rebased to 2017/18 and represent an all-in cost to cover all expenditure anticipated to be incurred in the delivery of the assets. Some of the costs and methodology were calculated from other cost assessment exercises such as the PR19 network maintenance scope and cost.

Process map
The diagram below illustrates the process used to derive the unit costs:

[51] *TM finalised cost_PR19*
[52] *PR19 R&M all cost summary*

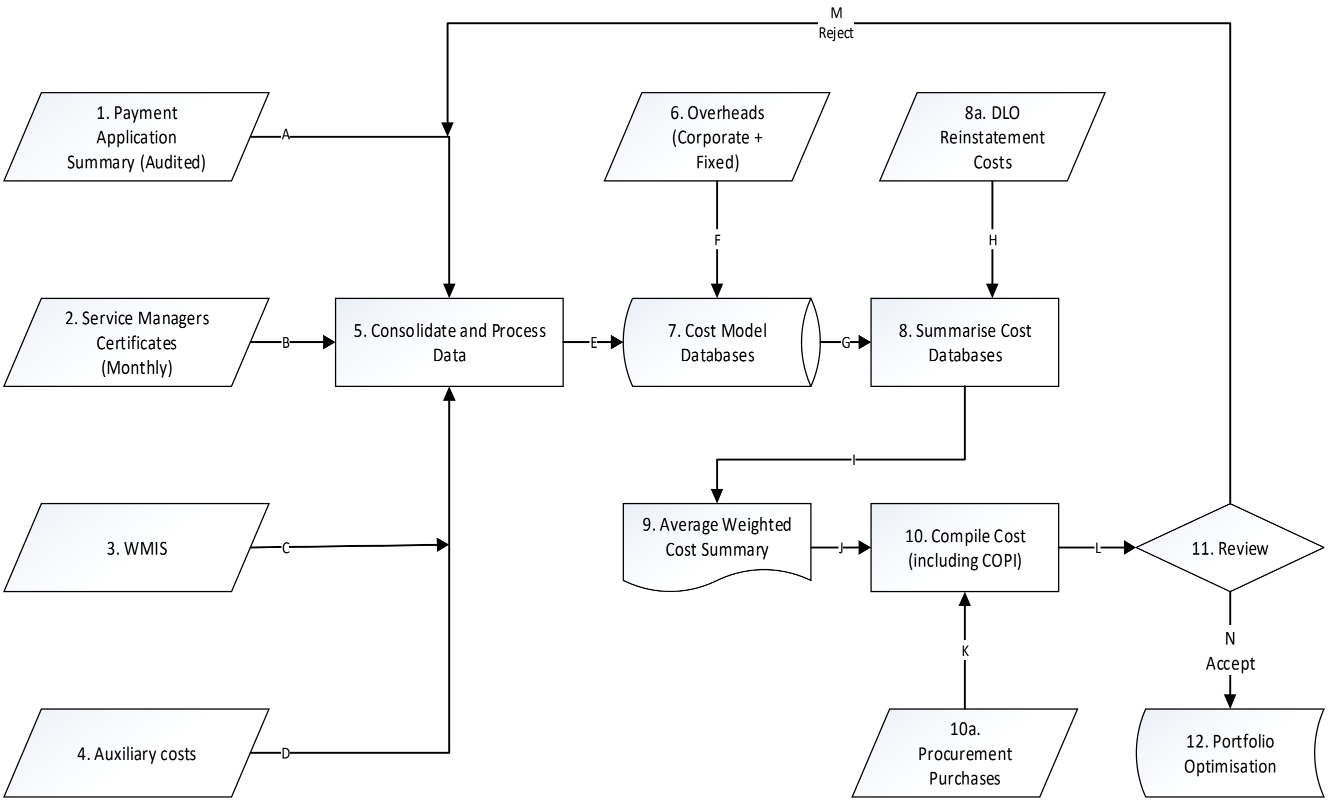

Figure 8-13: Infrastructure ancillary unit cost model process

8.2.2.3.2 Commentary

This section provides commentary on the process diagram by reference to the appropriate annotations.

1. and a] payment application Summary (audited)

A compilation of audited and reconciled payments made for various ancillary works were sourced, comprising of monthly payments made in 2016/17[53].

2. and b] service manager certificates

Works associated with payments collated in the Payment Application Summary are itemised in detail in the service manager certificates. This is a listing of the monthly works carried out for various ancillary, repair and maintenance work packages in 2016/17[54]. This contained information such as Job number, type of work completed and various unreconciled cost claims by the contractors.

3. and c] Works Management Information System (WMIS)

Work details captured in the service manager certificates are initially logged in the Works Management Information System (WMIS). The system contains information on jobs done, location, date and applicable work codes. It should be noted that cost related data is not sourced from this system. Missing data such as work codes for jobs captured in step 2 are sourced from WMIS and matched to the relevant job in the Service Manager Certificates.

4. and d] Auxiliary costs

Auxiliary costs such as management, traffic management, surveyor, plumbing, project management and collateral damage costs were considered and added to the unit cost for the applicable job types. The traffic management costs were matched to the applicable works by

[53] *Payment Application Summary*
[54] *Service Manager Certificates*

WMIS number while the other costs were matched using the applicable job codes or date of work. Traffic management costs are reported as a summarised cost in step ‘a’ while the other costs are reported as part of work data in step ‘b’.

5 - 7. and e - g] Consolidate data, overhead uplifts and cost model database
Data from steps 1 – 4 were consolidated and reconciled with the payment application summary. This ensured that for each of the work packages considered, a work summary consisting of actual job codes, quantities and reconciled monthly costs were captured to derive unit costs for each job. This process led to the creation of various ancillary costs for different job codes and eventually different cost model databases for each of the work packages evaluated.

Fixed and corporate overhead costs were derived specifically for the ancillary, repair and maintenance work packages by our finance team[55]. The data and workbooks are captured within each of the created cost models and added to the unit costs for each corresponding job code.

8 - 9. and I - j] Summarise data and average weighted cost summary database
The various cost models for each of the work packages were sorted and summarised based on activity references and job types and consolidated as a central cost database.

Reinstatement costs for works carried out by our direct labour team (DLO) and reinstated by our contractors were added to the derived unit costs in the central cost database. Both sets of costs are matched using their applicable job codes derived from their cost estimation methodology and weighted individually based on quantity of jobs completed respectively.
Weighted average costs were derived for each job code based on aggregating the quantity of work completed specifically for each code. This weighting was based on the amount of work completed by the different job sub-codes that make up a job code.

The methodology involves summation of the work quantities for all the job sub-codes within a job code and then using this to divide the work quantity for each individual job sub-code. This generated a weighted distribution which has been multiplied by the derived unit costs for each job sub-code, then aggregated to derive a weighted average cost for each job code.

This gives the basis for the final unit costs derived for the individual ancillary, repair and maintenance work packages and the final summarised central cost database.

10. and k – l] Compile costs and procurement purchases
Bespoke costs are derived for a few ancillary items like flowmeter head replacements in a chamber[56]. These tailored costs depend on applying a bottom-up approach in building the cost by integrating costs derived from steps 1 – 9 with single purchases made for various ancillary items.

The derived costs including the bespoke costs provide an accurate unit cost for each job type. Output is a consolidated list of unit rates based on the needs of the business.

11. and n] Cost review
Costs were reviewed and validated to ensure accuracy. Where unit rates were rejected, they were reappraised and adjusted at step 5. Once all rates were considered valid and applicable,

[55] *Corporate overhead calculation M&R only*
[56] *Procurement purchases*

the database was uploaded to the portfolio optimisation package (PIONEER) through the Excel add-in function[57].

8.2.2.3.3 Process outputs

N] Ancillary costs are developed for use in the PIONEER application.

Sources of data and inputs

Data	Scope	Date Range	Origin	Accuracy
Payment Application	Audited and reconciled payments for Ancillary, repair and maintenance work(s)	2016/17	Commercial Team	High
Service Manager Certificates	Listing of work carried out, DLO costs, unreconciled work costs, auxiliary costs such as management, traffic management, surveyor, plumbing, project manager and collateral damage costs.	2016/17	Commercial Team	Medium-High
Works Management Information System (WMIS)	Work management system for update of work details by Technicians	2016/17	WMIS	High
Oracle and Client Assistance Schedule (CAS)	Provided the data used to estimate the fixed and corporate overhead costs	2016/17	Finance Department	High
Procurement purchases	Single item purchases for bespoke cost estimates	2016-2018	Commercial Team	High
Construction Output Price Index (COPI)	Index to enable adjustment to 2017/18 prices	2017/18	Office for National Statistics (ONS)	High
Source: Affinity Water				

Table 8-6 Infrastructure ancillary unit costs data sources

8.2.2.4 Developer Services costs

8.2.2.4.1 Overview, purpose and scope

The information used to define the programme activities and cost for our AMP7 Developer Services (DS) plan will be covered in this section. The activities include construction of new mains and associated service connections, diversions, self-lay mains, local and strategic reinforcements, disconnections and ad-hoc service connections, including contributions received from developers. The primary aim of the DS programme is to satisfy our regulatory obligations to provide water supply connections to new developments and individual properties.

We have used a robust and auditable model to provide the necessary information for the Business Plan table App28 to calculate the net cost required for our proposed AMP7 DS programme[58]. Several data sources were used for the model analysis and they include our Water Resources Management Plan (WRMP) and several of our asset management systems like the Work Management Information System (WMIS) and HiAffinity, our customer service system.

[57] *Finalised cost Ancillary_PR19*
[58] *PR19 DS Initial App28 Calculation v9_mt.xls*

8.2.2.4.2 Commentary

1. Connections work mix ratio

The connections work mix ratio gives an indication of the predicted volumes of connections for our DS programme. It relies on data from several sources to estimate the annual volumes of work, forecast housing growth, including percentage splits of work type and new number of customers

- The record of physical works carried out and percentage splits of work type are extracted from WMIS through Business Objects (BO) reports. The individual annual volumes of work and work volume split (Internal meter only connections, on-site connections and off-site connections) are entered manually into the model.
- The HiAffinity portal provides data on our new customers.
- Our WRMP provides the data for expected housing growth in our supply regions over AMP7.

2. Unit cost analysis

Several unit costs are used in the model to estimate costs associated with various work types. These costs are construction only outturn costs and net of overhead and on-costs. They form the basis of the DS cost database and are used in conjunction with the connections work mix volume in the DS model to calculate our net costs of connections. The variables captured include:

- Unit cost associated with onsite connections as accessed from WMIS.
- The average cost for offsite connections.
- Current internal meter installation charge.
- Length and unit rate of new mains laid**.** This cost is the actual invoice notice sent to customers.
- Unit cost associated with reinforcements and diversions which are based on length of actual diversions and reinforcement works.

3. New mains, diversions, and reinforcement work mix ratio

The forecast length(s) of new mains, reinforcements and diversions for AMP7 were derived from the connections work mix ratio data process. Historic length(s) of new mains, diversions and reinforcements extracted from WMIS are used to calculate the length(s) of work type. The calculated connections work mix is used to forecast the length of diversions and reinforcements as follows:

- Length of new mains laid for every new connection
- Length of diverted mains for every new connection
- Length of reinforcements to existing mains projected for every new connection

The forecast length of new mains, diversions and reinforcements for AMP7 are derived from this process and used in the PR19 DS model as an input variable.

4. PR19 cost model

The PR19 (App28) cost model forms the basis of all cost outputs used to forecast costs associated with our AMP7 programme. It utilises data from steps 1 – 3 by taking the rates derived from the unit cost analysis and multiplies such with the annual volumes of work(s). The annual cost for new connections for each AMP7 activity is derived from onsite and offsite connections. Costs associated with various work types for new mains, diversions and reinforcements are also calculated using a similar method.

5. Overhead calculation

The PR19 DS overhead and on-costs were derived by a bottom-up approach using bespoke assumptions and aggregated costs associated with our core DS project management team and support services for procurement, wholesale operations and corporate on-costs. The derived costs rely on prorated FTE estimates to calculate various costs, including estimates for personnel number count and services associated with network modelling, water quality, design and contractor management fees.

6. Contributions and cost recovery forecast
The following assumptions are used in determining the level of contributions from developers.

- The broad balance between bill paying customers and developers has been maintained in line with our Charging Arrangements for New Connections Services 2018/2019.
- Costs and output are in base year 2017/18 and are forecast according to the change in volumes of connected properties.
- Infrastructure charges for new connections have been prepared in accordance with Ofwat's final rules 'New connections charges for the future - England in November 2017', in that the total value of income offset allowances have been included within our redefined water infrastructure charge.
- The strategic infrastructure programme expenditure is the result of a comprehensive zonal review of the future developments in our operational area and validated against our WRMP forecast.

7. Final data output – Developer Services net costs
The forecast AMP7 Developer Service programme cost is summarised below.

Activity cost	Total Budget (£)
Connections	47,369,000
Strategic infrastructure	30,666,000
Infrastructure	23,176,000
Total	**101,211,000**
Activity contributions	
Connections	47,369,000
Infrastructure charge	10,725,000
Requisition charge	22,769,000
Total	**80,863,000**
Net cost	**20,348,000**

Table 8-7 AMP 7 DS investment budget

8.2.3 Capital expenditure non-infrastructure assets

8.2.3.1 Production capex unit costs

8.2.3.1.1 Overview, purpose and scope

The methodology adopted in deriving the unit costs for the replacement and refurbishment of our production assets is explained in this section. This covers almost 70,000 production assets under 354 asset classifications termed Equipment Group Identifiers (EGI). This encompasses buildings, pumping stations, reservoirs, towers, telemetry systems, water treatment works and sources. The derived unit costs are representative rates for delivering the non-infrastructure assets capital programme in AMP 7.

Verified outturn costs from completed projects were used in deriving the desired unit costs wherever possible. In cases where some information has not been obtained from actual or completed projects, we have used our current framework agreement rates and adjusted to account for various project related and indirect costs. Where actual costs and framework agreements do not suffice, we depended on PR14 estimates inflated by COPI and benchmarked against current market rates to decide the right fit. In limited cases, we have also used asset costs from other available secondary data sources when all other options fail. Depending on the asset attribute (capacity or size classification), the unit costs from the analysis were either plotted in a cost model to derive their cost curve or represented as a single unit cost. Various associated costs such as project related costs, contractor and client on-costs and corporate overheads were also added to the derived costs to represent an all-in cost for the assets concerned. All finalised costs are rebased to 2017/18 using COPI.

The cost coefficients and single unit costs are primarily used in our portfolio optimisation application (PIONEER).

8.2.3.1.2 Process map

Figure 8-14 below shows the annotated modelling process for production asset unit costs

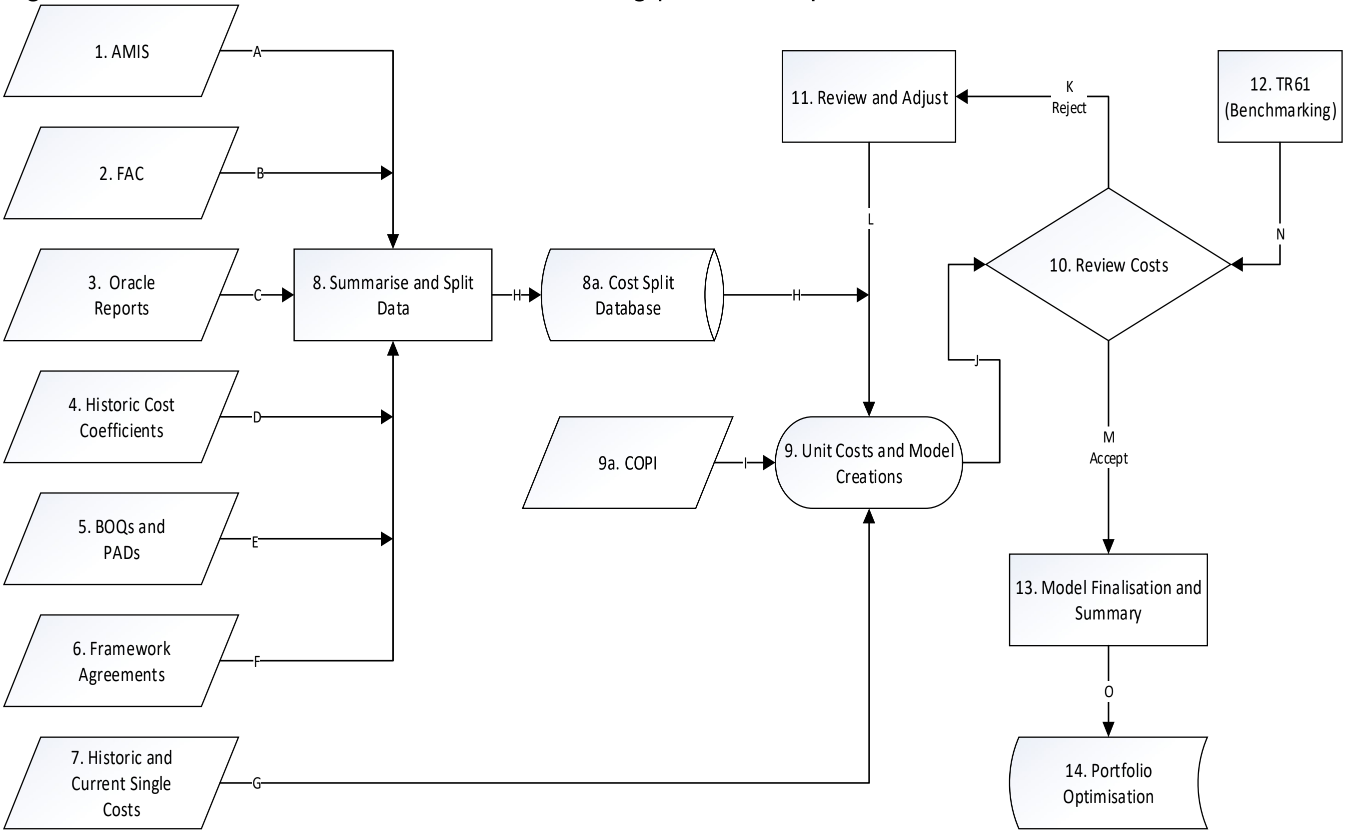

Figure 8-14 Production assets capex unit costs process

8.2.3.1.3 Commentary

This section provides commentary on the process diagram by reference to the appropriate annotations.

1. and a] AMIS (Asset Management Information System)

AMIS is our asset data repository, holding details of all our above ground assets, including active and decommissioned assets. It also captures details on maintenance activities carried out on the assets.

Asset data on projects completed in AMP5 and AMP6 were sourced from AMIS. This contained information such as project numbers aligned to asset types, asset identifiers, installation and commissioning dates, primary and secondary attributes of the asset (e.g. kW, Volts etc.).

2. and b] Final Account Certificate (FAC)
FAC's were used to confirm actual construction payments made to contractors for projects identified as completed from AMIS. They contain cost, project details and actual work carried out.

3. and c] Oracle Report
Data from the Oracle Project Database was used to derive gross project costs and specific asset costs. This data is combined with other data sources, such as specific project costs and AMIS data to derive the desired costs.

Cost data from the Oracle report has been aligned with AMIS asset data through the project numbers to generate asset costs based on the contribution of each asset to the gross project cost. The asset unit rates were largely sourced from the project Bill of Quantity (BOQ) and Project Authorisation Pad (PAD) documents. The asset unit rates were used to 'gauge' their weighting as a proportion of the gross project cost and to ensure that the gross project cost is accounted for in the various project asset unit costs.

The cost adjustments derived include preliminary costs, indirect costs, corporate overhead and management fees[59] [60] [61]. The preliminary costs account for costs incurred prior to construction completion and asset duty operations. This covers costs related to design, supervision, commissioning etc. This cost adjustment is derived by sourcing and analysing available detailed payment applications to establish the percentage that preliminary items represents, against total construction costs.

Indirect costs were established by comparing the difference between the total amount booked to a project, less costs identified for framework management fee or direct construction costs. Corporate overheads and management costs (asset delivery, management, procurement and wholesale operations) are recorded in separate (non-project) cost centres for non-infrastructure projects. These costs were calculated as a percentage addition to the project costs.

4. and d] Updated historic cost coefficients
Cost curves derived for PR14 were updated and used to estimate costs for individual assets that make up a project from the AMIS data, if the unit rates for those assets were not obtainable directly from their BOQ's or PAD's.

Historic PR14 non-infrastructure cost models are updated using COPI values, adding new asset cost sources to the models and rebasing the model to FY 17/18. This generates updated cost curves that were used to calculate unit costs for assets with no available unit rates.

5. and e] Payment applications (BOQ & PAD)
BOQ and PAD were used in steps 3 and 4 to establish various initial rates for assets within a project in the cost assessment exercise. They also provided relevant project related costs such as preliminary and decommissioning costs.

6. and f] Framework agreements
Framework agreements and schedules of rates were used to estimate various non-infrastructure asset costs in cases where we have existing contractual framework agreements with contractors. Costs associated with assets such as control panels, electric motors, kiosks

[59] *AGA Prelims, Indirect & Demo_PR19*
[60] *AGA Risk and Complexity Adjustments_PR19*
[61] *PR19 BGA&AGA on-costs combined*

and pumps were estimated using this methodology. This was done to reflect current indicative rates in cases where there were changes in the framework provider during the AMP period, where there were no interventions on the asset classification from AMIS and to improve historic cost coefficients through the update of the cost models.

The various cost adjustments derived from step 3 are applied to the framework asset costs from step 6 to reflect an all-inclusive cost before they are used in the cost assessment exercise.

7. and g] Historic and current single cost sources
Historic and current single unit cost sources are applied to assets where there is little variance in size. Assets such as fall arrest track, fixed ladders, monitoring equipment, etc. fall under this category.

Assets with no historic costs were either updated with existing framework agreements or price quotations from secondary data sources or costs from similar assets, with the necessary cost adjustments. Costs associated with bridges, conveyors, fume traps etc. were estimated using this methodology.

8. and h] Summary and cost split database
The data from steps 1 to 6 are collated and processed to create costs for various assets. The derived costs at this stage provide the indicative rates for each asset in a project. These costs were then expressed as percentages of the total project cost derived by adding all asset indicative rates within a project. The actual total project cost (FAC) was then apportioned across all the assets based on the derived percentages representing the contractors' costs[62]. Adjustments were applied to represent the on-costs for management fees and overheads.

9. and I & j] Unit costs and model creation
Costs from the assessment were used to create individual cost models, update historic models for assets EGIs with attributes or create single unit cost for assets with a constant attribute. The various cost sources were identified within each model, including their yardstick (attribute value or driver) and project commissioning year, which is used to adjust the price base to FY 17/18 using COPI.

The unit costs for assets with constant attributes are also rebased using COPI, with the various appropriate additions applied.

10 – 11. and k – m] Cost reviews and accept/reject
The unit costs and cost models were benchmarked against available market data and the National Technical Report 61 (TR61) data. This is needed to ensure that the costs are valid and realistic.

Cost outliers identified within the process are subjected to a further review with a view to reintegrating them into the main data stream or finally rejected.

12. and n] TR61 benchmark
Cost benchmarks from TR61 data were used during the review process to compare derived costs with average costs collated from a select group of water companies in the UK

This benchmark did not influence the costs derived, but was used to ensure we were confident with the outcome.

[62] *PR19 AGA cost split workbook*

13. and o] Model finalisation and summary
The finalised unit costs and cost coefficients from the cost models are summarised within a summary document used for upload to our Portfolio optimisation and Scheme Builder applications[63].

8.2.3.1.4 Sources of data and inputs

Data	Scope	Date Range	Origin	Accuracy
AMIS	Non-Infrastructure asset data repository. This provides key attributes on assets installed within a project, including maintenance details on assets.	AMP 5 & 6 Projects	Asset Management	Medium-High
FAC/ORACLE	Information relating to costs billed against a project, including contractors and other indirect costs	AMP 5 & 6 Projects	Asset Delivery / Finance	High
Cost Curves	Updated cost formulae used to derive costs for assets within a project. This is used in instances where such costs are not available through BOQs and PADs	AMP 5	Asset Management	Medium-High
BOQ's and PAD's	This is used to estimate initial unit rates as associated with assets within a project. It also provided further project related costs such as preliminary and decommissioning costs.	AMP 5 & 6 Projects	Asset delivery	Medium
Framework Agreements	Framework agreements were obtained and used as a source of information to establish unit costs for various assets	AMP 5 & 6	Commercial	High
Historic single cost sources	Costs for various asset with constant attribute	AMP 5 & 6	Asset Management	Medium-High
Construction Output Price Index (COPI)	Index to enable cost adjustment to 2017/18 prices	2017/18	Office for National Statistics (ONS)	High
Source: Affinity Water				

Table 8-8 Non-infrastructure asset unit cost data sources

[63] *PR19 AGA Summarised Costs & Coefficients_PIONEER Upload*

8.2.3.1.5 Process outputs
O] Models and unit costs are developed for use within our portfolio optimisation application (PIONEER) and Scheme Builder.

For all cost models, a quality grade is provided to give an indication of uncertainty. The scores are contained within the models. This summary score is based on the deviation of data points from the model curve. Each model is categorised, A to E, in accordance with the table below.

Grade	Uncertainty Level
A	The 10% and 90% percentiles (80% confidence level) are within 10% of the mean removed from the mean.
B	The 10% and 90% percentiles (80% confidence level) are within 20% of the mean removed from the mean.
C	The 10% and 90% percentiles (80% confidence level) are within 30% of the mean removed from the mean.
D	The 10% and 90% percentiles (80% confidence level) are within 40% of the mean removed from the mean.
E	The 10% and 90% percentiles (80% confidence level) are within 50% of the mean removed from the mean.

Table 8-9 Non-Infrastructure Confidence Grades

8.2.4 Capital costs metering

8.2.4.1 Overview, purpose and scope
This section sets out the analysis used in determining the unit costs and volumes of new and replaced revenue meters including non-household meters to determine the overall cost of the various metering programmes. Since cost and volume are linked, both are presented in this section. These programmes in most cases will be combined as one programme of work, with the main elements of the programme being:

- Universal metering- derived from the Water Resources Management Plan
- Meter Optants - derived from the Water Resources Management Plan
- Meter replacement following failure (domestic and non-household meters)

Information is provided in this section on all source documents and processes that were used to provide the final analysis and results. Some background information is given on the various metering programmes to give the cost estimating context.

Universal metering
Universal metering refers to the compulsory rollout of meters and Automatic Meter Reading (AMR) devices into unmeasured customer properties. This is planned across our Central region through AMP6 and AMP7 to reach 78% household metering penetration.

Optant metering
An unmetered customer's request for a meter to be installed in their property and subsequently switched to a measured tariff is captured under Optant metering.

This occurs sporadically across our Central region and we have an obligation to install a meter (if technically possible) to that property within 90 days. In AMP7, our policy for all newly installed customer meters in the Central region is to include an AMR device. In the East and Southeast regions, we will continue to only install dumb meters.

Replacement metering
Replacement metering refers to when a currently metered customer is recognised as having a failed meter. We visit and replace the meter, inform the customer of the change and update our systems to recognise this new asset. In AMP7, we will only be performing a 'Fix on Failure' programme, and will not be carrying out 'Age Replacements'. All meters will be fitted with an AMR device.

8.2.4.1.1 Commentary

Demand forecast model
This model was created by DecisionLab Limited for our WRMP and utilises historic data sets ranging from; population, property, meters, demand and supply to then forecast the future context and requirements. This model is an accurate prediction tool available for volumes of metering required over the AMP7 period. These results are used in the WRMP and also these volumes are used in the PR19 planning.

Meter failure model
This model was created by Mott MacDonald Limited (MM) on our behalf to forecast annual meter replacement volumes based on different replacement strategies (Fix on Failure or Reactive age replacement or mixes of both). This model was created for the Central Region only and was formed using historical meter make and age data combined with different failure curves. This logic was also applied to the East and South East region to derive replacement volumes for all of our regions.

Volume data sources and analysis
The following excel data work books were provided to the consultants

- Meter_History: giving replacement information over time (from Hi-Affinity)
- Meters_2017_07_09: giving the current meter stock (from Hi-Affinity)
- NHH Meter Installs and exchanges from Maximo
- Homerider data: details of the AMR installation at Folkestone

This information was transposed into an access database (MM_PR19.accdb). A number of assumptions were made during a data verification and cleansing process as outlined in the model report provided by MM[64]

The model is in excel[65] and the data process is shown below in Figure 8-15 below

[64] *PR19 Support Services- metering strategy (April 2018)*
[65] *Meter Failure Model 2017_v7 with growth.xls*

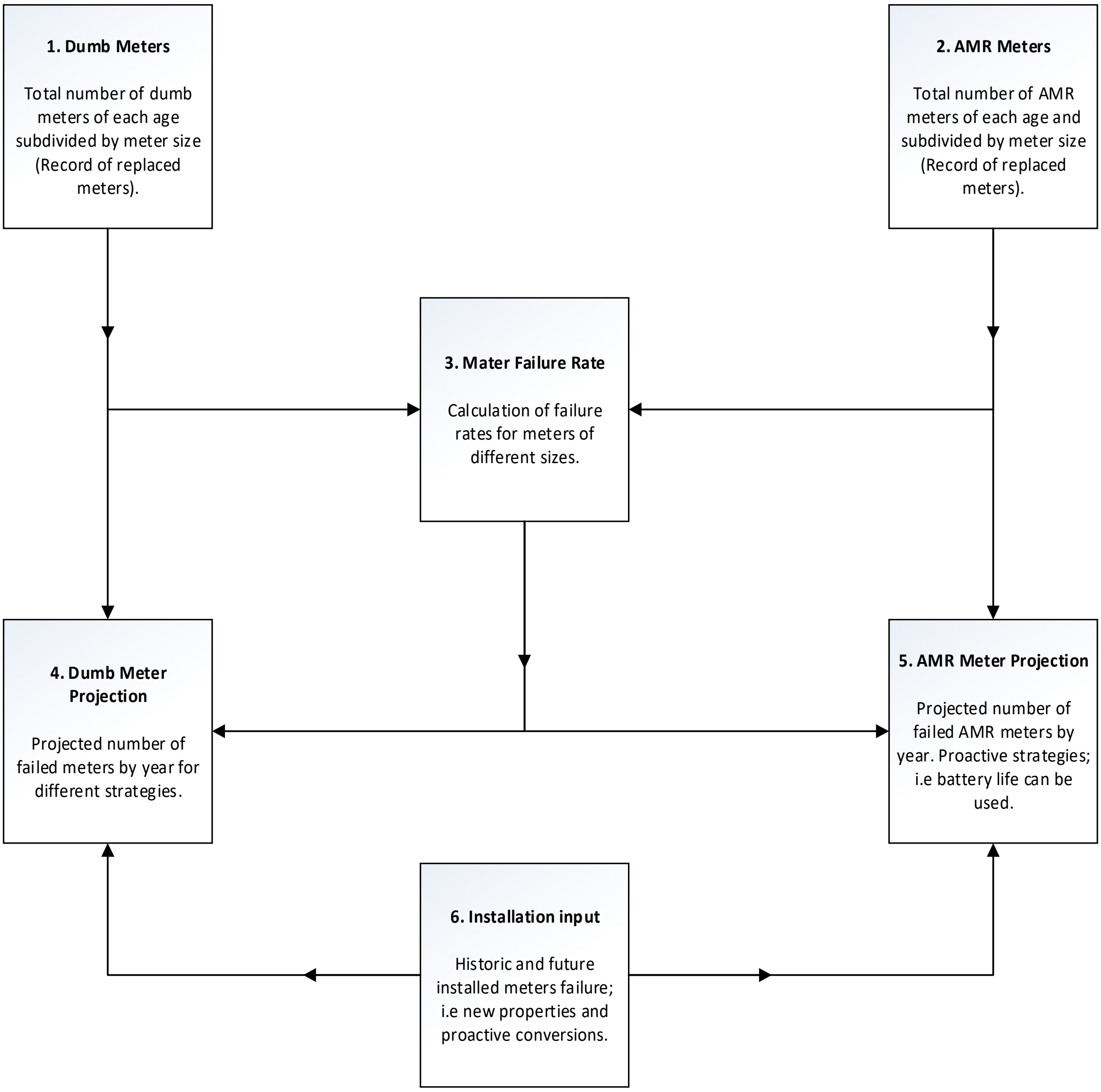

Figure 8-15 Meter volume calculation process

1. **Data input 1 - dumb meters tab**
   Populated with dumb meter stock data. This tab contains the total number of dumb meters of each age at the end of each year by size 15-20mm, 25-40mm and 50mm or greater.

2. **Data input 1 - AMR meters**
   As above but for AMR meters.

3. **Meter failure rate tab**
   Failure rates were derived by curve fitting through historic failure data and calibration using 2017 data – details of which are contained in the report PR19 Support Services-metering strategy (April 2018).

4. **Dumb meter projection tab**

Allows the user to review projected numbers of meters in future years based on a selected meter size and proactive replacement strategy. It is assumed that no new dumb meters have been installed since 2015.

5. **AMR meter projection tab**
   Similar to the Dumb meter projection tab but allows the user to reset the pro-active replacement based on the estimation of battery life i.e. currently forecast at 15 years.

6. **Install numbers tab**
   Contains historic and predicted new meter installations other than that for failure, up to 2055.

8.2.4.2 Process to derive the metering unit costs and volume data

8.2.4.2.1 Metering unit costs

We have calculated a robust estimate of how much it will cost to perform a single job in each of the following metering programmes; Universal Metering installation, Optant meter installation and Meter Replacement. In AMP7 we will continue to install new meters with AMR devices in our Central Region and only new 'dumb' meters being used in our East and Southeast regions. We also calculated the annual volumes of metering jobs to be carried out across the same period as part of these programmes.

The calculations and assessments were performed through iterative approach with several internal reviews of the components, costs and volumes including input from; Asset Strategy, Finance, Procurement and Operations departments and metering experts.

The quality of data that was gathered via Procurement, Operations and Customer Relations to feed into the cost models is described and explained in the table featured at the end of this section.

8.2.4.2.2 High level cost data sources

1. Itron contract

We have a contract with our meter and AMR supplier which contains current cost data. This step in the process relates to the flow of this data into the procurement data review.

2. Universal metering contract

We have a contract in place with our contractors who deliver the meter installations. This is based on a schedule of rates[66] and contains current cost data. This step in the process relates to the flow of this data into the procurement data review.

3. Internal finance systems

Our internal finance departmental systems contain cost predictions for department overheads and charge out rates of employees for AMP7. This step in the process relates to the flow of this data into the Procurement and Operations data review.

[66] *Metering Schedule of Rates*

4. Optants and replacement contract
Optants and replacements work will be delivered on a schedule of rates[67] based on a contract set up to deliver these works. This step in the process relates to the build-up of unit rate for optants and replacement work.

5. Historical data and reports
We use historical data to determine the proportion of job types to be performed in the Central Region. This step in the process relates to the flow of this job mix data into the Operations review.

8.2.4.2.3 Separate Data Reviews

6. Procurement data gathering
Cost data is gathered from various sources and reviewed as part of our AMP6 Universal and Optant metering programmes. This was reviewed with support from across the business to ensure that it was accurate and suitable for forecasting AMP7 unit costs[68].

7. Operations data gathering
This refers to the performance data of the universal metering and optant metering programmes in AMP6. The data was reviewed with expert opinion provided[69], including operational context and cost data predictions achieved.

8.2.4.2.4 Main Calculation Review Process

8. Calculation tables population

- Universal metering calculations were created in different ways ranging from bottom up estimations, market benchmarks and top down estimations. The results from these were summarised into a report.
- Optant calculation[69] was created in different ways ranging from bottom up estimations, market benchmarks and top down estimations. The results from these were summarised in a report.
- Replacement calculations were created in-line with the optant calculation table. These were filled with updated data assumptions relating to AMP6.
- The data gathered and reviewed by Procurement, Operations and Asset Strategy departments was pulled together in all the calculation tables. Any updated data or insights gathered were put into all of the calculation tables to ensure consistency.
- When the calculation tables had been reviewed, and 'not approved' at the decision point, any additional data or expert opinions were added back into the tables at this stage before further moving onto another challenge and decision point.

9. Internal Review
At this stage in the process, all the calculation tables were reviewed with key stakeholders across the business, including departments which had provided component data used in the calculations.

Reviews covered include:

- The calculation table logic, formula and structure
- The assumptions behind the data used in the tables
- The sources of the data used
- The output result against current performance and market benchmarks

[67] *Metering Schedule of rates*
[68] *Universal Metering Unit Cost Calculation*
[69] *Optants Unit Cost Calculation*

10. Decision point
At this stage in the process, the results of the internal review were assessed with regards to whether we were confident in using the unit costs based on the calculation tables for our PR19 plans. This decision was taken by senior management.

11. Updated data sets
Several iterations were performed as better data became available from our systems and with wider input from across the business, better assumptions and expert opinions were gained. This process helped to challenge our data, assumptions and calculation table structure and ensure assumptions built into the unit costs were consistent across the business plan.

8.2.4.3 Process output

12. Approval of unit costs
Senior asset managers approved and signed off the various metering unit costs. These costs were then summarised along with the metering volumes relating to the different programmes proposed to provide a complete AMP7 metering summary for PR19.

8.2.4.4 Volume and cost summary

The meter volumes and costs taken forward are shown in the table below:

Item	Numbers of meters AMP7	Unit cost (£/meter)	AMP7 (£)
Metering (universal)	245,000	244.00	59,780,000
Metering (optants)	28,100	244.00	6,856,400
Metering replacement – all sizes	117,700	182.25	21,450,825
Total	**390,800**		**88,087,225**

Table 8-10 Metering volume and cost summary

8.2.5 Infrastructure operational costs

8.2.5.1 Network maintenance costs

8.2.5.1.1 Overview, purpose and scope

The process undertaken to derive unit costs for our network maintenance as part of our AMP7 commitments is explained in this section. Network repairs and maintenance (R&M) works carried out and completed in 2016/17 were collated and analysed to calculate various unit costs. The derived costs are associated with various job types covered under our network maintenance framework and fall under 22 managed work scopes. The unit rates represent costs payable to contractors for a range of defined activities with an allowance for overheads incurred by the business. Types of work covered are bursts, leakage campaigns and customer generated works.

The R&M costs fall into the following categories:

- Trunk and distribution mains repairs
- Repair and replacement of communication and supply pipes
- Repair and replacement of stop taps, chambers and meters
- Repair and replacement of ancillaries - fire hydrants, washouts, ferrules etc.

The cost assessment aimed at providing indicative costs for unplanned reactive or ad-hoc work and are separate to the process undertaken to estimate the capex costs. The finalised costs are used in the PIONEER application and rebased to 2017/18.

The purpose of this section is to briefly summarise the process adopted and highlight the key sources of data used in the creation of the unit costs.

8.2.5.1.2 Process map

The diagram shown below illustrates the process followed to derive the unit costs.

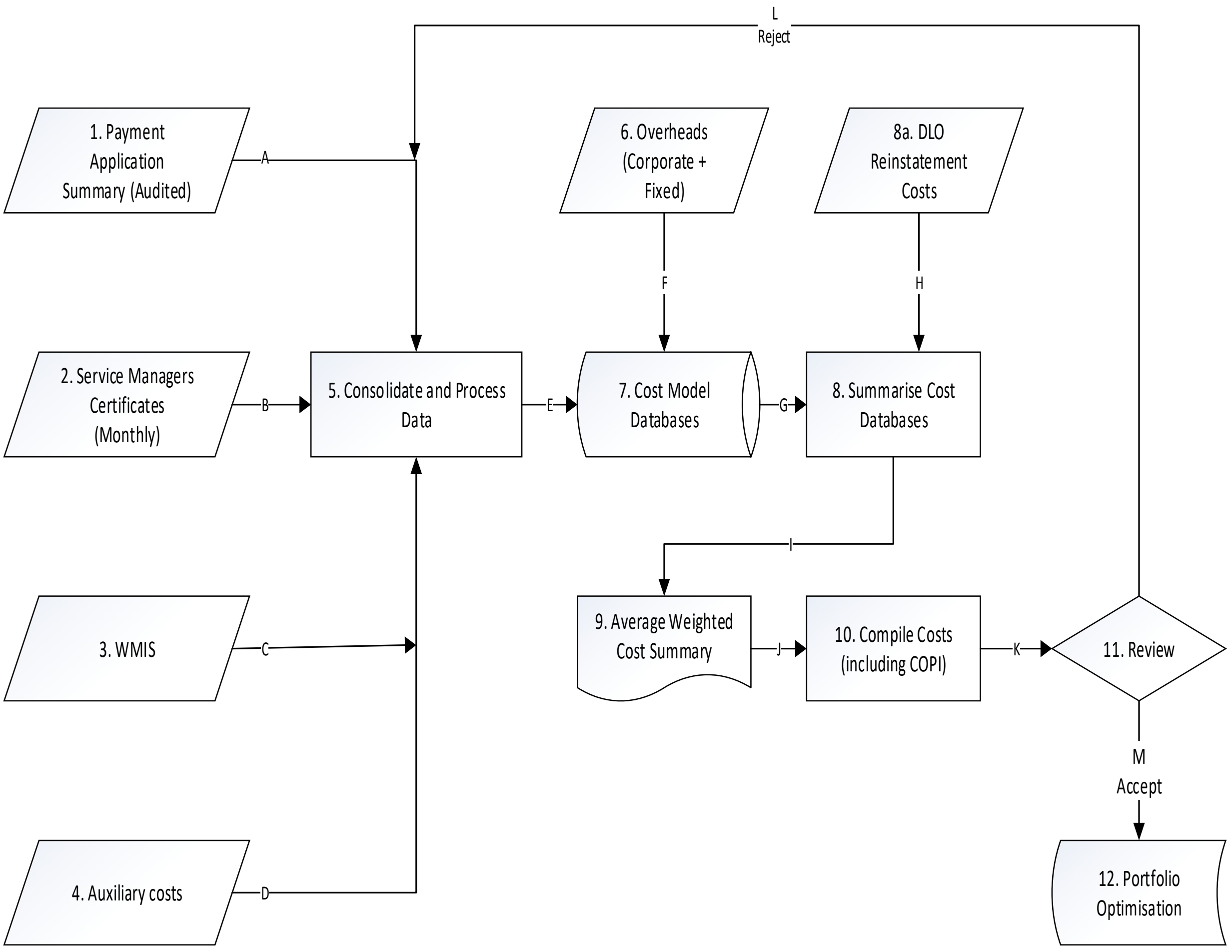

Figure 8-16 Infrastructure (Network) maintenance unit costs process

8.2.5.1.3 Commentary

1. and a] payment application summary (audited)

A compilation of audited and reconciled payments made for various R&M works were sourced, comprising of monthly payments made in 2016/17[70]. This was used with the service manager certificates to capture gross payments compared against individual works or highlight deferred payments.

2. and b] Service manager certificates

Work(s) associated with payments collated in the payment application summary are itemised in detail in the service manager certificates. This is a listing of the monthly work carried out for the various R&M work packages in 2016/17. This contained information such as Job number, the type of work completed and various costs.

3. and c] Works Management Information System (WMIS)

Work details captured in the service manager certificates are initially logged in the Works Management Information System (WMIS). The system contains information on jobs done,

[70] *PR19 R&M Payment Application Summary*

location, date and applicable work codes. It should be noted that cost related data is not sourced from this system. Missing data such as work codes for jobs captured in step 2 are sourced from WMIS and matched to the relevant job in the Service Manager Certificates.

4. and d] Auxiliary costs
Auxiliary costs such as management, traffic management, surveyor, plumbing, project management and collateral damage costs were considered and added to the derived unit cost for the applicable job types. The traffic management costs were also matched to the applicable work by its WMIS number, while the other costs were matched using the applicable job codes or date of work. Traffic management costs are reported as a summarised cost in step 'a' while the other costs are reported as part of work data in step 'b'.

5 - 7. and e - g] Consolidate data, overhead uplifts and cost model database
Data from steps 1 – 4 were consolidated and reconciled with the payment application summary. This ensured that for each of the work packages considered, a work summary consisting of actual job codes, quantities and reconciled monthly costs were captured to derive the unit costs for each job. This process led to the creation of various summarised R&M costs for different job codes and cost models for each of the work packages evaluated[71].

Fixed and corporate overhead costs were derived specifically for R&M activities[72]. Source data and workbooks were captured within each of the cost models and added to the derived unit costs for each of the job codes captured.

8 - 9. and h - j] Summarise data and average weighted cost summary database
The various cost models for each of the work packages were sorted and summarised based on activity references and job types and consolidated as a central cost database[73].

Reinstatement costs for works carried out by our DLO team and reinstated by our contractors were added to the derived unit costs in the central cost database. Both sets of costs are matched using their applicable job codes derived from their cost estimation methodology and weighted individually based on the quantity of jobs completed respectively.

Weighted average costs were derived for each job code based on aggregating the quantity of work(s) completed specifically for each code. This weighting was based on the amount of work completed by the different job sub-codes that make up a job code.

The methodology involves summation of the work quantities for all the job sub-codes within a job code and then using this to divide the work quantity for each individual job sub-code. This generated a weighted percentage which is used to multiply the derived unit costs for each job sub-codes and all aggregated to derive a weighted average cost for each job code.

This gives the basis for the final unit costs derived for all ancillary, R&M work packages and the final summarised central cost database.

10. and k] Compile costs (including COPI)
The derived final costs are compiled and rebased to FY 17/18, ready for review.

11. and m] Review
Cost were reviewed and validated to ensure accuracy and applicability. Where unit rates were rejected they were reappraised and adjusted at step 5. Once all rates were considered valid

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[71] *PR19 R&M cost models*
[72] *PR19 Overhead Calculations R&M only*
[73] *PR19 R&M all cost summary*

and applicable, the database was uploaded to the portfolio optimisation package (PIONEER) through the excel add-in function.

8.2.5.1.4 Process outputs

Selected R&M costs were used in the PIONEER application, in line with the Asset Strategy requirements.

Sources of data and inputs

Data	Scope	Date Range	Origin	Accuracy
Payment Application	Audited and reconciled payments for Ancillary, repair and maintenance work(s)	2016/17	Commercial Team	High
Service Manager Certificates	Listing of work(s) carried out, DLO costs, unreconciled work costs, auxiliary costs such as management, traffic management, surveyor, plumbing, project manager and collateral damage costs.	2016/17	Commercial Team	Medium/High
Works Management Information System (WMIS)	Work management system for update of work details by Technicians	2016/17	WMIS	High
Oracle & Client Assistance Schedule (CAS)	Provides the data used to estimate the fixed and corporate overhead costs	2016/17	Finance Department	High
Construction Output Price Index (COPI)	Index to enable adjustment to 2017/18 prices	2017/18	Office for National Statistics (ONS)	High
Source: Affinity Water				

Table 8-11 Infrastructure (Network) maintenance unit costs data sources

8.2.6 Operational costs non-infrastructure

8.2.6.1 Production operational maintenance costs

8.2.6.1.1 Overview, purpose and scope

Operational maintenance costs associated with ongoing reactive and planned maintenance schedules for our production assets is discussed in this section. This covers assets at water treatment works, sources, pumping stations, the telemetry system, reservoirs and towers. The adopted methodology forecasts annual gross expenditure associated with our reactive and planned maintenance activities. This also covers the average cost and maintenance frequency per reactive and planned maintenance schedule for each of our 354 EGIs (Equipment Group Identifiers), covering almost 70,000 active assets. The assessment and cost model developed ensured an integrated approach to asset costs aligned with monitoring asset performance and health.

The derived cost and maintenance frequencies are used in our investment optimiser (PIONEER) and forms part of the asset life-cycle cost calculations within the application. This enabled the calculation and forecast of failure costs for comparison with intervention options.

We have continually improved our asset and maintenance data since PR14. As part of this effort, we introduced the EGI asset classification which ensures a granular representation of our assets to optimally plan maintenance schedules in line with our asset requirements and intervention needs. This increased our asset classification from 157 physical asset classes to 354 'EGI' asset classes and ensured a more granular and clearer classification of our assets. This was achieved through an asset care survey project to reidentify and reclassify assets in view of carrying out optimal maintenance interventions. The survey project enabled a net increase in our active and available assets assigned a classification identifier by over 40%.

8.2.6.1.2 Process map

The diagram shown below illustrates the process followed to derive the various operational maintenance costs and frequencies.

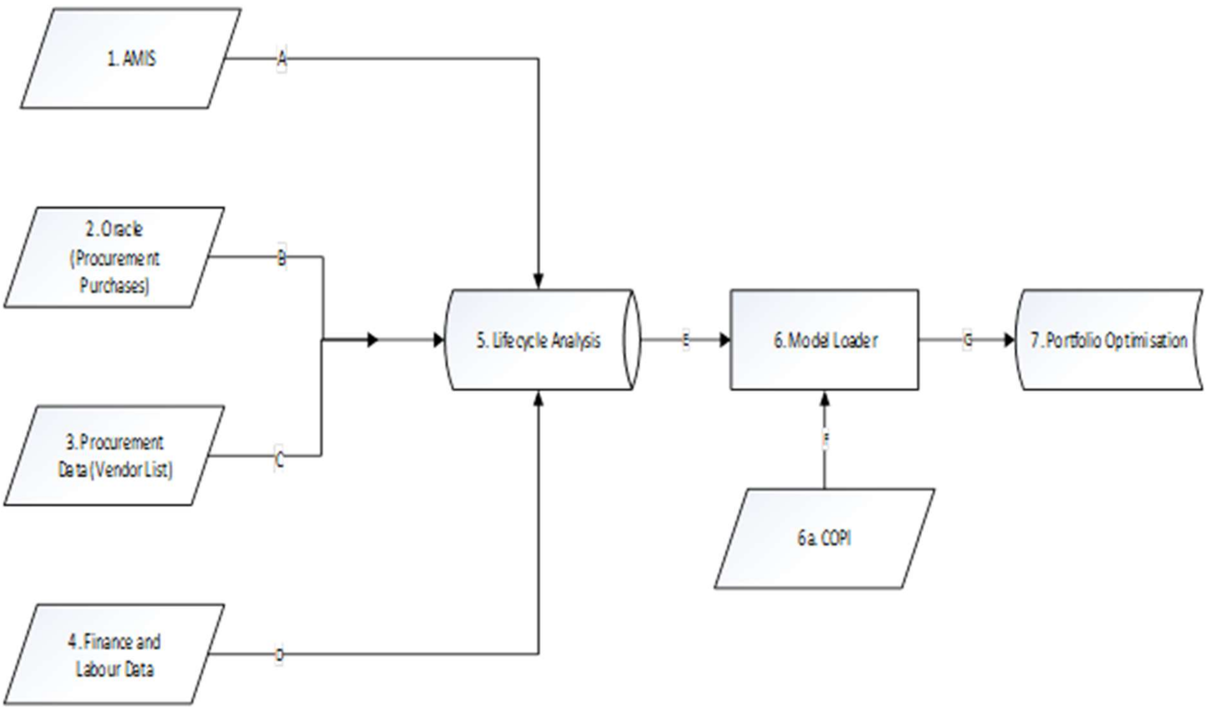

Figure 8-17 Production operational maintenance unit costs process

8.2.6.1.3 Commentary

1. and a] AMIS Data

AMIS (Asset Management Information System) is our asset data repository, holding details of all our above ground assets. This was used to access asset details such as asset listings and status (active and decommissioned assets) and maintenance schedules (reactive and planned) over a period of 5.5 years.

The asset listing and status show details of our assets such as asset names and descriptions aligned to asset types, asset identifiers, asset status, manufacture, installation and commissioning dates.

The maintenance schedules provide details on reactive and planned maintenance activities aligned to all available and active assets. Their details are generally aligned to the assets with the equipment identifier, number, location, maintenance frequency and duration.

The reactive maintenance activities span across details such as alarm investigation, assistance on work order, corrective work, defects and fault investigations, including date of maintenance activity.

The planned maintenance activities referred to as maintenance scheduled tasks (MST) provide details on future maintenance obligations on assets. Its details include the job description, scheduled frequency, average duration, job number, equipment identifier and number.

2 - 3. and b - c] Oracle

Details of our procurement purchases spanning 5.5 years were sourced from the Finance and Procurement Oracle data. Purchases relating only to production maintenance were sorted using several site codes, keywords and a vendor listing provided by the procurement team. This enabled procurement cost capture to be aligned with various EGI classifications through keywords assigned to the various purchase categories and vendors. This ensured that aggregated costs are captured at an EGI level, which could be redistributed to assets that fall within those EGI classifications.

4. and d] Finance and Labour Data

Finance and labour details relating to operatives involved directly with operation and maintenance of our production assets were obtained from the Finance department. This involved obtaining the number of our production and maintenance technicians, estimated annual travel miles per technician, operative hourly pay rates and contracted hourly and annual time. This enabled an estimated labour cost to be assigned to different work orders which can be aligned to different assets under the production maintenance scope.

5. and e] Lifecycle analysis

Collated data from steps 1 to 4 were analysed to derive maintenance frequencies and work order cost for each EGI[74]. Estimated cost per EGI for both reactive and planned maintenance activities were derived by aggregating analysed costs to EGI's. This is achieved by determining costs associated with labour, miles travelled for tasks, material and 3rd party services and work order resources. The generated cost profiles were further analysed to forecast an annual maintenance cost for both reactive and planned activities respectively.

[74] *PR19 Costs against EGI*

Reactive maintenance frequency per EGI was derived by analysing and aligning the various reactive maintenance data with the asset age, work orders and summation of work order age in comparison to the asset installation date. This resulted in deriving the rate of change of operational maintenance events per EGI. The number of work events are plotted for each year of age and trended to obtain an age based frequency forecast, aligned to cost per unit type of EGI.

Planned maintenance frequencies are calculated based on summation of the scheduled tasks against their respective EGI's divided against the number of assets assigned such an EGI. This is aligned to the derived planned maintenance cost per EGI to generate a planned maintenance scope for our assets.

6. and f – g] Model loader and COPI

The PIONEER excel model loader is used to import the deduced maintenance frequencies and costs for use in the optimisation process[75]. COPI is used to rebase the costs to FY 17/18.

[75] *PR19 P&R Maintenance_PIONEER Upload*

7. PIONEER
G] The derived attributes are linked to models in PIONEER.

There is a report further detailing the process from our consultant Mace Group[76].

8.2.6.1.4 Sources of data and inputs

Data	Scope	Date Range	Origin	Accuracy
AMIS	Non-Infrastructure asset data repository. This provides the asset listings, status and maintenance details	AMP 6	Asset Management	Medium/High
ORACLE	Procurement purchases relating to production operational maintenance	AMP 5 & 6	Procurement / Finance	High
Finance and Labour data	Number count of technicians, annual travel miles, hourly pay rates and contracted time	AMP 5 & 6	Finance	Medium/High
Construction Output Price Index (COPI)	Index to enable cost adjustment to 2017/18 prices	2017/18	Office for National Statistics (ONS)	High
Source: Affinity Water				

Table 8-12 Production operational maintenance unit costs data sources

[76] *Affinity Water PR19 Planned and Reactive Operational Cost Assessment*

8.2.6.2 Energy costs

8.2.6.2.1 Overview, purpose and scope

The approach to determining the change in energy costs associated with capital investments is described in this section.

Our PIONEER optimiser is configured to understand the effect of deterioration of pumping assets on our energy costs. This is important as inefficiency can lead to increased costs, which in some circumstances can be significant enough to make replacement or refurbishment cost beneficial over the lifecycle of the pump.

8.2.6.2.2 Application in PIONEER

We continue to utilise industry research from the Water Research Centre project CP348b[77] where we were part of the steering group and have adopted the findings in our investment optimisation. The functions are utilised in PIONEER to determine the increase in energy consumption because of deterioration, though the life-cycle of all our pump sets.

The cost functions use the run hours typically experienced by each pump type and age based performance curves to determine the change in performance for each asset at any given age.

Our costs also accommodate the impact of change in energy use on our carbon reduction commitment (CRC) costs and future price rise forecasts in the wholesale cost of power, based on our current contracts and supplier forecast.

8.2.7 Environmental, social, service measure and consequence costs

8.2.7.1 Carbon, environmental and social costs

8.2.7.1.1 Overview, purpose and scope

The approach to determining the carbon, environmental and social costs for the purposes of our investment optimisation is described in this section.

Jacobs Engineering Ltd., our environmental consultant, was commissioned in 2017 to update our carbon, environmental and social unit costs and emission footprint model and report[78]. This took account and referenced the latest research, environmental evaluation indices and introduced ecosystem services considerations for mains infrastructure.

The scope covers all our production assets, distribution and trunk mains in different urbanicity, surface types and meterage.

The model and report cover:

- All 354 production asset EGI's
- Distribution mains up to 300 mm in different surface types and urbanicity
- Trunk mains (above 300 mm diameter) in various surface types and techniques
- Communication pipes (short and long side)
- Domestic and commercial metering (internal/external/screw in) including AMR

The carbon assessment exercise aimed to derive carbon emission values and cost for various infrastructure and non - infrastructure intervention activities. The evaluation captures embedded carbon and changes in operational carbon. The emissions are expressed in tonnes carbon dioxide equivalent (tonnes CO_2e).

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[77] *P8688 Pumps Whole Life Cost Continuation Project – Final.pdf; WRc report C348b, December 2011*
[78] *Affinity Water Environmental and Social Costing database for Asset Management (PR19)*

The embedded carbon emission footprint and cost assessment covers activities associated with the following activities:

- The carbon impact for the manufacture of capital infrastructure and non-infrastructure items arising from the production of materials
- The carbon impact of travel for replacement and renewal of infrastructure and non-infrastructure assets through distribution of materials and equipment
- Impact due to traffic disruption owing to roadworks

The scope of operational carbon assessment, environmental and social impact covers the following activities:

- The carbon impact from operation of installation equipment applied in replace or renewal scenarios for infrastructure and non- infrastructure assets
- Carbon savings from energy savings that arise from leakage prevention
- Carbon impact of the operation of energy and fuel consuming items
- Landscape/visual impact (for major infrastructure projects only)
- Water quality impact
- Noise
- Abstraction (avoidance of additional water abstracted)

Furthermore, we introduced an ecosystem services consideration for mains infrastructure. This takes account of given interventions, a qualitative assessment of likely impacts, quantifying the impacts and monetising them where possible.

8.2.7.1.2 Commentary

Various environmental evaluation benchmarks and indices were collated prior to the commencement of the assessment. The cost components were majorly weighted from the published traded and non-traded prices for carbon depending on the activity and environmental scenario being evaluated. They are accessed from the Department for Business, Energy & Industrial Strategy (DBEIS).

Emission values, including other environmental and social costs, were generated from several other sources and assumptions such as:

- Bath University (Inventory of Carbon and Energy)
- Bespoke Affinity Water and Consultant assumptions on equipment operations
- Civil Engineering Standard Method of Measurement (CESMM)
- Department for Business, Energy & Industrial Strategy (DBEIS)
- Department for Transport (DfT)
- Department of Energy & Climate Change (DECC)
- Department for Environment, Food & Rural Affairs (DEFRA)
- Environment Agency - Benefits Assessment Guidance (BAG)
- Green Gas Protocol
- Original Equipment Manufacturer (OEM) references
- Spon’s Civil Engineering and Highways Price Book
- UK Water Industry Research (UKWIR)

8.2.7.1.3 Process

A simple approach has been adopted to estimate and derive the asset associated carbon emissions and costs.

Embedded carbon emissions and costs were derived mainly from change in operational emissions due to travel associated with distribution of materials and equipment, in addition to impact due to the asset manufacturing process.

Each of the EGI's are broken down into their constituent materials by mass (e.g. kg of Bronze / Steel / Iron) as sourced from either the OEM or bespoke assumptions. The appropriate carbon emission per unit of mass emitted based on the use of the material is sourced from a combination of several other references. This is multiplied by values associated with proportion of additional carbon assessed to be emitted due to energy in the manufacturing processes. The product of the both values is further multiplied by the actual mass of the asset to derive an emissions figure expressed in Tonnes (CO_2e) per asset (EGI). This emission figure is multiplied by the traded price for carbon sourced from DBEIS to calculate the embedded carbon cost associated with the asset manufacturing process.

Embedded carbon emissions associated with the journey to install or repair an asset is based on assumptions centring on the type of vehicle, distance and time of travel. The calculated emission values are multiplied with the non-traded price of carbon to derive the embedded carbon cost due to travel. The valuation indices are all obtained from the benchmark sources.

Further indices and assumptions were sourced to derive the change in operational emissions associated with replacing assets with new technology as against continuing with existing assets. This enabled the calculation associated with the operational carbon emission values and cost. This is in addition to emission impact due to works on infrastructure assets because of traffic congestion and road type. The DfT WebTAG published guidance, on the appraisal of decongestion benefits has been used to provide figures for the marginal external costs of congestion (per vehicle kilometre). This was also used for the average capacity per passenger car unit and per lane km, per hour for urban and rural roads.

8.2.7.1.4 Application in PIONEER

The emission costs, social costs and emission quantities are imported into PIONEER using the integrated excel add-in functions[79] [80]. The costs and quantities are configured as lookup models which are linked to interventions and failure modes.

When an intervention is selected in PIONEER, the embedded carbon emission and social cost are triggered. These are applied as a one-off cost and one-off emission (tonnes). At the point of intervention, the change in operational carbon per annum is also triggered by the selected intervention and this continues for the life of the asset. This is also applied as a change in annual cost and annual emission (tonnes). In the case of a failure mode, the carbon emission and costs are factored by the probability of occurrence.

The costs are considered in the whole life cost calculation and optimisation. The emission tonnage is captured as a service measure for reporting purposes.

8.2.7.2 Service measure and consequence costs

8.2.7.2.1 Overview, Purpose and Scope

We have a detailed Service Measure Framework which is linked to the service outcomes our customers expect:

- Supplying high quality water you can trust
- Making sure you have enough water, while leaving more water in the environment
- Providing a great service that you value

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[79] *PR19 Carbon Upload to PIONEER*
[80] *PR19 Carbon Costs*

- Minimising disruption to you and your community

This section documents the methods through which the service measure private costs have been obtained. These costs represent the financial impact on the business of service failure. These have been derived from actual costs wherever possible, originating from a variety of sources, using the most accurate and relevant information available.

The results of this work are presented as a unit cost per given metric e.g. per property, per Ml or per event for each of the service measures. They are put together based on relevant component costs. All costs are adjusted to the price base for financial year 2017/2018.

These consequence costs are used directly in our portfolio optimisation process (PIONEER).

8.2.7.2.2 Commentary

The consequence costs have been calculated in a master spreadsheet[81] When specific tabs are mentioned in this section, they refer to individual tabs which are part of this master spreadsheet.

1. Incident investigation
This represents the costs of investigating an incident - e.g. Water quality services investigation of PCV exceedances / customer complaints or Customer Service Technician/ Manager and Network Manager time to investigate supply interruptions.

The costs were based on an average investigation time by event/incident, which is then multiplied by staff rates (by job role) and on standard sampling costs.

If the incident is escalated to senior managers (and directors) or if it triggers involvement of our crisis management teams, then time and costs for their involvement are also included.

2. Increased monitoring
This covers the time and sampling costs required as part of enhanced monitoring of site/water quality zone in the long-term (e.g. water quality issue).

3. Emergency water supply
These are the relevant costs from our framework agreement with Water Direct for alternative emergency water supplies.

4. Flushing / disinfection of network
The associated costs are based on estimated lengths of network affected and unit cost per metre length. The cost was obtained from the Mains Cleaning project per metre length of pipe flushed. It has been used in the calculation of costs in each consequence scenario that involve flushing (water quality contamination, discolouration, taste and odour issues, supply interruptions).

5. Third party damage due to escape of water
The damage impact is based on average insurance claim costs for damage to properties due to escape of water. There are two different categories: flooding to properties due to burst mains and damage to properties due to leaks.

- It separates the two different categories: flooding to properties due to burst main (D3B), damage to property due to leak (D3O).
- We used the data provided by our claims handlers and data from our ‘In-House Settlements’ – this relates mainly to D3O incidents but does include some ‘minor’ bursts.

[81] *Service Measure Framework v6 PR19*

6. Pollution clean-up costs
These are costs to respond to an incident if remediation is required due to environmental pollution (it excludes potential prosecution costs). There is no precedent in the recent company history of pollution clean-up costs, so assumptions have been made.

7. Cost of lost water
The marginal cost of water supply by zone is based on the costs calculated for our ELL evaluation. It was based on energy, chemicals and labour costs and is used to represent the cost of lost water due to leakage.

8. Consequential damage
This is a combination of insurance claim costs for damage to other utilities and of reinstatement costs for damage to road infrastructure

- Insurance claim costs for damage to other utilities – from insurance claim analysis (UTO).
- Reinstatement costs for damage to roads.

9. Prosecution and fines
This category covers the potential direct fines and legal costs (OFWAT, EA, DWI, HSE). These are mostly external data relating to fines and legal costs, published by each regulator on their website.

10. Customer contacts
These costs are based on time and call agent rates for dealing with customer contacts– e.g. time to respond to calls, written contacts, time to deal with escalated complaints to CCW and to respond to CCW investigation. The operational call centre (OCC) staff rates have been updated with 2017/18 data and time estimates provided by the OCC at PR14 and have been reviewed and found adequate.

11. Customer compensations
Customer compensations include GSS and possible ex-gratia payments. The ex-gratia payments are payments to customers at our discretion for incidents that fall outside the GSS regulations (e.g. water quality contamination). The costs are based on the number of properties affected and the duration of the incident.

12. Restriction notices
These cover the issuing of boil / do not drink / do not use notices and include the cost of printing leaflets based on the number of properties ‘carded’ as well as the time to dispatch. These costs were based on contract costs for printing and use some assumptions on time for hand delivery and alternative of posting.

13. Communication costs
These include times and rates for various staff involved in an incident response. They are made up of comprehensive information provided by the communications manager from PR14 - these have been updated with most recent staff rates.

14. Service measure framework
Each service measure is built from these various components depending of impact on the customer, number of customers affected, and severity of incident. Consequence costs were calculated for each band within each service measure. The average band property numbers were used to weight the overall service consequence cost.

15. Service measure private values
The costs for various components were put together for each measure and then computed to give the service measure private costs in the appropriate metric (£/property, £/incident etc.)

Number of properties
The number of properties served by individual pipe sections was obtained from our hydraulic models.

The properties served by sites/asset types were taken from our criticality assessment.
The property numbers are added into a single table and then a pivot table is constructed which shows the spread of properties into 5 bands.

These bands were created to model incidents of different magnitudes:

- No impact on customers
- < 100 properties - Low
- 100 to 1,000 properties - Medium
- 1,000 to 10,000 properties - High
- 10,000 to 50,000 properties – Very High
- 50,000 properties affected - Above our capability (Mutual Aid)

A cumulative property number has been determined. When adding these together we obtain a number which is larger than the total number of customer connections. This can be explained by the redundancy in our network and overlap of sites – indeed the sites are split by asset groups into source pumping stations, water treatment plant, booster pumping station, service reservoir. Hence a single physical site could be represented multiple times in the property summary table if it has different functions.

The number of properties in each band was also calculated.

8.2.7.3 Sources of data and inputs

Data	Scope	Date Range	Origin	Accuracy
Staff rates	Hourly rates - include all employment costs e.g. NI, Pension, Vehicle costs, as well as an element of overheads for various roles	2012-13 Uplifted to 2017-18	Finance department (management accountants) from salary detail.	High
Sampling costs	Typical costs per chemical PCV sample and per microbiological sample	2012-13 Uplifted to 2017-18	Laboratory	High
Emergency water supply cost	Relevant costs based framework contract with Water Direct for emergency water alternative supplies.	2017-18	Water Direct Framework Contract	High
Restriction notices	Contract costs for printing and for hand delivery and alternative of posting	2012-13 Uplifted to 2017-18	From Communications Team	High
Flushing / disinfection of network or reservoir	The cost for network flushing	2017-18	Obtained from the Mains Cleaning project	High
Third party damage due to escape of water	Average insurance claim costs for damage to properties due to escape of water	Annual company data	Insurance team – In-house and 3rd Party claim handlers	High
Pollution clean-up costs	Remediation costs for environmental pollution - excluding prosecution costs	No historical data	Assumptions	Low
Cost of lost water	Marginal cost of water (MCoW) supply by zone	2017-18	MCoW figures obtained from Water Resources Team - as used in the SELL work package (WRMP)	High
Consequential damage	Insurance claim costs for damage to other utilities and reinstatement costs for damage to road infrastructure	2017-18	Costs are captured by the Insurance team – In-house and 3rd Party claim handlers	High
		2007-2010 Uplifted to 2017-18	Costs captured by Community Operations / Finance	High
Prosecution and fines	DWI incidents and prosecutions	2017-18	DWI website	High
	Ofwat enforcement notices	2017-18	OFWAT website	High
	EA enforcement notices	2017-18	Data of cases from various websites	Medium (small sample)
	HSE prosecutions	2017-18	HSE website	High
Customer contacts	Operational call centre (OCC) staff time to respond to calls and letters	2012-13 Uplifted to 2017-18	Time estimates provided by the OCC at PR14 and have been reviewed and found adequate	Medium

Data	Scope	Date Range	Origin	Accuracy
Personal Injury	Cash valuations of preventing health and safety effects on people	2003, uplifted to 2017-18 cost base	Values taken from the HSE Cost Benefit Analysis (CBA) checklist	Medium
Compensations	GSS compensations Ex-gratia payments at AWL discretion	2017-18	Estimate based on the GSS regulations	High
Productivity costs	Staff time lost due to IT system failure	2012-13 uplifted to 2017-18 cost base	Estimate	Medium
Communication costs	Staff rates and times	2012-13 –uplifted to 2017-18	Obtained from Communications Team	Medium
No. of properties	Number of properties served by individual pipe sections / sites	2017-18	Hydraulic Modelling and Site Criticality spreadsheets	High

Table 8-13 Service measure data sources

8.2.7.3.1 Process outputs

The output is service measure private costs, which are entered in PIONEER against ‘serviceability indicators’. They are also available to be used for cost benefit analysis outside of the optimisation tool.

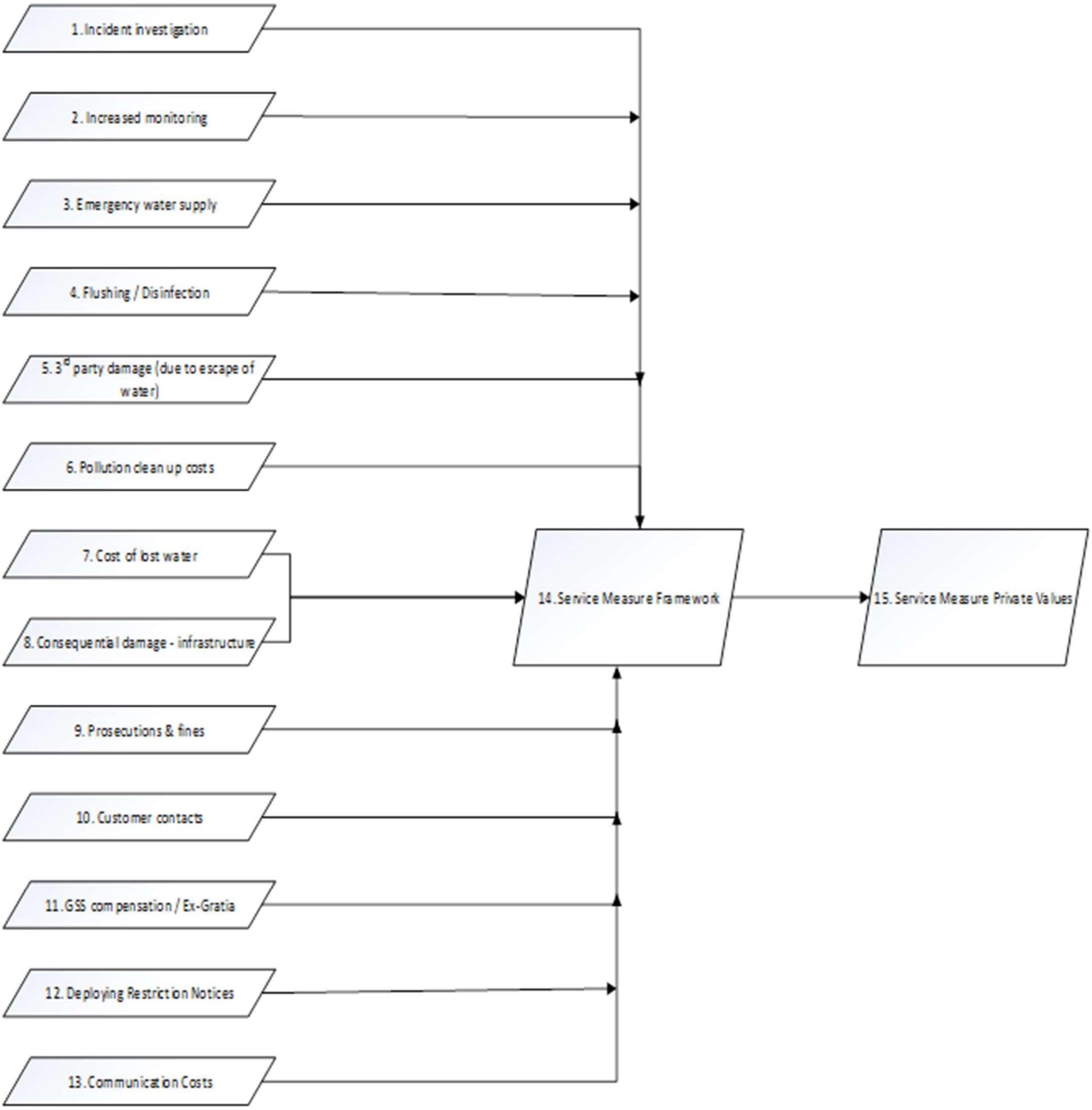


Figure 8-18 Service measure unit cost process

8.2.8 Benchmarking analysis, asset unit cost insights and outlook

PR19 unit costs were compared with estimates from PR14 and the WRc TR61 database. The TR61 database is a national cost database based on cost data from select water companies in the UK The TR61 estimates were only used for reference spot checks and did not influence the final derived costs or sway investment decisions.

The benchmarks and comparisons allowed us to review our competitiveness in the water and contract spectra and be assured that our unit costs are achievable and correct. We ensured that the most significant and critical assets were selected for the benchmarking exercise.

We faced the following challenges during the cost assessment and modelling exercise:

- Benchmarking recently tendered framework agreements and costs to historic data and works for infrastructure assets
- Mapping data and costs for non-infrastructure assets from 'Class' naming convention used in PR14 to 'Equipment Group Identifiers' (EGIs) for PR19

Our benchmarking has shown that we have confidence in our unit costs and they are comparable with industry benchmarks.

8.2.8.1 Infrastructure benchmarking analysis

8.2.8.1.1 Mains renewal – capex

Following competitive tendering, we changed our mains laying framework contractor in Q4 2016 from Amey to Morrison Utility Services and the Kier Group. With the introduction of the new framework agreements (MIPSA 2), there were insufficient outturn projects to derive unit costs based on the new contractual framework. This required us to use past framework projects and data to work-up costs, then weight the costs based on a proposed work program to derive a weighted run-rate cost, for comparison with our actual construction run-rate cost (refer: section 7.2.1; steps 12-13).

A benchmark analysis was carried out on our ten-year work programme ending in 2030 (subject to change) using the initial cost estimates derived from the modelling exercise to derive an overall weighted cost per metre of £135.11 (overlander costs excluded) and £145.15 (overlander costs included), based on our typical mix of work. The derived run-rate costs were compared to our actual MIPSA 2 construction run-rate per metre derived at £215.8 (overlander costs excluded) or £224.9 (overlander costs included). The latter cost approach was used as it is more representative of our need to ensure overlander connections for continuous supply during interventions and avoid planned interruptions.

The percentage variance between our actual construction run-rate and the cost modelling run rate was applied as an adjustment to one of the variable inputs of the modelling exercise to generate new sets of cost. On application of the costs to our proposed work programme, a weighted run rate cost per metre of £219.38 was derived (subject to change), consistent with the actual MIPSA 2 run rate cost. There is an ongoing programme by our Asset Delivery team to introduce innovations in the construction techniques and management to drive down costs.

As a check and balance for assurance purposes, to confirm that the derived rates were representative, we applied the PR14 cost summary to our PR14 10-year forecast work mix to deduce a weighted run-rate cost of £139.95/m. The resulting analysis showed that the weighted run-rate cost derived from the PR14 cost summary was in line with our actual outturn run-rate cost from 2012/13 (£138.06 (2017/18)). This proved a sufficient and effective comparison tool to align past framework rates to the current contractor rates.

8.2.8.1.2 Trunk mains – capex

The contractual framework benchmarking for mains renewal was not needed for trunk mains as our cost methodology uses our current MIPSA 2 schedule of rate and appropriate uplifts to generate the required unit costs.

The applicable adjustments are an inflation factor and a variance between the final account cost for projects and their base rate from the schedule of rates. Cost comparisons were undertaken by deriving a weighted run rate cost based on our AMP6 and AMP7 work programmes using the cost estimates derived from the trunk mains cost modelling.

8.2.8.1.3 Network maintenance costs – opex

We derived costs associated with our network maintenance by assessment of repair and maintenance works carried out in 2016/17. Costs relating to over 76 job types covering 186 sub-job types were derived following the cost assessment. Various R&M work packages were collated, aligned to their reconciled payments, with their weighted unit costs derived per job type. Reinstatement and auxiliary costs such as management, traffic management, surveyor, plumbing, project management and collateral damage costs were also considered and matched to our derived unit costs.

Communication pipe (CP2 and CP3) and mains burst repair costs (MB2) were only used for the portfolio optimisation, while other costs are used for reference purposes.

To confirm that the derived unit costs per job type are representative of actual costs, we used the derived costs to price our annual R&M work volume. We relied on historic R&M interventions and projected gross costs under various investment scenarios. This validated our cost methodology and forecast R&M budget.

The investment scenarios focused on projecting gross cost for several capitalised replacements, with and without metering and fire hydrants, creating scenarios where overhead costs are either included or excluded. The gross cost for each investment scenario using a bottom-up calculation of costs and work volume showed that the gross costs were consistent with the forecast R&M budget from our Infrastructure Strategy team. This provided the confidence that the weighted unit costs per job type derived are accurate.

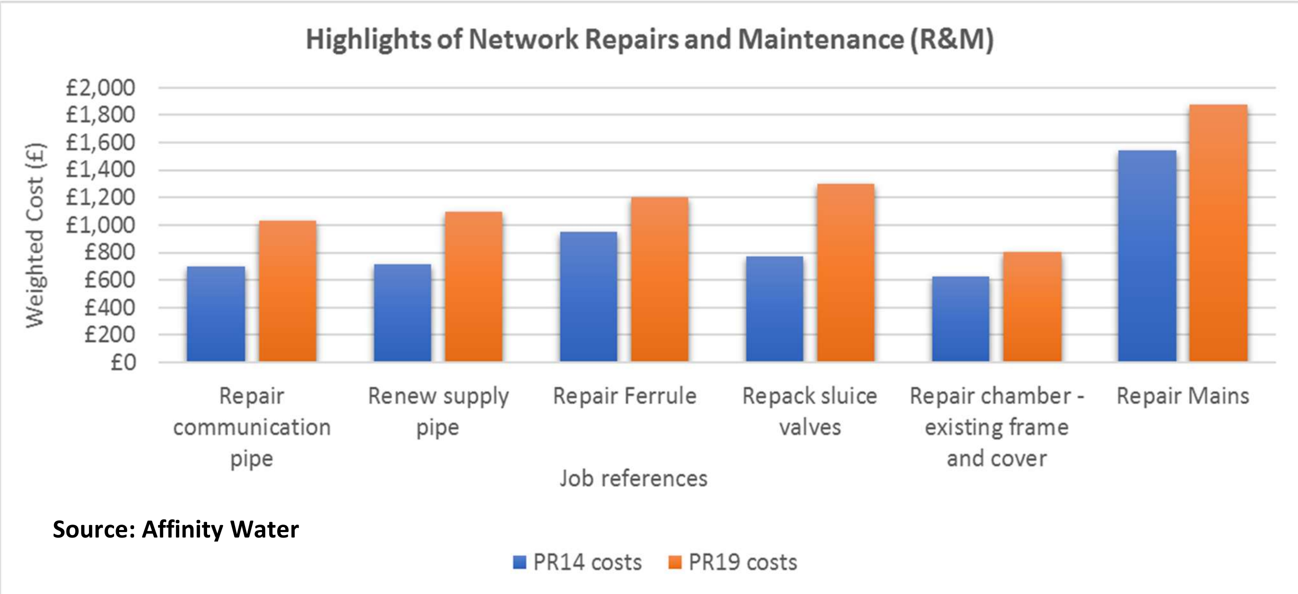


Figure 8-19 Network repair and maintenance costs comparison

8.2.8.2 Non-infrastructure benchmarking and cost comparisons

Due to a change in our above ground asset classification system, it was not possible to carry out a like-for-like comparison of all our non-infrastructure asset unit costs for the benchmarking exercise.

However, we used existing framework agreements as cost references for key assets such as pumps, kiosks and motor control centre (MCC). The framework costs are generally lower compared to spot prices for same assets. Below is a selection of assets to illustrate.

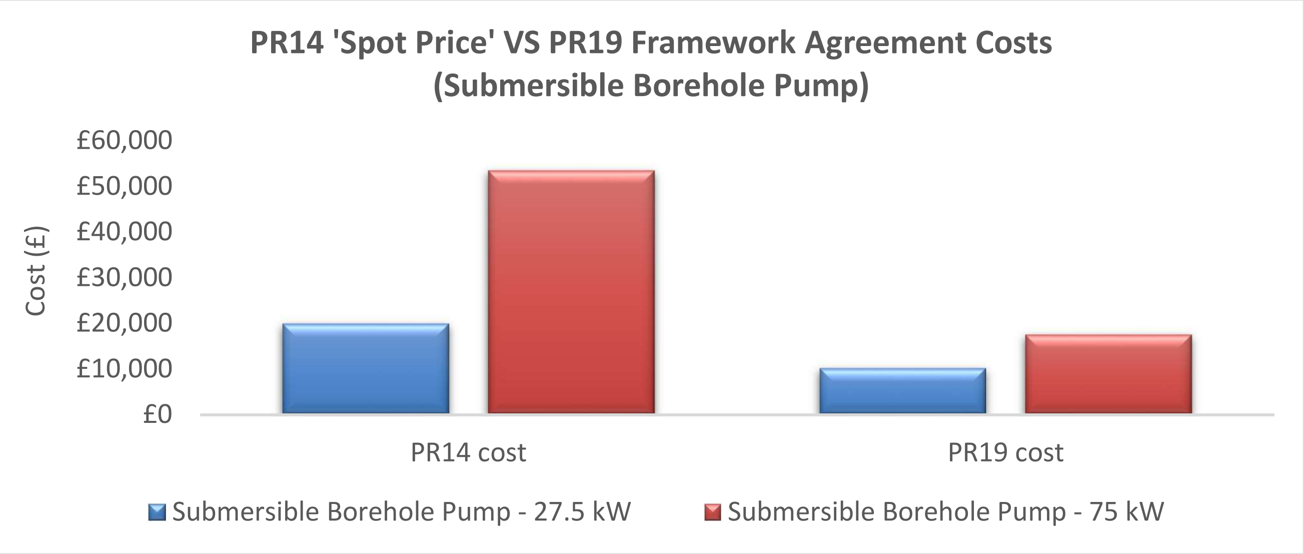


Figure 8-20 PR14 'spot price' VS PR19 framework agreement costs (submersible borehole pump)

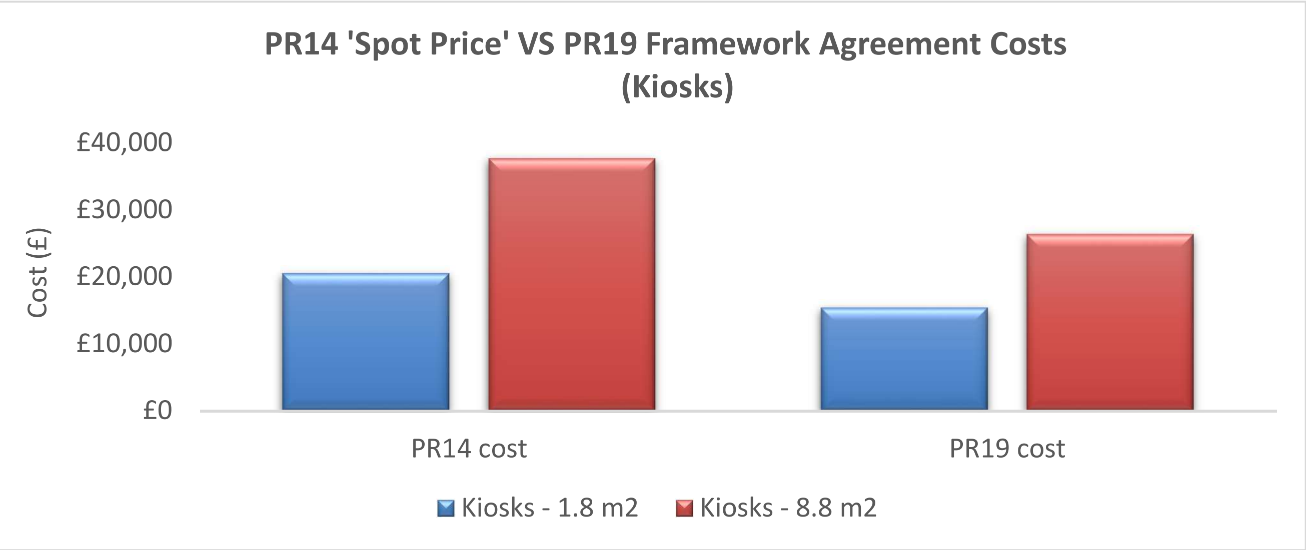


Figure 8-21 PR14 'spot price' VS PR19 framework agreement costs (kiosks)

8.2.8.3 Asset unit cost insight and outlook

8.2.8.1.1 Infrastructure assets – capex and opex

There is an ongoing drive by our Infrastructure Delivery team to reduce costs by being innovative in the delivery of these assets. Various innovations are being considered and they include:

- Changing the depth of mains laying from 900mm to 750mm
- Renegotiation of management fees – including office movements by the contractors

- Evaluating the possibility on focusing more works around rural urbanicity
- Working with a local contractor in the South East of England, knowledgeable of the terrain, due to labour costs

8.2.8.1.2 Non-infrastructure assets – capex and opex

Since PR14, we had an ongoing Asset Care Optimisation programme which re-identified and reclassified our asset base to enable optimisation of planned maintenance schedules in line with our maintenance strategy objectives. This has proved to be effective as we have been able to achieve a more granular and uniform inventory of our assets, leading to a net increase in our asset count and better maintenance regimes for our assets.

- Opex – we derived our annual operation maintenance cost at £6.2 million (reactive maintenance: £2.9 million; planned maintenance: £3.3 million), a cost reduction of 5.4% compared to PR14.

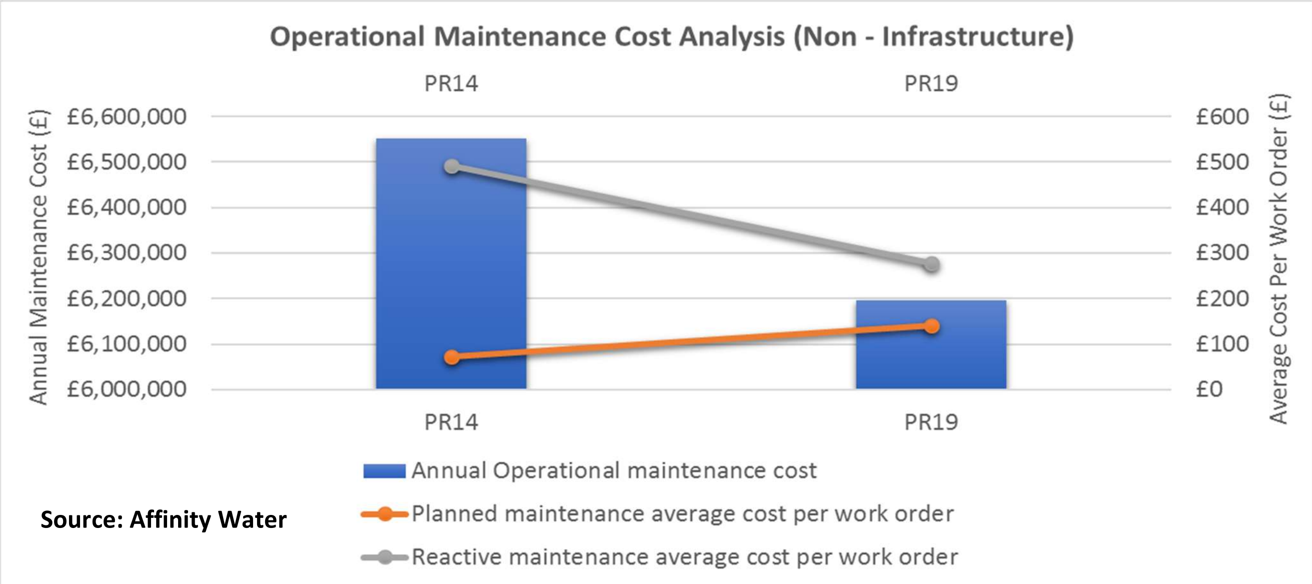


Figure 8-22 Operational maintenance cost analysis (non-infrastructure)

The operational maintenance cost analysis and modelling reflects our asset care initiative of optimising planned and reactive maintenance schedules to reduce risk to service.

8.2.8.4 Governance and assurance

We adopted the 'three lines of defence' in promoting governance and assurance for our PR19 costs and estimates. We ensured that effective operational management processes were adhered to, including reviewing various risks, compliance of methodologies to our contractual framework agreements, comparison to various market rates and carried out various peer reviews with our business leads. This culminated with external audits by Atkins Limited and PricewaterhouseCoopers (PwC) for our Board of Directors assurance purposes.

Governance Assurance	Asset Groups									
Risk profiles	DMP	TMS	CPs	MBs	AGA	Reservoirs	Energy	Metering	DS	SM
PR14 comparison	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

External benchmarking	✓	✓			✓	✓				
Market spot-prices					✓					
Source: Affinity Water										

Table 8-14 Governance assurance profile matrix

8.2.8.5 Asset cost data confidence bands

In line with Ofwat's guidance on data reliability and accuracy[82], we have graded our asset groups and related cost data sources based on their origin and accuracy. Our costs were derived from auditable records and analysis which are properly documented, with the best possible cost estimation methodologies applied.

Our primary source of data to build-up costs were from our historic costs of projects and assets. There were few exceptions in the case of non-infrastructure assets, where we have not delivered some specific types of asset in the previous AMP period. Those costs were gathered from other secondary data sources and updates to our PR14 cost models.

[82] *Guidance on Confidence Grades*

Asset Groups	Reliability Band	Accuracy Band	Compatible Confidence Grade
Distribution Mains	A	1	A2
Trunk Mains	A	2	A3
Ancillary Items	A	3	A3
Reservoirs and Towers	A	2	A2
Network Maintenance (BGA opex)	A	2	A2
Above Ground (capex)	B	2	B2
Operational Maintenance (AGA opex)	A	3	A3
Environmental and Social Costs (capex & opex)	A	2	A2
Energy (opex)	A	2	A2
Metering (capex)	A	2	A2
Developer Service (capex)	A	2	A2
Service Measure (opex)	A	2	A2
Source: Affinity Water			

Table 8-15 Asset cost data reliability and accuracy matrix

8.3 Portfolio optimisation

8.3.1 Overview

A key element of our Totex Plan development methodology is cross-portfolio optimisation. This ensures that the proposed Plan is affordable to customers, satisfactory to stakeholders and that investment is optimally balanced across all areas.

Our proposed Plan comprises investments from four different sources, as detailed below:

Source	Value (£m)	% of total portfolio
Deep dives	£519.88m	38%
Business cases	£461.04m	33%
Pioneer	£148.40m	11%
Water Resources Management Plan	£243.66m	18%

Table 8-16 AMP7 Wholesale Investment Portfolio sources, prior to application of efficiencies

We take a **risk-based approach** to portfolio optimisation at both macro and micro level. This involves assessing risk and targeting expenditure to achieve PC targets and deliver Outcomes for customers while meeting our legal and regulatory obligations. AMP7 expenditure decision making is set in the context of long and medium-term needs assessments such as:

- Our 60-year rdWRMP (2020-2080)
- A 35-year view of capital maintenance investment requirements from Pioneer
- Our ten-year energy strategy[83] (2020-2030)
- 50-year lead strategy[84] (2020-70)
- Our ambition to reduce leakage by 50% by 2050

We also continue to align our decision making with regional groups WRSE and WRE.
The tools and methodologies that we have used to develop our optimally balanced and thoroughly challenged Totex Plan are described below.

8.3.1.1 Whole-life cost assessment

We have completed Net Present Value (NPV) calculations to assess options and select efficient least cost whole-life solutions through our business case development process. Each business contains several potential options, one of which is ‘do nothing’. NPV was chosen to assess options and make choices because it accounts for the time value of money and because it is consistent with our approach to assessing water resources investment needs.

8.3.1.2 MoSCoW analysis

Prioritisation of expenditure items was achieved through the application of MoSCoW analysis. This involved investment proposals being categorised as ‘Must do’, ‘Should do’, ‘Could do’ or ‘Won’t do’ during the early stages of Totex Plan development.

8.3.1.3 Internal stakeholder challenge

All expenditure items included in the Totex Plan have been subject to rigorous challenge and scrutiny. The business cases have been through multiple iterations before being peer reviewed and signed-off. Business cases, Pioneer outputs and the results of EBSD modelling have been presented to internal stakeholders who have challenged assumptions and provided professional feedback. Stakeholder feedback has informed decision making throughout the Totex Plan development process.

[83] *Energy Strategy*
[84] *Lead Strategy 2020 - 2070*

8.3.1.4 Outcome, PC and strategic risk mapping

Throughout the development of the Totex Plan, expenditure items have been mapped to the Outcomes and PCs that they will contribute to achieving as well as to the legal and regulatory obligations that they fulfil and any risks that they will fully or partly mitigate. This mapping is evident in the business cases and is also exemplified in Pioneer modelling through the Service Measure Framework. This approach ensures that each expenditure item has a clear purpose.

Building on this approach, we have developed a bespoke methodology to inform investment decision making. The methodology compares the relative importance of investments in terms of their contribution toward delivering PCs and/or mitigating strategic company risks. First, the various PCs were weighted based on their estimated financial rewards/penalties. For strategic risks, gross risk scores, as held on the corporate risk register, were used as weightings. Every investment programme was then assessed in terms of its contribution towards delivery of each PC, mitigation of each strategic risk and fulfilment of our legal and regulatory obligations. Mappings were captured on a scale of 0 (no correlation) to 5 (very significant correlation). These assessments resulted in an overall weighted impact score.

The impact scores have aided decision making by comparing and contrasting investment programme impacts. It has also enabled us to ensure that the achievement of each PC is supported by relevant investment.

8.3.1.5 Risk assessment

To understand the deliverability of the Totex Plan and to test the optimum balance of expenditure across programmes we have assessed risk at programme, sub-portfolio and portfolio levels. The first step in this exercise was to determine the relative impact of the various planned investment programmes. This step was completed as described in 8.3.1.4 above.

The next step was to identify and score deliverability risks associated with each programme. Programme deliverability risks were estimated across seven risk categories (People, Supply Chain, etc.) and the average of those calculated to determine an overall deliverability risk score per programme. High scores for individual categories were reviewed and appropriate mitigation actions identified with a view to reducing those risks to medium or low. As a result, gross (pre-mitigation) and net (post-mitigation) deliverability risk scores were determined for each programme.

Information gained from this exercise has been used to test expenditure scenarios and optimise investment across the portfolio.

8.3.1.6 Risk-based expenditure rationalisation

Another risk-based approach was deployed earlier in the Totex Plan development process to challenge and rationalise expenditure at project and programme level. Through this approach, each business case was tested to understand the magnitude of risk (likelihood x impact) that would be incurred under scenarios where 100%, 75%, 50% and 0% of the preferred funding was made available. PR19 work package leads worked with the Executive Management Team (EMT) to complete risk scoring for projects and programmes under these different expenditure scenarios. Standardised company risk criteria were used in all cases.

The scores were mapped on risk matrices and used by EMT to challenge expenditure assumptions. This resulted in effective but rationalised levels of expenditure in some areas.

8.3.1.7 Benefit analysis

A multi-criterion benefit analysis was used to understand the optimum spread of business case benefits and to test the alignment of investments with customer preferences. The analysis used an explicit set of objectives and measurable benefit criteria to appraise the options. A standard sequence for this approach was used to identify objectives and criteria.

The chosen benefit criteria were measurable. This ensured that the performance of a business case could be quantifiably assessed against the criterion. A matrix was created and each of the criteria chosen for analysis was given a weighting dependent on its potential benefit.

An analysis of business cases based on these criteria was undertaken using the scoring scale and weighting to produce quantifiable results. The business cases were then ranked to analyse which came out with the highest and lowest benefit. Benefit scores were compared with PCs delivery incentives to determine any correlation. Figure 8-23 shows that there is a good correlation between delivery incentive and benefit. This shows that we plan to allocate expenditure to the areas where it matters most.

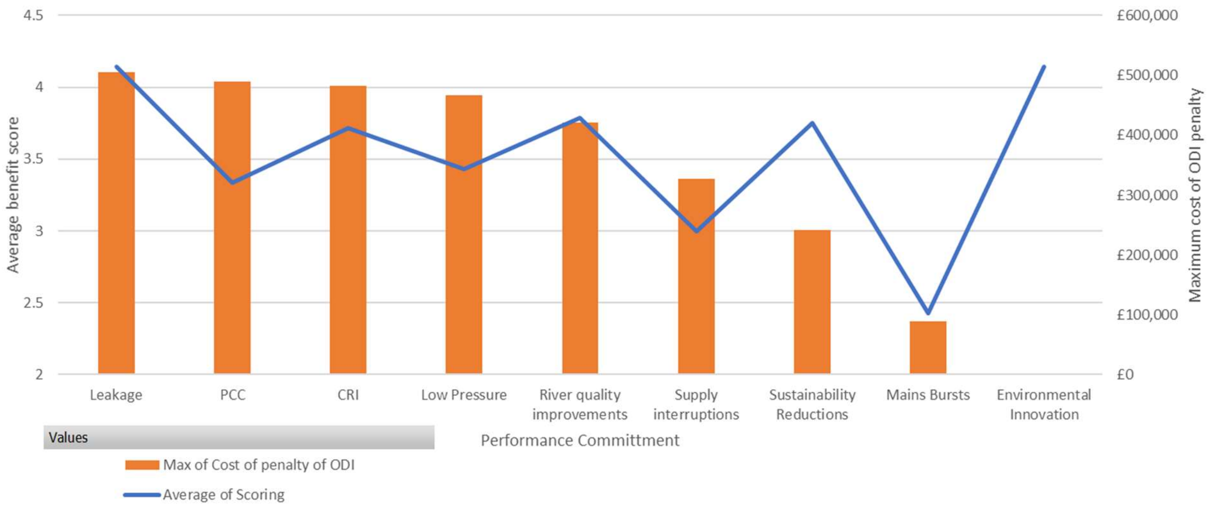


Figure 8-23 Correlation between benefit and maximum ODI penalty

8.3.1.8 EBSD modelling and verification

The WRMP produces enhancement expenditure required to maintain the supply demand balance in AMP7 and beyond. The Economic Balance Supply Demand (EBSD) model identifies least cost whole-life solutions to ensure that supply demand deficits are met in all zones, in all years of the planning period and under every planning condition. Multi-criteria analysis has been used to select the supply and demand side schemes selected for AMP7.

Schemes selected through this process were then developed into full, peer reviewed business case and subjected to the same tests and challenges as all other business cases.

8.3.1.9 PIONEER

We have optimised our capital maintenance investment by using PIONEER. The methodology is described in detail in the following section.

8.3.2 PIONEER methodology

8.3.2.1 Overview

For PR19 we have continued to utilise and improve our portfolio optimiser PIONEER (Pro - active Investment OptimisatioN by Evaluating Expenditure and Risk), developed by Servelec Technologies Ltd. PIONEER is described as:

"a web-browser based software tool designed to identify optimal investment and changes in operational strategies to achieve specified serviceability at least cost, subject to resource and capacity constraints."

The optimiser uses our asset data, deterioration curves, consequences and costs calculated by asset. It uses this to determine the optimal investment portfolio to meet our customers' needs. The assets considered in the optimisation process are all production assets, e.g. pumps, drives, buildings, telemetry; distribution mains, communication pipes and trunk mains. There are approximately 70,000 above ground assets and more than 16,500km of mains modelled in PIONEER. Together, investments arising from these assets cover most of the infrastructure and non-infrastructure maintenance requirement for AMP7.

Significant developments and restructuring of data and models have been performed in-house by our asset strategy team. These changes build on our extensive knowledge of investment modelling. Table 8-17 shows our bespoke configuration which we have developed. Through these developments, we maintain a detailed understanding of the PIONEER system, hence reducing its "black-box" nature. These include developing our own bespoke configuration to our required functionality. to our required functionality. to our required functionality. to our required functionality. There has also been significant restructuring and standardisation of our production asset data, so we can implement a risk based hierarchy which enables consistent and semi-automated calculation of consequence likelihood for every asset. Further details of the hierarchy can be found in section 5 Non-Infrastructure Assets.

The integration of above and below ground operational assets has been a significant success in our progress toward business-wide portfolio optimisation. We have also added DMA meters, observation boreholes and administration facilities in to the optimisation process, moving us closer to our objective of full asset coverage as part of business as usual activity.

Since PR14 we have invested in an integrated burst rate modelling module (Model Builder) which utilises burst data now transferred to PIONEER, along with pipe attributes from our GIS system. The tool enables multivariable regression of bursts against attributes to automatically produce models of burst rate over time by cohort for forecasting by PIONEER. Further modelling considering the relative acceleration and deceleration of the rate of bursts per pipe in recent years, was also undertaken in Model Builder using Pipe Level Conditional Probability (PLCP) adjustment. Model Builder has also been used to group the distribution pipes automatically to build practical schemes for implementation through our mains renewals programme. Further details of the modelling approach can be found in section 0 Infrastructure Assets.

We continue to utilise the integrated PIONEER ARM (Asset Risk Management) and Scheme Builder modules on a day-to-day basis. ARM allows operational risks and solutions to be added by field operators or managers for consideration in the investment portfolio. Asset risks are logged routinely and reviewed at monthly intervals by the Asset Engineer responsible for the local community and operational teams at Production Investment and Maintenance Meetings (PIMMS). The Scheme Builder module allows the addition of assets or modification of existing asset hierarchies at points in time on a project basis. It may also be used to group expenditure on individual assets together for delivery purposes and has been used to model the impact of project based investments, such as quality and supply-demand schemes.

Although substantially completed, the decision was taken to exclude mandatory AMP6 investments from the optimisation process to improve optimisation times, since the benefits are discrete. More details on these areas can be found in sections 3, 4, 5 and 0.

8.3.2.2 Application of planning objectives

Both the Cost effectiveness and cost beneficial objectives as defined in the Common Framework have been utilised in maintenance investment planning, where we follow the most advanced techniques as identified in the Common Framework Review of Current Practice[85], (1a - service modelling with repairable and non-repairable failure modes). For investments where there are obligations such as quality or sustainability drivers, the cost effectiveness objective has been adopted for the purposes of option evaluation, outside of PIONEER.

The two objectives are pictured below:

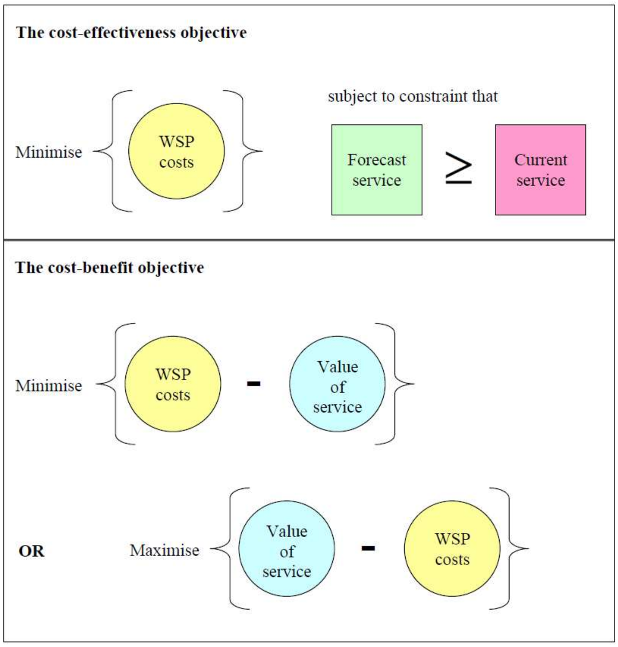


Figure 8-24 The Two Optimisation Objectives

Cost effectiveness objective

The cost effectiveness objective (minimise costs while maintaining service) has been utilised for most optimisation scenarios. The prime objective of optimisation was to achieve target levels of service for each of the key customer expectations defined in the March 2018 WRMP and April 2018 Business Plan consultations, which define expected levels of service at least cost. These are set as constraints to the optimisation process.

Further details of the consultation process, customer outcomes and willingness to pay work can be found in our main Business Plan.

Cost benefit objective

Though not used in our final plan, the cost benefit objective can be used to test the sensitivity to Willingness to Pay (WTP) valuations.

The WTP values can be used in PIONEER against the matching service measure to offset the costs identified in section 8.2.

[85] *UKWIR, Capital Maintenance Planning Common Framework: Review of Current Practice, Ref: 05/RG/05/14*

Details of the various scenarios and sensitivity tests run can be found in the next section.

Process

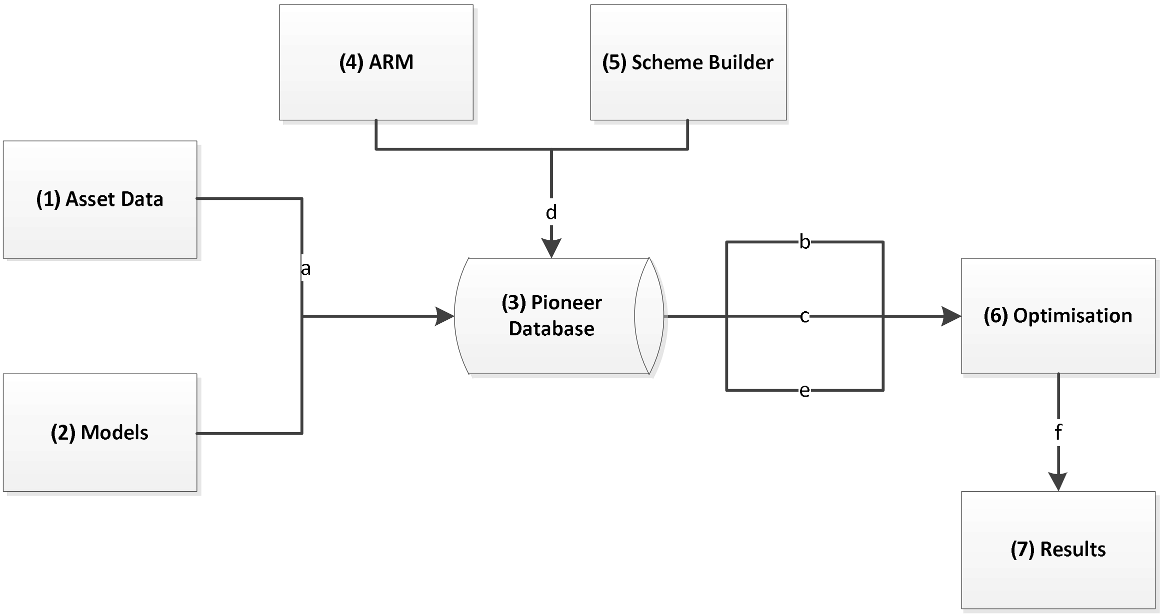


Figure 8-25 The PIONEER System

8.3.2.3 Asset data

Our asset inventory was arranged in the correct hierarchy as described in the previous sections. Each of these assets has a range of attributes, which define the asset and are used in the modelling process. The assets are arranged into asset types, which fail and are replaced in a similar manner. The asset data was held in the PIONEER Staging Area Database (*PIONEER_StagingArea_AWL).*

a] The data in the staging area is transformed into a format that is readable by PIONEER, imported into the main PIONEER database, and displayed in the Unit Hierarchy. From the Unit Hierarchy, this data can be used for modelling.

8.3.2.4 Models

Models are the main building blocks of the PIONEER system. They are used to calculate numerous values in the optimisation process including, failure likelihoods, costs, consequences and effects of interventions. There are numerous types of models that that have been used in the optimisation process,

- Calculation trees, a combination of mathematical functions to form a more complex equation
- Decision trees, allows the selection of a result based on decision logic
- Distributions, the most common mathematical distributions or can be a user defined distribution
- Lookup tables, allows the selection of a result based on the matching of attributes

The models can be combined to form more complex models, allowing detailed analysis to be performed.

The models are controlled by setting model coefficients; the model coefficients are used to make the specific models from the above lists. Different types of model coefficient can be used dependent on the need of the specific model, asset attributes, outputs of other models, information about the current year in the optimisation and static values. Static values can be added in one of two ways, a direct input into the PIONEER system, or by using the Excel Add-In module, which allows a vast number of coefficients to be added or edited at one time. The Excel Add-In has been used extensively and examples of this are explained in the previous sections.

In the case of the distribution mains likelihood models, these are populated with coefficients automatically by the Model Builder module.

Below is a table of the methods that were used to populate the coefficients and the types of models used in some of the most important models of our PIONEER configuration.

Unit Type	Model	Model Type	Model Coefficients
Distribution Mains	Failure Mode - Likelihood	Calculation tree - Multivariable regression with Bayesian conditional probability refinement	Asset attributes
Distribution Mains	Failure Mode – Costs	-	Direct input
Distribution Mains	Failure Mode – Consequence probability	-	Direct input (Global variable)
Distribution Mains	Failure Mode – Consequence quantity	-	Asset attributes
Distribution Mains	Intervention - Costs	Lookup table	Excel Add-In
Distribution Mains	Intervention – Grouping attribute	Populated by Model Builder	Asset attribute
Trunk Mains	Failure Mode - Likelihood	Calculation tree - Third order polynomial	Asset attributes
Trunk Mains	Failure Mode – Costs	-	Direct input
Trunk Mains	Failure Mode – Consequence probability	-	Direct input (Global variable)
Trunk Mains	Failure Mode – Consequence quantity	-	Asset attribute
Trunk Mains	Intervention - Costs	Lookup table	Excel Add-In
Non-Infrastructure & DMA Meters	Failure Mode - Likelihood	Calculation tree – Hazard Weibull function	Excel Add-In
Non-Infrastructure & DMA Meters	Failure Mode – Costs	Calculation tree *	Excel Add-In
Non-Infrastructure	Failure Mode – Consequence probability	Calculation tree – multiplication	Asset attribute/ Excel Add-In
Non-Infrastructure	Failure Mode – Consequence quantity	-	Asset attribute
Non-Infrastructure & DMA Meters	Intervention - Costs	Various calculation trees*	Excel Add-In

Table 8-17 A Summary of the Affinity Water PIONEER Configuration

* Different functions were combined into a single equation for the cost model, including constant, linear, power, quadratic, cubic, exponential and logarithmic functions.

8.3.2.5 PIONEER database

This is the main storage area where the optimiser keeps all the data retailed to models, failure modes, interventions and results. *PIONEER_AWL_PRD* is a SQL database held on the PIONEER server suite.

b] PIONEER uses failure modes as a method for calculating the impact of asset failure. A failure mode can apply to more than one type of unit and more than one failure mode can apply to each unit. There are three key parts of a failure mode, likelihood, costs and consequences.

The likelihood of a failure mode is the expected number of failures for a given amount of time (one year was used); they are calculated from the above models, which were based on the asset group analysis.

There are two main types of failure mode, repairable and non-repairable, this helps makes the distinction between a failure that can be repaired without replacing the asset, such as a main burst and one that cannot, such as a pump. The likelihood of a repairable failure mode is not affected by the past failures of the unit, whereas the non-repairable failure mode is affected. This is because past failures of the unit will affect its age in the current modelling time-step, this is done using Bayes' theorem.

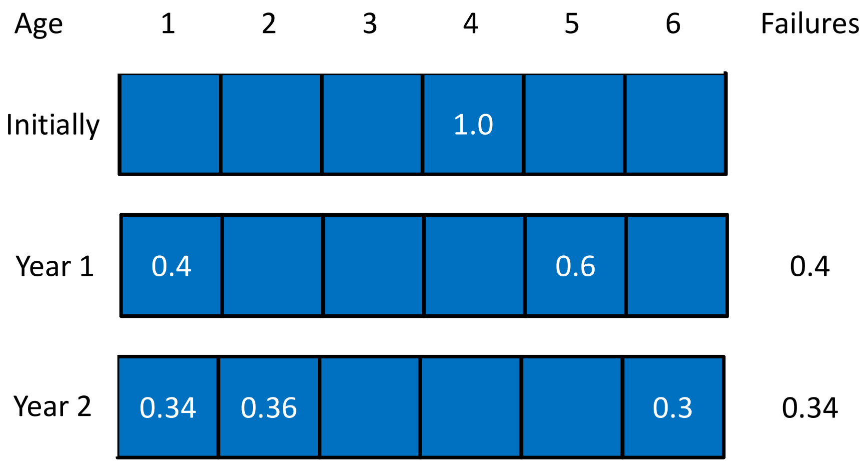


Figure 8-26 Age Profile of a Pump

(with 0.1 x age failures per year)

The change in the age profile considers that the pump may have failed and been replaced. For a repairable failure mode, the age profile is not affected by failures and the whole unit gets one year older.

The cost of failure mode is the expenditure associated with the repair of the asset and does not consider any consequential costs.

Asset failures affect the service measures through the consequence of failure. The consequences of failure have two parts, the probability of service measure failure given asset failure and the quantity of consequence.

$$Service\ Measure\ Consequence = Likel\ hood\ of\ failure \times (Consequence\ probability \times Consequence\ quantity)$$

An example of this is the burst failure of the distribution mains causing an interruption to supply, the consequence probability is the likelihood of a burst causing an interruption and the quantity is the number of properties affected by the interruption.

Each service measure has a cost per unit of failure as described in section 8.2.7.The total cost of failure is the cost of failure plus the consequential cost of failure. value is then used to calculate the consequential cost of the failure. The total cost of failure is the cost of failure plus the consequential cost of failure. value is then used to calculate the consequential cost of the failure. The total cost of failure is the cost of failure plus the consequential cost of failure.

c] Interventions are the proactive actions that the optimisation engine can select to change the effects of the failure modes and hence affect the service measures. Unlike failure modes an intervention can only affect one type of unit, however more than one intervention can affect each of the unit types. Effects of the interventions can be grouped into three main areas: attribute changes, failure mode changes and costs.

The most common change an intervention causes is to change the installation date of the unit, and hence affects the likelihood of subsequent failures. Other asset attributes can also be modified, changing the service measure impact or cost of repair. The model used to calculate the failure mode likelihood is also changed to allow a different deterioration curve to be used, when a partial replacement or refurbishment has occurred.

The final type of effect of an intervention is the cost associated with performing the proactive action. This is not only the capital cost of the intervention, but also any changes in operational expenditure not associated with failure, such as increases in chemicals used.

For some unit types, there are interdependences between the interventions that affect them. These interdependences may be a requirement of another intervention to have been performed with in a set time period or the intervention excludes other interventions being performed for a certain time period. For example, a replacement intervention may exclude a refurbishment intervention for 10 years due to an Asset Management policy.

Interventions may be required to be grouped together so that the modelled output is consistent with real life delivery. This is particularly relevant for the distribution mains where an intervention on the entire mains renewal group must be implemented.

Interventions can be mandated so that the optimiser must perform them. This is used for legislative requirements that cannot be optimised and for investment to which we are committed in AMP6.

8.3.2.6 Asset Risk Manager (ARM)

On occasions, assets do not perform as expected and modelled, this could be because they fail in a different way than expected or the consequence of failure has been different to that predicted. When a field-based engineer observes these differences, they can be added into the optimisation using the Asset Risk Manager (ARM) module. ARM is an add-on module for PIONEER; it allows new issues to be considered for inclusion into the capital maintenance programme. ARM has two main sections a risk (like a failure mode) and associated solutions (similar to an intervention). If more than one solution is present for a risk, then the optimisation engine will select the most appropriate and cost beneficial solution.

An ARM risk is a bespoke failure mode for a specific asset or process. Like a failure mode, a risk has a likelihood of failure and consequences, but these are simplified, to allow input with the reduced amount of data available for an isolated failure. An ARM risk can be solved by a bespoke ARM solution. Solutions use a limited selection of the main intervention types to remove the risk; the solutions are simplified to allow ease of use.

The ARM module also allows risks to be monitored in an area during every day operations so that managers can examine the risks in their area. This allows on-going maintenance and business planning to use the same risk framework.

8.3.2.7 Scheme Builder

Scheme Builder is a module that allows complex Schemes to be easily created. Schemes have several uses, not only during the capital planning process, but also for day-to-day project analysis. Scheme Builder allows the input of more complex solutions, such as non-like-for-like replacement when an asset is required to be up or down sized; these can then be linked to an ARM risk for use in the optimisation.

Prospective projects may be built in Scheme Builder to allow a localised cost benefit analysis to be performed, based on the same service measures and failure likelihoods as used in the capital maintenance optimiser. The schemes are priced using the PIONEER unit cost database, this allows Scheme Builder to be used as a project cost prediction tool.

d] The ARM and Scheme Builder values are transformed into the appropriate PIONEER values and stored in the PIONEER database.

e] A customer willingness to pay value can be attached to each service measure. These are then used in the optimiser as part of the net cost.

8.3.2.8 Optimisation

A PIONEER optimisation is based on several constraints that are applied through the optimisation configuration. Service measure targets can be set at any level of the hierarchy. The optimiser selects interventions so that the targets are met for each year of the optimisation period. It does this by calculating the benefits over the benefit period that would be achieved by each intervention and selecting those that meet the targets for the lowest cost.

Firstly, the optimiser performs all mandated interventions, and determines their impact on the service measures. The net cost for each intervention is then calculated, any that have a negative net cost (cost of intervention is smaller than the benefit costs) are automatically added into selected intervention list.

The optimiser compares the other interventions by calculating a “Z factor”

$$Z_i = \frac{\sum_{j=1}^{n} p_j s_{ij}}{q_i}$$

Where

Z = Cost effectiveness index
i = i^{th} Intervention
j = j^{th} service measure (that is constrained)
p = Service measure weighting – Optimisation factor
s = Benefit of the intervention with respect to the service measures
q = Total net cost of intervention

The optimisation engine selects the weighting factor so that the service measure targets are met with the lowest total cost. The interventions are then ranked based on their Z Factor. The interventions are then added to the selected intervention list based on the Z factor ranking, until all the service, measure targets are met.

f] The results were post processed using SQL queries and the inbuilt *PIONEER SQL Reporting Module*.

8.3.2.9 Output of results

The overall process for extraction and analysis of PIONEER results is summarised below.

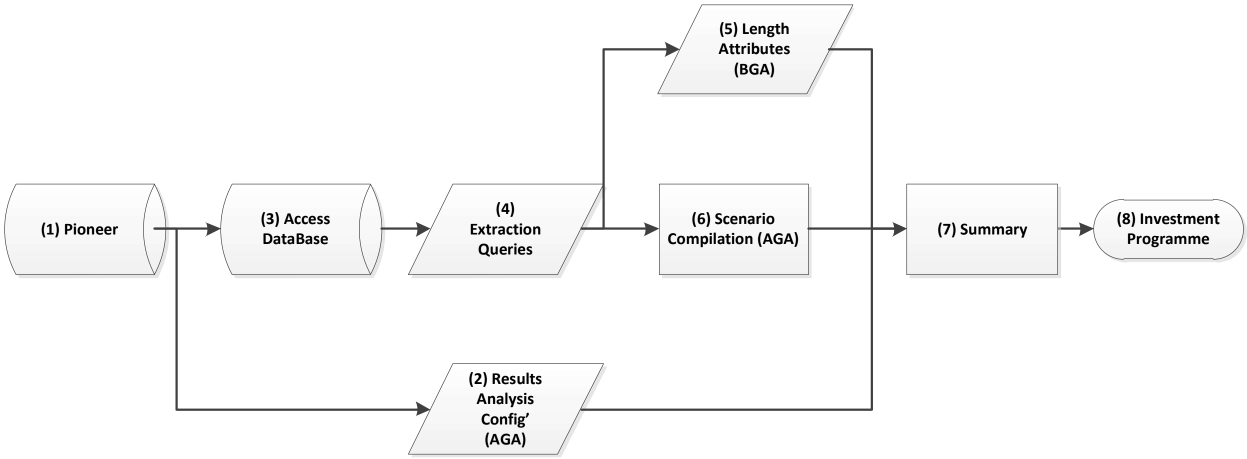


Figure 8-26 Outputs and Post Processing

1. PIONEER
The key source of information is the PIONEER system. The system has a number of pre-configured reports accessed via the integrated SQL Report Manager. Results from optimisations in PIONEER are stored in underlying database tables. Data can also be exported via an Excel Add-In or via an external database such as Microsoft Access.

2. Results Analysis Configuration Report
One of the standard reporting facilities in PIONEER is the Results Analysis Configuration Report. This is used to extract results for a selected optimisation scenario. It enables the selection of any costs or service measures to be viewed either graphically or in tabular format and if desired, compared with the baseline repair on failure scenario. This is used for calibration purposes to check baseline service levels are as per historic levels, and to export forecast above ground service measures and costs, using the Microsoft Excel export facility.

The costs to the business in this report are double discounted and annuitised as explained in section 8.3.1.1. These gross costs need to be factored to obtain net costs in real terms.

3. Access Database
There is the option to use an Access database direct Open Data Base Connectivity (ODBC) links into the PIONEER tables, Excel links or SQL queries which have been written and verified against the PIONEER internal reports, to enable full extraction of results for analysis.

4. Extraction Queries
There are numerous queries stored using MS SQL Server Management Studio used to export results to Excel workbooks for further analysis. For example:

a) Failure Costs: Extracts the reactive end-of-life probabilistic failure costs for all production assets.
b) Intervention Costs: Extracts the proactive intervention costs (replacement and refurbishment) for all production assets, converting the annuitized costs to real costs (2017/18 prices).

5. Length Attributes
The length attributes and intervention costs for pipelines are summated and linked directly to the overall summary.

6. Scenario Compilation
For each production asset scenario and iteration, a scenario workbook is compiled. The failure and intervention costs from queries (a) and (b) are pasted and the results are summarised in different ways to enable sense checks to be carried out on the mix of assets, regional balance etc.

7. Summary
A summary workbook[86] brings together the results from the non-infrastructure scenario compilations and the infrastructure results for all planning scenarios, sensitivity and materiality tests. At this point the investment profile is smoothed to minimise the impact of peaks on customer bills and ensure consistent delivery progress during the period.

8. Investment Programme
The results from the summary are copied to the overall investment programme with investments from other drivers such as supply/demand. For details of the final plan see section 9.

8.3.3 PIONEER service measures

8.3.3.1 Overview

This sub section covers:

- the approach to analysis performed using our investment portfolio optimisation software PIONEER using the UKWIR Framework for Expenditure Decision Making and Capital Maintenance Planning Common Framework
- the use of private costs, customer and environmental values as part of planning objectives
- the scope of analysis in terms of assets and drivers
- the targets set based on customer consultation
- the approach used in discounting future costs and benefits

8.3.3.2 Focusing the analysis

In respect of maintenance planning, two of the four customer outcome expectations are applicable:

- Supplying high quality water you can trust
- Minimising disruption to you and your community

While the quality, supply/demand and some management and general maintenance is evaluated outside of PIONEER, the outcomes and benefits are discrete. Aside from quality schemes, the benefits from these investments map to the other outcomes of '*Making sure you have enough water while leaving more water in the environment'* and '*Providing a great service that you value'*. The quality schemes impact on '*Supplying high quality water you can trust',* but with discrete objectives.

The maintenance outcomes are expressed by service measures from our Service Measure Framework as follows:

Outcome	Service Measures	PC
Supplying high quality water you can trust	Compliance with WQ Standards	-
	Compliance Risk Index (CRI)	Ofwat Common
Minimising disruption to you and your community	Interruptions >= 3hrs	Ofwat Common
	Mains Bursts (AHI)	Ofwat Common
	Unplanned Outage (AHI)	Ofwat Common

Table 8-18 Outcomes, Service Measures and PCs

[86] *Maintenance Scenarios Summary.xlsx*

Each of these service measures has been used to set constraints in PIONEER, so that service to customers and asset health targets are met throughout the optimisation period. Details of the service measures adopted, and PCs can be found in section 8.2.7.

The Service Measure Framework has also been used to allocate all our private costs (costs to the business) of asset failures should they occur.

The following paragraphs describe the setting of service objectives for our proposed plan.

Compliance with qater quality standards
Maintaining water quality compliance is a legislative requirement and in 2017 we achieved 99.96% compliance. In the consultations, customers have been clear that they want confidence that water quality will be maintained. The target service level to be met has therefore been set to maintain at the 2017/18 baseline level in all scenarios, however since the targeted improvement in CRI will also drive improvement in this measure, it is not necessary to set a constraint in PIONEER.

Compliance Risk Index (CRI)
This new index comprises three parts, compliance in water supply zones, compliance at water treatment works and compliance at storage facilities.

In 2017 we achieved a CRI index of 6.73. For AMP7 we aim to achieve median performance of last industry published year (2016) of 2.807 and this has been set as an annual constraint in PIONEER.

Interruptions more than 3 hours (property minutes)
This common PC comprises two components, planned and unplanned interruptions.
We plan to adopt a policy of installing temporary overland pipes to mitigate against the risk of planned interruptions arising from our renewal programme, when using pipe bursting/slip-lining techniques.

Reduction in unplanned interruptions > 3 hours will be achieved by improved operational response rather than capex investment, so a target has not been set in PIONEER.
There is a very low risk of widespread loss of supply from our production assets, but this is mitigated by keeping unplanned outage stable as below.

Number of burst mains
The maximum annual average level of mains bursts in our plan is 3,029 at the end of AMP7. This reflects the forecast starting point at the beginning of AMP7 given our AMP6 investments and the need to maintain asset health. The PC is set at 3,100 (as AMP6) allowing for fluctuations due to seasonal variance.

Unplanned Outage
For unplanned outage, we have used a surrogate measure of production asset failures at our non-infrastructure sites. This reflects adequate maintenance and long-term health of the assets and here, the target is to keep numbers stable over AMP7.

8.3.3.3 Discounting future costs and benefits in scenarios
PIONEER provides flexibility in the way that discounting is applied, namely:

- WACC (Weighted Average Cost of Capital) only
- STPR only (Social Time Preference Rate as recommended by HM Treasury ‘Green book’)
- Or double discounting using WACC and STPR.

Green Book Discounting is used on cost categories configured as follows:

- Costs borne by the company: "double discounting" using WACC and STPR
- Costs not borne by the company (e.g. social and environmental costs, carbon): STPR only.

This approach is known as the "The Spackman Approach" and is recommended by the Joint Regulators Group[87] on which Ofwat sat. Double discounting including STPR means that costs are discounted as follows:

- Costs are discounted to the start of the intervention period using the WACC
- Costs are annuitised using the same discount rate as above
- Costs are then discounted to the start of the intervention period using the STPR.

Double discounting has been applied to all business totex costs and STPR has been applied to social and environmental costs.

8.3.4 PIONEER options and scenarios run

8.3.4.1 Overview

This section describes the investment optimisation scenarios carried out. It also explains the sensitivity tests run and the materiality tests undertaken.

The scenarios and tests cover the maintenance of all distribution mains, trunk mains and above ground production assets.

The results and analysis arising from these scenarios are shown in section 8.3.5.

8.3.4.2 Scenarios

All the scenarios have been run for the combined portfolio of assets incorporating the distribution mains, communication pipes, trunk mains and above ground production assets. This allowed investment trade-offs between asset groups to be optimised in the best way to meet service constraints at best value for money (i.e. least cost).

All scenarios are compared with a 'do nothing' baseline service forecast which represents what would happen if assets were allowed to deteriorate without pro-active intervention. For production assets, this is represented by reactive replacement on failure, and for mains, by reactive repair.
The baseline forecast is run independently and is also run by the optimisation process, so that benefits of interventions can be calculated for each of the scenarios.

[87] *Discounting for CBA involving private investment, but public benefit, Statement published by the Joint Regulators Group (JRG), (July 2012), Further Ofwat Guidance on the Use of Cost Benefit Analysis for PR09, (December 2007).*

Several service scenarios were selected:

Scenarios					Constraints			
No.	**Scenario**	Green Book Discounting Applied	WTP	ARM Risks/ Solutions	CRI	WQ Compliance	Production Asset Failures (for Outage)	Mains Bursts
1	**Our Plan (All Consultation Scenarios)**	Y	N	N	2.807	>99.96%	3290	2999 (176 TMs)
2	**Our Affordable Plan with distribution pipes constrained to 210km**	Y	N	N	2.807	>99.96%	3290	unconstrained
3	**Unconstrained Plan**	Y	N	N	-	-	-	-
4	**Our Plan (All Consultation Scenarios)**	N	N	N	2.807	>99.96%	3290	2999 (176 TMs)

Table 8-19 Service Scenarios

Scenario 1
As the service levels proposed related to PIONEER are common, this scenario represents all plans (A, B and C) from our Business Plan Consultation in May 2018. Service is constrained to meet the levels in the plan above. This scenario is used as the basis for the Business Plan before affordability review. Green book discounting as described in section 8.3.3 is applied in this scenario. This scenario is to confirm the investment needed for the proposed plan that customers prefer.

Scenario 2
As per scenario 1, but with the length of distribution mains pipes constrained to 210km for affordability reasons to understand the effect on burst rate. Non-Infrastructure investment has also been smoothed across AMP7 and AMP8 and an efficiency reduction of 8.2% applied. This is our core plan.

Scenario 3
As per scenario 1, but without service measure constraints. This is to understand which investments are cost-beneficial or are renewal on failure costs.

Scenario 4
As per scenario 1, but without the green book discounting process applied. This scenario tests the sensitivity of the AMP6/7 programme to the WACC, the Social Time Preference Rate (STPR) and the effect of long term vs short term investments and benefits.

8.3.4.3 Materiality tests
All of the materiality tests are based on scenario 1.

Scenarios					Constraints			
No.	**Scenario**	Green Book Discounting Applied	WTP	ARM Risks/ Solutions	CRI	WQ Compliance	Production Asset Failures (for Outage)	Mains Bursts
5	**Preferred Plan - Environmental Test**	Y	N	N	2.807	>99.96%	3290	2999 (176 TMs)
6	**Preferred Plan – Maintenance Opex Test**	Y	N	N	2.807	>99.96%	3290	2999 (176 TMs)

Table 8-20 Materiality Tests

Scenario 5
Tests the impact on the plan by turning off carbon, environmental and social costs.

Scenario 6
This scenario tests the impact on the plan of risk of variance of unplanned maintenance activity through random events. This simulates historic high levels by increasing unplanned maintenance costs by 40%.

8.3.4.4 Sensitivity tests

Further scenarios were run to understand the effect of uncertainty of likelihoods and costs as listed in Table 8-21 below.

Scenarios					Constraints			
No.	**Scenario**	Green Book Discounting Applied	WTP	ARM Risks/ Solutions	CRI	WQ Compliance	Production Asset Failures (for Outage)	Mains Bursts
7	**Preferred Plan - Uncertainty Test**	Y	N	N	2.807	>99.96%	3290	2999 (176 TMs)
8	**Preferred Plan - Energy Test**	Y	N	N	2.807	>99.96%	3290	2999 (176 TMs)

Table 8-21 Sensitivity Tests

Scenario 7
This scenario tests the impact on the plan of uncertainty on both costs and failure mode likelihoods. By varying each cost or likelihood model by up to 20% depending on the accuracy of the model in question, it enables us to test the sensitivity of the plan to modelling uncertainties.

Scenario 8
This tests the impact on the plan of potential uncertainty around future energy costs. In this scenario, the energy price which increases over time is factored down by 20%.

8.3.4.5 *Intervention options*

For all the scenarios above, the investment portfolio optimisation considers different intervention options depending on the type of asset.

Asset (Unit) Type	Proactive Intervention Options	Reactive Intervention
Distribution Mains	Replace or New	Repair
Trunk Mains	Replace or New	Repair
District Flow Meters	None	Replace
Above Ground Civil assets	Refurbish, Replace or New	Replace
Pumps	Refurbish, Replace or New	Replace
Carbon Media	Regenerate, Replace or New	Replace
All other types	Replace or New	Replace

Table 8-22 Intervention Types

In all cases there is a replacement option and for pumps, media and most civil assets refurbishment is considered as an alternative where this is a feasible solution. There is also a 'new' option to cater for assets added by enhancement schemes via Scheme Builder.

8.3.5 PIONEER results and assurance

8.3.5.1 *Overview*

In this section, the results and analysis of the portfolio optimisation process using PIONEER are explained. The section should be read in conjunction with sections 8.3.4 which defines the scenarios run and the reasons for them, section 9 (Summary of our Plan) and our main Business Plan.

All the scenarios have been run for the combined portfolio of assets. The investment plan arising covers the maintenance of all distribution mains, trunk mains and production assets.

This section reveals the results of the PIONEER portfolio optimisation process and how tests were applied to assure our plan is the right plan for customers.

8.3.5.2 *Results and analysis*

The results for each scenario are listed in Table 8-23.

No.	Scenario	Distribution Mains (£m)	Trunk Mains (£m)	MNI (£m)	Total MI/MNI (£m)
1	Our Plan	58.2	29.8	92.8	180.8
2	Our Plan with Affordability and Efficiency adjustments	38.0	25.2	85.1	148.3
3	Unconstrained	0	7.3	92.8	100.1
4	Preferred Plan (No Green book)	69.5	35.9	96.8	202.2
5	Preferred Plan - Environmental Test	58.2	29.8	92.6	180.6
6	Preferred Plan – Maintenance Opex Test	58.2	29.8	101.8	189.8
7	Proposed Plan - Uncertainty Test	58.0	147.8	117.1	322.9
8	Proposed Plan - Energy Test	58.2	29.8	92.5	180.5

Table 8-23 Results Summary (2017/8 prices)

Scenario 1
The results shown represent the investment needed to meet the plans presented in our public consultation in May 2018 and is the starting point for our Plan. The main drivers for this plan in order of significance are:

Asset Group	Driving Service Measure	Outcome
Distribution Mains	Burst mains	Minimising Disruption and Asset Health
Trunk Mains	Burst mains	Minimising Disruption and Asset Health
Production Assets	End of life replacement (Least Cost) Energy (Deterioration) Water Quality Compliance Failures	Value for money Value for money High Quality Water Minimising Outage

Table 8-24 Proposed Plan: Drivers and Customer Outcomes

To maintain service levels, £180.8m of capital maintenance investment is required in AMP7: £58.2m on distribution mains, £29.8m on trunk mains and £92.8m on production assets. The profile of production investment has been smoothed over AMP7 and AMP8 to minimise the impact on customer bills of peaks in the profile and ensure consistent delivery progress during the period. Investment needed to maintain production assets has increased slightly since FD14. During AMP6 non-infrastructure serviceability has remained stable. Improved risk modelling combined with the introduction of TRACE and asset care plans (see section 5.2.7), has meant we are introducing more focused investments and preventative maintenance at asset level.

The scenario generates energy cost savings from pump set replacement and refurbishment, which offset the natural deterioration in efficiency over time. Without investment (renewal on failure) we would see an increase in energy use, due to deterioration of efficiency, over AMP7. With the proposed plan, a saving of £6.3m compared with renewal on failure is achieved. The change in energy use from production maintenance is reflected in our opex modelling and totex calculations. The saving in energy also impacts on carbon emissions; however, this is partly displaced by embedded carbon from replacement of infrastructure and production assets. The net impact is a reduction in emissions of 339,899 tonnes over AMP7.

Scenario 2 (Our Plan)
In the interests of affordability of our plan, we have constrained distribution mains investment to 210km. We believe this strikes the right balance between affordability and risks to underlying asset health, measured by the average burst rate. We have also set ourselves challenging unit cost efficiency targets of 11% and 8.2% for infrastructure and non-infrastructure respectively, to be achieved by repackaging of the portfolio to optimise contract size vs value for money and re-tendering.

To maintain service levels, £148.3m of capital maintenance investment is required in AMP7: £38m on distribution mains, £25.2m on trunk mains and £85.1m on production assets. The profile of production investment has been smoothed over AMP7 and AMP8 to minimise the impact on customer bills of peaks in the profile and ensure consistent delivery progress during the period. This represents a reduction from our PR14 Determination as follows:

Asset Group	PR14 Determination (£m) 2017/8 prices	PR19 Proposed Plan (£m)
Distribution Mains	66.9	38.0
Trunk Mains	24.8	25.2
Production Assets	96.4	85.1
Total	188.1	148.3

Table 8-25 Comparison of Modelled Investment with AMP6

With these investments in distribution and trunk mains we expect the average annual burst rate to remain under 3,029 p.a. during AMP7. This will accommodate seasonal fluctuations up to our proposed PC of 3,100 p.a. with a degree of confidence that is balanced with the affordability of our plan. This is achievable because over the last 7 years the average burst rate has trended lower partly due to milder winters, but also because our AMP5/6 renewal programme and our network calming initiative, have been successful in reducing bursts.

During AMP6 non-infrastructure serviceability has remained stable. More accurate risk modelling combined with the introduction of TRACE and asset care plans (see section 5.2.7)has meant we are introducing more focused investments and preventative maintenance at asset level.

As with scenario 1, our plan generates opex savings from pump set replacement and refurbishment, which offset the natural deterioration in efficiency over time. Without investment (renewal on failure) we would see an increase in energy use, due to deterioration of efficiency, over AMP7. With the proposed plan a saving of £6.3m is seen compared with renewal on failure. The change in energy use from production maintenance is reflected in our opex modelling and totex calculations.

The saving in energy also impacts on carbon emissions; however, this is partly displaced by embedded carbon from replacement of infrastructure and production assets. The net impact is a reduction in emissions of 339,899 tonnes over AMP7.

Scenario 3
Without service measure constraints the only incentive for PIONEER to choose planned interventions is because the intervention is cost-beneficial, so we expect to see these and any reactive capex to renew assets on failure.

There is no investment required in distribution mains, indicating the investment is driven by burst rate and CRI. Some trunk mains prove cost beneficial, but investment here is primarily about maintaining asset health. Turning to production assets, planned investment levels stay the same, as most interventions are pump sets which are cost beneficial to save on energy costs.

Scenario 4
Without the green book discounting process applied the plan increases slightly, but this is expected since the annuitisation as part of the discounting process favours longer term benefits in scenario 1.

8.3.5.3 Conclusions from materiality tests

Scenario 5
Turning off carbon, environmental and social costs changes the plan by a negligible amount (£0.2m) over AMP7 indicating that results are not sensitive to externalities.

Scenario 6
Increasing unplanned maintenance costs by 40% increases production capex by £14.7m per AMP. This is because the opex arising from the increased maintenance is making more investments cost-effective. However, the net totex would reduce. This is considered a low likelihood event, as our asset care Initiative has put in place improved planned operational maintenance and is therefore deemed immaterial.

8.3.5.4 Conclusions from sensitivity tests

Scenario 7

This scenario tests the impact on the plan of uncertainty of failure mode likelihoods and on intervention and failure costs. The analysis concluded that capex will be less than £323m in AMP7 given the distribution of likelihoods and costs. The greatest uncertainty is around the trunk main likelihood of failure. However, the change in the numbers of bursts over AMP7 is minimal and so there is little uncertainty about our burst rate PC. Based on experience of AMP6 where we laid similar lengths of trunk main, we are confident that the investment level will maintain asset health.

Scenario 8

In this scenario the forecast increase in energy price over time is factored down by 20%. Whilst this reduces investment in pumps slightly, the effect is not material (£0.3m). We can therefore be reasonably confident in the future price forecast.

8.3.5.5 Selection of Our Plan

Scenario 2 has been selected as the basis for the PIONEER maintenance investment in the preferred plan because:

- The feedback from customers on the public consultation in May 2018 and stakeholder engagement detailed in our plan shows that this is the desired option.
- It provides the service outcomes expected by customers at lowest cost and with the optimum mix of intervention options across the infrastructure and non-infrastructure portfolio
- It offers a reduction from our AMP6 plan for maintenance. This is primarily because over the last five years the average burst rate has trended lower, partly due to benign milder winters, but also because our AMP5/6 renewal programme and our network calming initiative, have been successful in reducing bursts. As a result, we can offer a lower level of distribution main investment to maintain burst rate.
- Investment needed to maintain production assets has decreased once our proposed efficiency reductions are considered. During AMP6, non-infrastructure serviceability has remained stable. More accurate risk modelling combined with the introduction of TRACE and Asset Care plans has meant we are introducing more focused investments and preventative maintenance at asset level where risk is highest.
- The plan is relatively insensitive to changes in energy prices and carbon and environmental costs offering reduced risk to price volatility.

Outputs from PIONEER are worth £148m capex and make up 11% of the AMP7 investment portfolio.

8.4 Service Delivery Map and network management

8.4.1 Overview

The Service Delivery Map (SDM) is a framework developed with the aim of creating enhanced customer value from our assets through efficient zone planning and operation. Its main objective is to achieve optimised investment and operating costs against asset and operations performance, risks and environmental performance. It uses prediction tools to forecast changes to service that are important to customers as laid out in the outcomes relating to water quality, minimising disruption and supplying enough water whilst leaving more in the environment. This therefore allows us to identify medium and long-term plans to manage any changes.

The optimisation of our non-infrastructure costs (pumping and treatment) is achieved by the Source Delivery Map, which is an important part of the Service Delivery Map framework. It is the means by which we guarantee water supply to all communities in the most efficient and sustainable way. It comprises the systems and processes that we have in place to manage the abstraction of water and minimise the operating costs of water production and supply across the strategic network. This section explains how we optimise our source outputs and how we have devised software to maximise pumping efficiency and minimise operating costs. We also explain the functionality and benefits of Navig-8, our in-house developed SDM support application, which enables us to map historical service and expenditure and future performance geospatially and allows us to take a true source to tap view on operations.

These systems will:

- Provide support and justification for future Business Plan and Water Resource Management Plan submissions
- Deliver savings in AMP7 through improved asset efficiency, optimisation and energy savings.
- Define investment needed in our communities in the future and enable profit and loss responsibility at community level

8.4.2 Our community assets and current performance

The term "community" is used in so many diverse contexts that it is virtually impossible to provide a simple definition for wide application. For our specific purposes, a community is "people living in a defined, localised geography with common attributes of water supply." This could refer to geographies covering a wide range of scales, from District Metered Areas up to entire catchments. We made the decision that, at least initially, the appropriate scale should be that of Water Resource Zones so that it is aligned with the basic spatial element used for Water Resources Management Planning. These are defined primarily on the configuration of our water resources, supply and assets and the pattern of our customer populations.

The boundaries of communities are set without explicit reference to political or administrative boundaries. Although we would expect them to remain relatively stable, secular changes in the configurations of our supply and asset base and in customer demographics will probably make it desirable from time to time to adjust boundaries.

Our communities are represented in Figure 8-27 below. We have named them after local rivers. These eight communities form the basis of our strategic and water resource planning.

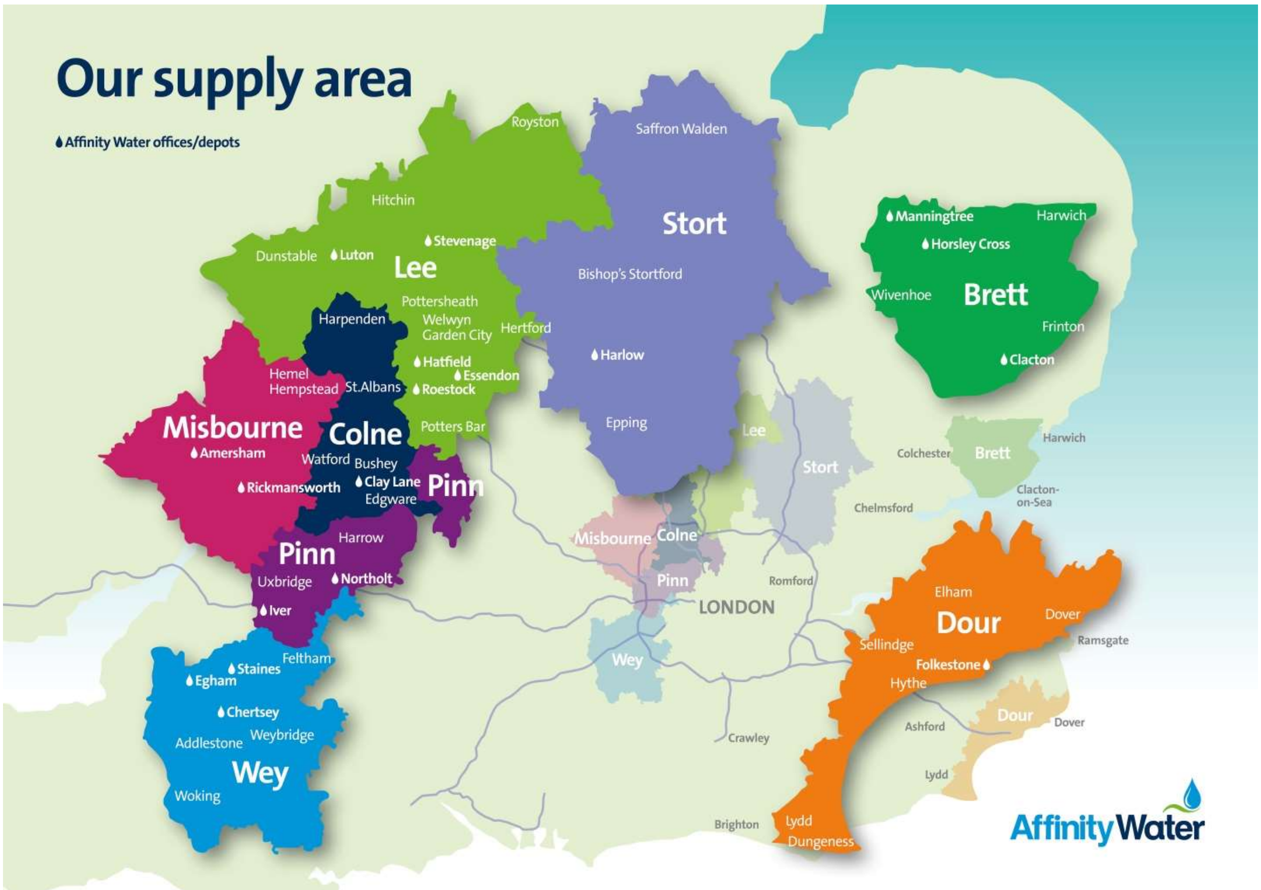


Figure 8-27 Our Eight Communities

Misbourne Community

Population served	331,000
Length of main	2,100km
Area of community	476km²
Average water usage (litres per person per day)	167
Annual Performance Commitment	**February 2018**
Affected customers not notified of planned works	0
Number of mains bursts on our network	39
Unplanned interruptions to supply of more than 12 hours	22
Planned works taking longer to complete than notified	0

Colne Community

Population served	448,000
Length of main	1,800km
Area of community	299km²
Average water usage (litres per person per day)	161
Annual Performance Commitment	**February 2018**
Affected customers not notified of planned works	0
Number of mains bursts on our network	22
Unplanned interruptions to supply of more than 12 hours	0
Planned works taking longer to complete than notified	0

Lee Community

Population served	717,000
Length of main	3,200km
Area of community	986km²
Average water usage (litres per person per day)	151
Annual Performance Commitment	**February 2018**
Affected customers not notified of planned works	0
Number of mains bursts on our network	46
Unplanned interruptions to supply of more than 12 hours	47
Planned works taking longer to complete than notified	0

Pinn Community

Population served	977,000
Length of main	2,700km
Area of community	273km²
Average water usage (litres per person per day)	166
Annual Performance Commitment	**February 2018**
Affected customers not notified of planned works	0
Number of mains bursts on our network	42
Unplanned interruptions to supply of more than 12 hours	63
Planned works taking longer to complete than notified	0

Stort Community

Population served	298,000
Length of main	2,300km
Area of community	1192km²
Average water usage (litres per person per day)	150
Annual Performance Commitment	**February 2018**
Affected customers not notified of planned works	0
Number of mains bursts on our network	27
Unplanned interruptions to supply of more than 12 hours	0
Planned works taking longer to complete than notified	0

Wey Community

Population served	537,000
Length of main	2,600km
Area of community	496km²
Average water usage (litres per person per day)	164
Annual Performance Commitment	**February 2018**
Affected customers not notified of planned works	0
Number of mains bursts on our network	46
Unplanned interruptions to supply of more than 12 hours	0
Planned works taking longer to complete than notified	9

Dour Community

Population served	180,000
Length of main	1,100km
Area of community	413km²
Average water usage (litres per person per day)	125
Annual Performance Commitment	**February 2018**
Affected customers not notified of planned works	0
Number of mains bursts on our network	10
Unplanned interruptions to supply of more than 12 hours	17
Planned works taking longer to complete than notified	0

Brett Community

Population served	151,200
Length of main	900km
Area of community	382km²
Average water usage (litres per person per day)	121
Annual Performance Commitment	**February 2018**
Affected customers not notified of planned works	0
Number of mains bursts on our network	9
Unplanned interruptions to supply of more than 12 hours	9
Planned works taking longer to complete than notified	0

*All performance figures are unaudited and subject to change

Figure 8-28 Community Dashboard 1

Our communities are supported by various asset layers (Figure 8-29).

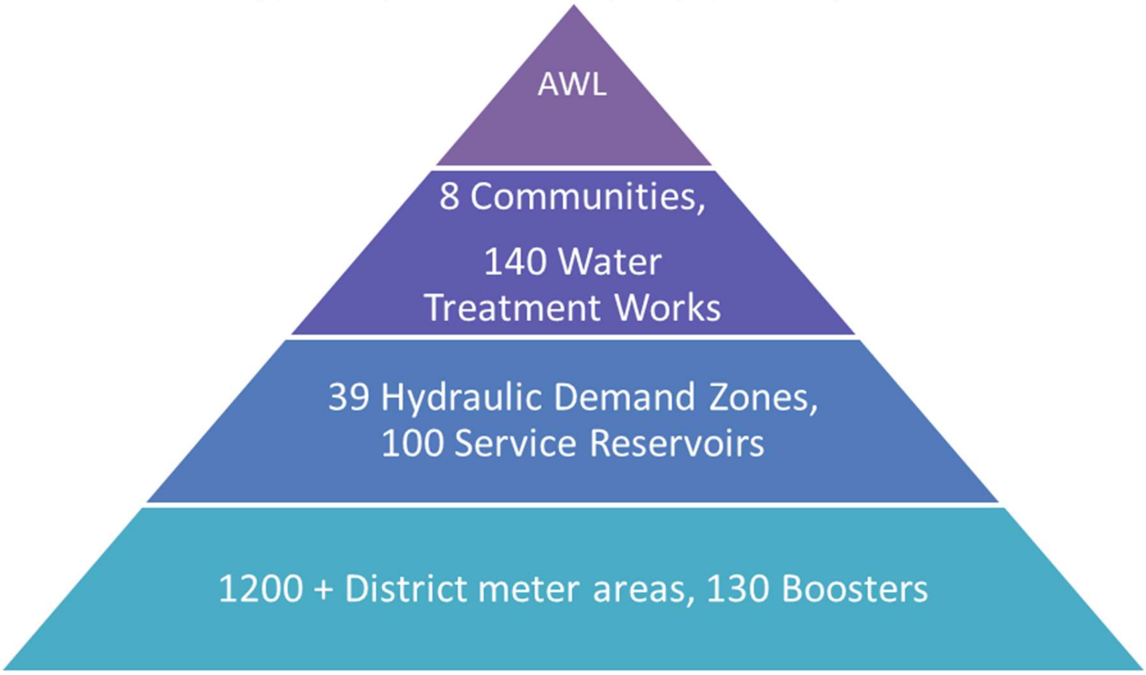


Figure 8-29 Community Asset Layers

Figure 8-30 represents the key strategic transfers that occur in our Central region across community boundaries between the Hydraulic Demand Zones (HDZ).

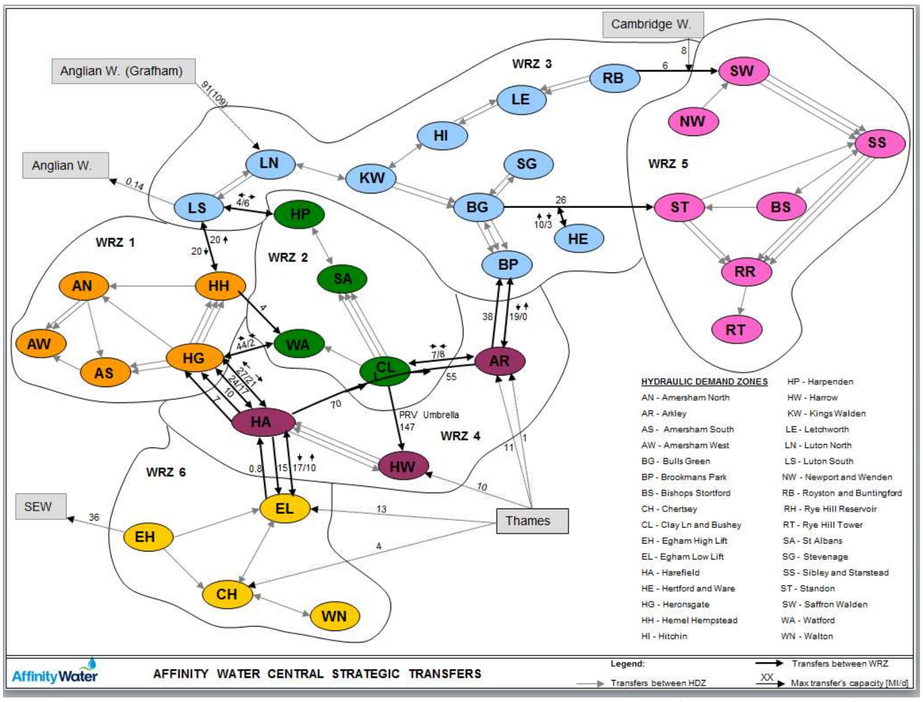


Figure 8-30 HDZ Map with Strategic Transfers – Central Region

8.4.3 Service Delivery Map

The main objective of the Service Delivery Map is to achieve optimised investment and operating cost against asset and operations performance, risks and environmental performance, ensuring that we:

- Provide support and justification for our Business Plan and Water Resource Management Plan submissions
- Deliver operational savings in AMP7
- Define investment needed in our communities in the future and enable profit and loss responsibility at community level

It essentially aims to link customers with our asset performance, and service and the required investment to deliver that service.

It is an essential component of our approach to deliver our Business Plan and planning preparation for AMP7. It is both an operational concept to be more efficient and a service delivery strategy for the community, which we have called the Community Delivery Model (CDM).

The SDM enables the ‘contract’ between customers, Asset Management and Community Operations to work in unison. It creates a proper dialogue with customers on improvements needed at the community level and how much these might cost. It builds on the proven data sources, tools and methodologies employed in the company.

Figure 8-31 The Community Delivery Model

We use prediction tools to forecast changes to service that are important to customers (water availability and usage restrictions, short-term interruptions, pressure, water quality, leakage etc.) and therefore we can identify medium and long-term plans to manage any changes. The SDM process also allows us to investigate how we can change the type and volume of operational activities we carry out, through investment in new technology, therefore contributing to the efficiencies that our Operations colleagues are focusing on.

The Service Delivery Map is essentially the knowledge that enables the impact of asset condition and performance on customers to be understood in terms of service. It explains how assets provide service – and by looking at the assets from this point of view, allows us to better understand the potential trade-off between risk and cost. As a result, we can link the operation and investment needs of pipes and production sites with the level of service provided to our customers.

We predict service levels (using existing forecasting tools such as PIONEER and Model Builder burst model, EBSD model and hydraulic models) and cost/risk outcomes (using PIONEER) from various asset management and operational inputs e.g. impact of bursts on service, leakage detection effort against water savings. We use other tools such as Navig-8, TRACE, TrackDown, Outage, PSPM, asset risk profiling workshops, ARM (Asset Risk Manager module in PIONEER), Network MOTs and Asset Care Plans as described in Figure 8-32.

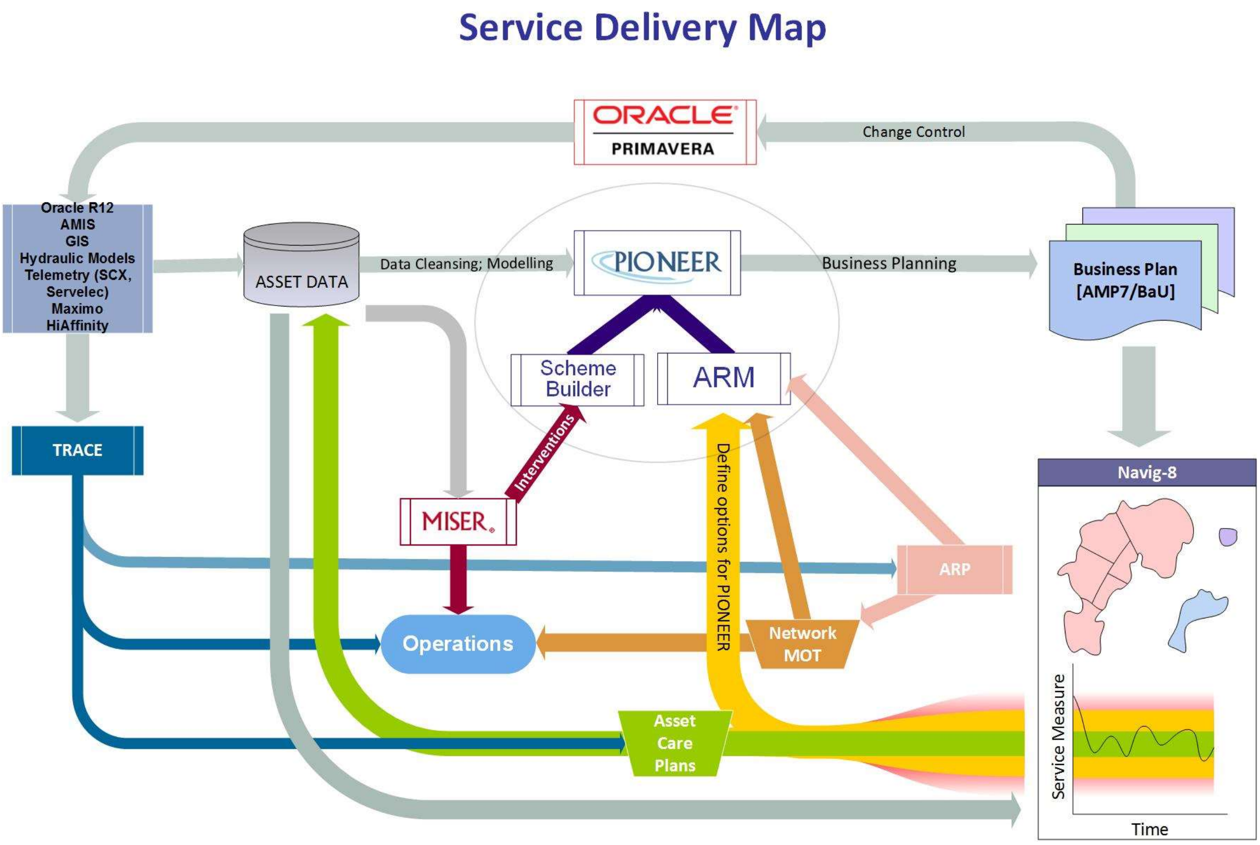


Figure 8-32 The Service Delivery Map Framework

8.4.4 Community-based asset plans

8.4.4.1 Community focus

Community focus is a key element of the company's vision. We have designed the Community Delivery Model to deliver a more tailored service to each community by involving each of them in decisions. Through our programme of engagement and regular contact with the community, we are able to involve customers in the SDM process. It breaks down our traditional approach of managing assets and customer services separately. Instead it focuses on how we can manage our network, assets and service levels as an integrated whole, to deliver the service to each community.

We recognise that the community approach is particularly important for dealing with future challenges in water resource management - a more personalised and community-based approach that combines maintenance, repairs, metering, efficiency devices and education may make customers more accepting of variable pricing, as they would be able to see that we are doing all we can to address the problems of supplying water in the future. The resilience of our community assets is also considered in great detail as part of this business plan – this is further explored and discussed (in the context of community investment) within the "investment by community" chapter of the Business Plan.

Customers want to see where the money from their bills goes and have more information about what improvements have been delivered. We have answered this as part of our business plan through our community investment posters, which detail the initiatives which are taking place in each department. There is also a need for more information to be provided to customers on water supply issues and our responsibilities and activities. In the last five years, we have developed our external engagement initiatives to enable the customer to receive more information on our website on monthly community performance.

The type of information and format of information, along with the channel it is delivered through (on-line, face-to-face, etc.) is further discussed in our business plan, which discusses the customer communication strategy in more detail.

8.4.5 Mapping service with performance of assets

8.4.5.1 Service and consequence modelling

Our fault tree and outage reporting tools TRACE and Trackdown have been used extensively in the last five years to better understand the asset failure and outage for our non-infrastructure assets – we have been reporting all asset failures, fault cause and repair times in order to calculate the true cost of unplanned outages. This is further explored in section 5 where the benefits of long term planned investment reduced unplanned outage in our non-infrastructure assets.

Historical data has been used to define the impact of asset failure on service failure[9]. For example, asset failure consequence probabilities were determined for trunk mains and distribution mains

8.4.5.2 Navig-8 – mapping asset performance across all eight communities.

Navig-8 is the SDM support application. It enables us to map historical service and expenditure as well as future performance. Navig-8 is named after the eight regions or communities served by Affinity Water. These communities are aligned with the Water Resource Zones (WRZ) used for water resources management planning.

Despite the generally recognised and accepted need to ensure a joined-up approach to asset planning, delivery and operation, before the development of Navig-8 there was no single place to view this spatial and temporal information. The tool was designed to support our vision for data mastering and quality, which is further discussed in our data strategy appendix.

We use Navig-8 to inform decisions and improve customer experience, also to promote collaboration between Asset Strategy and Operations to provide sustainable savings now and in future AMP cycles. Navig-8 provides a framework for ‘source to tap’ system planning.

8.4.5.2.1 Main functionalities of Navig-8

Navig-8 is a top-end, web-based application available in the Citrix environment, which uses a Business Intelligence technology (QlikView) coupled with a mapping element (ESRI ArcGIS).
The main functionalities of the tool are:

- Visual representation of the link between condition and performance of our assets and customer service levels
- Modelling of future scenarios and validation against past performance
- Ability to present the impact of operational and capital interventions on customer service
- Visual representation of the risk profiles to achieve or maintain desired service levels

It connects business systems and combines information from our key corporate databases, sourcing data from WMIS, GIS, HiAffinity, PIONEER etc. as described in Figure 8-33.

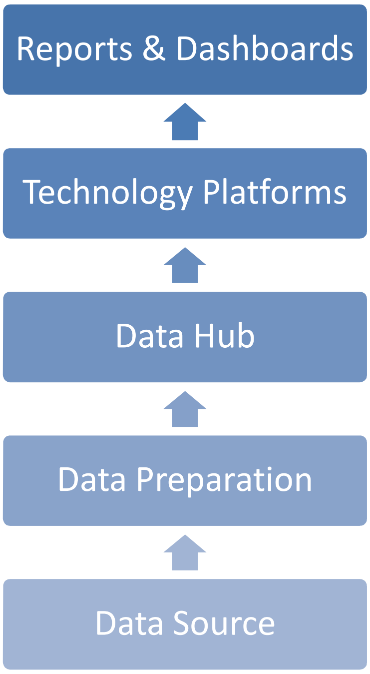


Figure 8-33 Asset Data Management Connecting Business Systems to Inform Decisions and Improve Customer Experience

8.4.5.2.2 Dashboards and Data sources

Navig-8 combines the following datasets from key corporate systems with GIS map layers (company area boundaries and trunk/distribution mains asset layers):

Asset performance data

- Mains Bursts AMP4-6 (WMIS/MAXIMO/GIS),
- Modelled bursts for 1997 – 2060 (PIONEER)
- Source utilisation 2012 to date (TRACE)
- Leakage levels 2010 to date – end of year month leakage (Waternet)

Service level impact

- DG2 and DG3 2007-18 (Regulatory registers)
- Customer complaints (Hi-Affinity)
- Planned developments (GIS)

Operational performance

- Network jobs AMP4-6 (WMIS/MAXIMO)
- Financial performance data
- Network Repair and Maintenance costs (Customer Operations Resource Model)
- Mains renewals AMP4-6 (GIS)
- Forecast investment (PIONEER)

Level of risk

- Discolouration and Taste and Odour risks – yearly analysis (DOMS)
- Asset Criticality
- Forecast risk (PIONEER)

Water Resources

- Supply-demand balance - including sustainability reductions impact (WRMP)

These datasets are fed into our Navig-8 dashboard which currently cover (but are not limited to):

- Leakage management dashboard
- Burst tracker dashboard
- Distribution input and Water balance dashboard
- Asset care and maintenance dashboard
- Water quality dashboard
- Activity Based Costing Dashboard

8.4.6 Further development

8.4.6.1 Risk profiling

Following the development and roll out of the asset risk workshops for MNI assets in 2011-12, we have automated the process. under the Asset Care Optimisation project and also linked to SDM process (using the TRACE platform).

The process has now been extended to the infrastructure assets in order to review network asset condition and performance, determine risks and opportunities and maintenance requirements. All recent initiatives (TrackDown approach, Outage, PSPM, Asset Risk Profiling) are now joined up under a source-to-tap approach with consistent risk quantification.

The zonal workshops are a key element needed to validate the data/information provided by the key corporate systems into Navig-8 with expert knowledge from the field. Their aim is to collect field knowledge on network asset performance and risk, and to clearly identify the root cause of issues (as described in Figure 8-34. During the workshops, Navig-8 is used to highlight areas of issues and good performance; it easily identifies the relative best and worst DMA performers. It also helps to identify and learn lessons from ‘own goals’ and to put in place corrective actions where appropriate.

Proactive maintenance has been developed in order to support our investment needs, from source to tap. The cycle of risk profiling is captured as part of the service delivery framework, as outlined in our Strategic Asset Management Plan and detailed in the ongoing asset management segment of the wholesale technical appendix.

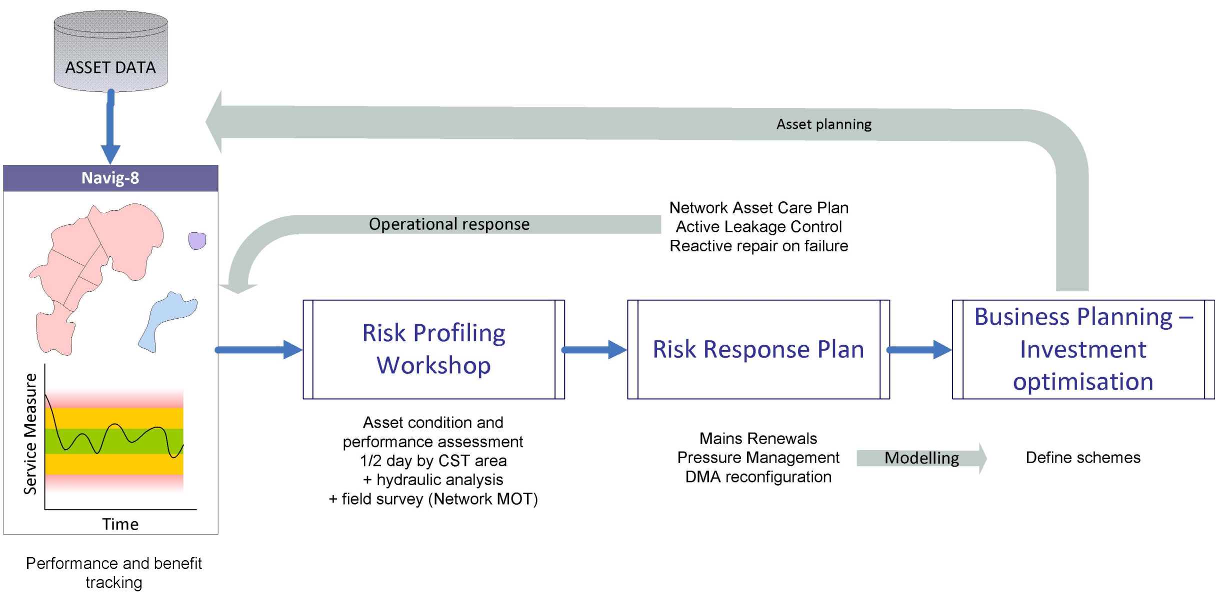


Figure 8-34 Risk Profiling Process

The approach complements the work carried out by our Asset Performance Laboratory which is used to improve our understanding of pipe condition. We carry out proactive analysis to assess mains to be replaced as part of renewal programme and reactive investigations to assess root cause of failures. The results help keep our investment planning process current and accurate, and provide verifiable data to support decision making on individual pipes selected for renewal.
Hydraulic performance studies are also carried out to provide timely feedback on the condition and performance of the network. These include RAPID assessment, anomaly solving and DG2 pressure analysis.

8.4.7 Source Delivery Maps

8.4.7.1 Source Delivery Map overview

The Source Delivery Map is the means by which we guarantee water supply to all communities in the most efficient and sustainable way. It comprises the systems and processes in place to manage the abstraction of water and minimise the operating costs of water production and supply across the strategic network. The Source Delivery Map ensures that we:

- Provide water during average demand times in the most efficient way
- Efficiently plan for disparities in demand and supply such as peak summer or a drought year while also making sure this is achieved as efficiently as possible
- Meet our medium and long-term needs looking holistically across the supply network and managing the change in risk that may result from changes in the supply (e.g. sustainability reductions) or demand (e.g. metering and water use changes)

Significant marginal cost drivers are energy, treatment and maintenance. We manage and control (reduce where possible) these source marginal costs, by optimising the network, capital maintenance targeted at replacing or refurbishing inefficient plant and new schemes to reduce bottlenecks in our network mains and maximising source abstraction and the transfer of water between zones.

Our production sources are geographically located within communities, abstracting water from the underground aquifer, or the river Thames. In addition to producing water locally, we choose to pump water from low cost sources to supplement demand in other zones.

We use the optimisation software package MISER_S, provided by Servelec Technologies Ltd. who we worked with to configure the software to our exact requirements. Uniquely within our industry, the MISER_S model covering our largest region contains marginal cost curves for each source and pumping transfer. This means optimisation is not simply a mass balance / average cost optimiser, but optimises on marginal costs which change according to flow. A summary of optimisation models throughout our regions are;

- Our Central Region's 33 Hydraulic Demand Zones and interconnectivity are shown in Figure 8-30. This forms the basis of the Region's MISER_S model, which optimises daily operations over the year. Additionally, over 30% of the region is configured in a single MISER_PS model, which optimises half hourly operations over the week, to maximise tariff benefits.
- Our South East Region is configured in a MISER_PSL model, which utilises a live connection from telemetry to produce half hourly optimised pumping schedule, starting from current conditions.
- Our Eastern Region is relatively simple, with extensive cost optimisation in the local control systems. The system minimises pumping pressures and uses available storage for tariff advantage. With sources being restricted on water quality blending requirements, there is little scope to improve upon this.

8.4.7.2 Source Delivery Map value

The systems and models we use are designed to reduce operational costs. However, the use of the MISER_S models is extensive providing optimum cost operation during diverse scenarios;

- Minimising costs under normal conditions.
- The examination and analysis of operation during drought planning (e.g. 2018), where source availability is reduced considerably. The model is used to confirm optimum use of the remaining sources and any increased need for imported water.
- Medium and long terms analysis in conjunction with water resource planning especially under proposed source reduction and demand reduction scenarios (AMP6/AMP7 sustainability reductions and increased metering). We model the options future capital schemes and transfers and associated energy costs to make sure cost-effective solutions are chosen. With Servelec Technologies we have improved the MISER model to now include zone storage. This allows us to model risk in terms of storage during extreme events.

Other tools are currently used to support the optimisation of our network operation thus reduction in operational costs – thanks to pump performance monitor (PSPM) and activity based costing analysis, we can continuously review our mode of operation (opex) whilst information on capital pump replacement programmes ensures we replace the least efficient pumps in our network.

8.4.8 Source Delivery Map components

Our Source Delivery Map processes are combined to deliver efficient production and supply of water across the regions. The component parts enable us to;

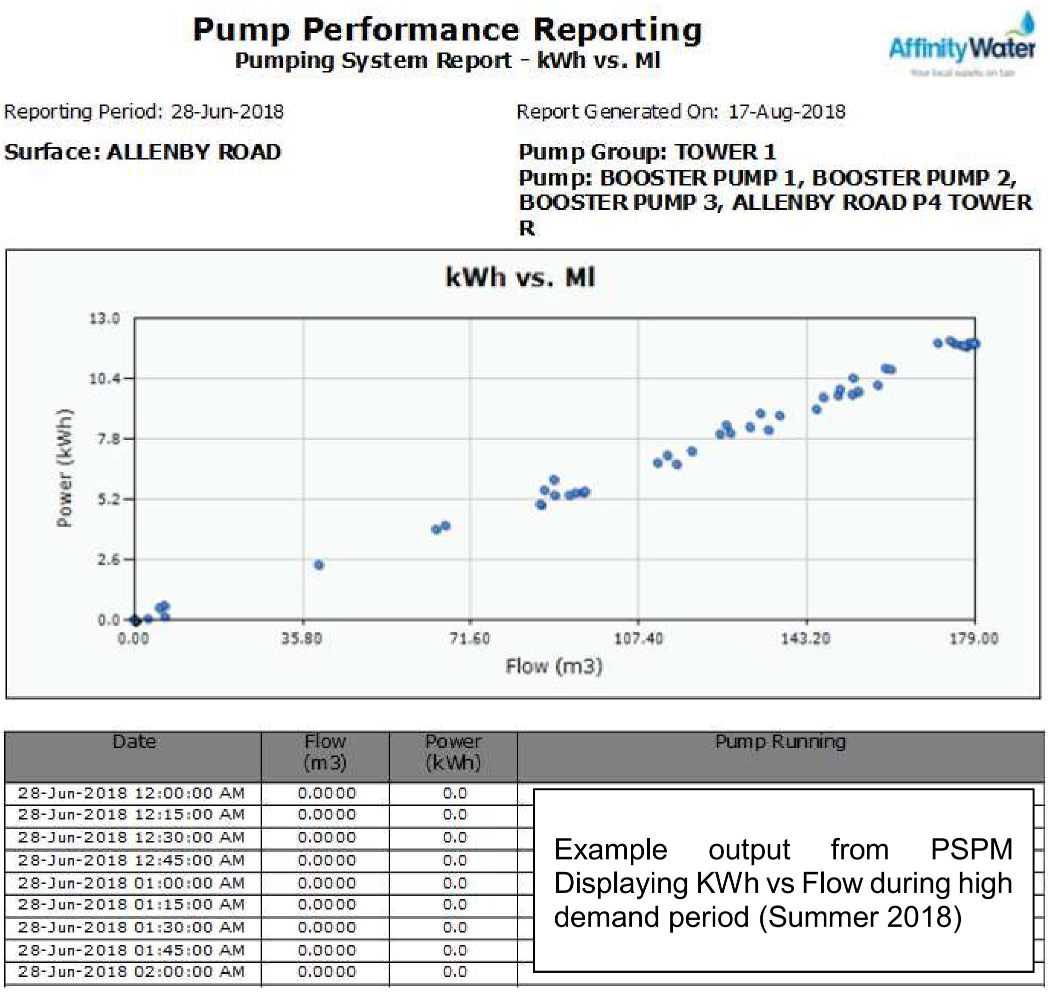
- Understand marginal costs and capacities of sources and transfers, minimising or reducing associated effects on below ground assets:
    - Chemical average costs.
    - Maintenance average costs.
    - Energy kWh/Ml performance curves and individual site energy tariffs, plus Carbon Reduction Commitment costs.
    - Import Marginal costs, £/Ml
- Reduce cost of production at source abstraction sites.
- Reduce cost of transfers from source to demand (Using tools such as PSPM).
- Understand network connectivity and demand, in hydraulic demand zones (HDZ's).
- Understand source availability annually and short-term adjustments, due to outage.
- Use MISER_S model for annual licence profiling and advise optimum source and transfer daily operation, with monthly updates.
- Use MISER_PS to advise Southeast region and Central's LANE/HWFS/Harrow system optimum operation on a half hour basis.
- Agree and record site optimum operation strategies, for peak tariff avoidance and operation during TRIAD times.
- Communicate optimum strategy to production managers and all stakeholders, in the Operations Centre's monthly plan.
- Monitor divergence from optimum and feedback for improvement in operation and capacities.
- Monitor model accuracy and feedback configuration improvements.

8.4.8.1 Understanding marginal costs

In order to optimise costs, it is critical that marginal costs are measured, understood and correctly configured in the MISER models. Additionally, we ensure that pressure changes and pumping on our underground assets are not significantly increased, as the marginal cost of leakage and bursts are significant.

The marginal costs of each source and transfer is determined as follows:

- Site marginal energy performance (kWh/Ml) were configured in the MISER systems by Servelec Technologies and ourselves, derived from actual energy use recorded in our Optima energy database and flow data taken from our site flow-meters on telemetry. On selected systems, site level data is not appropriate, therefore measured kWh/Ml data from our "Pumping System Performance Monitor (PSPM)" system was used, if available. An example of this measured data is below in Figure 8-35, displaying the measured kWh/Ml pumping transfer performance, for the MISER configuration.


Pump Performance Reporting
Pumping System Report - kWh vs. Ml

Reporting Period: 28-Jun-2018
Report Generated On: 17-Aug-2018

Surface: ALLENBY ROAD
Pump Group: TOWER 1
Pump: BOOSTER PUMP 1, BOOSTER PUMP 2, BOOSTER PUMP 3, ALLENBY ROAD P4 TOWER R

Date	Flow (m3)	Power (kWh)	Pump Running
28-Jun-2018 12:00:00 AM	0.0000	0.0	
28-Jun-2018 12:15:00 AM	0.0000	0.0	
28-Jun-2018 12:30:00 AM	0.0000	0.0	
28-Jun-2018 12:45:00 AM	0.0000	0.0	
28-Jun-2018 01:00:00 AM	0.0000	0.0	
28-Jun-2018 01:15:00 AM	0.0000	0.0	
28-Jun-2018 01:30:00 AM	0.0000	0.0	
28-Jun-2018 01:45:00 AM	0.0000	0.0	
28-Jun-2018 02:00:00 AM	0.0000	0.0	

Example output from PSPM Displaying KWh vs Flow during high demand period (Summer 2018)

Figure 8-35 PSPM Output

- Our tariffs are marginally different at each site. However, our >100kW sites, which use over 92% of total energy, follow the same diurnal pattern. When configuring tariffs, all sites were categorised into 1 of 8 tariff profiles, the categorisation generally following their location in the National Grid and therefore their associated DUOS costs. In addition to this, the cost of the Carbon Reduction Commitment (CRC) is configured. Daily optimisation in the Central Region's MISER_S model uses average tariff rates.
- Sensitivity analysis is carried out on our MISER_S model, using weekday peak tariff rates, in addition to average daily tariffs, to confirm operations at peak tariffs are optimised. If this was not carried out average daily tariffs optimisation could lead to sub-optimum operation during the peak tariff periods.
- Site chemical costs were determined from actual chemical use, flows and cost data, which is captured as part of our activity based costing reports (ABC). We have currently

proceeded to develop our operational cost reporting capabilities in 2018 to provide granular, site level opex costs.

- Site maintenance costs were determined from the actual number of reactive and planned work orders, at each site, as recorded in our AMIS system.
- Import marginal costs are confirmed annually with Finance and the Operations Centre.

These are significant and usually higher than our own source costs. However, if we re-lift our water several times then, particularly at peak tariffs, the ANGL import could be less expensive.

The MISER_S and MISER_PS models on occasions require alternative configurations. For the MISER_S model, the average daily volume performance is sufficient. The MISER_PS model requires the marginal performance in volumes per half hour, for optimisation against half hourly tariffs and storage requirements.

8.4.8.2 Reducing marginal costs

Besides personnel, energy costs are our highest operational costs. Being a water-only company, we have been focused on reducing the energy use in our water pumping systems, as opposed to other companies (WASC's) who may focus on the installation of combined heat and power plants, to reduce energy costs. AMP6 contained a significant pump replacement programme, reducing energy costs on these sites by over £1,000,000 per annum. The replacement programme was built up from initial analysis of sites, followed by specific pump testing and approval of numerous optimisation schemes.

Significant emphasis has been provided for many years in optimising the marginal cost of treatment from source works. The aim is to reduce energy and chemicals costs used during treatment processes. We have also focused significantly on our overall pumping and energy use – below is a table of our energy use over a seven-year period:

Year	Energy (MWh) Treatment	Energy (MWh) Network	TOTAL
2011/12	42,495	184,255	226,750
2012/13	40,154	179,144	219,298
2013/14	40,329	183,116	223,445
2014/15	38,602	177,504	216,106
2015/16	39,332	181,023	220,355
2016/17	40,678	179,856	220,543
2017/18	33,185	195,143	228,328

Table 8-26 Energy use (Kwh)

8.4.8.3 Network and Demand Configuration

The optimisation process requires an accurate understanding of demand, sources and transfer between demand zones.

MISER_S Model – Central Region

For our MISER_S model, this is approached at HDZ level. Each source is configured within its respective HDZ. The interconnectivity is then configured with each transfer route. Figure 8-36 below shows the configuration map of our Central Region within the MISER_S model. During commissioning, scenarios are run to ensure the model matches actual performance.

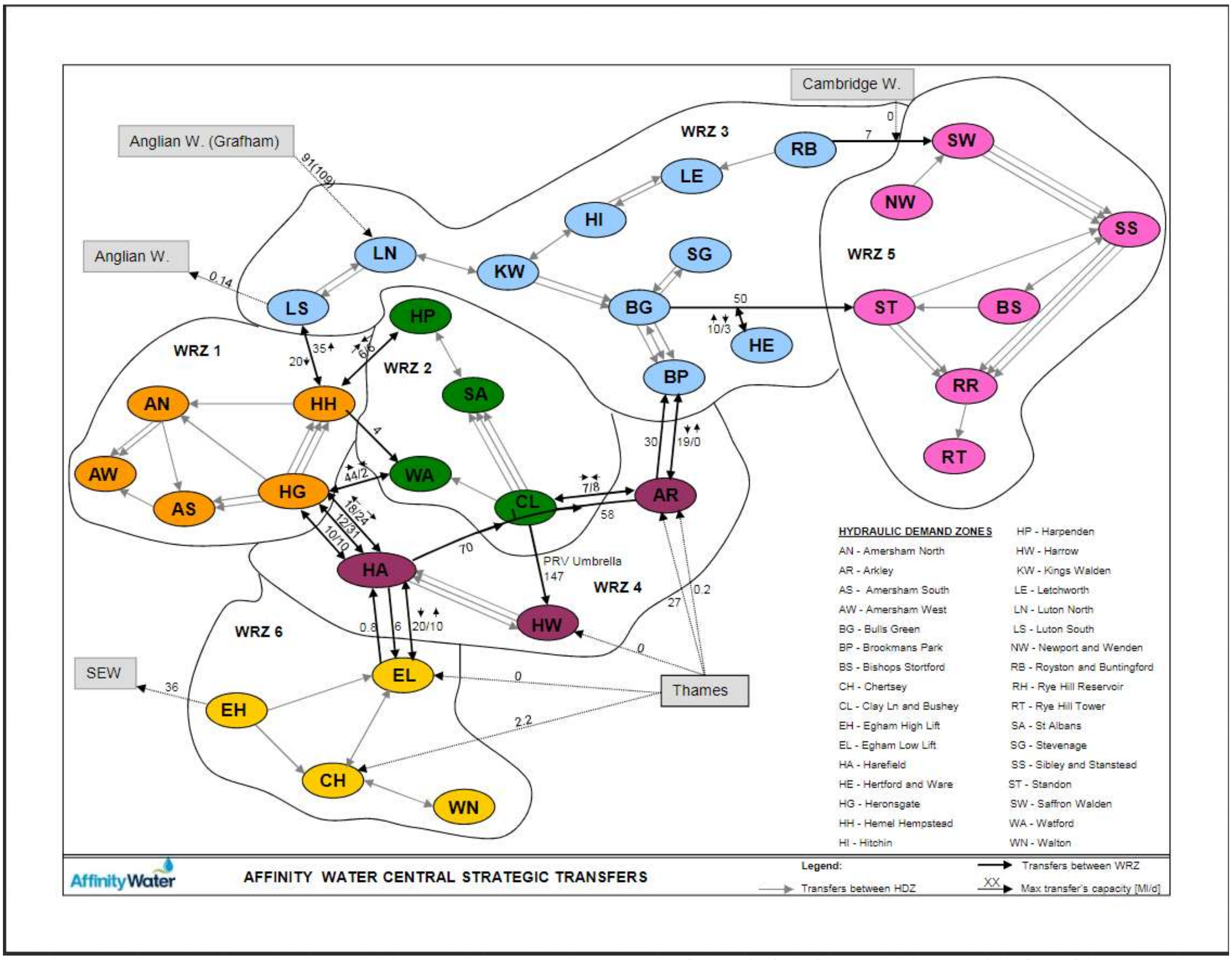


Figure 8-36 MISER_S Configuration Map for Our Central Region

MISER_PS(L) Models

More accuracy in demand, sources and transfer interconnectivity is included. Here the configuration includes reservoir, tower and treated water tank (TWT) volumes. Working storage volumes are significant, when optimising against half-hourly tariff rates. The trade-off between storage and risk from low storage levels is often the limiting factor in the optimisation process. With pumping being reduced at high cost periods, the volume in TWT's can rise significantly. Reservoir working volumes limit the use of lower cost electricity overnight and at weekends.

8.4.8.4 Optimisation strategy and communication

The optimisation strategy, transferring information and communication is critical to ensure implementation of the required operation. Measuring deviation from preferred operation, feedback and follow up is additionally required to ensure the critical items are adhered to, with this process covering numerous sites and requirements. Once optimised, changes on a monthly basis are minimal. It is usually seasonal changes which see the greatest change. The overall run strategy for our MISER_S model is shown below (Figure 8-37).

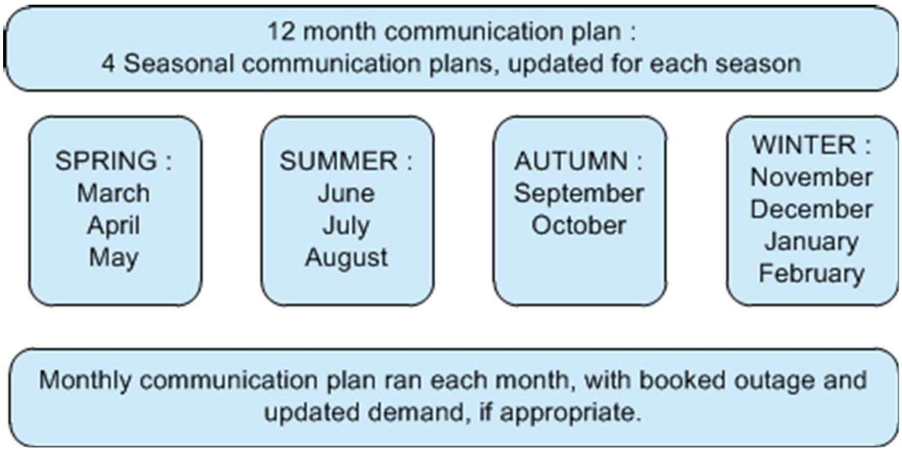


Figure 8-37 MISER_S Strategy for Optimisation Runs

Each optimisation run provides data, which must be reviewed and presented in a suitable format for strategic planning and communication. Figure 8-40 summarises the output processes, with the operations centre providing regular communication to the production business leads. In addition to these there are numerous conversations and discussions to agree source capability and modes of operation.

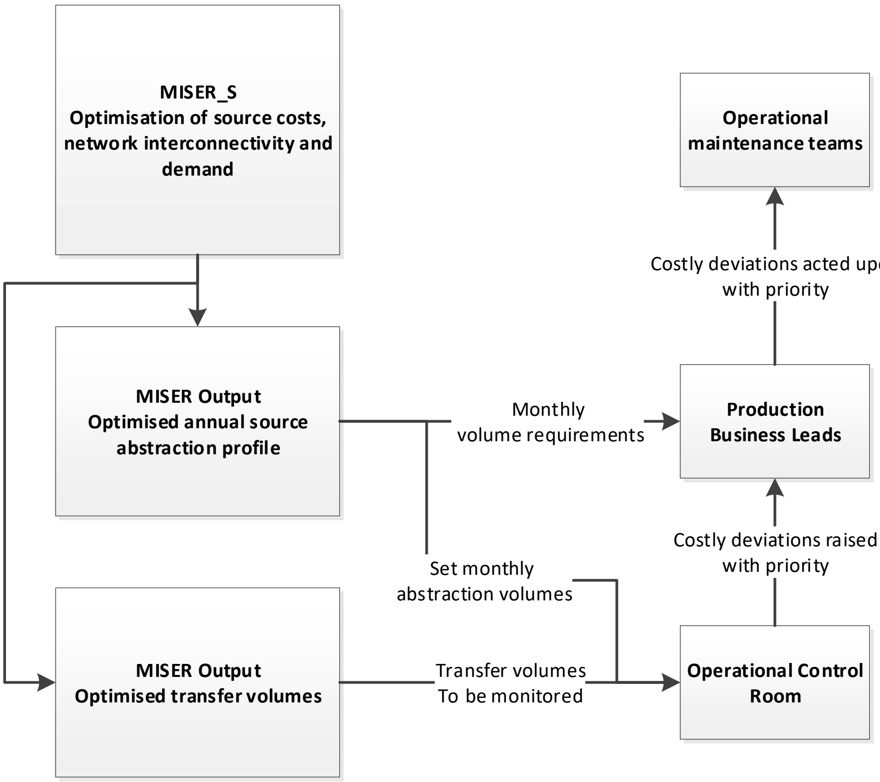


Figure 8-38 MISER_S Model Output and Communication

Our Operations Centre lead the optimisation process, with support from Asset Strategy, Water Quality and others as required. Optimisation records, training and communications to confirm understanding are vital. Some examples of these are listed below.

- Site by site annual average and peak targets are agreed and communicated. Additionally, optimum operation strategies, for summer and winter peak tariff avoidance are maintained, together with operational checklists.

- Site by site operation during TRIAD times are similarly agreed and recorded, together with operational checklists. This process reduces TRIAD charges from over £700,000 per annum to less than half.
- Site by site outage requests agreed and recorded.

8.5 Resilience

8.5.1 Overview

8.5.1.1 Background

Resilience has always been recognised and been part of our previous business planning, but in PR19 OFWAT puts a lot more emphasis on this topic and encourages all water companies to focus, not only on the operational resilience, but on resilience in the round. That includes water resource resilience; customer resilience; financial; corporate; operational and supply chain resilience. For that reason, resilience in AMP7 should be at the core of how we plan and deliver our service to the customer.

8.5.1.2 Purpose

Our strategy and methodology is in line with OFWAT's seven resilience planning principles for the short, medium and long term. It also describes how to maintain adequate levels of resilience for Affinity Water customers while price of water remains affordable, in line with OFWAT's methodology for resilience in the round and for the long term.

8.5.1.3 Definition

Resilience is the ability to cope with and recover from disruption and anticipate trends and variability to maintain services for people and protect the natural environment, now and in the future.

8.5.1.4 Our approach

Our approach is illustrated by Figure 8-39 below.

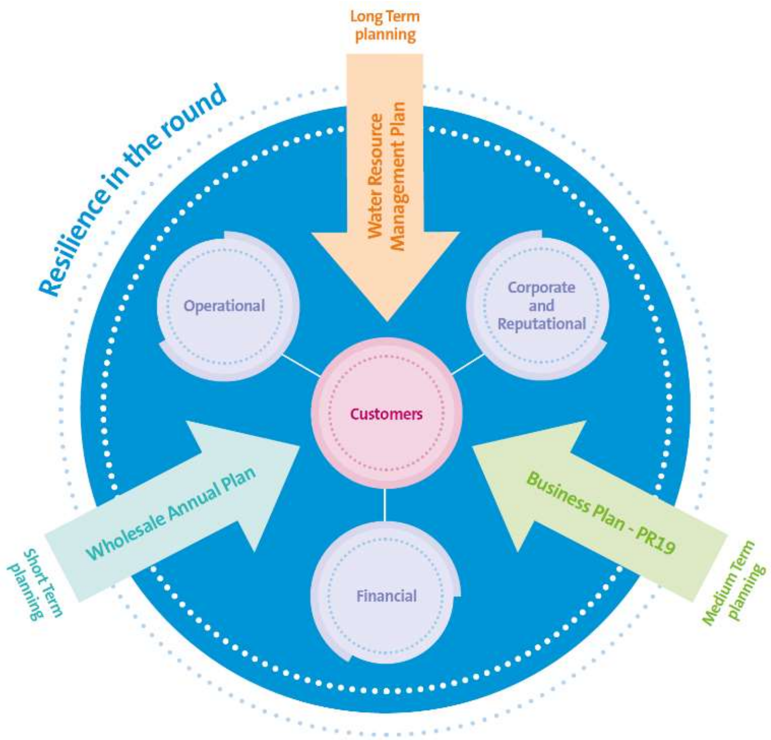


Figure 8-39 Affinity Water Resilience Approach

Our approach fully integrates operational, financial, corporate and reputational resilience on the short, medium and long term. Our proposals in this Price Review are the enablers, fitting between our Water Resource Management Plan, which sets out our strategy for the next 25 years and beyond, and our Wholesale Portfolio Annual Report, to ensure that we can provide our customers with dependable, high quality and affordable water now and in the future.

8.5.2 Scope

8.5.2.1 Risk management process

Our process to manage risk is represented in Figure 8-40. It is cyclical in nature and is made up of five key phases:

1. Establishing the context
2. Risk identification
3. Risk analysis
4. Risk evaluation
5. Risk management

On-going monitoring and review shall be carried out in each team to ensure continued application of the risk process and the risk action plan.

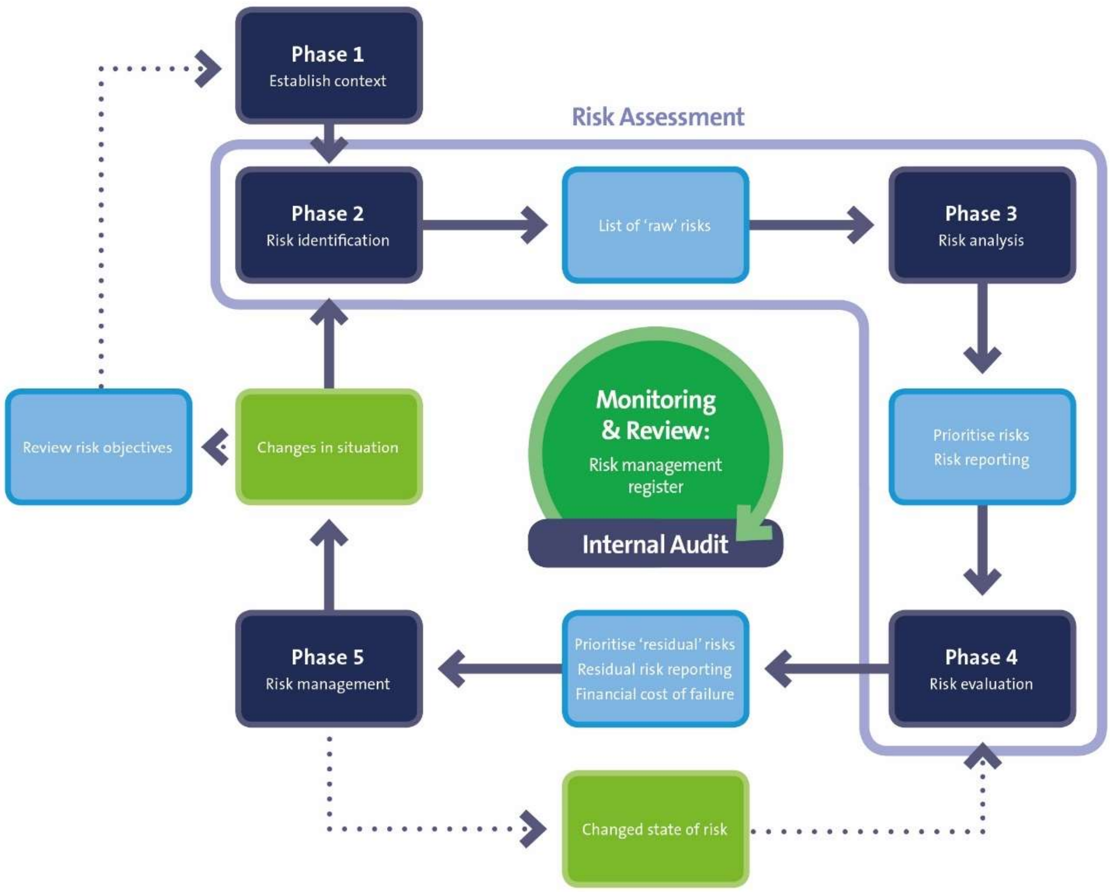


Figure 8-40 Risk management process overview

Communication and consultation is a key aspect of risk management and is promoted where there is a positive risk culture. It ensures common understanding and openness to best address risks.

8.5.2.2 Scope of resilience assessment

The concept of resilience in the round is at the core of how we defined the scope of this work package, which covers the following aspects of resilience:

- Corporate and reputational – this work package section is defined as ability of our governance, accountability and assurance processes to avoid, cope with and recover from adversity, as well as anticipating changes in our corporate operation. We closely manage our corporate and reputational resilience by identification of strategic risks, their assessment in terms of their potential impact on achievement of our strategic objectives and effectiveness of risk management processes. All risks are categorised as operational, regulatory or financial.
- Financial – this work package section is defined as our ability to avoid, cope with and recover from disruption to our finance and instability of the financial market.
- Operational – this section of the resilience work package is defined as our ability to avoid, cope with and recover from disruption to our infrastructure's performance and skills to operate and maintain this infrastructure. The exact scope of our operation resilience section was guided by key risks to the operational resilience, illustrated by Figure 8-41 below.

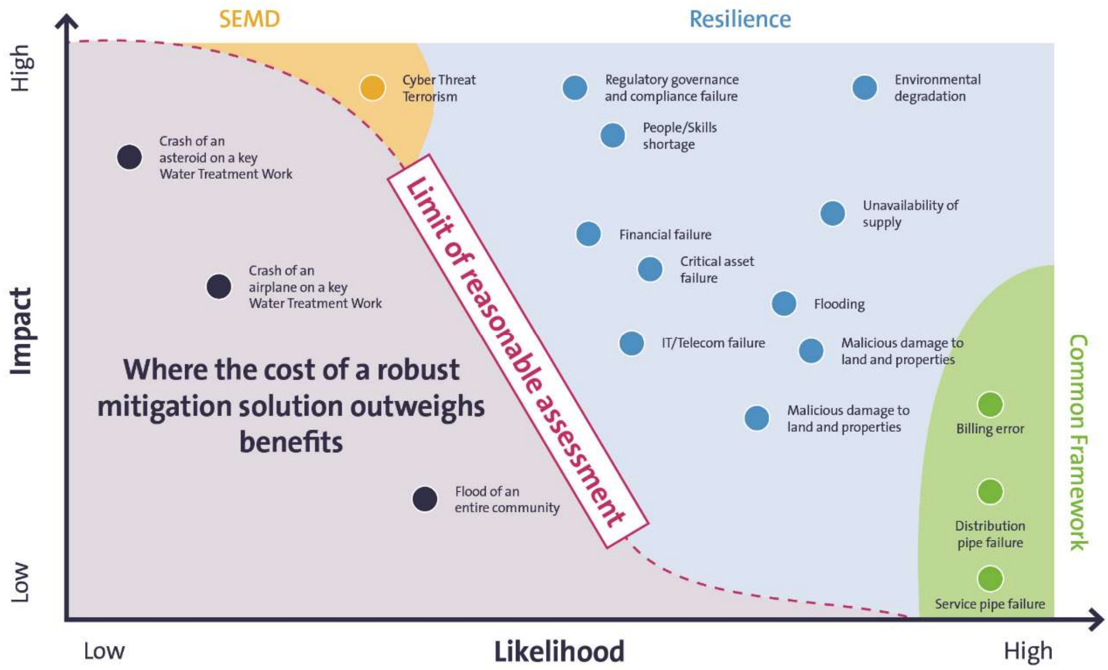


Figure 8-41 Scope of resilience

In some scenarios, the cost of delivering a redundancy mitigation solution outweighs the benefits due affordability for customers. For these scenarios, we focus on ensuring that our assets are reliable and as resistance as reasonably practical. There is an emphasis on response to failure and recovery of these assets. We ensure that we can bring back critical assets within 24 hours. These include long term outage of our top 4 water treatment works (EGHA, HWFS, LANE and HORC).

However, the assessment included scope of work in the other PR19 work packages, investment proposals were only put forward when the resilience concern was not covered under any other work package.

8.5.3 Methodology

8.5.3.1 Overview

Our methodology[88] for resilience, illustrated below, is in line with OFWAT's seven principles for resilience in the round and for the long term. The methodology considers the assessment and understanding of risks to our systems and services provided in the round for short, medium and long term. It takes into account the environment as part of our decision-making.

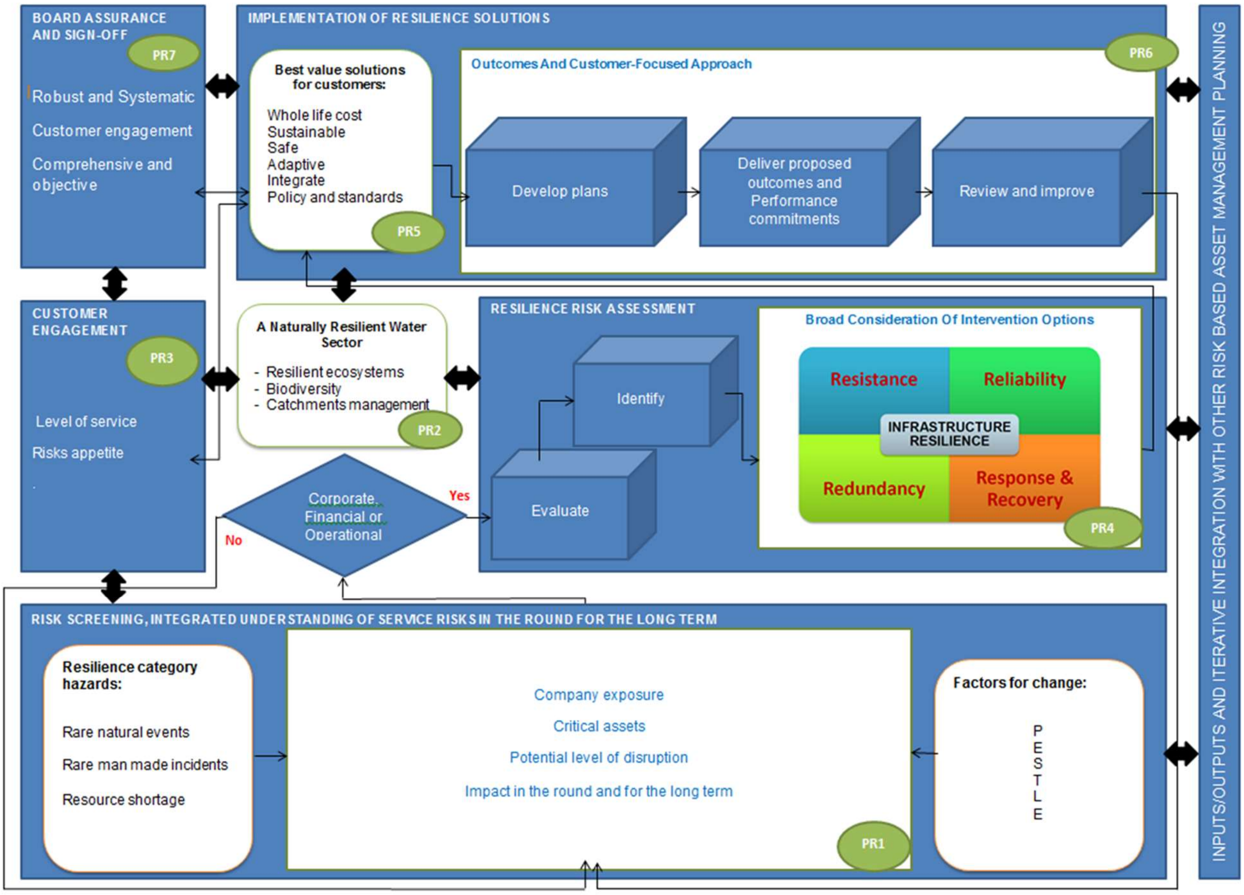


Figure 8-42 Affinity Water methodology for Resilience

Our methodology covers consideration of the full set of interventions to deliver best value solutions for customers. Everything is underpinned by the engagement with customers and their preferences and finally requires board assurance and sign off.

8.5.3.2 Process map

Resilience work package assesses our current and future resilience levels and identifies the gaps that require investment. In the work package we articulate, appraise and value resilience requirements and develop resilience metrics and propose possible ODIs.

Resilience work package outlines our resilience strategy which is defined following the process described in Figure 8-43.

[88] *Methodology for Resilience in Affinity Water*

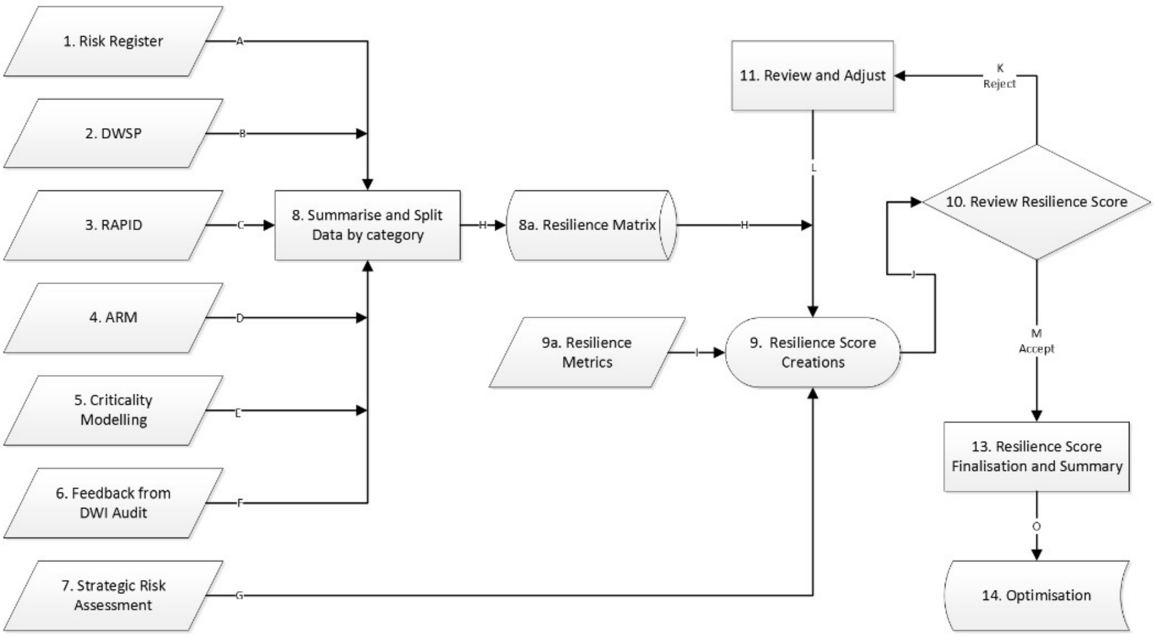


Figure 8-43 Process flow diagram

Based on the existing processes embedded in our current operations we were able to identify and split our main risks into categories, match them with the associated business risks and identify potential impact that was later used to create the resilience matrix. In parallel resilience metrics were created, which are further described in section 8.5.4. Taking into account risk and control measures planned for AMP6, as well as the resilience metrics, we were able to score resilience in each of our eight communities and identify gaps, which led to investment recommendations. A portfolio of recommendations was optimised and based on that a resilience investment finalised.

8.5.4 Metrics

8.5.4.1 Overview

To ensure a robust and consistent resilience risk assessment across all our assets, a suite of metrics around key resilience concerns was developed. The resilience metrics and the scoring method are based on our risk management framework.

These metrics are composed of scores with regards to our exposure to environmental, water contamination, ability to supply water, failure of critical assets, malicious damage and IT risks.

8.5.4.2 Risk Management Framework

Our risk management framework has been approved by our Audit Committee and signed off by our Board. It describes how and why we implement risk management and who is responsible and accountable for it.

It focusses on strategic risk, to ensure risk management is active at Board and Executive level. Risks are managed in accordance with the risk management policy.

8.5.4.3 Example of resilience metrics

The table below provides display for our flood and storm resilience metrics used to assess risk exposure and the robustness of our mitigation plan.

An additional six matrices were developed to measure resilience in the following six resilience concern area: environment, contamination of water in distribution, unavailability of supply, critical asset failure, malicious damage and IT.

Flood and storm resilience	Resilience	Reliability	Response and recovery	Redundancy
Score	Is there a flood barrier in place and what is this design to	Has the system be designed or upgraded to be able to continue functioning in the event of a flood	Is there an on-site and regularly reviewed recovery plan and this been embedded?	What is the maximum percentage of properties that would be off supply, taking account contingency measures?
5 – High	not at risk	Yes	ERP (Emergency Response Plan) in place for this hazard and imbedded	0
4 – Major	Barrier design to - at least 1 in 1000/>0.1%	0	ERP in place for this hazard to best practice	Up to 10%
3 - Medium	Barrier design to - at least 1 in 200/>0.5%	0	Generic ERP developed	Up to 25%
2 – Minor	Barrier design to - at least 1 in 100/>1%	0	Local knowledge	Up to 50%
1 – Low	No Barrier	No	No ERP	50%+
0 - Don't know	Don't know	Don't know	Don't know	Don't know

Table 8-27 Example of resilience metrics for flooding

8.5.5 Resilience

8.5.5.1 Financial resilience

As a regulated business our finances are scrutinised by OFWAT, which sets out the maximum financial risk that we are able to take as a company via various financial mechanisms. The regulator imposes a limit and requires annual reports on our post tax return on capital, credit rating, gearing and interest cover. These financial mechanisms direct our financial resilience.

With regards to the credit rating from Moody and S&P, our score presents as follows: Moody's corporate family group Baa1, Moody's senior A3 and S&P secured debt A-. Our licence requires us to hold at least investment grade rating. Our Baa1 credit rating is three notches into the investment grade credit rating and therefore two notches above the minimum investment grade rating required in our licence. Our credit ratings are stronger than a number of water companies, with only Wessex Water, Welsh Water and Dee Valley Water holding higher rating. They also compare well with other respected companies from outside the water sector.

Our gearing and interest cover are reported to the Board monthly with the minimum of a two-year look forward. Our compliance against the covenants is reported to securitisation trustee six monthly. For gearing, the target is 80% against a lockup and trigger of 85% and a default of 90%. This is effectively £120m of headroom against the trigger. Annually a longer-term viability statement is completed and included in our Annual Report and Financial Statements.

We have continued to have a strong commitment to our employees on pensions, as a socially responsible company we understand the importance of providing a good pension for our employees and meeting the commitments made on their pensions earned to date. Pension plans are governed by the Trustees who are both member nominated and company nominated, along with an independent trustee who also chairs the investment and funding committee. The Trustees have appointed advisors that cover actuarial, administration, legal, investments and audit. The Trustees regularly assess the strength of the Participating Employer's covenant.

We operate with the highest level of governance to ensure we comply with the requirements of the whole business securitisation. We are expected in our licence to use all reasonable endeavours to maintain a listing of corporate date of an investment grade rating. This structure allows an enhanced rating for creditors with a company "family" rating of Baa1 (Moody's). Enhanced rating from the structure enables us to achieve low cost funding, which minimises cost and enables savings to be passed onto customers during a Price Review. This stronger credit rating resulting from the structure also provides better access to the long-term debt markets for any future debt issuance, which is vital in funding our investment in infrastructure and maintaining services for customers.

8.5.5.2 Corporate and reputational resilience

We have an established framework for identifying, evaluating and managing the key risks we face. A key aim is to foster a culture in which teams, throughout the business, manage risks as part of their management of day-to-day operations. Operational risks are recorded and assessed, including existing management and control processes, and action plans are prepared, if necessary, for further mitigation. Activities against these plans are monitored on an on-going basis.

Operational risks are also ranked by our teams during the year. Based on these rankings the most significant risks are discussed by our senior management and included in the strategic risk register, which is reviewed by the Board and the Audit Committee. The latter reviews senior management's work on risk management and reports to the Board on the effectiveness of risk management processes. Strategic risks are assessed in terms of their potential impact on achievement of our strategic objectives and are categorised as operational, regulatory and financial.

We take our duties and obligations seriously and responsibly manage the risks to our reputation. We are using a management system to meet the quality assurance demands and expectations of the regulators and shareholders. The policies and procedures of the management system provide clear instructions and information so as to minimise the risks and to provide records that demonstrate our compliance. The management system is structured around established management processes incorporated into the International Standards Organisation ISO and OHSAS documents and as an enhancement, we subscribe to an accredited third-party assessment of our management system.

Through this assessment, we have maintained accredited certification for our management system covering OHSAS18001:2007 Health & Safety, ISO14001:2015 Environment and ISO9001:2015 Quality Assurance throughout the 32 man-day assessment visits carried out in 2017/2018. The management system is considered mature and is currently going through a planned migration to meet the requirements of the new ISO45001:2018 Occupational Health and safety management system standard for late 2019 delivery to support our commitment to 'zero harm'.

The quality assurance procedures and system continue to reflect the expectations of customers and the Environmental procedures will continue to support CRC, GHG, ESOS 2019 requirements with the system meeting the Environment Agency expectations on preventing pollution and minimising our environmental impact. There have been no reported notifiable pollution events in 2017/2018 however, we have continued to be proactive with regards to the potential environmental impact from bursts on the water network and have reported 89 burst events to the Environment Agency during this period.

8.5.5.3 Operational resilience

Under the resilience work package, several stakeholder engagement sessions took place, including: community workshops with local teams, meetings with different directorates, our security and emergency planning team, resilience programme manager, risk and compliance team; review of our Drinking Water Safety Plans with the WQ team. This enabled us to confirm our strategic risks and review our resilience matrix. Metrics for key resilience areas were created, which enabled us to assess and score the current resilience in our communities and identify interventions required to improve the resilience scores.

The resilience assessment concluded that in each community overall operational resilience was fair (Figure 8-44 Average operational resilience score per community). Each community has specific strengths and weaknesses and some face very particular challenges. Score of specific risk categories by community is illustrated at the end of this section.

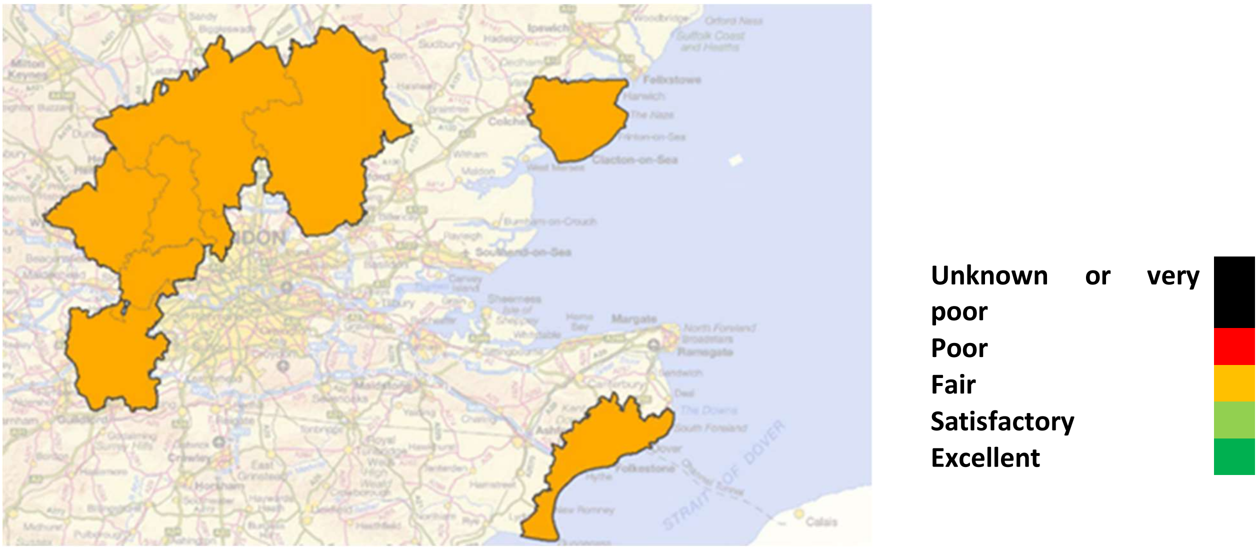


Figure 8-44 Average operational resilience score per community

Our operational systems have high resilience in that we currently have a diversity of water sources, good interconnectivity of the network and established imports from neighbouring companies. Programmes in previous and current AMPs have addressed or minimised our exposure to flooding, security, mains failure or IT failure. Although we are resilient to operational single events or single year drought, longer or multiple events reduce our resilience and may affect our level of service. For that reason, different work packages for AMP7 include interventions to improve our resilience even further and some additional interventions are being recommended under the resilience work package.

8.5.6 Our plan

8.5.6.1 Overview

In order to improve our resilience in AMP7, a list of recommended initiatives was put in place (Table 8-28) in order to address our main concerns. Also, investments included in our AMP7 portfolio all consider resilience; additionally, we identified two initiatives under the resilience work package.

Resilience area	Topic	Position at the End of AMP6 (RAG)	What we will continue doing in AMP7	Additional in AMP7	Forecasted Position at End of AMP7 (RAG)
Infrastructure	**Flooding**	A	- Review of risk exposure following network changes (SR)	None - We consider that we have mitigated against this risk as much as it was reasonably practical.	A
	Critical Asset Failure	A	- Review Contingency plans (OPEX) - Review Emergency Response Plan(OPEX) - Main Renewal AMP7 Programme (CAPEX) - Pump replacement AMP7 Programme (CAPEX) - Standby generators maintenance (OPEX) - Emergency Exercises (OPEX) - Asset Maintenance AMP6 Programme (Mix CAPEX and OPEX) - Maintain Hydraulic models, GIS and AIC (Mix CAPEX and OPEX)	- Water always on (Mix CAPEX and OPEX) - Sundon Treatment scheme - Dead legs removal (CAPEX) - Trunk Main Serviceability (CAPEX) - Additional Storage (CAPEX) - Sustainability reductions enabling works, including new storage cells (Bulls Green) - Cells replacement (Farthing Common, Windmill, St Georges)	G
	Network Contamination	G	- Reservoir Inspections remaining AMP6 Programme - Water Quality sampling - SEMD - DOMS - Dead Legs Flushing programme - Manganese Mains Cleaning	- Dead legs removal (CAPEX)	G
	Supply Chain	G	- Cost Modelling - Benchmarking		G
	Telemetry/IT Failure	G	- Move to the cloud - Infrastructure upgrade - Patching		G
	Cyber threat & terrorism	A	- Sites security upgrades - Move to Cloud computing - Monthly assessments of cyber security		A
	Land and Properties & Malicious Damage	A	- Security Upgrades of Critical sites		A

Table 8-28 Recommended AMP7 initiatives

Capital investment recommended under the resilience work package is explained in sections 5 and 6.

8.5.6.2 Pilot schemes

Resilience and environment community pilot schemes propose an innovative way of working in partnership with other organisations (i.e. river groups, Hubbub, councils) and communities on various environmental and community schemes to improve our eco systems, water availability and increase customers' awareness of water related issues. There will be one pilot scheme per community tackling a specific feature for each area, starting from a small-scale proposal with a potential of scaling up in AMP8. Pilot schemes will also enable us to improve the knowledge and collect evidence of water use within our catchments.

8.5.6.3 Pressure improvement schemes

Insufficient or irregular pressure at the property boundary (below 15m) can affect service to customers and is one of the most common customer complaints. Poor pressure can be caused by an operational incident, high demand or network configuration. We are planning to improve pressure experienced by customers by reducing the average impact of poor pressure from 13 hours per property per year to either 8.7 hours (-33%) or 6.5 hours (-50%). This proposed commitment will prioritise pressure improvement schemes to target those properties which currently experience the most frequent drops in mains pressure.

We propose development of a bespoke resilience PCs around this measure to improve low water pressure for customers in our communities.

8.6 On-going asset management

8.6.1 Introduction

Applying strong asset management principles is key to our ways of working and this section summarises the aspects of on-going asset management that fully support our business plan.

Through our leading and innovative approach with:

- the use of technology such as storing our data in the Cloud, using Maximo on a windows platform or developing TRACE, our in-house built tool to fully assess the root cause of failure for our production (non-infrastructure) assets
- the supportive development of our people and the strong build of strategic relationships in the Industry
- the development of our asset management system and processes to ensure that there is a clear line of sight between from Company outcomes through to our asset management plans,

We strive to be a leading and efficient water company.

Continuous improvement is also a key element of our culture and as a result, we have assessed ourselves against the clauses of the ISO 55001 standard for our water production and distribution assets and planning to achieve accreditation for the whole business in the next five years.

8.6.2 Our asset management system

8.6.2.1 Overview

To effectively deliver our customer needs, we have developed a robust asset management framework based on the ISO 55001 best practice. Our asset management system incorporates a strategic plan, an overarching policy and asset management plans. The scope of our leading asset management practices will extend to all company assets in the next five years.

8.6.2.2 Policy

Our asset management policy states our commitment and our approach to manage our assets in the most efficient way, so customers' expectations are fully met. The policy is owned by the Director of Asset Strategy, which has been approved by the Chief Executive Officer and is fully endorsed by our board of directors. In particular, the policy is a summary of our commitments and our approach to ensure we focus on the delivery of a source to tap strategy tailored to all our communities. In brief, we are committed to:

- Optimise the health, value and the resilience of our assets always
- Meet our regulatory and statutory obligations
- Continuously improve our asset management system by applying new research and learning

The Policy has been reviewed before our business plan submission to confirm our approach which is to:

- Set clear objectives reflecting our asset strategy and business plan
- Regularly monitor progress against our customer commitments
- develop clear plans for managing our assets
- focus on a source-to-tap perspective tailored to our communities
- ensure that our people are in the right roles
- ensure our people are capable, trained and have appropriate tools
- operate and maintain our assets with financial responsibility now and in the future

More emphasis has been placed on our need for pro-active engagement with customers to deliver a value for money service namely by the management of our assets through optimising their health, value and resilience. This is particularly important as part of our service delivery strategy, where we aim to deliver the most cost-effective service to customers at a community level (see section 8.4).

8.6.2.3 Asset management strategy and enablers

The Strategic Asset Management Plan (SAMP) links how we implement our asset management principles. It defines the relationship between our company vision, our engagement with customers and how our assets will deliver our commitments. In summary, the SAMP:

- Sets out how the asset management policy is to be delivered (gives the policy context and structure)
- Identifies asset performance objectives for the medium and long term
- Introduces the principles of risks, lifecycles and needs at an asset group or network level
- Covers the methodology for defining the current and future demand on the assets and the condition and performance requirements of the assets
- Describes the current and future asset management capabilities of the organisation, i.e. its processes, information, systems, people, tools, resources and how the organisation intends to develop its future capabilities to a level of maturity necessary to deliver its organisational goals

It details the strategic alignment between the defined Outcomes and asset management planning, providing a line of sight to everything we do. The policy and strategy framework shown in Figure 8-45 below describes how the policy and strategies will be developed and aligned to meet the needs of sustainable business planning and long-term stakeholder requirements for our asset Portfolio. Each level of the framework is dependent on the one above, requiring alignment to the corporate strategic direction to deliver our Outcomes:

- Supply high quality water you can trust
- Make sure you have enough water while leaving more in the environment
- Providing a great service that you value
- Minimise disruption to you and your community

Figure 8-45 Asset management policy and strategic framework

The key enabling functions of our strategy are:

- Knowledge
- Process
- Decision making
- People

8.6.2.3.1 Asset management knowledge

This is the collection, usage and management of the appropriate asset data, the development of this into information and then into asset knowledge. This cycle is clearly detailed in our asset management lifecycle process, where data is considered a fundamental asset to the company, which enables best practice asset management to be applied.

To achieve this, we ensure we have the framework and ability to:

- Understand the present and future for the:
    - external and internal environment (e.g. water resources, supply and demand)
    - customers (e.g. changing customer needs, growth and lifestyle changes)
    - resource needs and capabilities
- Forecast future demand
- Develop base asset knowledge (e.g. asset specific knowledge with regards to serviceability, performance including deterioration, and criticality)

Through the development of our asset knowledge, we have embedded criticality assessment and asset care plans for our non-infrastructure assets within our day-to-day operational practice. This is possible through careful planning and risk ranking of assets based on their criticality. Asset care plans form the basis of our maintenance planning regime for non-infrastructure assets.

For our infrastructure assets, we have developed a deep understanding of their behaviour through 20 years of analysis, pipe sampling and development of the burst prediction (MOSARE and now PIONEER ModelBuilder) model. This is now used as a targeting tool by our integrated design teams. We have also developed our criticality link analysis, to better understand the impact of network failures on customers which impact our PCs.

We support our planning for AMP7 with up to date burst modelling of our trunk main and smaller diameter main assets. This allows us to prioritise the key areas of investment based on impact on service, and criticality.

We also actively monitor network performance and dynamically adapt to meet our obligations in terms of pressure and outage mitigation by implementing pressure management where necessary, thereby ensuring that customers receive an adequate level of service whilst minimising planned and unplanned disruption.

We continually strive to increase our knowledge of our assets through modelling and field monitoring and this also helps to ensure expenditure is targeted where it adds value and provided the maximum improvement to our level of service.

8.6.2.3.2 Asset management process

Our asset management process enables the delivery of asset management plans as determined by the strategy. The process covers the data acquisition, decision making, operational feedback, risk management and implementation stages. Overarching the asset management process is the Service Delivery map (Figure 8-32) which is our link between the condition and performance of our assets and the service they provide to customers. The way we use the Service Delivery Map is given in greater detail in Section 8 of this document.

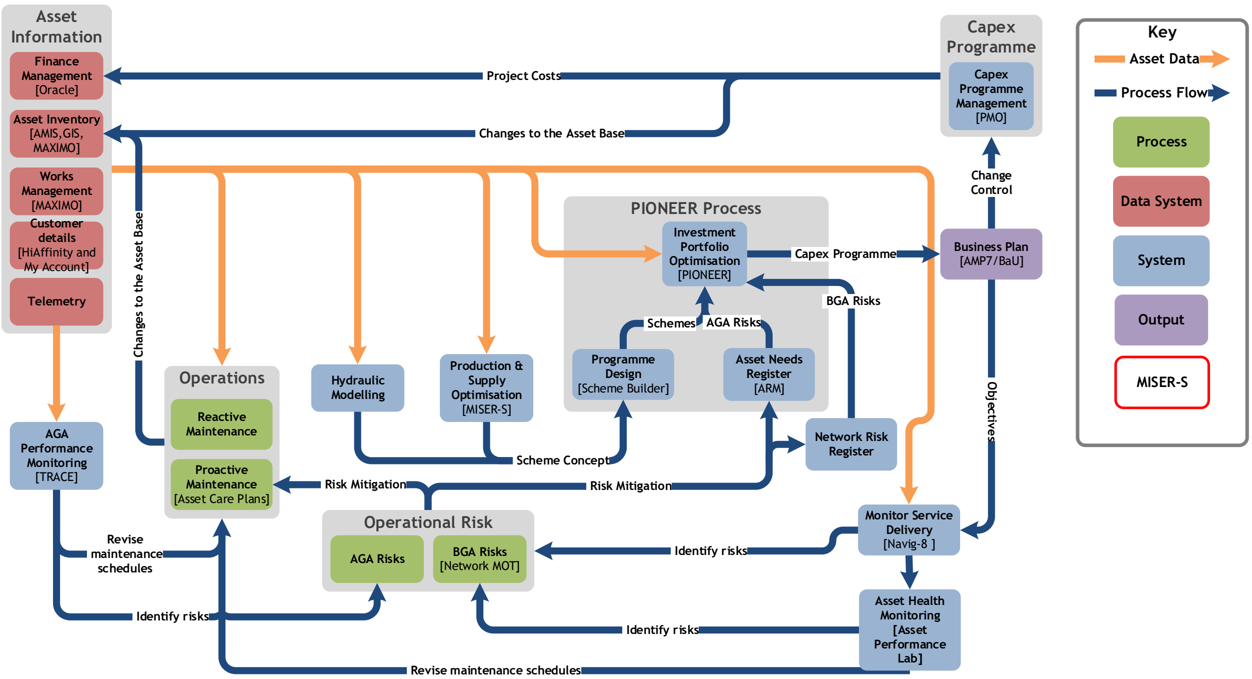


Figure 8-46 The asset investment and decision making process

8.6.2.3.3 Asset management decision making

At the heart of the asset management process is the decision-making stage. The strengthening of our decision-making process through implementation of portfolio optimisation (using the PIONEER software) and monetary measures of service has been an important step forward from our last business plan. This enabler, by which sub strategies and asset plans are derived, provides the capability of optimisation at portfolio level. We are able to trade off cost and benefit, asset risk and reward, therefore balancing needs across the asset base. Operational maintenance decisions are compared against proactive capital investment based on the principle of best whole life cost and community plans set in line with the Service Delivery Map.

For this business plan, whilst 100% of our capital investment proposals have been optimised, 50% of our asset groups have been optimised using PIONEER. Those assets not optimised using PIONEER are mainly non-discretionary such as meters or IT whereby replacement occurs when they fail as those assets do not directly link to customer service, but provide essential support to the delivery of our outcomes. The use of PIONEER has been key to achieve a balanced expenditure using service measures and affordability constraints across all asset groups. The ability to model scenarios relatively quickly means that we understand the sensitivity of the plan to changes. The modelling highlighted areas such as the difference between proactive planned replacement of assets say, inefficient pumps to reduce energy costs, and reactive maintenance. This allows extending the asset lives further, whilst actively managing the incurred risk.

8.6.2.3.4 People

Having an asset management organisation fit for purpose to deliver the asset management strategy is a key enabler. We understand and have recorded the technical, business and behavioural capabilities that exist in teams involved with asset management. This enables us to map capability in order to create a capability profile for the business. This is used to identify any gaps between the future organisational competency requirement and the present skills and competencies – these are identified across three core capabilities:

Behavioural: Our ambition and commitment to deliver our company objectives – this is measured in terms of the contribution made by all.

Technical: Critical aptitude, ability and relevance to the job, ensuring all are equipped with the tools to develop and progress as appropriate

Business: Support the business wide objectives through collaboration and balance company objectives with sound technical know-how and behavioural aptitude.

8.6.3 Asset Management planning

To enable us to fulfil our asset management strategy, a number of plans have been developed in the last three years. Asset plans have been developed as part of each core programme of work within the asset portfolio and reflect our portfolio asset lifecycle process and investment programmes. These include, but are not limited to:

- Distribution and trunk mains programme plans
- Metering installation and lead replacement programme plans
- Water service reservoirs inspections plans
- Drinking Water Safety Plans (water quality)
- Asset care plans (non-infrastructure Assets)
- Treatment pumping programme plan
- Catchment management and NEP plans
- Leakage programme plan

The Asset Risk Manager (ARM), interface which enables operators and managers to log operational risks, has already been rolled out to our production teams and will continue to provide valuable feedback on the status of the need in respect of inclusion into optimisation and programme. We have also begun the process of introducing this to our infrastructure teams and this will assist us in refining our asset management planning.

8.6.4 People, continuous improvement and innovation

8.6.4.1 People and continuous improvement

In order to deliver continuous improvement and innovation, we ensure that our people are fully competent, and train and skill our workforce appropriately, developing the technical, managerial and behavioural capabilities to provide fit for purpose asset management (see Figure 8-47 below).

For example, as part of our drive to adopt improved processes in asset management, we have ensured that all stakeholders involved in the process are trained to the right level and provided with the competencies to manage, operate or deliver existing and new assets; this commitment is also applied throughout our supply chain.

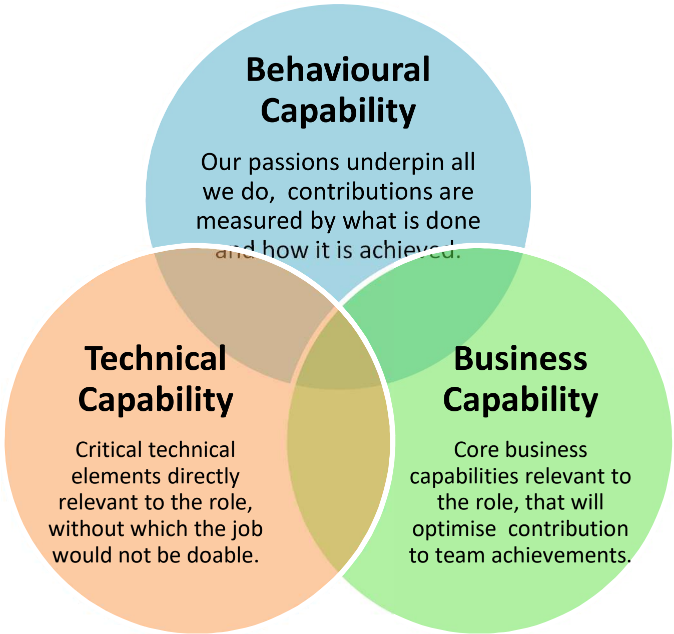


Figure 8-47 Capabilities matrix

We are recognised throughout the industry for our strategic partnerships which have shaped our vision in terms asset management – our team plays a leading role in the collaboration of WRSE, steering the future of water infrastructure in the southeast; we have developed a number of partnerships within the R&D sector (UKWIR, WaterUK, Artesia) and developed numerous partnership projects with academic institutions (e.g. University of Hertfordshire, Sheffield University, Brunel university) promoting career developments in Infrastructure and Asset management. We also support our people with becoming chartered and sponsor memberships with professional institutions such as CIWEM, IChemE, IWO.

8.6.4.2 Delivering efficiencies through continuous improvement

Our focus for delivering efficiencies via asset management and continuous improvement concentrates on three areas:

8.6.4.2.1 Plans for reducing our increasing costs of network operation and meeting tougher leakage targets

To achieve cost efficiency for the operation of our network, we have been using better zone planning and the Service Delivery Map framework. The use of zone planning and the software developed to help us (NAVIG-8, Waternet) is fully explained in section 8. In addition, the concept of calmer networks to avoid aggressive interventions has been used extensively and thus contributed to a stabilisation in our burst rate over the last 12 months. For example, pressure "spikes" and abnormal fluctuations in operating pressure of a main are detected via our telemetry and data logging equipment, which has been actively analysed in order to understand the extent of those pressure transient points, particularly overnight flow, where demand is typically low and steady – identified location of pressure anomalies are immediately monitored through our network control centre who are able to calm the network where necessary and thus reduce the risk of bursts further.

8.6.4.2.2 Plans for reducing the cost of maintenance of our non-infrastructure assets

To deliver more efficient maintenance on non-infrastructure assets, we have developed a process of asset care that is linked to our asset management investment process and uses TRACE, an in house developed application to provide us with up to date failure cause and effect information on individual processes. We then determine what is affecting us in terms of loss of supply and what is costing us in terms of defects and callouts and amend care plans and investment policies accordingly.

8.6.4.2.3 Plans for the optimisation of our capital projects

After successfully planning our asset investment needs through PIONEER for our previous business plan, we have continued to use the asset planning investment suite in order to optimise our portfolio and balance the investment needs across the board.

We made significant developments to the standard configuration of PIONEER and these improvements have helped us in establishing PIONEER as a business as usual tool. We have already moved our mains burst and production deterioration models, properties affected, consequence factors and risk calculations inside PIONEER, which will facilitate rapid maintenance and update and reduce the quantity of data we need to import from other systems. This in-house development has ensured that PIONEER is not a “black box”, and is fully utilised by the teams in Asset Strategy. This knowledge will pave the way for automation of the links to our corporate systems to update asset information and attributes. We will use this tool to enable micro optimisation of the programme, based on our service measure framework performance. This will help us deliver a fully optimised programme, and hence deliver benefits to customers in an efficient way.

These in-house changes have resulted in a significant reduction in load times and optimisation run times, meaning that we can change data and rerun a full optimisation in just 6 hours, compared to over 24 hours originally. This has meant we have been able to run significantly more optimisations than was originally, thus saving valuable resource to support other investment planning tasks such as burst modelling and unit cost modelling. Other changes made to the base configuration have also been used to improve other company’ models.

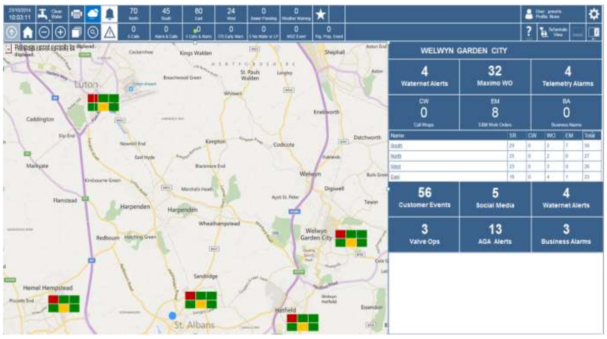
We have also recently incorporated the PIONEER Scheme Builder into our project initiation process, allowing us to measure benefits and costs using the same framework across all asset groups. This will help to ensure that all future capital projects are cost beneficial and appropriately ranked within our portfolio.

8.6.5 Innovation

Innovation is a fundamental part of our asset management culture. It is primarily aimed at delivering improvement in processes and efficiency in our ability to serve customers and stakeholders better. This is achieved through the use of new tools and techniques leading to enhanced customer satisfaction, improved service delivery and increased efficiency. A number of innovation initiatives have been developed to support our asset management practice, including work in leakage detection, telemetry, hydraulic modelling and pipe analysis and water quality improvements. Below are details of two of those initiatives.

8.6.5.1 Situational Awareness

Staying up to date when repairing network assets is critical – this becomes even more important when dealing with leakage and burst main operations which can have a significant impact on local residents. Situational awareness is a tool we have developed to integrate asset performance, social media and location information designed to provide a near real time understanding of service delivery in our network. This will help us to prioritise work and attend crucial repairs whilst also mitigating its impact on customers and public attention.



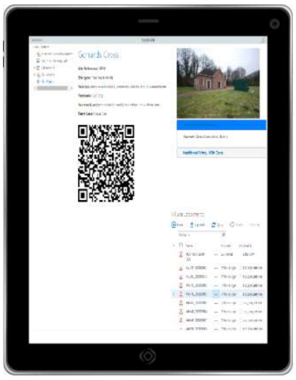
8.6.5.2 Online pesticides monitor

We have installed an online pesticide monitor at one of our Treatment Works in the Lee community in AMP6. The system comprises a custom designed cabin on the treatment works site, pumped feeds of sample water from three locations through the treatment process, three Amazon filters arranged in series to filter the sample water down to 1μm (to ensure a suitable quality of sample water for use in the instrument) and an Agilent 7000 GC/MS/MS and Dual Head GERSTEL multi-purpose sampler with on-line ITSP, SFS and flow cell instrument.

The results are returned in 36 minutes, giving near 'real time' concentrations of metaldehyde in the raw, partially treated and final water. We are proposing to install similar instrument at two locations in AMP7 to further improve our ability to monitor and control the concentration of specific compounds of concern in our treated water. The new instruments will be LC/MS instruments, meaning that we will have the capability to monitor a wider range of contaminants.

8.6.5.3 Asset information centre

Through the use of cloud technology and thanks to a lengthy testing period, we were able to implement a secure, online asset documentation system which allows operational staff and asset management to access critical documentation on the go, saving precious time when responding to operational incidents and emergencies – this in turn has helps to improve our response which impact customers on pressure, supply interruptions and bursts within the network. It also helps us to mitigate against our unplanned outages and to carry out asset maintenance at least cost.



8.6.6 Asset Management assessment

As part of our business planning process, we have undertaken a full review of our asset management practice to determine our position ahead of 2020-2025. This will help us reaching our goal of ISO 55001 compliance, which is a target for the whole company between 2020 and 2025. Our previous assessment in 2014 revealed that the organisation had matured in its delivery since 2009, on the basis of improved Infrastructure and non-infrastructure asset planning and management. We have now changed the methodology for our asset management assessment for this business plan to benchmark our performance against the requirements of ISO 55001, the relevant Asset Management ISO standard. In addition to this, the assessment has deliberately been measured across the portfolio, as opposed to Infrastructure and Non-Infrastructure to help us develop our holistic source to tap approach for asset management.

Our maturity rating against ISO 550000:2014 (broken down into 39 'topic areas') was found to be compliant (average score 3.1, maturity threshold for achieving ISO 55000:2014 compliance is 3).

The 39 topic areas are grouped into six activity areas

- Asset management and planning
- Asset decision making
- Life cycle delivery
- Asset knowledge enablers
- Organisation and people enablers
- Risk, review and continuous improvement

The average scores by activity area are as follows Figure 8-46
The scores for each individual category can be seen in Figure 8-48 below

Your local supply, on tap

Summary Results Table

ID	Diagnostic Date	Institute of Asset Managenet (IAM) & Global Forum on Maintenance and Asset Management (GFMAM) Grouping	IAM & GFMAM Subject	Assessed?	AWL ISO55000 Maturity Assessment: Innocent - 0	Aware - 1	Developing - 2	Competent - 3	Optimising - 4	Excellent - 5
1	May '18	Asset Management Strategy & Planning	Asset Management System	Y				3		
2	May '18	Asset Management Strategy & Planning	Asset Management Policy	Y				3		
3	May '18	Asset Management Strategy & Planning	Asset Management Strategy & Objectives	Y				3		
4	May '18	Asset Management Strategy & Planning	Strategic Planning	Y				3		
5	May '18	Asset Management Strategy & Planning	Asset Management Planning	Y				3		
6	May '18	Asset Management Decision Making	Capital Investment Decision-Making	Y				3		
7	May '18	Asset Management Decision Making	Operations & Maintenance Decision Making	Y				3		
8	May '18	Asset Management Decision Making	Life Cycle Value Realisation	Y				3		
9	May '18	Asset Management Decision Making	Resourcing Strategy	Y					4	
10	May '18	Asset Management Decision Making	Shutdowns & Outage Strategy	Y					4	
11	May '18	Life Cycle Delivery Activities	Technical Standards & Legislation	Y				3		
12	May '18	Life Cycle Delivery Activities	Asset Creation & Acquisition	Y				3		
13	May '18	Life Cycle Delivery Activities	Systems Engineering	Y				3		
14	May '18	Life Cycle Delivery Activities	Configuration Management	Y				3		
15	May '18	Life Cycle Delivery Activities	Maintenance Delivery	Y				3		
16	May '18	Life Cycle Delivery Activities	Reliability Engineering	Y				3		
17	May '18	Life Cycle Delivery Activities	Asset Operations	Y				3		
18	May '18	Life Cycle Delivery Activities	Resource Management	Y				3		
19	May '18	Life Cycle Delivery Activities	Shutdown & Outage Management	Y					4	
20	May '18	Life Cycle Delivery Activities	Fault & Incident Response	Y				3		
21	May '18	Life Cycle Delivery Activities	Asset Decommissioning & Desposal	Y			2			
22	May '18	Asset Knowledge Enablers	Asset Information Strategy	Y				3		
23	May '18	Asset Knowledge Enablers	Asset Information Management	Y				3		
24	May '18	Asset Knowledge Enablers	Asset Information Systems	Y				3		
25	May '18	Asset Knowledge Enablers	Data & Information	Y			2			
26	May '18	Organisation & People Enables	Procurement & Supply Chain Management	Y					4	
27	May '18	Organisation & People Enables	Asset Information Leadership	Y				3		
28	May '18	Organisation & People Enables	Organisational Structure	Y				3		
29	May '18	Organisation & People Enables	Organisational Culture	Y					4	
30	May '18	Organisation & People Enables	Competence Management	Y				3		
31	May '18	Risk, Review & Continual Improvement	Risk Assessment Management	Y				3		
32	May '18	Risk, Review & Continual Improvement	Contingency Planning & Resilience Analysis	Y				3		
33	May '18	Risk, Review & Continual Improvement	Sustainable Development	Y				3		
34	May '18	Risk, Review & Continual Improvement	Management of Change	Y			2			
35	May '18	Risk, Review & Continual Improvement	Asset Performance & Health Monitoring	Y				3		
36	May '18	Risk, Review & Continual Improvement	Asset Management System Monitoring	Y				3		
37	May '18	Risk, Review & Continual Improvement	Management Review, Audit & Assurance	Y				3		
38	May '18	Risk, Review & Continual Improvement	Asset Costing & Valuation	Y				3		
39	May '18	Risk, Review & Continual Improvement	Stakeholder Engagement	Y					4	
40	May '18	Risk, Review & Continual Improvement	Health, Safety & Environmental	Y				3		
			Counts		0	0	3	31	6	0
			Average		3.1					

* Based on median scores from 36 asset intensive organisations in the UK, Europe and North America

Figure 8-48 The AMA Assessment

The scores for the maturity levels are based on the following definitions

Maturity Level	Description	Definition
0	Innocent	The organisation has not recognised the need for this requirement and/or there is no evidence of commitment to put it in place.
1	Aware	The organisation has identified the need for this requirement, and there is evidence of intent to progress it.
2	Developing	The organisation has identified the means of systematically and consistently achieving the requirements, and can demonstrate that these are being progressed with credible and resourced plans in place.
3	Competent	The organisation can demonstrate that it systematically and consistently achieves relevant requirements set out in ISO 55001.
4	Optimising	The organisation can demonstrate that it is systematically and consistently optimizing its Asset Management practice, in line with the organisation's objectives and operating context.
5	Excellent	The organisation can demonstrate that it employs the leading practices, and achieves maximum value from the management of its assets, in line with the organisation's objectives and operating context.

Table 8-29 The Asset Investment and Decision-Making process

Our average initial score is significantly higher than the average, which reflects our progress, which has accelerated with the formation of the Asset Strategy team in the last three years and the greater emphasis that is being placed on embedding asset management at all levels of the organisation. Whilst it is noted that our score was not directly compared with ‘like for like’ industries during the assessment, the engineering, asset management and maintenance best practices are relatively generic across asset intensive industries and there are many asset classes that are common (e.g. civils, premises, mechanical, electrical, communications). Overall our strategic planning and organisational structure was found to be strong, however we are still developing in areas such as data, asset disposal and decommissioning and change management. Like most asset intensive organisations, we can be ‘data rich and information poor’ though it was noted during the assessment that through our initiative of the establishment of information governance boards we expect our data architecture, quality and completeness to improve over time.

8.6.7 Proposed asset modelling and tools for AMP7

We require to continue our work for the development and management of the required tools, systems and support required to manage our infrastructure and non-infrastructure assets.

Geographic Information System (GIS) (asset information and modelling)

Our Geographic Information System is the below ground asset database. There is a requirement for the on-going maintenance of the data that is held within the system. This data is used for many purposes including the upkeep of hydraulic models, asset planning through PIONEER, operational response and mains renewal design.

AMIS and MAXIMO works and asset register systems (asset information and modelling)

In AMP7, AMIS and MAXIMO will become our fully commissioned work and asset register systems for Non-infrastructure and Infrastructure assets. All work (planned and unplanned interventions) will be scheduled and held within those respective systems and we will endeavour to manage and maintain its consistency and quality, and to provide ongoing analysis to support operations and capital delivery, whilst also supporting the requirements of our Open water function. The team will also play an active role in our data management framework and support our data governance strategy.

Hydraulic performance modelling (asset information and modelling)

We will continuously update and renew our suite of hydraulic models to ensure that they are fit for purpose for the design of works for the capital programme, new developments, operational support and incidents. (NEW design work itself is not included in this line but under project and developer services (DS) costs).

Hydraulic performance studies (service delivery, analytics and reporting)

We will continue to carry out hydraulic performance studies to provide timely feedback on the condition and performance of the network including RAPIDs (incident analysis), anomaly solving and DG2 pressure analysis. This also includes support for planned operational works, e.g. meter outage, leakage support, Pressure Losses across Network (PLaN) activity, proactive flushing.

Asset Performance Laboratory (asset health, risk and investment)

We will continue to operate our Asset Performance Laboratory to improve understanding of pipe condition - proactive analysis to assess mains to be replaced as part of renewal programme and reactive to assess root cause of failures. The results are key to keeping our investment planning process current and accurate, and provide verifiable data to support decision making on individual pipes selected for renewal. Our multi-skilled laboratory technicians operate a range of workshop and field based equipment. The laboratory analyses and assesses the condition of approximately 300 pipe samples a year. The team provide in-situ pipe assessment capability of our mains network using a fiberscope to support flushing schemes, water quality, incident investigation and mains renewals. CCTV camera and geo-physical logging inspections of the company's boreholes are conducted by the lab. The laboratory also monitors borehole condition and provides guidance when planning asset investment to protect our raw water assets.

Supply demand modelling and analysis (service delivery, analytics and reporting)

We will be measuring the benefits of the supply-demand plan for the AMP now including increased metering and water efficiency. The EBSD modelling will be improved to reflect new leakage information and improved demand data. Analysis will be carried out on an annual basis to see if changes need to be made to the strategy or level of sustainability reductions

Asset condition assessment and criticality modelling (asset health, risk and investment)

We will continue to make improvements to the non-infrastructure asset performance and deterioration data (as supported by the AMA recommendations), promote better data collection through Ellipse, update models in line with ACO process, failure modelling of the distribution assets, communication pipes and trunk mains including updating with new data, including into PIONEER so that we are not as reliant on external suppliers and we will have updated models to run for future business plans. The information will be used for trend assessments, incentive reporting and medium and long-term planning.

Investment planning, risk profiling and asset care optimisation (asset health, risk and investment)

We will use our investment planning process and software suite in a business-as-usual approach, refreshing and prioritising the capital delivery programme on a regular basis based on new needs and requirements raised by Production and Community Operations teams. Key systems and processes (Risk Profiling approach, Outage tracking, Pump System Performance Monitoring, Asset Risk Profiling, Asset Care Optimisation, Navig-8) are now joined up under a source-to-tap approach with consistent risk quantification. This aligns with the AMA recommendations. We will risk profile our assets using the suite of existing asset tools to inform minor capital investment and provide performance data for maintenance (ACO) and replacement of assets. We will manage risk through the Asset Risk Manager Module in PIONEER.

Metering performance management (service delivery, analytics and reporting)

We will provide technical support on metering performance modelling, customer side leakage, specifications, and procurement. This will help to support all strands of our overall metering strategy.

Asset and service performance management (SDM) (service delivery, analytics and reporting)

We will further develop and run our Service Delivery Map support tool, NAVIG-8, to report on asset performance and impact on customer service. Navig-8 is used to produce KPI dashboards on asset and service performance as well as to track benefit realisation from various asset interventions – further details are given in section 6. Navig-8 Phase 2 will also support data collection to enable richer communication of asset and network performance within individual communities to our customers. We also seek to develop our dashboard suite to enable full integration of asset and customer information in one unified platform.

Energy and import optimisation (asset health, risk and investment)

We will continue monitoring our energy usage and marginal costs to assess pump efficiency and build a yearly plan for pump testing. We use a variety of tools such as Optima Energy Billing system and our Pumping System Performance Monitoring system enabling us to adjust pump schedules in order to optimise pumping costs, risk of failures and asset life. We will further develop MISER to manage the impact of sustainability reductions on our operational ability to meet demand between 2020 and 2025. We will support our operational teams by providing the required platform for APH calculations within PSPM, as well as linking opex energy spend with our MEICA equipment.

Leakage programme (service delivery, analytics and reporting)

We will continue using current tools and develop new ones to manage the leakage programme from 2020 to 2025 to deliver (and maintain) the additional reduction target. This includes updating the Active Leakage Control (ALC) leakage cost curves which are required to calculate the Economic Level of Leakage; updating the Natural Rate of Rise; development of the Leakage targeting dashboard, carrying out benefit realisation studies and further development to leakage detection timesheets to serve Community Operations. It also includes trials of tools for early warning leakage alarm management to complement data logging improvements.

9 Summary of the plan

9.1 Overview

This section summarises the Totex Plan by:

- Expenditure type – maintenance and enhancement (9.2)
- Community area – Wey, Pinn, Misbourne, Colne, Lee, Stort, Brett, Dour (9.3)
- Outcome – (9.4)
- Sub-portfolio – (9.5)
- Tables submission – (9.6)

This section also compares the Totex Plan to AMP6 (9.2 and 9.4) and profiles expenditure over a ten-year period (9.2.3). Expenditure requirements beyond 2025 are discussed in section 9.7.

9.2 Expenditure by type

Our Totex Plan for AMP7 totals £1.373 billion (an increase of 15% or £175.58m since AMP6):

- Maintenance expenditure is £946.14m (a reduction of 4% or £42.4m since AMP6)
- Enhancement expenditure is £426.85m (an increase of 104% or £217.98m since AMP6)

The changes since AMP6 are summarised in Figure 9-1.

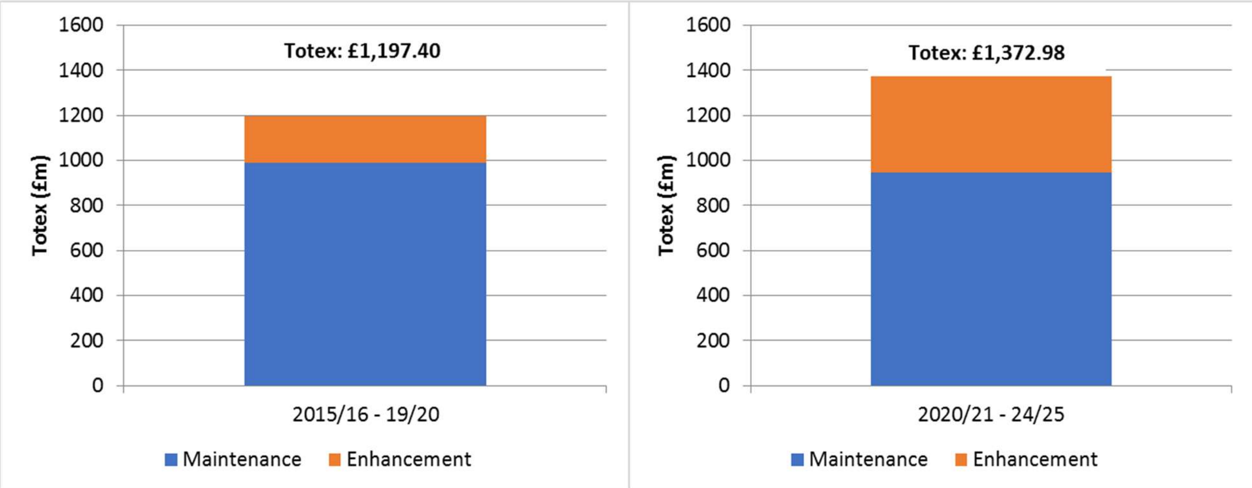


Figure 9-1 Totex 2015-20 Vs 2020-25

9.2.1 Maintenance expenditure

Planned maintenance expenditure for 2020/21-24/25 is reducing by £42.4m from 2015/16-19/20. That's 4% lower. The reduction is a result of **improved investment targeting** and **ambitious efficiency savings**. This is best exemplified by breaking planned investment into infrastructure and non-infrastructure types:

- **Infrastructure** assets comprise underground systems of pipes and associated network equipment. This includes stop taps, fire hydrants and information about infrastructure assets. Meters and boreholes are excluded.
- **Non-infrastructure** assets comprise all other assets, typically above ground. This includes catchment, abstraction, treatment, service reservoir and metering assets as well as IT systems and laboratory equipment.

Figure 9-2 shows that we plan to invest less in maintenance infrastructure between 2020-25 than we did between 2015-20.

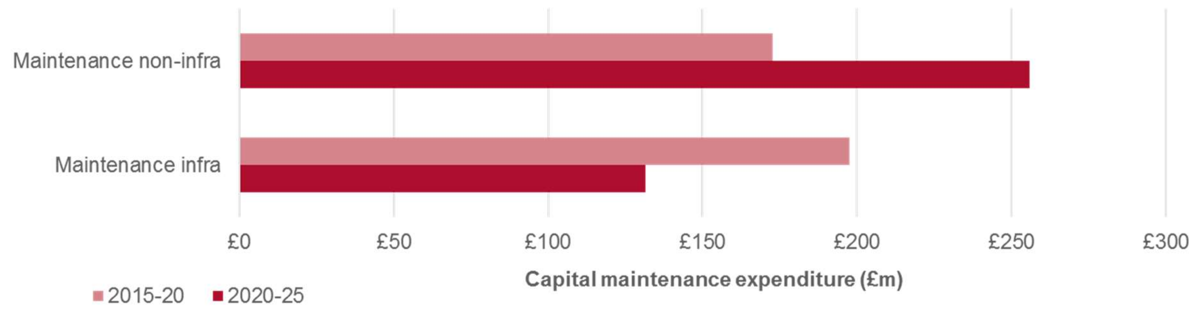


Figure 9-2 Capital maintenance expenditure by infrastructure and non-infrastructure types

The reduction in capital maintenance infrastructure investment shown in Figure 9-2 is mainly due to improved investment targeting. We have improved our asset management capabilities and this has enabled us to plan for a reduced yet effective programme of targeted mains renewals. Comprehensive modelling has given us confidence that service levels, including burst rates, will remain stable. This means that customers can benefit from an affordable, well targeted maintenance plan that meets expectations.

Figure 9-2 also shows an increase in capital maintenance non-infrastructure expenditure. There are three reasons for this:

Reason 1 is the inclusion of new funding to ‘unlock’ operational efficiencies in areas such as energy, automation of processes and improved data capture and utilisation.

Reason 2 is the inclusion of funding to maintain resilience where it is eroding due to climate change, farming practices, historical pollution incidents and national infrastructure projects. For example, we are investing in new nitrate removal plants at abstraction sites we have identified, through trend analysis, as being at high risk between 2020/21-24/25.

Reason 3 is an increase in the amount of non-infrastructure maintenance work that we must complete to maintain a stable service. This is exemplified by our storage assets. Figure 9-3 below shows that nine of our storage assets were constructed pre-1900. Their deteriorating condition and increased risk of ingress mean that they are approaching the end of their service life. Our maintenance expenditure plan includes investment to replace three of these assets, compared with two replacements between 2015/16-19/20. The remaining six assets will continue to be monitored with some planned for replacement between 2025/26-29/30.

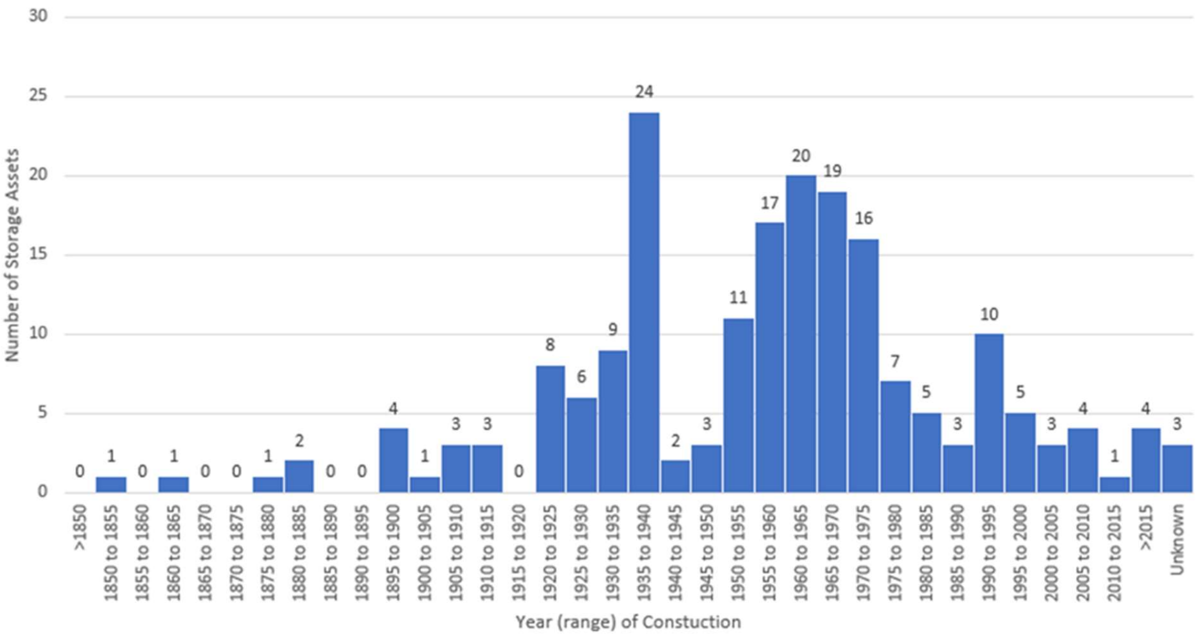


Figure 9-3 In-service storage assets presented by the year in which they were constructed

Between 2020/21-24/25 we will do more for less. For example, the number of reactive meter replacements that we expect to complete is rising by 66%. This is because we now have more customers (by 2024/25 we'll have 8.5% more than we did in 2015/16) and more of those customers now have water meters. We're combating this by using efficient unit costs. The cost of a reactive water meter replacement is reducing from £213 to £188, resulting in an efficiency of £2.9 million.

Overall our improved investment targeting, asset knowledge and efficient unit costs have enabled our maintenance totex to reduce from £988.53 million for the period 2015/16-19/20 to £946.14 million for the period 2020/21-24/25. This means that customers will benefit from a £42.4 million totex efficiency, as exemplified in Figure 9-1.

9.2.2 Enhancement expenditure

Enhancement expenditure is increasing by £217.89m since 2015/16-19/20. That's an increase of 104%. The increase is mostly due to three large investment initiatives, which are integral to making sure customers have enough water while leaving enough water in the environment, and are a requirement of our rdWRMP:

9.2.2.1 Reducing customer consumption - £140.23m

Further ambitious consumption reduction measures to achieve a normal year annual average PCC of 129 l/h/d by 2024/25. This challenging target will be achieved through metering, improved sharing of customer consumption data, further water efficiency measures and a behavioural change programme.

This expenditure is necessary because:

- **Need:** This programme is an output of the rdWRMP and is required to maintain the supply demand balance in AMP7 and into the future
- **Optioneering**: The EBSD model selected this combination of options because they contribute to the least-cost whole-life solution to maintaining the supply demand balance. The lead times for this programme of options are relatively short, making it one of the only feasible solutions available to us for meeting our statutory and legal obligation in AMP7

- **Efficient costs**: We have worked with expert consultants to develop efficient unit costs for the pioneering water efficiency and behavioural change aspects. Our demand reduction programme is innovative and industry leading to achieve a reduction in December of 12% in AMP7 on top of 7% achieved in AMP6. We have taken expert advice from industry leading consultants to develop our cost estimates for this innovative programme. We recognise there is a significant challenge in setting ourselves an ambitious target for overall demand reduction and have already started out planning to implement out new integrated water saving programme by 2019/20.
- **Comparison to AMP6**: The metering programme is a continuation of AMP6 and has been costed based on AMP6 actual costs.

9.2.2.2 Sustainability reductions - £58.42m
Reducing the amount that we abstract from environmentally sensitive sources by a further 36.31Ml/d by 20/2425. We plan to deliver this challenging target without compromising current levels of supply resilience through an extensive programme of network enhancements and asset upgrades.

This expenditure is necessary because:

- **Need:** Sustainability reductions are a requirement of WINEP3
- **Optioneering**: Extensive modelling, optioneering and workshops have been undertaken to define solutions that are feasible to implement within the timeframe and yet are cost effective
- **Efficient cost**: All costs are derived from our central unit cost model
- **Comparison to AMP6**: Although the volume of sustainability reductions is decreasing, the amount of work required to enable each reduction while retaining the same level of localised resilience is increasing significantly. For example, in AMP6, 6km of new mains were required. In AMP7, six times the length of new mains are required (35.5km), plus up to 96km of communication pipe replacements and a new 12-hour storage reservoir. The cost of the programme has increased by £41.88m since AMP6.

9.2.2.3 Securing water resources - £74.64m
We will invest in supply transfer schemes to make better use of the resources available to us and to release 17Ml/d of surplus water currently trapped in the Wey community. We will develop a new groundwater source fed from the greensands aquifer and we will develop an innovative new conditioning treatment plant to secure full access to one of Anglian Waters' large WTW. We will also invest to develop a new resource - the Upper Thames regional reservoir – in collaboration with Thames Water. Finally, we will work with the Environment Agency to explore potential licence variations at sites in the Dour community.

This expenditure is necessary because:

- **Need:** These schemes are an output of the rdWRMP and are required to maintain the supply demand balance in AMP7 and into the future
- **Optioneering**: The EBSD model selected these schemes because they are part of the least-cost whole-life solution to maintaining the supply demand balance
- **Efficient cost**: costs have been tested, challenged and verified through the bottom-up costing of schemes during the production of robust peer reviewed business cases

9.2.3 Ten-year expenditure profile
In Figure 9-4 expenditure is presented by type and profiled over a ten-year period.

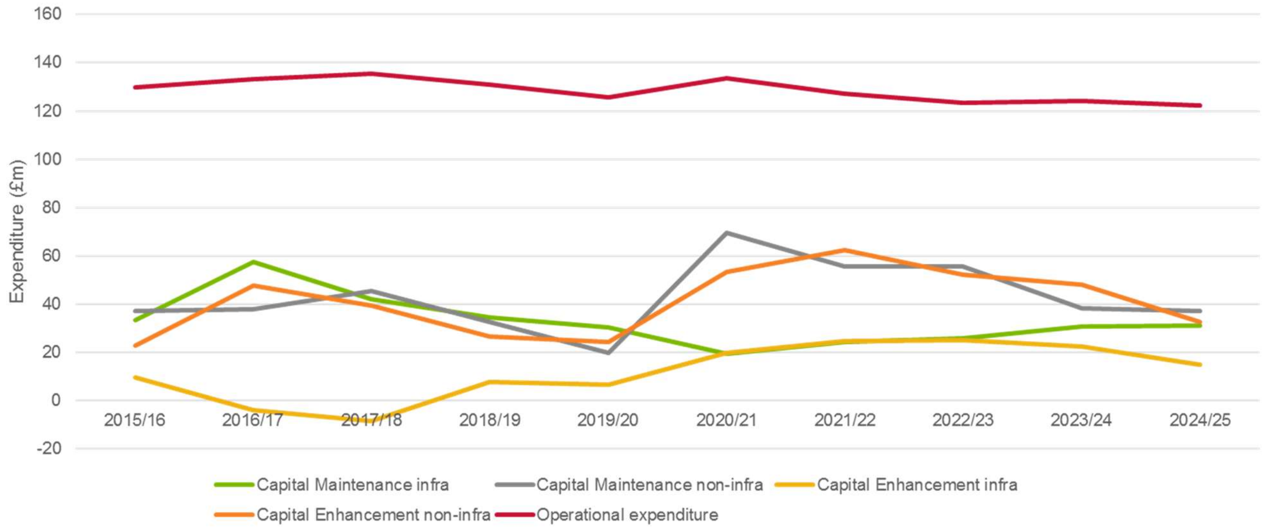


Figure 9-4 Ten-year expenditure profile

Figure 9-4 shows that there will be an increase in capital maintenance non-infrastructure and capital enhancement non-infrastructure expenditure during the first year of AMP7 (2020-21). Negative capital enhancement infrastructure during AMP6 is temporary and is caused by the timing of developer services contributions.

9.3 Expenditure by community area

Our Plan balances expenditure across the eight communities as shown in Figure 9-5.

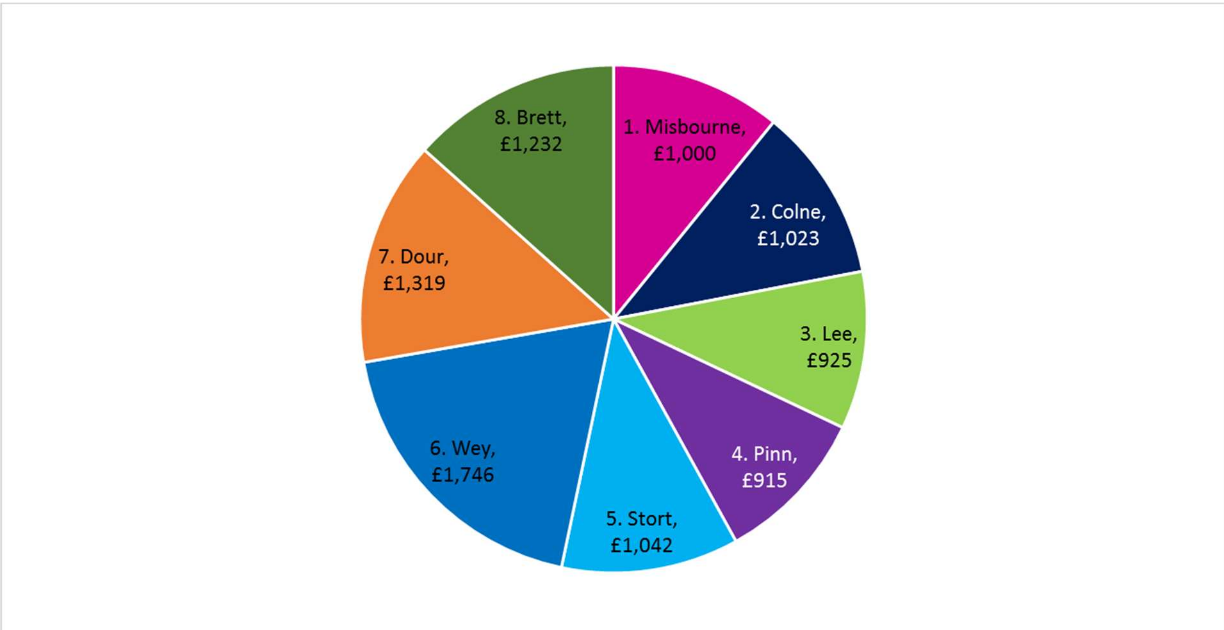


Figure 9-5 Totex per household by community

Figure 9-5 shows that planned expenditure is slightly greater within the Wey, Brett and Dour communities. This is due to:

Brett: we are trialling a lead communication and supply pipe replacement scheme to reduce concentrations of lead in customers' tap water and we're implementing sustainability reductions

Dour: we are building two new nitrate removal plants to maintain water quality and investing in ageing production assets

Wey: we are extending our universal metering programme to households in Wey and we're investing in deteriorating production assets

9.4 Investment by Outcome

Our Plan supports Outcomes. Each AMP7 planned capital investment has been mapped to the Outcome that it most supports and compared to AMP6 (PR14). **Providing great service that you value** is a cross cutting Outcome is supported through all the investments.

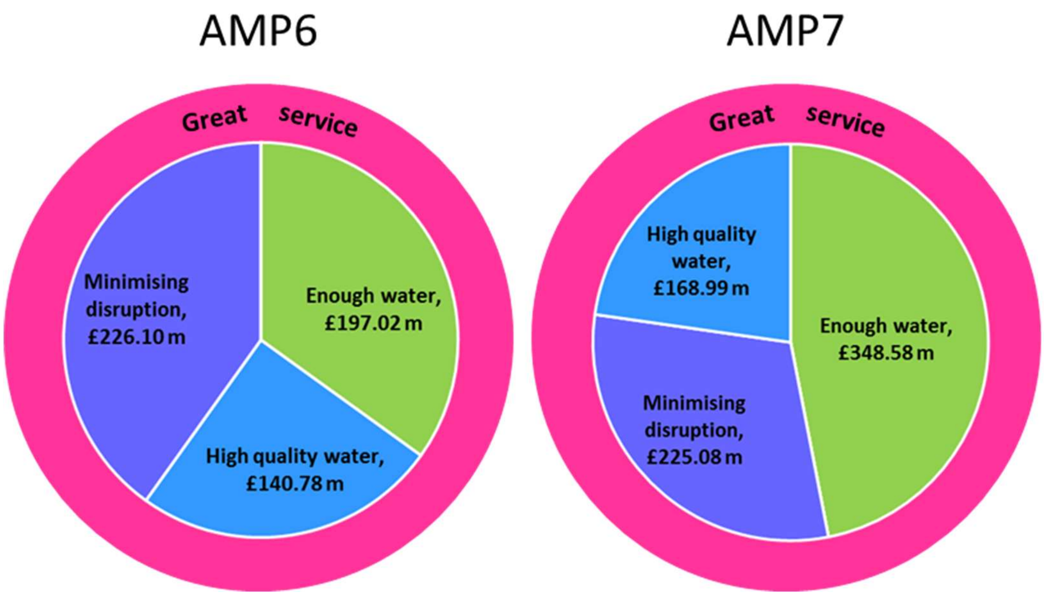


Figure 9-6 Capex investment by Outcome in AMP6 (PR14) and AMP7

Figure 9-6 shows that investment for **making sure you have enough water while leaving more water in the environment** and **supplying high quality water you can trust** is increasing and that investment for **minimising disruption to you and your community** remains consistent. This is due to the large step-up in investment required to maintain the balance of supply and demand whilst also meet our environmental regulatory obligations.

9.5 Expenditure by sub-portfolio

We have categorised proposed expenditure by sub-portfolio and programme:

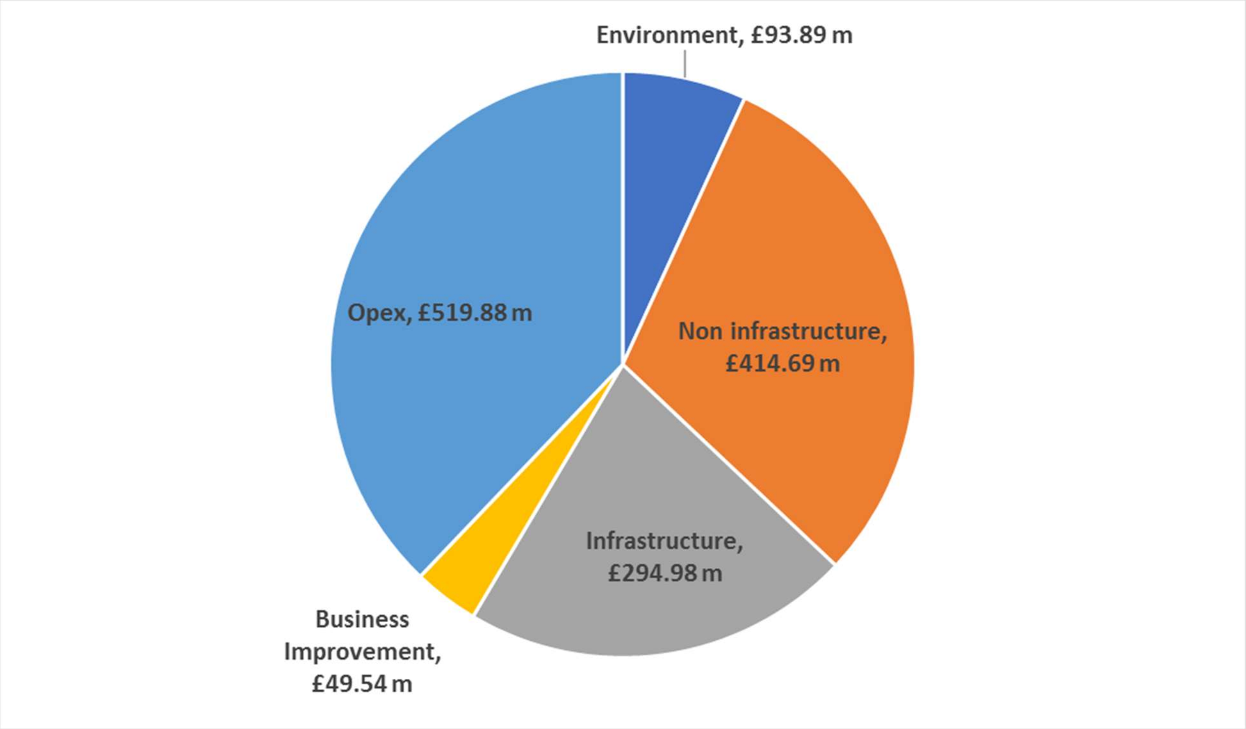


Figure 9-7 AMP7 Totex by sub-portfolio

In the following sub-sections, we describe the major programmes and deliverables within each sub-portfolio.

9.5.1 Environment sub-portfolio

Expenditure in this sub-portfolio supports our commitments to **making sure you have enough water while leaving more water in the environment**, **supplying high quality water you can trust** and **providing a great service that you value**. The expenditure is necessary to maintain the supply demand balance, deliver WINEP schemes, improve water quality and comply with other environmental legal and regulatory obligations. We plan to deliver the following by 2025:

- 25 investigations and options appraisals on the impact of our abstractions on water bodies
- A further 36.31Ml of sustainability reductions
- Six catchment investigations and 17 catchment improvement schemes
- Improvements to 157km of river
- Biodiversity obligations at our landholdings

Expenditure programmes in the environment sub-portfolio are summarised in Table 9-1 below:

Programme	Capex (£m)	Opex (£m)	Contributions (£m)	Total (£m)
Abstraction impact assessments	6.33	0.00	0.00	6.33
Reducing our abstractions (sustainability reductions)	58.42	0.00	0.00	58.42
Catchment management	7.11	0.00	0.00	7.11
River enhancement	19.04	0.00	0.00	19.04
Biodiversity	3.00	0.00	0.00	3.00
	93.89	**£0**	**£0**	**93.89**

Table 9-1 Environment expenditure

9.5.2 Non-infrastructure sub-portfolio

Expenditure in this sub-portfolio supports our commitments to **making sure you have enough water while leaving more water in the environment**, **supplying high quality water you can trust**, **minimising disruption to you and your community** and **providing a great service that you value**. The expenditure is necessary to maintain the supply demand balance, mitigate water quality risk, combat rising energy prices, meet regulatory or legal obligations and maintain efficient and resilient assets.

We plan to deliver the following by 2025:

- Replacement of 11Ml of storage assets and disconnection of 18 disused storage assets
- Nitrates removal treatment at four sites
- Full, flexible utilisation of our large Anglian Water import under average and peak conditions
- Production plant maintenance
- Reducing PCC to 129 l/p/d by 2025
- Eight resilience and environment community pilot schemes
- 10% reduction in forecast energy consumption and a 40% reduced reliance of grid energy by 2030
- Planning for the Upper Thames regional reservoir
- 117,000 meter replacements

Expenditure programmes in the non-infrastructure sub-portfolio are summarised in Table 9-2 below:

Programme	Capex (£m)	Opex (£m)	Contributions (£m)	Total (£m)
Storage	19.63	1.37	0.00	21.00
Pesticides	1.20	0.00	0.00	1.20
Nitrates	9.96	0.00	0.00	9.96
Conditioning treatment	11.22	2.12	0.00	13.34
Contribution for the shared reservoir in Brett Community	1.65	0.00	0.00	1.65
Treatment investment	149.41	3.90	0.00	153.31
Desalination	0.00	0.00	0.00	0.00
Reducing customer consumption	134.36	5.87	0.00	140.23
Resilience and environment community pilot schemes	2.00	0.00	0.00	2.00
Ongoing asset management	9.65	0.00	0.00	9.65
Upper Thames regional reservoir	18.49	0.00	0.00	18.49
Lab equipment	1.83	0.00	0.00	1.83
Fleet	0.35	0.00	0.00	0.35
Energy	19.70	0.00	0.00	19.70
Meter replacement	22.00	0.00	0.00	22.00
	401.43	**13.26**	**0.00**	**414.69**

Table 9-2 Non-infrastructure expenditure

9.5.3 Infrastructure sub-portfolio

Expenditure in this sub-portfolio supports our commitments to **making sure you have enough water while leaving more water in the environment**, **supplying high quality water you can trust**, **minimising disruption to you and your community** and **providing a great service that you value**. The expenditure is necessary to maintain the supply demand balance, mitigate water quality risk, meet regulatory and legal obligations and maintain efficient and resilient assets.

We plan to deliver the following by 2025:

- Trunk main renewals
- Three-minute supply interruption target
- 210km of distribution main rehabilitations
- Reducing customer exposure to lead
- Releasing 17Ml of surplus water from the Wey community and maintaining supply resilience
- Providing a further 80,000 new connections
- A further 15% leakage reductions

Expenditure programmes in the distribution sub-portfolio are summarised in Table 9-3 below:

Investment Programme	Capex (£m)	Opex (£m)	Contributions (£m)	Total (£m)
Trunk mains	33.74	0.00	0.00	58.24
Distribution mains	38.00	0.00	0.00	38.00
Replacement and refurbishment of lead supply and communications pipes	9.20	0.00	0.00	9.20
Supply 2040	36.67	0.00	0.00	36.67
Developer services	53.84	0.00	-33.49	20.35
Maintaining adequate pressure	3.75	0.00	0.00	3.75
Interruptions to supply	0.00	24.50	0.00	24.50
Leakage	54.17	71.98	0.00	126.15
National infrastructure contributions	2.63	0.00	0.00	2.63
	232.00	**96.48**	**-33.49**	**294.98**

Table 9-3 Infrastructure expenditure

9.5.4 Business improvement sub-portfolio

Expenditure in this sub-portfolio supports our commitments to **making sure you have enough water while leaving more water in the environment**, **supplying high quality water you can trust, minimising disruption to you and your community** and **providing a great service that you value**. The expenditure is necessary to support vital business functions, meet regulatory and legal obligations and plan for the future.

We plan to deliver the following by 2025:

- PR24 business plan
- PR24 WRMP
- PR24 drought management plan

- Continuous IT maintenance and innovation

Expenditure programmes in the business improvement sub-portfolio are summarised in Table 9-4 below:

Programme	Capex (£m)	Opex (£m)	Contributions (£m)	Total (£m)
Business planning	18.40	0.00	0.00	18.40
IT	20.42	0.72	0.00	21.14
Spend to save	10.00	0.00	0.00	10.00
	48.82	0.72	0.00	**49.54**

Table 9-4 Business planning expenditure

9.5.5 Wholesale operating costs

Operating expenditure support our commitments to **providing a great service that you value**, **making sure you have enough water while leaving more water in the environment**, **supplying high quality water you can trust** and **minimising disruption to you and your community**. The expenditure is necessary to support vital business functions, meet regulatory and legal obligations and deliver our business plan.

Operating costs can be thought of in two parts:

- **Incremental opex** is linked with specific capital investment programmes and has been evidenced through the business case development process. It sums to a net total of £110.46m.
- **Base opex** is the core operating expenditure required to operate in our communities. It sums to a net total of £519.88m

Operational expenditure sums to a net total of £630.34m and is summarised in Table 9-5 below:

Expenditure	Capex (£m)	Opex (£m)	Contributions (£m)	Total (£m)
Incremental opex		110.46	0.00	110.46
Base opex		567.25	-47.37	519.88
			Total:	**630.34**

Table 9-5 Wholesale operating costs

Operational expenditure is presented by regulatory category (as per WS1 table submission) in Figure 9-8 below:

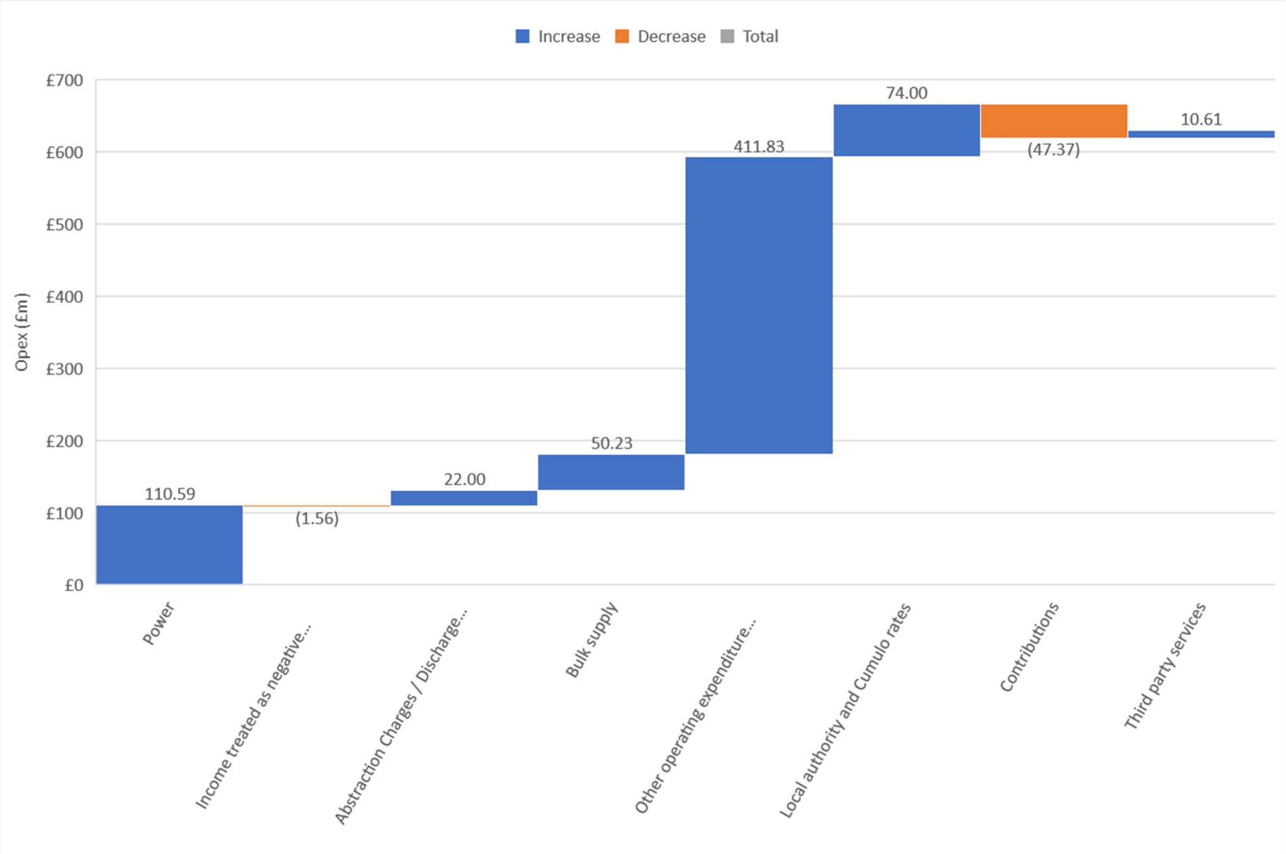


Figure 9-8 AMP7 operational expenditure

9.6 Tables submission

The purpose of this sub-section is to explain the processes used to populate years 2020/21 – 2024/25 in the following business plan tables:

- WS1 – B: Wholesale water capital expenditure by business unit
- WS2 – A: Wholesale water capital enhancement expenditure by purpose

For further information please refer to the tables and the table Commentary[89].

9.6.1 WS1 wholesale capital expenditure by business unit

Capital expenditure discussed in this sub-section originates from the finalised outputs of business cases, PIONEER or the EBSD model. Each gross capital expenditure item included in the Totex Plan has been individually assessed and mapped to one or more of the following regulatory categories:

- Maintenance infrastructure (WS1 line 12 and block A given how infrastructure renewal expenditure (IRE) is accounted for)
- Maintenance non-infrastructure (WS1 line 13)
- Enhancement infrastructure (WS1 line 14)
- Enhancement non-infrastructure (WS1 line 15)

The categorisation has been audited and signed-off by external auditors Atkins. The gross totals are summarised in Table 9-6 below:

[89] WS1 Commentary, WS1 Table, WS2 Commentary, WS2 Table

Maintenance infrastructure (WS1 line 12)	Maintenance non-infrastructure (WS1 line 13)	Enhancement infrastructure (WS1 line 14)	Enhancement non-infrastructure (WS1 line 15)
£131.36m	£255.93m	£149.00m	£239.85m
		TOTAL CAPEX:	**£776.14m**

Table 9-6 Gross capital expenditure by regulatory category

The individual expenditure components that make up the gross totals set out in table 10.6 are detailed in Table 9-7- Table 9-10 below.

Maintenance infrastructure (WS1 line 12)

Expenditure (Affinity Water title)	% for inclusion	£m for inclusion
Network ancillaries	100%	40.00
Distribution mains renewals	100%	38.00
Trunk Main Renewals	100%	25.24
Leakage infrastructure and maintenance	100%	14.17
Trunk main maintenance and risk mitigation	100%	8.50
National infrastructure contributions	100%	2.63
Pressure and DG2	100%	1.25
Aluminium (1)	50%	0.32
Single points of failure	25%	1.25
	Total:	**£131.36m**

Table 9-7 Maintenance Infrastructure expenditure by regulatory category

Maintenance non-infrastructure (WS1 line 13)

Expenditure (Affinity Water title)	% for inclusion	£m for inclusion
Capital maintenance non-infrastructure Pioneer output	100%	85.16
Meter replacement	100%	22.00
Energy strategy	100%	19.70
Storage	100%	19.63
IT strategy	100%	12.00
Spend to save	100%	10.00
IT infrastructure	100%	8.32
GAC regeneration	100%	7.15
RGF house WALT	100%	6.86
Asset information & data modelling tools	100%	5.75
Slow sand filters	100%	5.40
Ozone refurbishment at HWFS	100%	4.80
Business plan	100%	4.60
Turbidity and waste water recovery at NORM	100%	3.85
Disinfection (1)	100%	3.00
Aluminium (2)	100%	2.32
SDM analytics, reporting & monitoring	100%	2.30
Waste water recovery LANE	100%	2.20
Waste water recovery DENG	100%	2.04
Ozone refurbishment at three WTW	100%	1.90

Lab equipment	100%	1.83
Waste water recovery at CHER	100%	1.80
Contributions for the shared reservoir in Brett	100%	1.65
Asset health, risk & investment	100%	1.60
Reservoir cleaning at WALT	100%	1.58
Dewatering at HWFS	100%	1.15
Waste water recovery WALT	100%	1.10
Waste water treatment ROYD	100%	1.00
Waste water upgrade at EGHA	100%	0.90
Disinfection (2)	100%	0.89
Water tower DENG	100%	0.48
RGF house CHER	100%	0.46
Vehicles	100%	0.35
Disinfection (3)	100%	0.29
Drought management plan	100%	0.25
Laboratory information management system	100%	0.10
Single points of failure	75%	3.75
Nitrate treatment	75%	7.47
Aluminium (1)	50%	0.32
	Total:	**£255.93m**

Table 9-8 Maintenance non-infrastructure expenditure by regulatory category

Enhancement infrastructure (WS1 line 14)

Expenditure (Affinity Water title)	% for inclusion	£m for inclusion
Developer services*	100%	53.84
Upper Thames regional reservoir	100%	18.49
Lead	100%	9.20
WRMP (1)	100%	5.00
Sustainability reductions (1)	73%	33.03
Sustainability reductions (2)	73%	5.50
Sustainability reductions (3)	73%	4.36
Supply 2040	50%	18.33
Low pressure	50%	1.25
	Total:	**£149.00m**

Table 9-9 Enhancement Infrastructure expenditure by regulatory category

*Please note that £53.84m is the estimated gross capital cost of the developer services function. Contributions of £33.49m are anticipated, meaning that the net cost is £20.35m.

Enhancement non-infrastructure (WS1 line 15)

Expenditure (Affinity Water title)	% for inclusion	£m for inclusion
Water saving programme	100%	69.35
Water efficiency and behavioural change (1)	100%	28.04
Conditioning treatment	100%	11.22
River enhancement (1)	100%	18.54
Water efficiency and behavioural change (2)	100%	14.14

Water efficiency and behavioural change (3)	100%	12.30
Water efficiency and behavioural change (4)	100%	7.53
WINEP supply investigations and options appraisals	100%	6.33
RUNGS	100%	5.54
Water resources feasibility studies	100%	5.00
HORC	100%	3.30
Water efficiency and behavioural change (5)	100%	3.00
Biodiversity	100%	3.00
Catchment management: River Thames pesticides	100%	2.27
Resilience and environment community pilot schemes	100%	2.00
WRMP (2)	100%	2.00
Catchment management: groundwater pesticides	100%	1.88
Catchment Management: nitrate affected sources	100%	1.81
Regional group membership	100%	1.55
Pesticides	100%	1.20
Catchment management: drinking water quality plans	100%	0.61
Increasing abstraction	100%	0.60
Catchment management: investigations	100%	0.54
River enhancement (2)	100%	0.50
Supply 2040	50%	18.33
Low Pressure	50%	1.25
Sustainability reductions (1)	27%	11.96
Sustainability reductions (2)	27%	1.99
Sustainability reductions (3)	27%	1.58
Nitrate treatment	25%	2.49
	Total:	**£239.85m**

Table 9-10 Enhancement Non-infrastructure expenditure by regulatory category

Each gross capital expenditure line included in the Totex Plan has also been mapped to one or more of the following price control categories:

- Water resources
- Raw water distribution
- Water treatment
- Treated water distribution

The categorisation has been audited and signed-off by external auditors Atkins and our own Audit Committee. The gross totals are summarised in Table 9-11below:

Water resources	Raw water distribution	Water treatment	Treated water distribution
£183.03m	£20.51m	£137.43m	£435.17m
		TOTAL CAPEX:	**£776.14m**

Table 9-11 Gross capital expenditure by regulatory price control category

The components of the gross totals set out in Table 9-11 are detailed in Table 9-12–Table 9-15 below.

Water resources

Expenditure (Affinity Water title)	% for inclusion	£m for inclusion
Sustainability reductions (1)	100%	44.99
Supply 2040	100%	36.67
River enhancement (1)	100%	18.54
Water efficiency and behavioural change (4)	100%	7.53
WINEP supply investigations and options appraisals	100%	6.33
RUNGS	100%	5.54
WRMP (1)	100%	5.00
Water resources feasibility studies	100%	5.00
Biodiversity	100%	3.00
Catchment management: River Thames pesticides	100%	2.27
Resilience and environment community pilot schemes	100%	2.00
WRMP (2)	100%	2.00
Catchment management: groundwater pesticides	100%	1.88
Catchment management: nitrate affected sources	100%	1.81
Regional group membership	100%	1.55
Pesticides	100%	1.20
Catchment management: drinking water quality plans	100%	0.61
Increasing abstraction	100%	0.60
Catchment management: investigations	100%	0.54
River enhancement (2)	100%	0.50
Drought management plan	100%	0.25
Upper Thames regional reservoir	33%	6.16
Sustainability reductions (3)	33%	1.98
Spend to save	27%	2.70
IT strategy	25%	3.00
IT infrastructure	25%	2.08
SDM analytics, reporting & monitoring	25%	0.57
Laboratory information management system	25%	0.03
Capital maintenance non-infrastructure Pioneer output	20%	17.03
Business planning	20%	0.92
Asset information & data modelling tools	10%	0.58
Lab equipment	10%	0.18
	Total:	**£183.03m**

Table 9-12 Water Resources capital expenditure

Raw water distribution

Expenditure (Affinity Water title)	% for inclusion	£m for inclusion
Upper Thames regional reservoir	33%	6.16
IT strategy	25%	3.00
IT Infrastructure	25%	2.08
Laboratory information management system	25%	0.03
Capital maintenance non-infrastructure Pioneer output	10%	8.52

Business planning	5%	0.23
Lab equipment	5%	0.09
Spend to save	4%	0.40
	Total:	**£20.51m**

Table 9-13 Raw water distribution capital expenditure

Water treatment

Expenditure (Affinity Water title)	% for inclusion	£m for inclusion
Conditioning treatment	100%	11.22
Nitrate treatment	100%	9.96
GAC regeneration	100%	7.15
RGF house WALT	100%	6.86
Slow sand filters	100%	5.40
Ozone refurbishment at HWFS	100%	4.80
Turbidity and waste water recovery at NORM	100%	3.85
HORC	100%	3.30
Disinfection (1)	100%	3.00
Waste water recovery LANE	100%	2.20
Waste water recovery DENG	100%	2.04
Ozone refurbishment at three WTW	100%	1.90
Waste water recovery at CHER	100%	1.80
Contributions for the shared reservoir in Brett	100%	1.65
Reservoir cleaning at WALT	100%	1.58
Dewatering at HWFS	100%	1.15
Waste water recovery WALT	100%	1.10
Waste water treatment ROYD	100%	1.00
Waste water upgrade at EGHA	100%	0.90
Disinfection (2)	100%	0.89
RGF house CHER	100%	0.46
Disinfection (3)	100%	0.29
Single points of failure	75%	3.75
Aluminium (2)	50%	1.16
Lab equipment	45%	0.82
Capital maintenance non-infrastructure Pioneer output	40%	34.06
Business planning	40%	1.84
Asset health, risk & investment	40%	0.64
Upper Thames regional reservoir	33%	6.16
Sustainability reductions (3)	33%	1.98
Aluminium (1)	33%	0.21
Asset information & data modelling tools	30%	1.73
Storage	25%	4.91
IT strategy	25%	3.00
IT infrastructure	25%	2.08
SDM analytics, reporting & monitoring	25%	0.57

Laboratory Information Management System	25%	0.03
Spend to save	20%	2.00
	Total:	**£137.43m**

Table 9-14 Water Treatment capital expenditure

Treated water distribution

Expenditure (Affinity Water title)	% for inclusion	£m for inclusion
Water saving programme	100%	69.35
Developer services	100%	53.84
Network ancillaries	100%	40.00
Distribution mains renewals	100%	38.00
Water efficiency and behavioural change (1)	100%	28.04
Trunk main renewals	100%	25.24
Meter replacement	100%	22.00
Energy strategy	100%	19.70
Leakage infrastructure and maintenance	100%	14.17
Water efficiency and behavioural change (2)	100%	14.14
Water efficiency and behavioural change (3)	100%	12.30
Lead	100%	9.20
Trunk main maintenance and risk Mitigation	100%	8.50
Sustainability reductions (2)	100%	7.49
Water efficiency and behavioural change (5)	100%	3.00
National infrastructure contributions	100%	2.63
Low pressure	100%	2.50
Pressure and DG2	100%	1.25
Water tower DENG	100%	0.48
Vehicles	100%	0.35
Storage	75%	14.72
Aluminium (1)	67%	0.43
Asset information & data modelling tools	60%	3.45
Asset health, risk & investment	60%	0.96
Aluminium (2)	50%	1.16
SDM Analytics, reporting & monitoring	50%	1.15
Spend to save	49%	4.90
Lab equipment	40%	0.73
Business planning	35%	1.61
Sustainability reductions (3)	33%	1.98
Capital maintenance non-infrastructure Pioneer output	30%	25.55
IT strategy	25%	3.00
IT infrastructure	25%	2.08
Single points of failure	25%	1.25
Laboratory information management system	25%	0.03
	Total:	**£435.17m**

Table 9-15 Treated water Distribution capital expenditure

9.6.2 WS2 Wholesale water capital enhancement expenditure by purpose

Each gross capital expenditure item included in the Totex Plan that is classified as enhancement (the sum of WS1 lines 14 and 15) has been mapped to one or more of the regulatory enhancement categories. The regulatory enhancement categories are:

1: WINEP / NEP ~ Making ecological improvements at abstractions (WS2 line 1)
2: WINEP / NEP ~ Eels Regulations (WS2 line 2)
3: WINEP / NEP ~ Invasive non-native species (WS2 line 3)
4: Addressing low pressure (WS2 line 4)
5: Improving taste / odour / colour (WS2 line 5)
6: Meeting lead standards (WS2 line 6)
7: Supply side enhancements to the supply/demand balance (dry year critical) (WS2 line 7)
8: Supply side enhancements to the supply/demand balance (dry year average) (WS2 line 8)
9: Demand side enhancements to the supply/demand balance (dry year critical) (WS2 line 9)
10: Demand side enhancements to the supply/demand balance (dry year average) (WS2 line 10)
11: New developments (WS2 line 11)
12: New connections element of new development (WS2 line 12)
13: Investment to address raw water deterioration (WS2 line 13)
14: Resilience (WS2 line 14)
15: SEMD (WS2 line 15)
16: Non-SEMD related security enhancement (WS2 line 16)
17: WINEP / NEP ~ Drinking Water Protected Areas (WS2 line 17)
18: WINEP / NEP ~ Water Framework Directive measures (WS2 line 18)
19: WINEP / NEP ~ Investigations (WS2 line 19)
20: Improvements to river flows (WS2 line 20)
21: Metering for meters requested by optants (WS2 line 21)
22: Metering for meters introduced by companies (WS2 line 22)
23: Metering for businesses (WS2 line 23)

No expenditure was mapped to the following categories:

2: WINEP / NEP ~ Eels Regulations (WS2 line 2)
5: Improving taste / odour / colour (WS2 line 5)
7: Supply side enhancements to the supply/demand balance (dry year critical) (WS2 line 7)
9: Demand side enhancements to the supply/demand balance (dry year critical) (WS2 line 9)
12: New connections element of new development (WS2 line 12)
15: SEMD (WS2 line 15)
16: Non-SEMD related security enhancement (WS2 line 16)
17: WINEP / NEP ~ Drinking Water Protected Areas (WS2 line 17)

The categorisation has been audited and signed-off by external auditors Atkins. The gross totals for the categories with expenditure mapped to them are summarised in Table 9-16 below:

WS2 line number	£m
1	21.14
3	0.39
4	2.50
6	9.20
8	78.89
10	69.43
11	53.84

13	3.69
14	3.30
18	64.99
19	6.87
20	0.50
21	6.94
22	59.64
23	7.53
Total:	**388.85**

Table 9-16 Gross enhancement capital expenditure by regulatory category

The components of the gross totals set out in Table 9-16 are detailed in Table 9-17–Table 9-31 below.

1: WINEP / NEP ~ Making ecological improvements at abstractions (WS2 line 1)

Enhancement expenditure item	% for inclusion	£m for inclusion
River enhancements (1)	100%	18.54
Biodiversity	87%	2.61
	Total:	**£21.14m**

Table 9-17 WINEP / NEP ~ Making ecological improvements at abstractions

3: WINEP / NEP ~ Invasive non-native species (WS2 line 3)

Enhancement expenditure item	% for inclusion	£m for inclusion
Biodiversity	13%	0.39
	Total:	**£0.39m**

Table 9-18 WINEP / NEP ~ Invasive non-native species

4: Addressing low pressure (WS2 line 4)

Enhancement expenditure item	% for inclusion	£m for inclusion
Low pressure	100%	2.50
	Total:	**£2.50m**

Table 9-19 Addressing low pressure

6: Meeting lead standards (WS2 line 6)

Enhancement expenditure item	% for inclusion	£m for inclusion
Lead	100%	9.20
	Total:	**£9.20m**

Table 9-20 Meeting lead standards

8: Supply side enhancements to the supply/demand balance (dry year average) (WS2 line 8)

Enhancement expenditure item	% for inclusion	£m for inclusion
RWGS	100%	5.54
Conditioning treatment	100%	11.22
Increasing abstraction	100%	0.60

Supply 2040	100%	36.67
Upper Thames regional reservoir	100%	18.49
Regional group membership	50%	0.78
WRMP (2)	50%	1.00
WRMP (1)	50%	2.50
Water resources feasibility studies	30%	1.50
Resilience and environment community pilot schemes	30%	0.60
	Total:	**£78.89m**

Table 9-21 Supply side enhancements to the supply/demand balance (dry year average)

10: Demand side enhancements to the supply/demand balance (dry year average) (WS2 line 10)

Enhancement expenditure item	% for inclusion	£m for inclusion
Water efficiency and behavioural change (3)	100%	12.30
Water efficiency and behavioural change (2)	100%	14.14
Water efficiency and behavioural change (1)	100%	28.04
Water efficiency and behavioural change (5)	100%	3.00
Water resources feasibility studies	70%	3.50
Resilience and environment community pilot schemes	70%	1.40
Regional group membership	50%	0.78
WRMP (2)	50%	1.00
WRMP (1)	50%	2.50
Water saving programme	4%	2.77
	Total:	**£69.43m**

Table 9-22 Demand side enhancements to the supply/demand balance (dry year average)

11: New developments (WS2 line 11)

Enhancement expenditure item	% for inclusion	£m for inclusion
Developer services	100%	53.84
	Total:	**£53.84 m**

Table 9-23 New developments

13: Investment to address raw water deterioration (WS2 line 13)

Enhancement expenditure item	% for inclusion	£m for inclusion
Pesticides	100%	1.20
Nitrate treatment	100%	2.49
	Total:	**£3.69m**

Table 9-24 Investment to address raw water deterioration

14: Resilience (WS2 line 14)

Enhancement expenditure item	% for inclusion	£m for inclusion
HORC	100%	3.30
	Total:	**£3.30m**

Table 9-25 Resilience

18: WINEP / NEP ~ Water Framework Directive measures (WS2 line 18)

Enhancement expenditure item	% for inclusion	£m for inclusion
Catchment management: drinking water quality plans	100%	0.61
Catchment management: River Thames pesticides	100%	2.27
Catchment management: groundwater pesticides	100%	1.88
Catchment management: nitrate affected sources	100%	1.81
Sustainability Reductions (3)	100%	5.94
Sustainability Reductions (1)	100%	44.99
Sustainability Reductions (2)	100%	7.49
	Total:	**£64.99m**

Table 9-26 WINEP / NEP ~ Water Framework Directive measures

19: WINEP / NEP ~ Investigations (WS2 line 19)

Enhancement expenditure item	% for inclusion	£m for inclusion
Catchment management: investigations	100%	0.54
WINEP supply investigations and options appraisals	100%	6.33
	Total:	**£6.87m**

Table 9-27 WINEP / NEP ~ Investigations

20: Improvements to river flows (WS2 line 20)

Enhancement expenditure item	% for inclusion	£m for inclusion
River enhancement (2)	100%	0.50
	Total:	**£0.50m**

Table 9-28 Improvements to river flows

21: Metering for meters requested by optants (WS2 line 21)

Enhancement expenditure item	% for inclusion	£m for inclusion
Water saving programme	10%	6.94
	Total:	**£6.94m**

Table 9-29 Metering for meters requested by optants

22: Metering for meters introduced by companies (WS2 line 22)

Enhancement expenditure item	% for inclusion	£m for inclusion
Water saving programme	86%	59.64
	Total:	**£59.64m**

Table 9-30 Metering for meters introduced by companies

23: Metering for businesses (WS2 line 23)

Enhancement expenditure item	% for inclusion	£m for inclusion
Water efficiency and behavioural change (4)	100%	7.53
	Total:	**£7.53m**

Table 9-31 Metering for businesses

9.7 Future expenditure

We constantly assess the health of our assets and analyse risk to inform investment decision making. All expenditure discussed in this section is therefore subject to change.

9.7.1 Supplying customers and communities with water

Our rdWRMP provides a 60-year forecast of the expenditure required to maintain the supply demand balance. The planning process is iterative and expenditure requirements are subject to alteration as customer and stakeholder expectations change, the regulatory and legal landscape evolves and forecasts are updated. At the time of writing, likely significant expenditure requirements to supply customers and communities with water post 2025 include:

9.7.1.1 Upper Thames Regional Reservoir

Our rdWRMP includes plans to invest in developing a new regional reservoir in the Upper Thames catchment in partnership with Thames Water. See section 5.3 for more information. Due to its size, the reservoir is expected to be funded through the direct procurement mechanism with Affinity Water absorbing 1/3 and Thames Water absorbing 2/3. The project is anticipated to start in 2022/23 and costs have been estimated through to 2049/50 in App21 of our Tables submission[90].

A summary of post 2025 capex costs attributed to Affinity Water, to be funded through direct procurement, is provided in Table 9-32 below:

	AMP7	AMP8	AMP9	AMP10
Affinity Water	£18.49m	£162.38m	£364.61m	£19.87m
Thames Water	£36.98m	£324.75m	£729.22m	£39.75m
Total	**£55.47m**	**£487.13m**	**£1093.84m**	**£59.62m**

Table 9-32 Anticipated funding requirement for Upper Thames Regional Reservoir

9.7.1.2 Supply 2040

Supply 2040 is our long-term strategic plan to ensure supply resilience. Investments identified through Supply 2040 will enable us to:

- transfer 17Ml/d of surplus water to areas where there is deficit (AMP7)
- improve interconnectivity in our Central Region (AMP7, 8 and 9)
- protect and maximise existing critical resources (AMP7, 8 and 9)
- prepare the network for a 100Ml import of water upon completion of the Upper Thames regional reservoir in 2037 (AMP8, 9 and 10)

Schemes identified for completion post 2025 are summarised in Table 9-33 below. Please note that these schemes are in the process of being developed and are subject to change. See section 6.6 for more information on Supply 2040.

Reference	Scheme Name	Description
ST1b	EGHS to HWFS	2nd stage: Replace existing 450mm main with 700mm main and install a booster pump capable of 40Ml/d average (60Ml/d peak)
ST4	BUSY to ARKR	Install an 8km 500mm main and booster to move water from BUSY to ARKR

[90] *Business Plan Tables Submission App21*

ST15	WESH to WICK + 10Ml/day WESH to WICK + 10Ml/day	Booster upgrade to enable an additional 10Ml/day to be transferred through WESH to WICK Booster upgrade to enable an additional 10Ml/day to be transferred through WESH to WICK
ST16	UTTL to SIBR	Install 8.5km of 400mm main between UTTL and SIBR
ST17	BOXT to CHAU	Install 21km of 500mm main between BOXT and CHAU
ST18	BUGR To HADHBUGR to HADH	Install 17km of 400mm main between BUGR and HADH
ST19	EGHA to HATTEGHS to Hatton Cross	Install 9.5 Km of 500mm main from EGHA to HATT and replace HATT booster
ST20	HWFS to HARR HWFS to HARR	Install 14km of 800mm main from HFWS to HARR reservoir and replace Harrow high lift
ST21	HARE to HERG	Install 9km of 500mm main from HARE to HERG
ST22	HERG to AMER	Install 8.1km of 500mm main from HERG to AMER
ST23	AMER to BOVI	Install 16km of 500mm main from AMER to BOVI
ST24	AMER to BOXT	Install 20.7km of 500mm main from AMER to BOXT

Table 9-33 Supply 2040 schemes (post 2025)

9.7.2 Storage

Most of the water that we abstract is treated and then goes straight into our treated water network. To provide supply resilience, we store our treated water in strategically located storage assets. As we are reliant on these assets it is critical that we continue to monitor the rate at which these assets are deteriorating to assess the likelihood and impact of both water quality and supply interruption risks. Through our condition monitoring and risk-based review processes we have identified that four of our storage assets that are primarily constructed from brick in Dour, Lee and Misbourne are gradually deteriorating beyond economical repair and will require full replacement in AMP8.

Water age is a major factor contributing to water quality deterioration and can lead to supply failures. We have identified three of our reservoirs with long water residence times from monitoring their operation. To reduce water age and improve turnover in these reservoirs, we are investigating where we need to reconfigure our network to allow for better fluctuation in reservoir water levels. These modifications will take place in AMP8 and will include works at HARE No.3, which is our largest service reservoir with a total capacity of 146Ml.

We are also planning on building a new reservoir in our Dour community to maintain our supply resilience because of a new residential development. Our existing storage assets in Dour do not have the capacity to meet the projected increased demand fluctuations that the new development creates. It is therefore crucial that we construct a reservoir in Dour to preserve supply resilience in AMP8.

10 List of supporting information

1	dWRMP December 2017
2	Final Methodology for PR19 Price Review
3	Published WRMP
4	Drought Management Plan
5	Water Resources Planning Guideline – The technical methods and instructions, (June 2012)
6	The ELL excludes trunk mains leakage as trunk mains and service reservoir (TMSR) costs for detection & repair differ considerably to DMA cost-leakage relationships. Similarly, the policies for managing leakage on TMSR assets also differ greatly from those for DMAs. For further explanation please refer to Technical Report 4.8.1.
7	This is made up of 42.09Ml/d (AMP6 sustainability reduction), 8Ml/d from the River Misbourne, 13Ml/d River Ver (FRIA). A further 1.3Ml/d reduction in DO has been implemented for provision of river support (0.3Ml/d River Hiz and 1Ml/d River Oughton).
8	UKWIR, Framework for Expenditure Decision Making. Ref 14/RG/05/40
9	UKWIR, Capital Maintenance Planning a Common Framework. Ref 02/RG/05
10	UKWIR, Capital Maintenance Planning Common Framework: Review of Current Practice, Ref: 05/RG/05/14
11	PR19 ES Costing FBP v1.31.xlsx, Affinity Water 2017 Report v1.2
12	P8688 Pumps Whole Life Cost Continuation Project – Final.pdf; WRc report C348b, December 2011
13	Mace EGI PR19 Cost Assessment Report- v2.2.pdf
14	Site Search.xlsx
15	Asset Dependency Final – Database Ready
16	Asset Dependency Database
17	Affinity Water List of Water Storage Asset.xlsx
18	PR19 Storage Business Case.doc
19	Affinity Water Storage Asset Inspection Database.accdb
20	MAINTENANCE OF SERVICE RESERVOIRS PD027.doc
21	PR19 Storage Scope & Budgetary Assessment.xlsx
22	STGE No.2 Replacement Feasibility Study
23	WINH No.2 Replacement Feasibility Study
24	FARC No.1 Replacement Feasibility Study
25	Potable Water Storage Cost Model.xlsx
26	Disused Storage Asset Isolations Concept Design
27	AFW – Cost adjustment claim AFW005
28	10 Year Rolling Replacement Calendar Oct 13.xlsx
29	Cornwall Pricing Guide
30	Energy Strategy
31	Affinity Water PR19 Communication Pipes – Reliability Modelling
32	Affinity Water PR19 Trunk Mains – Reliability and Consequence Modelling
33	Leakage Strategy AMP7
34	Supply 2040 Technical Report
35	National Infrastructure Costs Estimate
36	WRSE file 795; future funding options

37	Business System Planning was the IT road mapping exercise undertaken towards the end of year 2, to determine the IT investment required for Years 3-5 of AMP6. This provided a baseline plan and ringfenced funding to deliver the agreed IT strategy and plan for AMP6
38	
39	IT Supporting Information
40	Meeting our Business outcomes
41	BGA Dataset
42	BGA capex OH calculations
43	BGA capex OH calculations
44	Ref to gov website ONS
45	PIONEER output benchmark_BGA
46	PR19 Final Model Summary (MR)
47	MR finalised cost_PR19
48	PR19 Final Model Summary (TM)
49	PR19 Final Model Summary (TM)
50	BGA capex OH calculations
51	TM finalised cost_PR19
52	PR19 R&M all cost summary
53	Payment Application Summary
54	Service Manager Certificates
55	Corporate overhead calculation M&R only
56	Procurement purchases
57	Finalised cost Ancillary_PR19
58	PR19 DS Initial App28 Calculation v9_mt.xls
59	AGA Prelims, Indirect & Demo_PR19
60	AGA Risk and Complexity Adjustments_PR19
61	PR19 BGA&AGA on-costs combined
62	PR19 AGA cost split workbook
63	PR19 AGA Summarised Costs & Coefficients_PIONEER Upload
64	PR19 Support Services- metering strategy (April 2018)
65	Meter Failure Model 2017_v7 with growth.xls
66	Metering Schedule of Rates
67	Metering Schedule of Rates
68	Universal Metering Unit Cost Calculation
69	Optants Unit Cost Calculation
70	PR19 R&M Payment Application Summary
71	PR19 R&M cost models
72	PR19 Overhead Calculations R&M only
73	PR19 R&M all cost summary
74	PR19 Costs against EGI
75	PR19 P&R Maintenance_PIONEER Upload
76	Affinity Water PR19 Planned and Reactive Operational Cost Assessment
77	P8688 Pumps Whole Life Cost Continuation Project – Final.pdf; WRc report C348b, December 2011

78	Affinity Water Environmental and Social Costing database for Asset Management (PR19)
79	PR19 Carbon Upload to PIONEER
80	PR19 Carbon Costs
81	Service Measure Framework v6 PR19
82	Guidance on Confidence Grades
83	Energy Strategy
84	Lead Strategy 2020-2070
85	UKWIR, Capital Maintenance Planning Common Framework: Review of Current Practice, Ref: 05/RG/05/14
86	Maintenance Scenarios Summary.xlsx
87	Discounting for CBA involving private investment, but public benefit, Statement published by the Joint Regulators Group (JRG), (July 2012), Further Ofwat Guidance on the Use of Cost Benefit Analysis for PR09, (December 2007).
88	Methodology for Resilience in Affinity Water
89	WS1 Commentary, WS1 Table, WS2 Commentary, WS2 Table
90	Business Plan Tables Submission APP21