Affinity Water

AFW08 - Our investment development process

Contents

1. Introduction

1.1 Key Messages

Our investment decision making process has prioritised the importance of affordability to customers and ensuring the health of our assets, whilst counteracting the emerging challenges within the industry such as climate change. We have built a best practice approach to investment planning for PR24, including the introduction of industry-leading decision support tools, business case development and portfolio-wide optimisation.

The confidence in our investment decision making is reliant on the accuracy of the costing of investment options, the risks they will mitigate, and the benefits that will be realised. Considering the recent volatility of prices, particularly affecting the construction industry, the understanding and confidence of the costs associated with the delivery of our investments is more important than ever. We have significantly improved our understanding of the capital and operational expenditure costs across the business as a part of the development a unit cost database (UCD). Our UCD has been built using information from a range of sources, such as: our framework contracts and breakdowns from historic scheme outturn costs, supplemented by additional data and industry intelligence from Mott MacDonald.

Like the investment planning completed for PR19, we have continued to use the asset management system, PIONEER, to aid in our investment decision making. The system uses data on our large range of assets, cost models for each individual asset class from the UCD and asset deterioration models. Using this information, we used PIONEER to understand the deterioration of our assets over a 25-year period, in alignment with our long-term delivery strategies, and to understand the investment requirements and serviceability resulting from different scenarios.

Initially, we used serviceability targets stated within our network strategy to understand the investments required to meet performance targets relating to the number of annual bursts and the interruptions to supply for customers. As shown in Section 3.5, the resulting AMP8 infrastructure investments required range from between £79.1m, to maintain a stable burst performance, to £1.651bn, to be within the upper quartile of the UK water industry.

As our business plan developed, it was apparent that the investment levels indicated by our deterioration modelling through our PIONEER system may be unaffordable in the short term, particularly given the significant increases in statutory enhancement requirements. To remain within an affordability envelope, our PIONEER scenario configuration was adapted to consider optimal serviceability, whilst applying affordability constraints. The effect of the reduction in investment into mains renewals is counteracted by the network calming business case, which is split between base and enhancement expenditure. The network calming business case has been modelled to deliver a greater burst benefit for money than mains renewals alone, with additional benefits to leakage, interruptions to supply and CRI. The small enhancement component of the investment focuses on counteracting the increased burst rate that will be driven by climate change.

The serviceability and investment results from all the scenarios optimised with PIONEER were used to build a range of options that were inputted into Copperleaf for full portfolio optimisation.

We have updated our Service Measure Framework (SMF), which now quantifies over 85 differing categories of valve that we can bring to customers across the six capitals. This is a significant increase to the 30 used within PR19, which enables us to optimise our portfolio ensuring the best value solutions to meet our customer's needs. This increase in sophistication is an outcome of our two-year asset management transformation programme, which has focused on improving the maturity of our asset management.

Our investment portfolio comprises over 45 individual business cases. In building the business cases, we have set out to follow industry best practice. We have drawn guidance from a range of sources, including the HM Treasury Green Book, the Environment Agency's WINEP guidance, and the Office for National Statistics (ONS). We have also sought to replicate Ofwat method for economic assessments, including using the Ofwat valuations developed in the industry collaborative Willingness to Pay (WTP) study.

We have used our Copperleaf investment planning and portfolio optimisation tool to ensure that we have selected the optimal portfolio of investments, balancing ambitious short-term performance improvements with long-term asset health and affordability. The tool takes inputs from base and enhancement business cases (including investments defined by the WINEP and our WRMP) and PIONEER outputs for; the varying levels of investments in each area, the benefits for each investment level using our SMF, and the impact of not securing each investment level. To provide confidence that our base investments are delivering the greatest performance improvements to our customers, we undertook 25 separate optimisation runs at set cost increments, to sensitivity test how shifts in focus between short- and long-term performance or increased bias to certain performance commitments changes the investments in the portfolio. Our portfolio was optimised based on a 25+ year view of benefits which, combined with our Long-Term Delivery Strategy, provides us with confidence that our plan forms the foundations of strong performance and resilient service into AMP9 and beyond. The tool has been used as a post-optimisation optimiser, and the final business plan has not been decided on its outputs alone.

1.2 Decision Support Tools

The order in which the decision support tools aided our business plan is described throughout the sections of this report. This is also demonstrated below in Figure 1, which highlights the key milestones within the development of our final business plan.

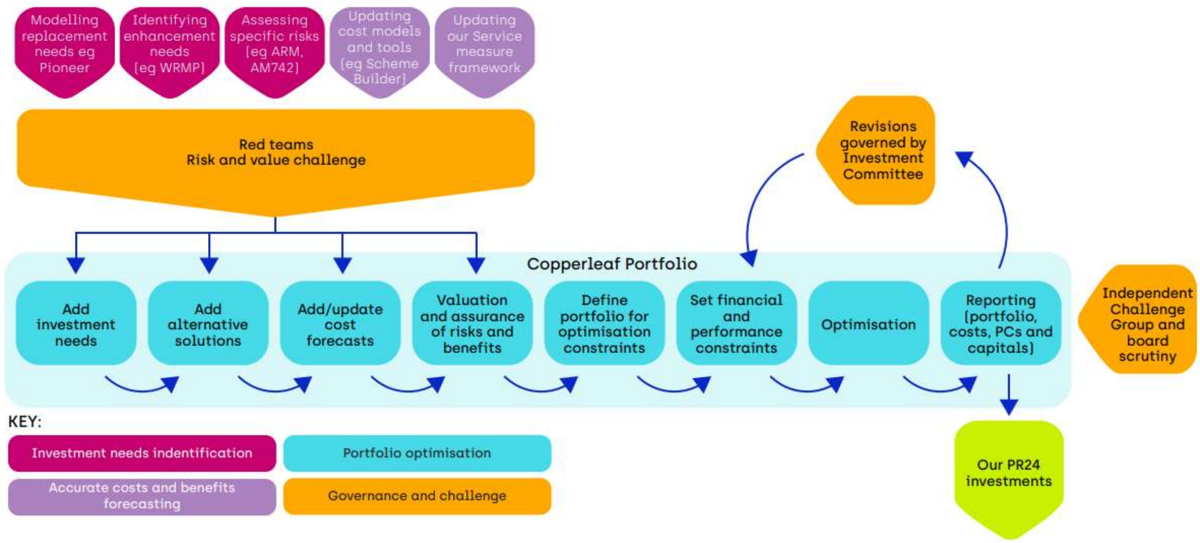

Figure 1 - Decision Support Tools

1.3 Governance and Assurance

We have increased the level of challenge and scrutiny of our investments to ensure that the options that we have selected are ambitious, deliverable, and have the customer's needs at the forefront. Every business case has undergone three phases of scrutiny before being put forward as an investment option within our portfolio. Furthermore, our Board and Independent Challenge Group have scrutinised our approach and the proposed investment strategy to ensure these reflect the best interests of our customers over the long-term.

Following the completion of the internal scrutiny of our business cases, Baringa conducted audits of our enhancement business cases. Atkins has also conducted audits to ensure that the overarching process for business case development has been conducted appropriately.

2. Generating Efficient Cost Estimates

2.1 Overview

This section sets out the methodologies applied to determine accurate unit costs for our Business Plan. It explains how we have derived the unit costs that were used to forecast our future expenditure, assessing risks, and evaluating benefits. These costs are predominately capital expenditure (Capex), but also cover operating expenditure (OPEX), when 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 capital maintenance optimisation applications (PIONEER and the Copperleaf Portfolio optimisation suite) for decision support in deriving our investment plan, schemes, and costs.

We analysed and reviewed resulting costs to ensure alignment with our existing contractual frameworks, reasonability, and comprehensive coverage of potential investments. Estimates that use cost model figures within the plan can be assessed qualitatively based on the individual models used.

We have adopted a dynamic and well-structured approach to create competitive cost estimates for our Business Plan, aligning with management objectives and customer expectations. We have:

- Analysed and utilised final accounting project costs from AMP6 and AMP7, rebased to the financial year 2022/23, to derive unit costs where applicable.
- Carried out various benchmarking exercises to ensure that costs produced align with recent outturn projects costs.
- Calculated all on-costs, overheads, and management fees from first principles using 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.
- Updated over 500 cost curve formulae used to price the various elements of our Business Plan.
- Had our costs independently audited and benchmarked by Atkins with their due diligence and risk report provided to our Board.
- 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.
- Assessed the improvement of cost models through a RAG system, supported by Mott Macdonald. After the cost model update, the overall proportion of infrastructure, EGI and Process models in GREEN increased from 27% to 58%. More detail on the model improvements is included in the Process Outputs section.

The following asset groups are covered in this section:

Infrastructure

- Capex unit costs for combinations of main laying techniques, urbanicity, diameter and surface type. Ancillary works such as air valves, district meters, hydrants etc. are captured within the framework and accounted for in unit costs.
- Unit costs are indexed in line with the annual framework adjustment with the primary network contractor.
- Repair and maintenance costs for network operations including-ancillary assets such as air valves, district meters, ferrules, fire hydrants, sluice valves, stop tap, washouts etc.

Non-infrastructure

- Capex unit cost curve functions at equipment and process level.
- Capex unit costs for discrete items such as security and alarm systems, barriers, doors, fences, and gates, etc.
- Energy unit costs.
- Production asset operational maintenance costs.

Non-infra model datapoints have been adjusted for inflation using the integrated Mott Macdonald Water Index (MMWI). The index is based on over £800m worth of project spend within the Water Industry. The index extends to 2040 future forecasts if required.

We have ensured consistency in approach to non-tangible costs within our models across the Infrastructure and Non-Infra cost models. Both account for risk, internal staff time and corporate overheads within the unit rates derived. This is directly accounted for where outturn cost datapoints are used, for non-Infra models. Where tender stage or framework cost data is used, the datapoints have been uplifted to account for typical risk allowance, internal time and corporate overheads typically incurred during our projects.

Corporate overheads have been accounted for in the cost models, using a flat rate of 8.6%. This is calculated using the size of the Capex overhead programme relative to the overall Capex portfolio in Year 4 of AMP7 (around £180m). The Cost Intelligence Strategy plans to map out overheads by programme to ensure more accurate overheads allocation to programme investment plans. Our Finance team advised overheads are assumed to remain relatively flat compared to the total portfolio.

General

- Carbon, environmental and social footprint costs for infrastructure and non-infrastructure assets
- Service measure 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.

2.2 Capital Expenditure - Infrastructure Assets

2.2.1 Distribution and Trunk Mains Capex Unit Costs

2.2.1.1 Overview, Purpose, and Scope

This section describes the process adopted to derive the Capex unit cost for construction and installation of distribution mains pipe (DMP) (up to 320mm) and trunk mains (above 320mm) which forms part of our AMP8 capital programme. A summary of the process and key sources of data used in the creation of the unit costs are highlighted.

The latest contract framework rates (contract commenced Q1 2022) form the basis for derived unit rates, along with information on projects completed in AMP7. 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. The price base is 2022/23.

2.2.1.2 Process Map

The diagram below illustrates the process for determining trunk and distribution mains replacement unit costs.

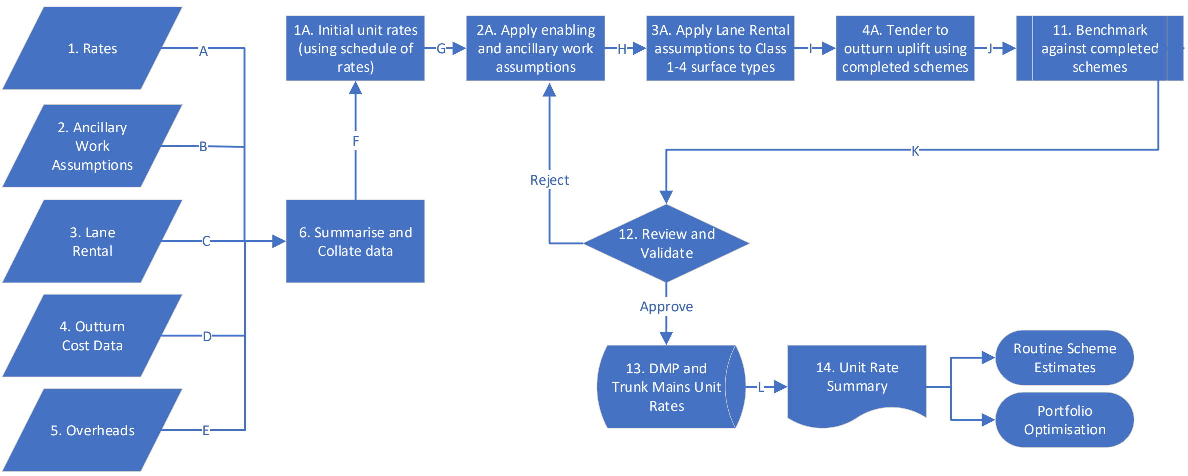

Figure 2 - Distribution Mains Renewals Costs Model Process

2.2.1.3 Commentary

This section provides commentary on the above methodology diagram (Figure 2) by reference to the appropriate annotations and data flow adopted.

1. and 1A. Infrastructure Framework Schedule of Rates

The latest schedule of rates for mains infrastructure were obtained from our infrastructure delivery team. The contract rates are used to apply a bottom-up approach to estimate project costs for various work(s) identified for the cost modelling. The schedule of rates is valid from March 2022 and accounts for annual adjustments for Inflation based on CPIH.

Included in the contract rates are unit rates (cost per metre) for open cut, directional drilling, slip lining and pipe bursting mains laying methods, for pipe diameters from 50mm up to 710mm. Staff, reinstatement and equipment rates are built into the unit rates for each method and pipe diameter. Rate adjustments are made depending on surface type, urbanicity and work outside normal hours.

2. and 2A. Ancillary work cost assumptions

Rates for design and investigation services, (pipe samples, surveys, trial pits etc.), enabling works (site clearance, fencing, site compounds etc.), service pipe and meter installations, and assemblies and fittings work (branch connections, fire hydrants, air valves etc.) are also included in the schedule of rates. These ancillary works are used to build up all-in costs for distribution and trunk mains pipe laying.

The ancillary work requirements were assessed by senior members of our delivery team. Collaboratively, assumptions for the frequency and likelihood of each service and fitting were built up, as well as the number of schemes expected to be completed outside normal working hours, using the best available information and experience from existing schemes. A weighted approach for ancillary work was applied to the unit rates.

3. and 3A. Lane Rental

With lane rental schemes scheduled to continue their rollout across Hertfordshire, Surrey, and London in AMP8, lane rental costs were also assumed for works on our Class 1 & 2 and Class 3 & 4 surface types. Assumptions were aligned with data through our GIS system and advice provided by our Highway Planning Manager. A weighted application of lane rental costs has been implemented in our unit rates for the relevant surface types.

4. and 4A. Outturn Scheme Costs

Details of select recently completed schemes were collated, reviewed, and processed as part of the build-up of all-in costs. Certificates were provided by the delivery team which detailed compensation events and scope changes which impacted the outturn cost of the schemes, which was compared against the tender price. The average increase in cost from tender to outturn was the applied to the unit rates, pricing potential risk into our cost estimates.

5. Overheads

A flat rate of overheads allocation was applied to the unit rates, based on data provided by our Finance Department. Total business overheads were related to the expenditure on the distribution and trunk mains programmes as a proportion of overall Capex spend.

6. and F. Summarise and Collate Data, Review and Validate

The collated data from steps 1 to 5 were validated and analysed to create the mains infrastructure unit cost model.

11. and 12. Benchmark and Review

The contents of the mains infrastructure unit rates database were reviewed to ensure validity. Rates were used to retrospectively estimate the cost of completed schemes with known lengths, surface types and urbanicities. Where estimates varied significantly different from completed schemes, the assumptions for those estimates were adjusted. Ultimately, more risk was allocated for larger diameter mains in urban and suburban environments.

13. and 14. Finalisation and Summary

The validated and finalised costs per metre were summarised in line with the portfolio optimisation requirements. A summary file was created and used to upload the finalised costs to the portfolio optimisation package (PIONEER) via an Excel add-in function. A separate unit rate summary sheet with more granularity was created for estimation and benchmarking of routine infrastructure schemes.

2.3.1.4 Sources of Data and Inputs

Data Source	Scope	Date Range	Origin	Accuracy
Framework Contract	Schedule of rates for the installation and reinstatement of mains based on pipe size, material, and environment.	AMP 7	Supplied by contractor (John Brown Construction)	High

Ancillary work cost assumptions	Frequency and likelihood for ancillary work activity along mains pipes.	AMP 7	Supplied by contractor (JBC), consulted with project delivery managers.	High-Medium
Outturn Scheme Costs	Breakdown of completed scheme costs, compensation events and final length.	AMP 7	Supplied by relevant project managers.	High
Lane Rental	Information and documentation on lane rental schemes within Affinity's catchment area.	AMP 7	Online sources, consulted with Highway Manager at Affinity Water.	Medium-High
Overheads	Annual overhead allocation for Infrastructure Capex	AMP 7	Consulted with Finance department	Medium-High

Table 1 - Distribution and Trunk Mains Data Sources

2.3 Capital Expenditure - Non-Infrastructure Assets

2.3.1 Production Capex Unit Costs

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 over 81,000 production assets under 374 asset classifications termed Equipment Group Identifiers (EGI). This encompasses buildings, pumping stations, reservoirs, towers, telemetry systems, water treatment works and raw water sources. The derived cost curves and unit costs are representative rates for delivering the non-infrastructure assets capital programme in AMP8.

Verified outturn costs from completed projects were used in deriving the desired unit costs wherever possible. In cases where information has not been obtained from actual or completed projects, we have used current framework agreement rates and adjusted to account for various project related and indirect costs. To further improve the quality of the unit cost models for PR24, we engaged Mott Macdonald (MM), to assist and expedite inclusion of new datapoints.

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 2022/23 using the Mott MacDonald Water Index.

The cost coefficients and single unit costs are primarily used in our capital maintenance optimisation application (PIONEER) and Scheme Builder estimating application, along with direct use in concept level project cost estimates.

2.3.1.2 Process Map

Figure 3 below shows the annotated modelling process for production asset unit costs.

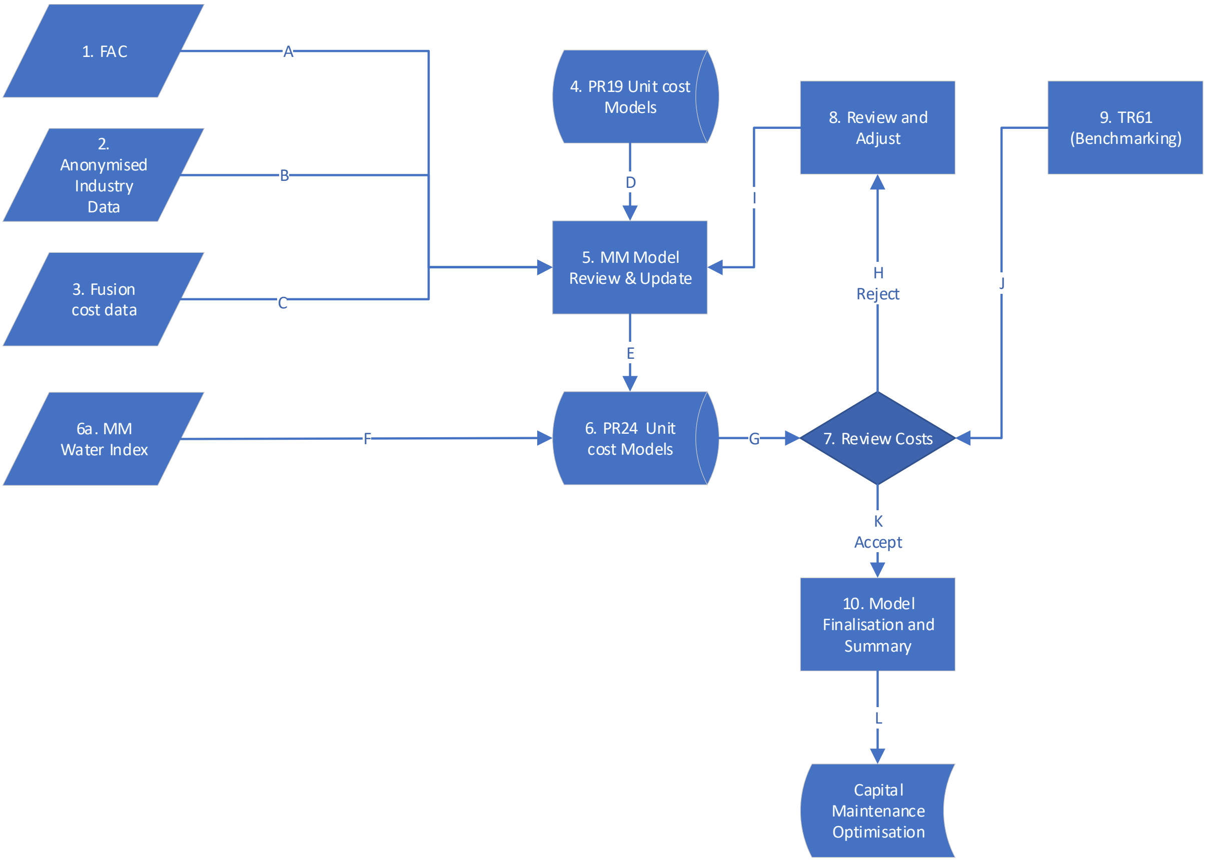

Figure 3 - Production Assets Capex Unit Costing Process

2.3.1.3 Commentary

This section provides commentary on the process diagram by reference to the appropriate annotations.

1. Final Account Certificate (FAC)

FAC's were used to confirm actual construction payments made to contractors for projects identified as provided by Project Managers. They contain details on costs, project scope and actual work carried out.

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.

3. Fusion costs data

To identify the projects which were most likely to contain useful cost data, a download our Fusion project accounting system was taken which showed the costs of closed projects.

The projects which were deemed more likely to provide useful data were those which contained costs for actual construction work as well as on-costs and reallocations of funds, and these were ranked by magnitude of total cost, on the basis that the larger schemes would provide more data.

4. PR19 Unit Costs Models

Equipment and process level unit cost models were previously reviewed in bulk for our PR19 Business Plan. For PR24, the entire library of EGI and Process level models were reviewed by MM and updated based on agreed portfolio priorities. For more detail on the formation of unit cost models, refer to the PR19 Business plan[1].

2. and 5. MM Model Review & Update

MM were provided with above set of data to review and update the unit cost models. There were four main methods used for improving model quality, detailed below.

1. Inflating historic costs to the present price base using a bespoke Water Industry Index.
2. Addition of new data samples from our projects.
3. Addition of anonymised data samples from relevant comparator clients to supplement and sense check the AW internal data.
4. Extending model bandwidth with data samples at outer ends of the desired range.

The ideal source of cost data was from our projects, however where external data was used, it was necessary to normalise costs based on date, location factors, yardstick units and inclusion rules. 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 accounted for and allocated as a percentage addition to the project costs.

For detailed information on the MM methodology, please refer to the MM Project Report.

6. PR24 Unit Costs Models

The output of engagement with MM resulted in an updated unit cost model library for PR24. The library of over 400 models was extensively evaluated for anomalies, by applying model curves across the full range of cost drivers in our unit cost library (UCL). Where anomalies were identified, the datapoints were reviewed, outliers identified and subjected to a further review, allowing them to be reintegrated or finally rejected.

Cost curve regression types were also adjusted to align with realistic asset and process costs, based on historic projects and logical extensions for drivers outside of the active range, i.e., where marginal costs for an increasing driver value is thought to tail off (such as adding another $1m^3$ capacity to a $1000m^3$ reservoir), a power curve is

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[1] (Affinity Water, 2018)

selected, whereas where marginal costs are more related to material costs (such as for filter media), a linear curve is selected for the model. Where new assets have been introduced to our asset base, new models were built using the existing templates.

All datapoints were brought to the 2022/23 price base using the MM Water Index.

7 – 9. Cost reviews and accept/reject.

The unit costs and cost models were benchmarked against available market data and Water Research Centre National Technical Report 61 (TR61) data. This enabled us to compare derived costs with average costs collated from a select group of water companies in the UK, ensuring we were confident with the MM outputs, and that costs were valid and realistic.

This benchmark did not influence the costs derived but was used to ensure we were confident with the outcome.

10. 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 capital maintenance and scheme cost estimation applications.

2.3.1.4 Sources of Data and Inputs

The sources of data for the capital expenditure – non-infrastructure assets are shown below within Table 2.

Data	Scope	Date Range	Origin	Accuracy
Fusion Cost Data	Costs of closed project data includes of actual construction work, on-costs, reallocation of funds.	AMP7 Projects	Asset Manageme nt	Medium-High
FAC	Information relating to final costs billed against a project, including contractors fees and other project costs	AMP7 Projects	Asset Delivery / Finance	High
PR19 Unit Cost Models	PR19 cost models were previously updated and improved with data form AMIS, FAC, Oracle Reports, Historic cost Coefficients, Bill of Quantity (BOQ) and Project Authorisation Pad (PAD), Framework Agreements & Historic	AMP5 & 6	Asset Manageme nt	Medium-High

Data	Scope	Date Range	Origin	Accuracy
	and Current Single Costs. These formed the basis for the update.[2]			
MM Water Sector Index	Index to enable cost adjustment to 2022/23 prices	2022/23	Mott MacDonald	High-Medium
Source: Affinity Water				

Table 2 - Non-Infrastructure Asset Unit Cost Data Sources

2 (Affinity Water, 2018)

2.3.1.5 Process Outputs

To assess and quantify improvement in the models created and updated for PR24, Mott MacDonald devised a qualitative scoring criterion for the Mains Laying, EGI and Process Level models. Each model was individually assessed based on the following:

- Number of data points used in the model.
- Driver bandwidth – coverage of our asset size ranges.
- Model fit to data.
- Age of data used in the model.
- Use of surrogate data.
- Balance of outturn and tendered data.

Models were given a score, using a Red-Amber-Green (RAG) system, where: less than 2.5 = Red; 2.51 to 3.5 = Amber; greater than 3.51 = Green. The overall result for Mains Laying, EGI and Process Level models is displayed in the Table below, showing improvement in the proportion of models which are classified as Green.

RAG Status	Before Interventions	After Interventions
RED	31%	17%
AMBER	42%	25%
GREEN	27%	58%

Table 3 - Model Score Rating

The qualitative scoring criteria has also been applied to the Network R&M model and Operational Planned and Reactive Maintenance model.

Model Type	Average Quality Score Before Interventions	Average Quality Score After Interventions
Mains Laying	1.9	5.0
EGI Level Cost Models	3.1	4.0
Process Level Cost Models	2.0	3.5
Network Repair and Maintenance	4.0	5.3
Planned & Reactive Maintenance	2.0	3.5

Table 4 - Quality Scoring of Models

2.3.1.5 Examples of Parametric Process-Level Cost Curves and Datapoint Sheets

Two examples of the parametric process-level cost curves and datapoint sheets are shown below.

The cost curves and datapoint sheets for the UV model are shown below within Figure 4 and Figure 5.

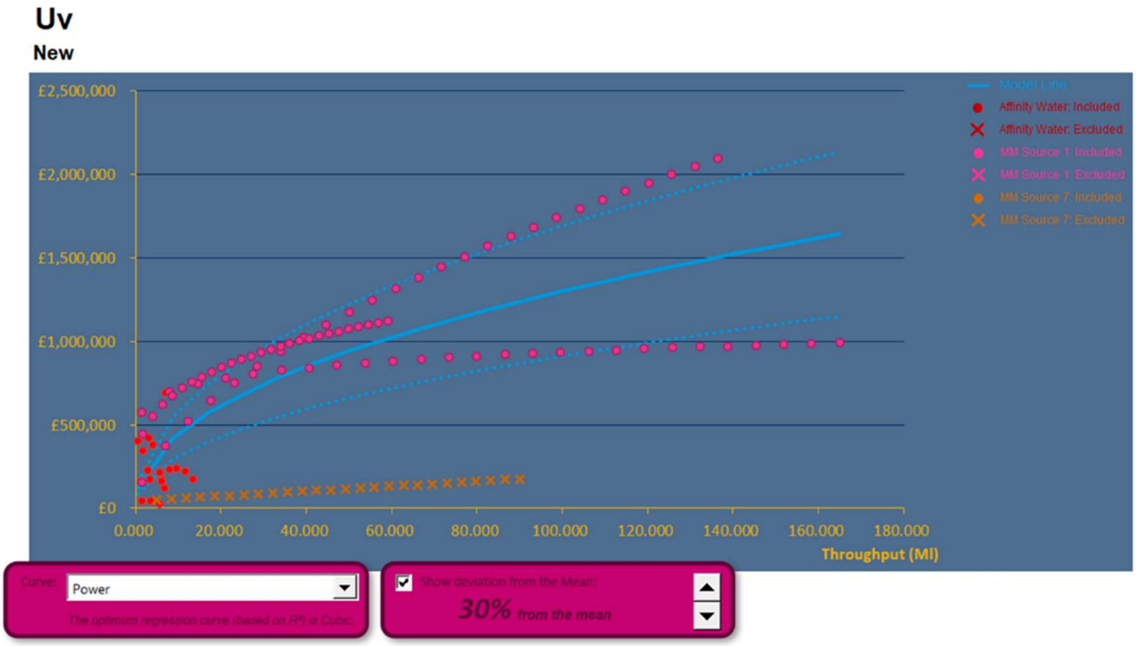


Figure 4 - UV Model Cost Curve

Data

This worksheet holds the data that generates the model.

Asset:	UV
Activity:	New
Driver:	Throughput (Ml)

Create [0,0] datapoint

Baseline Factors	
Adjustment	Factor
Region	108.6
Date	147.98
Environment	100

Adjusted Factors	
Adjustment	Factor
Region	108.6
Date	147.98
Environment	100

Data Quality		
Calculation Basis:	Model Level	
Data-Level Score:	0.0	E
Model-Level Score:	-	E

No. Datapoints:	123
Q_1	£5,447.91
Q_3	£26,424.57
Exclude datapoints outside IQR?	No

Description	Driver Value	Cost	Region	Base Date	Environment	Exclude	Set	Data Quality	Quality Rating	Region Adj.	Date Adj.	Env. Adj.	Baseline Cost	Baseline Unit Cost	Adjusted Cost	Adjusted Unit Cost	Interquartile Range
WP-1158-Sanombe WATER TREATMENTWORKS [W	13.542	£126,076.41	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£172,924.16	£12,769.47	£172,924.16	£12,769.47	Yes
WP-1175-Shakespeare Road WATER TREATMENT	1.5391	£33,657.45	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£46,163.96	£29,994.13	£46,163.96	£29,994.13	No
WP-425-Amersham WATER TREATMENTWORKS [W	11.71	£159,951.49	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£219,386.61	£18,734.50	£219,386.61	£18,734.50	Yes
WP-481-Berkhamstead WATER TREATMENTWORK	6.1537	£130,307.55	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£178,727.51	£29,043.91	£178,727.51	£29,043.91	No
WP-506-Bow Bridge WATER TREATMENTWORKS	6.7146	£88,946.31	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£121,997.17	£18,168.94	£121,997.17	£18,168.94	Yes
WP-511-Bouring WATER TREATMENTWORKS [WT	5.677	£17,695.72	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£24,271.14	£4,275.35	£24,271.14	£4,275.35	No
WP-533-Bulstrode WATER TREATMENTWORKS		2.9687	£164,115.83	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£225,098.34	£75,823.88	£225,098.34	£75,823.88	No
WP-567-Canons WATER TREATMENTWORKS [W	3.187	£308,694.51	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£423,399.88	£132,852.17	£423,399.88	£132,852.17	No
WP-601-Chipping WATER TREATMENTWORKS [W	3.9372	£277,057.42	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£380,007.02	£96,517.07	£380,007.02	£96,517.07	No
WP-628-Clanden WATER TREATMENTWORKS [WT	1.2425	£118,197.16	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£162,117.12	£130,476.56	£162,117.12	£130,476.56	No
WP-648-Cadinale WATER TREATMENTWORKS [W	0.6239	£294,418.27	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£403,818.84	£647,249.31	£403,818.84	£647,249.31	No
WP-686-Earl Hyde WATER TREATMENTWORKS		3.4424	£30,153.16	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£41,357.54	£12,014.16	£41,357.54	£12,014.16	Yes
WP-745-Feller WATER TREATMENTWORKS [WTW	5.9991	£117,291.28	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£160,874.62	£26,816.46	£160,874.62	£26,816.46	No
WP-758-Gerrards Cross WATER TREATMENTWO	5.668	£156,499.08	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£214,651.34	£37,870.74	£214,651.34	£37,870.74	No
WP-775-Great Missenden WATER TREATMENTW	3.3875	£126,799.62	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£173,916.10	£51,340.55	£173,916.10	£51,340.55	No
WP-874-Henlee Bridge WATER TREATMENTWOR	9.5907	£174,585.29	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£239,458.07	£24,967.74	£239,458.07	£24,967.74	Yes
WP-89622-Water Treatment Plant-Namansla	7.9206	£168,987.11	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£231,779.71	£29,262.90	£231,779.71	£29,262.90	No
WP-909-Knowsworth Lynch WATER TREATMENTW	6.9602	£504,909.33	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£692,524.63	£99,497.81	£692,524.63	£99,497.81	No
WP-995-London Road WATER TREATMENTWORKS	1.6827	£251,267.73	Central	FY12	Not Applicable	No	Affinity Water	0.0	E	108.6	107.89	100	£344,634.33	£204,810.33	£344,634.33	£204,810.33	No
MM Source 1	1.5	£416,825.14	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£416,825.14	£277,883.43	£416,825.14	£277,883.43	No
MM Source 1	8.04	£507,471.92	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£507,471.92	£63,118.40	£507,471.92	£63,118.40	No
MM Source 1	14.58	£544,137.17	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£544,137.17	£37,320.79	£544,137.17	£37,320.79	No
MM Source 1	21.12	£568,290.16	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£568,290.16	£26,907.68	£568,290.16	£26,907.68	No
MM Source 1	27.66	£586,544.66	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£586,544.66	£21,205.52	£586,544.66	£21,205.52	Yes
MM Source 1	34.2	£601,317.54	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£601,317.54	£17,582.38	£601,317.54	£17,582.38	Yes
MM Source 1	40.74	£613,776.81	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£613,776.81	£15,065.70	£613,776.81	£15,065.70	Yes
MM Source 1	47.28	£624,580.19	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£624,580.19	£13,210.24	£624,580.19	£13,210.24	Yes
MM Source 1	53.82	£634,136.29	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£634,136.29	£11,782.54	£634,136.29	£11,782.54	Yes
MM Source 1	60.36	£642,717.05	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£642,717.05	£10,648.06	£642,717.05	£10,648.06	Yes
MM Source 1	66.9	£650,512.96	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£650,512.96	£9,723.66	£650,512.96	£9,723.66	Yes
MM Source 1	73.44	£657,662.86	Central	FY22	Not Applicable	No	MM Source 1	0.0	E	108.6	147.98	100	£657,662.86	£8,955.10	£657,662.86	£8,955.10	Yes

Figure 5 – UV Model Datapoint Sheets

The cost curves and datapoint sheets for the Potable Water Storage model are shown below within Figure 6 and Figure 7.

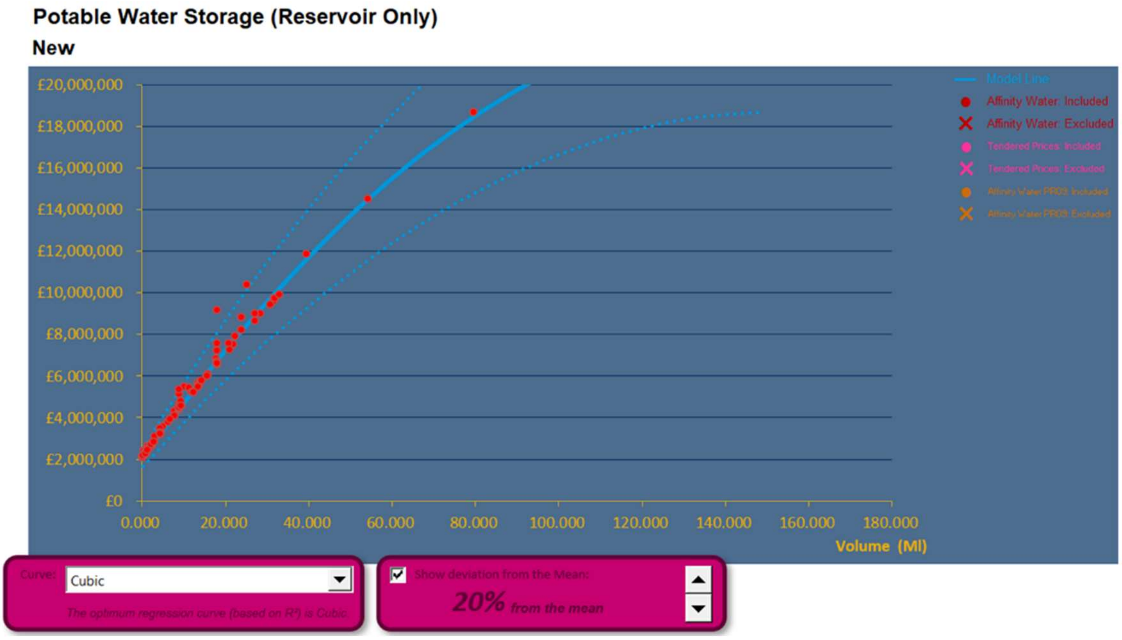
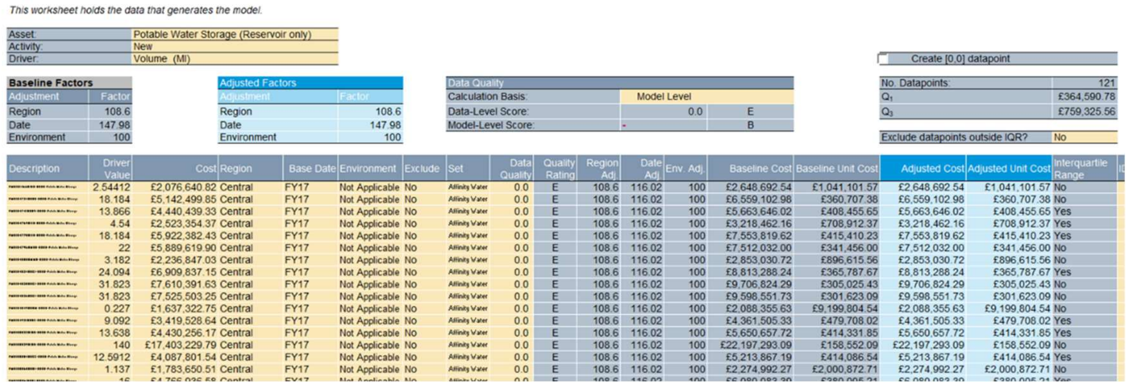


Figure 6 - Potable Water Storage Model Cost Curve



This worksheet holds the data that generates the model.

Asset:	Potable Water Storage (Reservoir only)
Activity:	New
Driver:	Volume (Ml)

Baseline Factors	
Adjustment	Factor
Region	108.6
Date	147.98
Environment	100

Adjusted Factors	
Adjustment	Factor
Region	108.6
Date	147.98
Environment	100

Data Quality		
Calculation Basis:	Model Level	
Data-Level Score:	0.0	E
Model-Level Score:	-	B

Create [0,0] datapoint

No. Datapoints:	121
Q_1	£364,590.78
Q_3	£759,325.56

Exclude datapoints outside IQR?	No

Description	Driver Value	Cost	Region	Base Date	Environment	Exclude	Set	Data Quality	Quality Rating	Region Adj.	Date Adj.	Env. Adj.	Baseline Cost	Baseline Unit Cost	Adjusted Cost	Adjusted Unit Cost	Interquartile Range
[illegible]	2.54412	£2,076,640.82	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£2,648,692.54	£1,041,101.57	£2,648,692.54	£1,041,101.57	No
[illegible]	18.184	£5,142,499.85	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£6,559,102.98	£360,707.38	£6,559,102.98	£360,707.38	No
[illegible]	13.866	£4,440,439.33	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£5,663,646.02	£408,455.65	£5,663,646.02	£408,455.65	Yes
[illegible]	4.54	£2,523,354.37	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£3,218,462.16	£708,912.37	£3,218,462.16	£708,912.37	Yes
[illegible]	18.184	£5,922,382.43	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£7,553,819.62	£415,410.23	£7,553,819.62	£415,410.23	Yes
[illegible]	22	£5,889,619.90	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£7,512,032.00	£341,456.00	£7,512,032.00	£341,456.00	No
[illegible]	3.182	£2,236,847.03	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£2,853,030.72	£896,615.56	£2,853,030.72	£896,615.56	No
[illegible]	24.094	£6,909,837.15	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£8,813,288.24	£365,787.67	£8,813,288.24	£365,787.67	Yes
[illegible]	31.823	£7,610,391.63	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£9,706,824.29	£305,025.43	£9,706,824.29	£305,025.43	No
[illegible]	31.823	£7,525,503.25	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£9,598,551.73	£301,623.09	£9,598,551.73	£301,623.09	No
[illegible]	0.227	£1,637,322.75	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£2,088,355.63	£9,199,804.54	£2,088,355.63	£9,199,804.54	No
[illegible]	9.092	£3,419,528.64	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£4,361,505.33	£479,708.02	£4,361,505.33	£479,708.02	Yes
[illegible]	13.638	£4,430,256.17	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£5,650,657.72	£414,331.85	£5,650,657.72	£414,331.85	Yes
[illegible]	140	£17,403,229.79	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£22,197,293.09	£158,552.09	£22,197,293.09	£158,552.09	No
[illegible]	12.5912	£4,087,801.54	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£5,213,867.19	£414,086.54	£5,213,867.19	£414,086.54	Yes
[illegible]	1.137	£1,783,650.51	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	£2,274,992.27	£2,000,872.71	£2,274,992.27	£2,000,872.71	No
[illegible]	16	[illegible]	Central	FY17	Not Applicable	No	Affinity Water	0.0	E	108.6	116.02	100	[illegible]	[illegible]	[illegible]	[illegible]	Yes

Figure 7 - Potable Water Storage Model Datapoint Sheet

2.4 Operational Expenditure - Infrastructure Assets

2.4.1 Network Maintenance Costs

2.4.1.1 Overview, Purpose, and Scope

The process undertaken to derive unit costs for our network maintenance as part of our AMP8 commitments is explained in this section. Network repair and maintenance (R&M) works carried out and completed from February 2021 to May 2022 were assessed in this model, which marks activity from the beginning of our latest contractor framework. This activity was collated and analysed to calculate unit costs associated with various job types covered under our network maintenance framework.

The derived unit rates represent all-in costs payable for a range of defined activities with allowances for free issue materials purchased, required traffic management, and overheads incurred by the business.

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 provided costs for unplanned reactive or ad-hoc work. The finalised costs are used in the PIONEER application and rebased to 2022/23.

2.4.1.2 Process Map

The diagram shown in Figure 8 below, illustrates the process followed to derive the unit costs.

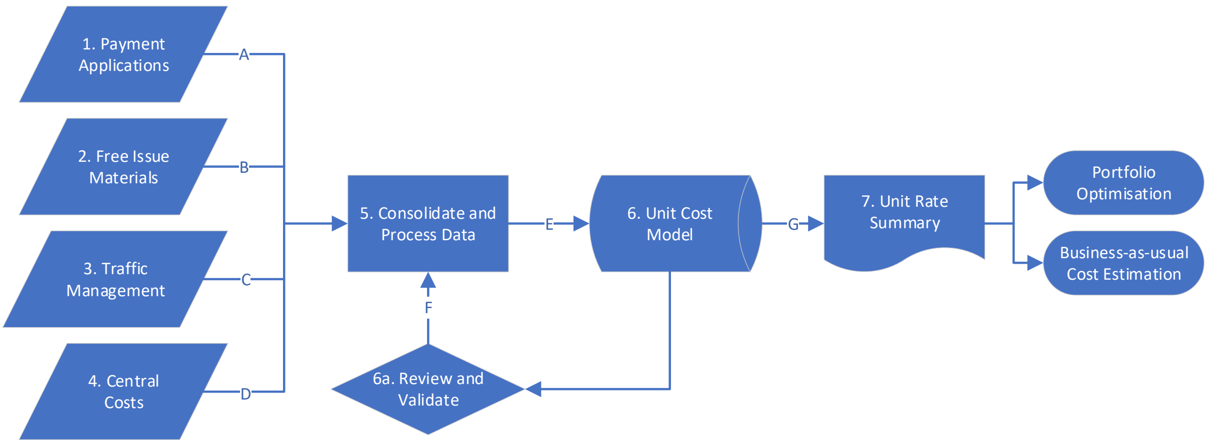


Figure 8 - Infrastructure (Network) Maintenance Unit Costing Process

2.4.1.3 Commentary

1. Payment application summary (audited)

R&M activity data from February 2021 to May 2022 was collated through audited and reconciled work orders provided by our Repair Management Team, with jobs summarised monthly.

Each activity is assigned a Work Type Code (WTC) and sub-code which identifies the job repair details. Each WTC sits within a target price basket, with decreasing cost from A through to E and F for aborted works, which still incurs a cost. Included within the price basket is all activity required to complete works, including excavation and reinstatement.

Activity for the month is reviewed and the total target price is obtained from the job number multiplied by the basket price. The actual outturn cost for overall activity, however, may be higher or lower than the target price, depending on the efficiency of the contractors or any additional works carried out due to complications on the job. This is accounted for in the model, using the monthly defined cost as a percentage uplift to the costs in that period. Contractor fees and pain/gain share are also included in the actual outturn cost as an uplift.

Non-routine activity is captured separately, with the total actual cost for each job provided in the contractor's application for payment.

2. Free Issue Materials (FIM) Report

FIMs refer to parts and materials provided from our stores for repair activities but not covered by the work basket target price.

Costs were sourced from Maximo reports, where Work Order (WO), WTC and material costs are described. Total material costs for each WTC in each month were summarised and distributed as an uplift across the jobs from our Contractor's Payment Application.

Due to use of separate cost sources, there was some deviation between the number of WOs raised in the Maximo reports and the audited payment applications from Repair Managers. An assumption was made that deviations in material orders and payment applications are assumed to balance out towards the true unit rate. A total count was taken over the period to ensure that there were no large deviations.

3. Traffic Management Reports

Traffic Management (TM) costs are sourced from our Quantity Surveyor reports. There are currently four main TM providers: Herts, Hatton, FM Conways and Fenton. The reports contain all TM WOs, summarised by invoice month.

As the WTC is not provided in TM reports, the WO is verified against the FIM report WO which is then related to a specific WTC. TM costs are applied an uplift to those job types in that month. Where there is no match, the TM costs are allocated as 'General', and that category is spread across all job types within that month, pro-rated to the Work Basket cost.

When considering activity over the period investigated, deviations in material orders and payment applications are assumed to balance out towards the true unit rate.

4. Overheads

An overhead uplift was calculated using costs from our Capex tracking tool the Latest Best Estimate (LBE) from June 2022. Total expenditure (Totex) overheads and management overheads provided by our Finance department were applied to M&R unit rates as a percentage uplift. The total overheads for M&R are assumed to be proportional to the share of M&R programme spend to the overall portfolio.

Payments and work orders from steps 1 - 3 were summarised and merged into monthly costs. Pivot tables for payment applications, FIM and TM and overheads were created, to apply uplifts over the completed R&M activities within the relevant month. This led to the creation of various R&M costs for different WTCs even for jobs in the same price basket.

6., 6A. & 7. Review and Validate, Unit Rate Summary

For the few instances where differences occurred in the uplifts applied, they were investigated and reconciled at this stage. For example, where there were material costs incurred in a month with no payment applications submitted of the same WTC, (depending on the magnitude of the cost) the cost was ignored or transferred to the next month's material uplift.

Costs 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 and applicable, select unit rates for mains burst repairs were uploaded to the capital maintenance optimisation package (PIONEER) and for use in Scheme Builder, our estimating tool, and in our portfolio optimisation tool (Copperleaf)

Process outputs

Selected R&M costs were used in the PIONEER application, in line with the Asset Strategy requirements.

2.4.1.4 Sources of Data and Inputs

The sources of data an inputs for the operational expenditure – infrastructure assets are shown below within Table 5.

Data	Scope	Date Range	Origin	Accuracy
Payment Applications	Framework payment applications summarised by month and WTC	February 2021 – May 2022	Maintenance and Repair team	High
Free Issue Materials Report	Maximo report summarising monthly FIM orders from Affinity stores, summarised by WTC	February 2021 – May 2022	Work Order Report - Maximo Specialists	High
Traffic Management Report	Procurement reports for reconciled Traffic Management costs incurred, and associated WO.	February 2021 – May 2022	Procurement	High
Overheads	Affinity Water's financial statements for overheads, and M&R Totex.	February 2021 – May 2022	Finance Department	Medium
Source: Affinity Water				

Table 5 - Infrastructure (Network) Maintenance Unit Costs Data Sources

2.5 Operational Expenditure - Non-Infrastructure Assets

2.5.1 Production Operational Maintenance Costs

2.5.1.1 Overview, Purpose, and Scope

Operational maintenance costs associated with ongoing reactive and planned maintenance schedules for our production assets are 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 expenditure associated with our reactive and planned maintenance activities. This also covers the average cost and maintenance frequency per reactive and planned maintenance job for each of our 374 EGIs (Equipment Group Identifiers), covering more than 81,000 active assets. The assessment and cost model developed ensured an integrated approach to asset costs including monitoring of asset performance and health.

The derived cost and maintenance frequencies are used in our capital maintenance 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 PR19. 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 353 'EGI' in PR19 and further increased to 374 'EGI' to include 100% of all 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 to carry out optimal maintenance interventions.

2.5.1.2 Process Map

Figure 9 below illustrates the process followed to derive the various operational maintenance costs and frequencies.

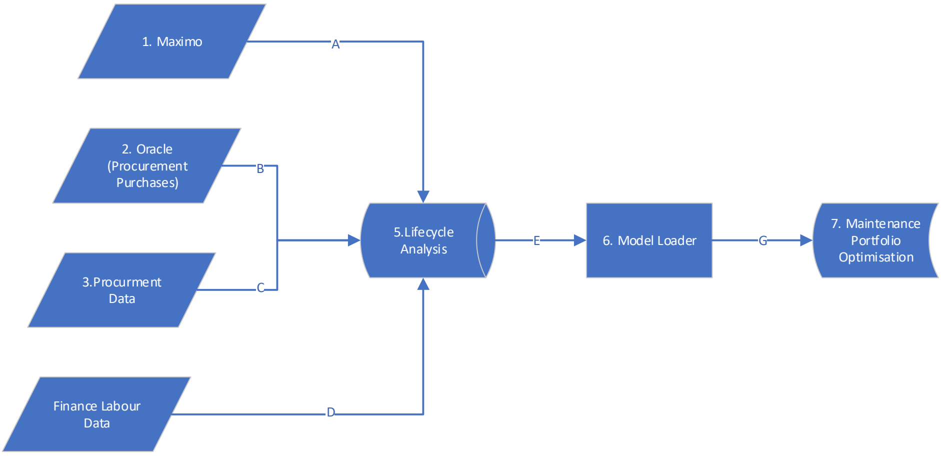


Figure 9 - Production Operational Maintenance Unit Costing Process

2.5.1.3 Commentary

1. Maximo Data

Maximo (Enterprise Asset Management software) 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 7 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 aligned to the assets with the equipment identifier, number, location, maintenance frequency and duration.

The reactive maintenance activities span across activities such as alarm investigation, assistance on work orders, 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. and 3. Oracle

Details of our procurement purchases were sourced from the Finance and Procurement Oracle data. Purchases relating only to production maintenance were filtered using several cost centres codes, keywords and a vendor listing provided by our Procurement Team.

Purchase orders (PO) data span over a period that is reflective of the new asset care regime where a planned approach is generally adopted over a reactive approach.

4. Finance and Labour Data

Finance and labour details relating to operatives involved directly with operation and maintenance of our production assets were obtained from our Finance Department. This involved obtaining the number of our production and maintenance technicians, estimated annual travel miles per technician, operative hourly pay rates at 2022/2023 price base 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. Lifecycle analysis

Collated data from steps 1 to 4 were analysed to derive maintenance frequencies and work order cost for each EGI. 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.

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. Model loader

The PIONEER excel model loader is used to import the deduced maintenance frequencies and costs for use in the optimisation process.

7. PIONEER

G] The derived attributes are linked to models in PIONEER.

2.5.1.4 Sources of Data and Inputs

The sources of data an inputs for the operational expenditure – non-infrastructure assets are shown below within Table 6.

Data	Scope	Date Range	Origin	Accuracy
Maximo	Non-Infrastructure asset data repository. This provides the asset listings, status, and maintenance details	AMP 7	Asset Management	Medium
ORACLE	Procurement purchases relating to production operational maintenance	AMP 7	Procurement / Finance	Medium
Finance and Labour data	Number count of technicians, annual travel miles, hourly pay rates and contracted time	AMP 7	Finance	Medium/High
Consumer Price Index including owner occupiers housing costs (CPIH)	Index to enable cost adjustment to 2022/23 prices	2022/23	Office for National Statistics (ONS)	High
Source: Affinity Water				

Table 6 - Production Operational Maintenance Unit Costing Data Sources

2.6 Other Business Areas

2.6.1 Overview

We use our unit cost models across both enhancement and base costs where relevant. Models are based on real project data, or existing frameworks, and so can be applied to both expenditure areas.

Portfolio plans that fall outside the scope of the existing unit cost library, use their own costing methodologies. However, the team responsible for managing the cost models have also provided support and assurance to ensure assumptions and inclusions are aligned across the portfolio. For example, the WINEP model used to determine cost for environmental projects was developed with Motts alongside the cost models update. Quality assurance was carried out to ensure unit costs in the model were traceable and appropriate, and the same corporate overhead uplift of 8.6% was applied to costs.

The same team also provided ad-hoc benchmarking support to the Network Calming programme, using our EGI asset models to ensure the magnitude of costs provided by consultants were appropriate. Further detail into some of the individual costing methodologies which have been quality assured are as follows.

2.6.2 Energy Costs

The approach to determining the change in energy costs associated with capital investments is described in this section. The unit rate for wholesale energy for 2022/23 was provided by our Head of Energy Management, which is based on current contractual rates.

Our PIONEER maintenance 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.

In addition, due to the significant increase in energy costs over the last AMP, energy costs arising from Capex investments are also considered when assessing investment value.

2.6.3 Chemical Prices

Chemical usage and prices were provided by our Procurement Category Managers, who are involved with procurement and agreement of prices with suppliers. There are currently four major chemical suppliers used by Affinity Water, with a range of chemicals being purchased from each one. Specific chemicals not covered by the four major suppliers have also been included in the model.

Prices are updated annually, with Figures taken from Financial Year 2022/23. The new rates were compared against those used at PR19, where the same chemicals are used, to get a sense of overall inflation over the period.

A small amount of procurement overheads was applied to the chemical prices, on the assumption that procurement's time spent on chemicals is proportional to the chemical OPEX relative to our overall company OPEX budget.

Lifecycle cost estimates for new schemes consider changes in chemical usage, drawing from the unit costs for chemicals captured and uploaded into PIONEER for use in Scheme Builder.

2.6.4 Lab Equipment

Lab equipment replacement is based on risk-based replacement and consists of 4 strategies:

1. Replacement ahead of target lifespan (TL) for high-risk items by 1 year
2. Replacement at target lifespan for items with spare capacity
3. Replacement at target lifespan +20% or on failure for medium and low risk
4. Replacement only on failure, target lifespan +50% or when maintenance costs begin to exceed replacement cost.

The above policy has generated a forward plan Capex spend profile that would maintain the status quo of the current equipment register.

However, it is expected that technological developments will occur in the future, with new equipment entering the market that provides the opportunity for efficiency savings that make replacement of existing. As it is not possible to predict with any degree of accuracy the timing and value of these benefits. the suggested options to fund this potential spend are either via an estimated annual 'innovation' fund built into our Capex projections or to fund investment out of the Opex budget at the time of purchase.

Costs for maintenance and purchase are based on 2022/2023 price base. The replacement costs of items may include the cost of the purchase only for simpler items and for more complex instruments, the cost may also include staff time in procurement, mobilisation, and validation the item, facilities costs if some lab adjustments are needed and IT licencing costs for any associated software.

2.6.5 Developer Services

2.6.5.1 Connections and Reinforcement

Strategic reinforcement for growth schemes were estimated using PR24 cost models verified against delivery framework rates, completed with Asset Delivery colleague inputs to capture additional cost specific to engineering difficulties. The current estimated portfolio of reinforcement totals £41 million, however, requires further analysis and review to ensure the full reinforcement catalogue including strategic schemes, local schemes and related overheads are included but do not exceed a fair, predictable, and acceptable infrastructure charge forecast for developer customers. Currently only some large local reinforcement schemes are included.

Infrastructure reinforcement is forecasted utilising Edge Analytics data, ONS21-P planning scenarios and housing forecasts with a low-confidence regional reduction factor to align more closely to the historic actual trend of the performance of our region and associated constructed developments. Each development has an associated hydraulic model to determine the change requirements to the network to support such growth.

Where site specific reinforcement is required, this remains to be fully funded by the developer and is not included in reinforcement calculations or forecasts.

2.6.5.2 Charges and Overheads

Overheads are determined as part of the charging process on an annual basis and are applied as an uplift against the forecasted value of local reinforcement schemes to provide developer services operational cost coverage for each of the five years accounted for in the build-up of the infrastructure charge calculation.

For the associated PR24 data tables, unit costs are determined for the following: costs of connections to existing mains, costs of connections to requisitioned mains, costs of connections to requisitioned mains undertaken by Self Lay Providers (SLP), internally meters connections and, internally metered connections by SLPs. These are determined by revenue and/or expenditure for the base year divided by number of connections of each; these base year unit costs are used as multipliers for future years in the tables.

2.6.6 IT

The modelling for IT solutions is primarily conducted in Microsoft Excel supplemented by Microsoft SharePoint Online, giving the flexibility, control, and configurability to both categorise the data and to financially model based on lookups and variables.

For maintenance, the aim is for investments to reduce the number of service failures and impact on internal and external customers. The "cost of change" is based on key attributes such as:

- Date asset was commissioned.
- Refresh policy – number of years till obsolete.
- Capital cost of asset – cost to buy like for like asset.
- Capital cost to commission asset – cost of resource to be commissioned.
- 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).

The "cost of downtime" is an IT standard term within IT Service Management, for which initiatives are selected to minimise the overall impact to the business. To calculate the cost of downtime:

- Determine the average hourly salary of the impacted employees. This is a rough estimate.

- Decide on the productivity impact factor. This can be as low as 10 percent or as high as 100 percent depending upon what the outage is and the nature of the work of the impacted employees. This % factor is used to understand the impact on a user for the outage.
- Calculate the "Cost of Downtime." per annum (Z), as shown in Equation 1:

$$Z = ((A \times B) \times C)$$

Equation 1 - Calculation for the Cost of Downtime of IT Assets

Where:

- A = Total Hours Failure in Year
  = (((Average Time to Fix) * (Working Day Hours)) * (Expected Failures in Specified Year))
- B = Total Expected Cost of failure = ((Average hourly salary) * (A))
- C = ((No. Impacted Employees) * (Productivity Factor %))

Once a planned change has been selected, and is aligned with the business strategic aims, a delivery plan is constructed. The delivery model is assessed to determine the cost of implementing a change. The delivery models are categorised as light, medium and heavy, with varying degrees of resource hours required for different employees within the IT department. Risk is also allocated to each project at 10-30% of the total cost.

For strategic projects, the overall target is to invest in IT initiatives which drive down the technology and IT OPEX costs, whilst exceeding our service levels and customer expectations.

2.6.7 Application in PIONEER

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.

2.7 Environmental, Social, Service Measure and Consequence Costs

2.7.1 Carbon, Environmental and Social Costs

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.

Mott MacDonald Ltd., our environmental consultant, was commissioned in 2022 to update our carbon modelling capability. Environmental and social unit costs were updated with the support of ICS and QASR consultants.

The scope of our carbon modelling capability encompasses production assets, distribution, and trunk mains in different urbanicity, surface types and meterage.

The models and report cover:

- All 374-production asset EGI's.
- Distribution mains at different dimensions, materials, surface types, urbanicity and techniques.
- Trunk mains at different dimensions, materials, surface types, urbanicity and techniques.
- Communication pipes (short and long side).

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).

The embedded carbon emission footprint and cost assessment covers activities associated with the following:

- The carbon impact of the manufacture of capital infrastructure and non-infrastructure equipment arising from the production of materials utilised.
- The carbon impact of transporting materials to and from site for replacement and renewal of infrastructure and non- infrastructure assets.
- The carbon impact of the construction and installation process of equipment for replacement and renewal of infrastructure and non- infrastructure assets.

The scope of operational carbon assessment, environmental and social impact covers the following activities:

- The carbon impact from operation of installed 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.

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 prices for carbon depending on the activity and environmental scenario being evaluated. They are accessed from the Department for Energy Security and Net Zero (DESNZ), which was formerly Department for Business, Energy & Industrial Strategy (DBEIS).

Emission values and other environmental and social costs, were generated from several other sources and assumptions including:

- 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 Energy Security and Net Zero (DESNZ)
- Department for Transport (DfT)
- Department for Environment, Food & Rural Affairs (DEFRA)
- Environment Agency - Benefits Assessment Guidance (BAG)
- Original Equipment Manufacturer (OEM) references
- Spon's Civil Engineering and Highways Price Book
- UK Water Industry Research (UKWIR)

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 using Affinity's Asset Carbon Estimating Tool based on carbon arising from the asset manufacturing, transportation, and installation activities.

Each of the EGI's are built up from 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 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 and, distance travelled. 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.

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. 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.

Embedded carbon emissions are also available in Scheme Builder for ad-hoc estimation.

2.7.2 Service Measure and Consequence Costs

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:

- Leave the environment in a sustainable and measurably improved state.
- Be prepared for change, and resilient to shocks and stresses.
- Deliver what our customers need, ensuring affordability for all.
- Work with our communities to create value for the local economy and society.

The following 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 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 2022/2023.

These consequence costs are used directly in our capital maintenance optimisation process (PIONEER) and to value risks and benefits in our portfolio optimisation tool (Copperleaf).

There are more than 20 value models in the SMF. However, ERI (Event Risk Index) and C-Mex (Customer Experience Measure) private costs models were developed specifically for PR24. their methodology is described below:

ERI (Event Risk Index)

Workshops and historic ERI data analysis were carried out to develop ERI model from scratch for PR24 to account for all potential consequence costs and to be mutually exclusive from all consequence costs occurring from the CRI (compliance Risk Index).

C-Mex (Customer Experience Measure)

Two C-Mex models were purpose-built for PR24 service measure framework to model score change and monetised score change to account for private costs resulting from events impacting customers such as interruption to supply, ERI, low pressure etc. and private costs per unit of score occurring from consequential actions respectively.

We also cover C-Mex impacts from all the common and bespoke [i.e., Pressure] PCs and our own consequence costs [e.g., H&S, consequential damage].

2.7.2.2 Commentary

Service measure framework

Each service measure is built from these various components below depending on 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.

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.)

The consequence costs have been calculated in a master spreadsheet When specific tabs are mentioned in this section, they refer to separate individual spreadsheet 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 claim's handlers and data from our 'In-House Settlements' and indexed to 2022-2023 price base– this relates mainly to D3O incidents but does include some 'minor' bursts.

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 our 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 costs for water transfer at key sites within separate Hydraulic Demand Zones. Cost information is taken from the Energy and Performance dashboard from our Energy Management Team. Other components include chemical usage and external transfer agreements such as Grafham Import to derive 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 rebased 22/23 price base:

- 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 2022/23 data and time estimates provided by the OCC at PR19 and have been reviewed and found to be 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 based on comprehensive information provided by our communications manager - these have been updated with most recent staff rates.

14. 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.

2.7.2.3 Sources of Data and Inputs

The sources of data and inputs for the service measures and consequence costs are shown below within Table 7.

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	2017-18 Uplifted to 2022-23	Finance department (management accountants) from salary detail.	Medium
Sampling costs	Typical costs per chemical PCV sample and per microbiological sample	2017-18 Uplifted to 2022-23	Laboratory	Medium
Emergency water supply cost	Relevant cost-based framework contract with Water Direct for emergency water alternative supplies.	2017-18 Uplifted to 2022-23	Water Direct Framework Contract	Medium
Restriction notices	Contract costs for printing and for hand delivery and alternative of posting	2017-18 Uplifted to 2022-23	From Communications Team	Medium
Flushing / disinfection of network or reservoir	The cost for network flushing	2017-18 Uplifted to 2022-23	Obtained from the Mains Cleaning project	Medium
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

Data	Scope	Date Range	Origin	Accuracy
Cost of lost water	Marginal cost of water (MCoW) supply by zone	2022-23	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	2022-2023	Costs are captured by the Insurance team – In-house and 3rd Party claim handlers	High
		2007-2010 Uplifted to 2022-2023	Costs captured by Community Operations / Finance	Medium
Prosecution and fines	DWI incidents and prosecutions	2022-2023	DWI website	High
	Ofwat enforcement notices	2022-2023	Ofwat website	High
	EA enforcement notices	2022-2023	Data of cases from various websites	Medium (small sample)
	HSE prosecutions	2022-23	HSE website	High
Customer contacts	Operational call centre (OCC) staff time to respond to calls and letters	2017-18 Uplifted to 2022-23	Time estimates provided by the OCC at PR19 and have been reviewed for PR24 and found adequate	Medium

Data	Scope	Date Range	Origin	Accuracy
Personal Injury	Cash valuations of preventing health and safety effects on people	2017-18, uplifted to 2022-23 cost base	Values taken from the HSE Cost Benefit Analysis (CBA) checklist	Medium
Compensations	GSS compensations Ex-gratia payments at AWL discretion	2017-18 Uplifted to 2022-23	Estimate based on the GSS regulations	High
Productivity costs	Staff time lost due to IT system failure	2017-18 Uplifted to 2022-23	Estimate	Medium
Communication costs	Staff rates and times	2017-18 Uplifted to 2022-23	Based on data provided by Communications Team	Medium
No. of properties	Number of properties served by individual pipe sections / sites	2022-23	Hydraulic Modelling and Site Criticality spreadsheets	High

Table 7 - Service Measure Data Sources

2.7.2.4 Process Outputs

The output is service measure private costs, which are entered in PIONEER and Copperleaf against 'serviceability indicators/measures. They are also available to be used for cost benefit analysis outside of the optimisation tool. The process for developing the Service Measure Unit Costs is shown below in Figure 10.

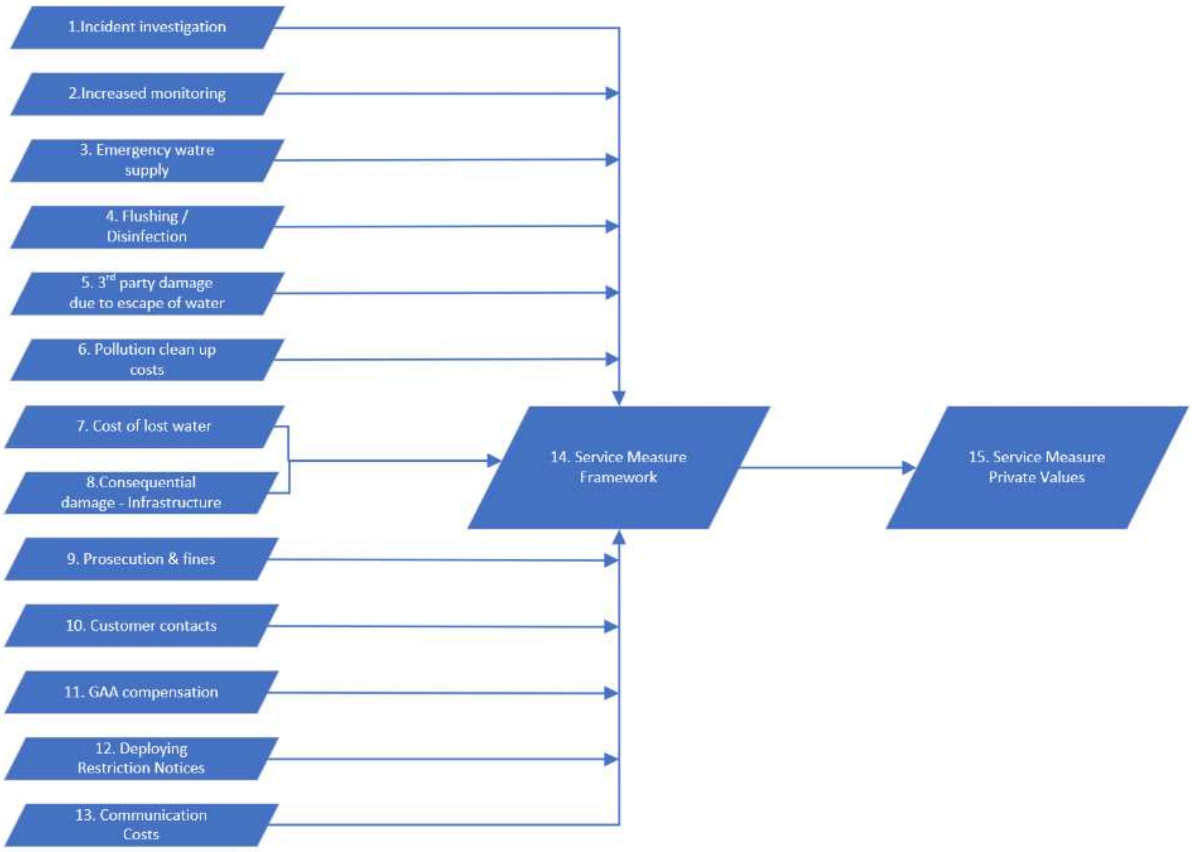


Figure 10 - Service Measure Unit Cost Process

2.8 Benchmarking Analysis and Unit Cost Insights

2.8.1 Overview

To improve our assurance on costs and cost control for PR24, we are currently implementing the pilot Cost Intelligence Strategy (CIS). The full business-as-usual CIS aims to use an intelligent centralised system to analyse historical project cost information, identify trends and lessons learned, and make data-driven decisions, resulting in more reliable cost control at all gateway stages of the project lifecycle. Business-as-usual benchmarking of our cost estimates against historic projects will create a feedback loop to improve our process for future estimates.

The ability to capture cost data through Maximo will lead to increased transparency and better cost control. The CIS enables us to optimize our Capex processes, increasing efficiency and enhancing overall financial performance.

2.8.2 Benchmarking Analysis

PR24 unit costs were compared with estimates from PR19 and the WRc TR61 V14 database. The TR61 database is a national cost database based on cost data from selected water companies.

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 relevant and comparable processes 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 of PR19 non-infrastructure EGI 'Equipment Group Identifiers' assets to PR24 reclassified EGI assets.
- Benchmarking our process cost models against comparable external models with similar inclusions and exclusions, and a comparable yardstick active and theoretical range.

Our benchmarking has shown that we have confidence in our unit costs, and they are comparable with industry benchmarks:

2.8.3 Infrastructure Benchmarking

The most recent main laying framework contract commenced in Q2 2022, an agreement with J Browne. The unit costs derived from the framework contract could therefore be benchmarked most effectively against recently completed projects.

Project costs were sourced from Oracle Fusion, while the mains pipe details were taken from GIS downloads.

A benchmark analysis was carried out on projects started and completed in Year 3 of AMP7, against the derived unit rates, resulting in a 7% variance below the total spend on benchmarked projects. Variance in different areas of the model were investigated, e.g., significant error for shorter length mains and for smaller nominal diameters.

As more projects are completed and benchmarked, the rates for specific subgroups can continuously be adjusted to suit the outturn data from recent projects. The diagram below, within Figure 11 shows the real and model estimate cost for various projects.

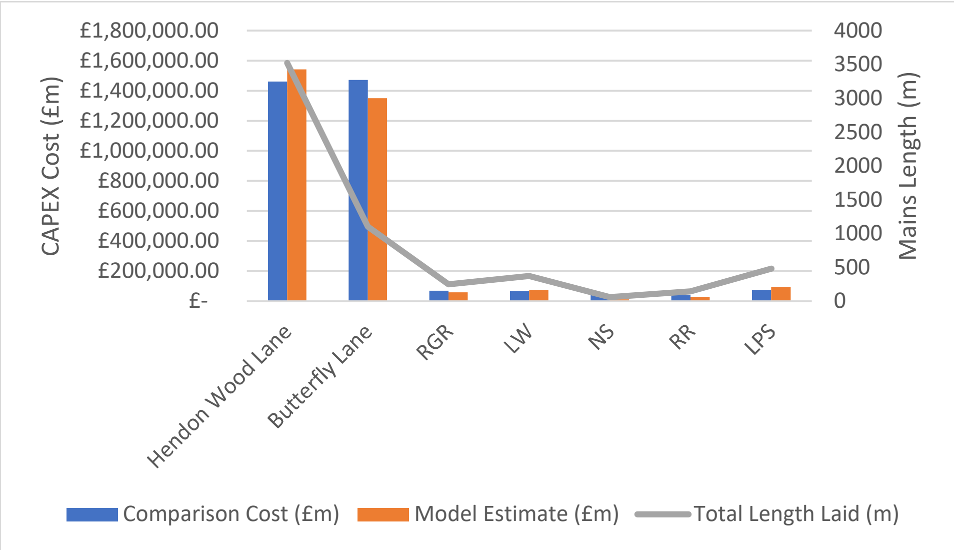


Figure 11 - Comparison of the Real and Model Estimate Costs for Recent Projects

2.8.4 Non-Infrastructure Benchmarking and Cost Comparisons

We decided to benchmark our process level models against Water Research Centre's TR61 V14 models as this provided an effective evaluation of our high-level cost accuracy. Costs were obtained for the minimum, median and maximum yardstick values in the theoretical range of our models (as shown in the graph below). We then used the same yardstick values to obtain costs from the TR61 V14 calculator and compared costs at each part of the range.

For the selected models, we found that Affinity's costs were around 16% higher than the TR61 models. Based on internal project data assessed, the design and corporate overheads not included in the TR61 model is expected to make up most of the difference between our Figures and TR61 estimates, therefore the variance should be closer to nil. A comparison between Affinity Water costs and TR61 costs are shown below within Figure 12 and Figure 13.

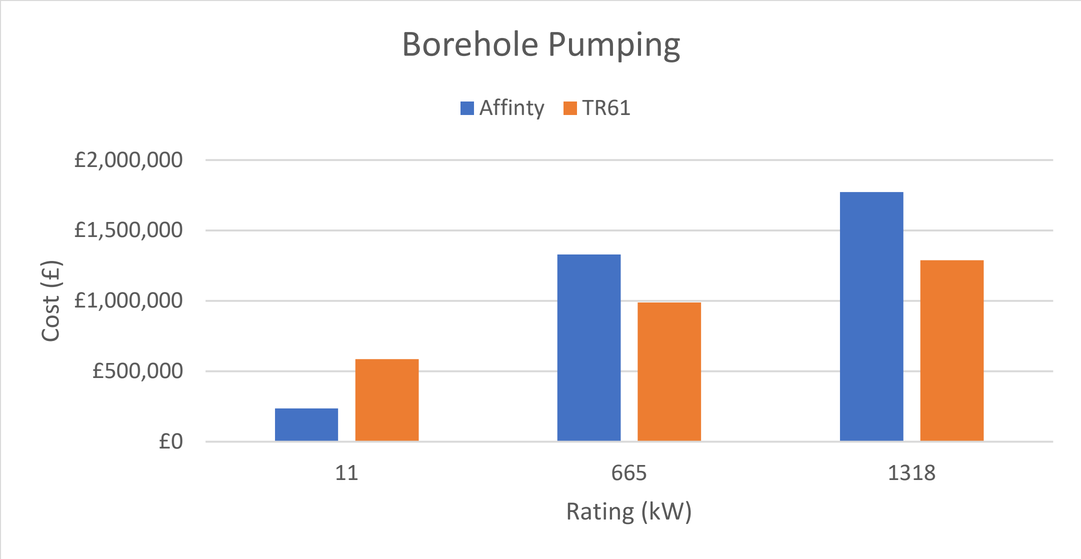


Figure 12 - Comparison Between Affinity Water and TR61 Costs for Borehole Pumping

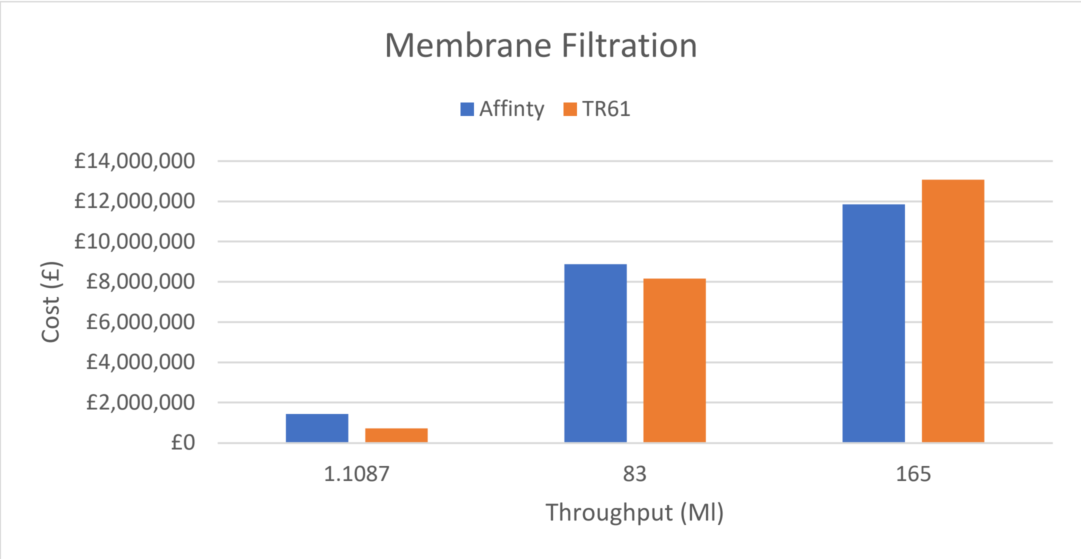


Figure 13 - Comparison Between Affinity Water and TR61 Costs for Membrane Filtration

AW received a tender quote for a denitrification plant which was benchmarked against our process cost model with advice from an internal senior quantity surveyor. As shown below the median cost estimate with reasonable adjustments for the current economic climate and inflation since July 2022 was 99% accurate with tender quote. This is shown within below.

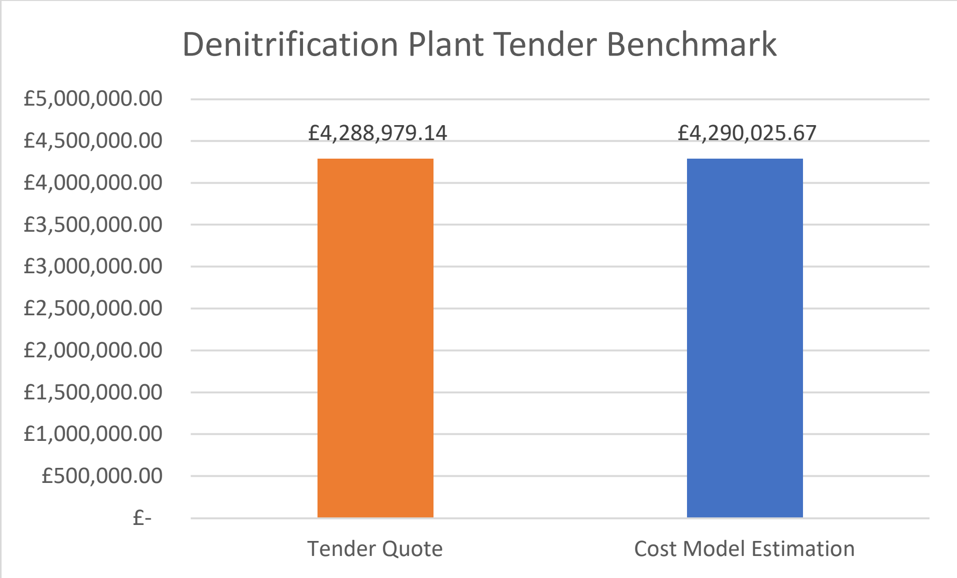


Figure 14 – Comparison Between Tender Quote and Cost Model Estimation for a Denitrification Plant

We have carried out an internal insurance evaluation of our top 5 operational sites by value which accounts for approximately 30% of total value of all operations sites in AW and benchmarked against an independent external evaluation (Kroll) of the top 5 sites. Our evaluation was only 3% lower than Kroll evaluation which shows our evaluation methodology of asset replacement cost is adequate. The comparison between the two evaluations is shown within Figure 15 below.

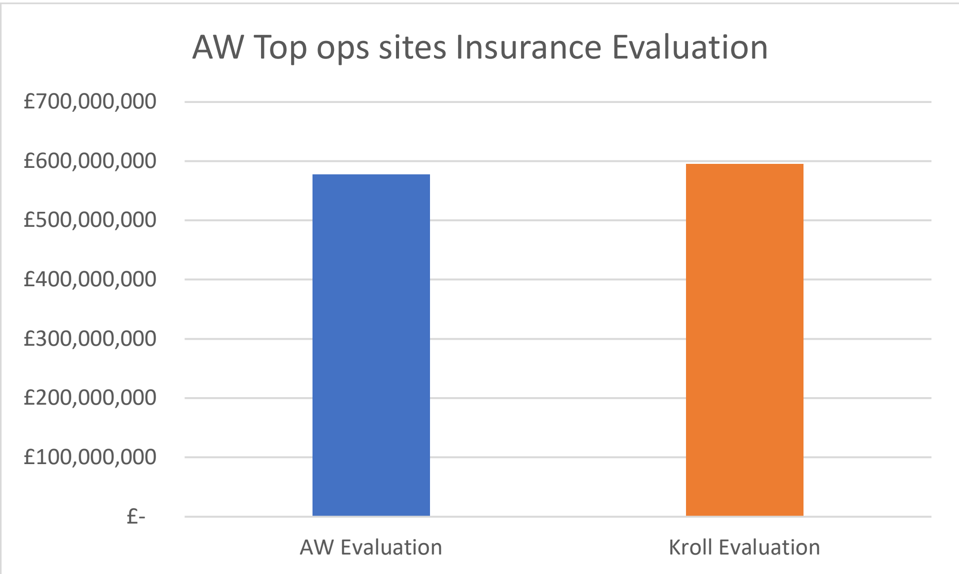


Figure 15 – Comparison Between Affinity Water Evaluation and an Insurance Evaluation

2.8.5 Governance and Assurance

We adopted the 'three lines of defence' in promoting governance and assurance for our PR24 costs and estimates.

We have engaged independent consultants to review and improve our processes and some cost models, providing us with industry wide knowledge and context. There have also been rounds of internal peer reviews of our methodologies for the more bespoke parts of our costing models, ensuring our calculations are correct, assumptions are robust, and all influencing factors have been considered. We have also conducted SME reviews with relevant programme managers and cost experts, to ensure that our models were appropriate for use across the AMP and that assumptions for overheads, all-in costs etc. have been included. This culminated with external audits by Atkins Limited for our Board assurance purposes. The Governance and Assurance for Each Asset Group is shown below within Table 8.

Governance Assurance	Asset Groups							
Risk profiles	DMP & TMS	MBs	Unit cost Models	P&R Maintenance	Network R&M	Metering	DS	SMs
Internal Assurance and review	✓	✓	✓	✓	✓	✓	✓	✓
Consultant review/Audit	✓	✓	✓	✓	✓	✓	✓	✓
External Benchmarking			✓					
Source: Affinity Water								

Table 8 - Governance and Assurance for Each Asset Group

2.8.6 River Restoration

As a company, Affinity Water, are supporting our customers to reduce their water usage as well as our own leakage. This underpins our plans to leave more water in the environment and meet customer needs now and in the future. A reduction in abstraction means more water is left in the environment, contributing towards the protection of rare chalk streams which provide an important habitat for numerous species in our local communities, such as dragonflies, fish, water voles, kingfishers, and otters.

It's not just about having more water in the environment though. Our river restoration programme is creating resilient chalk stream ecosystems by restoring the rivers and enhancing habitats. We have been working with the Environment Agency, landowners, and other partners to meet Water Framework Directive objectives.

The river restoration programme at Affinity Water began in AMP6 with a focus to deliver projects on 6 chalk streams. The river restoration programme continued into AMP7 with the original 6 chalk streams and an additional 8 chalk streams added to the programme, 14 chalk streams in total. In AMP7, Affinity Water signed up to 2 Ofwat performance commitments to be able to track progress of the river restoration programme delivery.

One Ofwat performance commitment is the river restoration performance commitment (this only includes the 6 rivers which have been worked on since the start of AMP6) where project units are signed off by the Environment Agency depending on the scale of river restoration activity delivered. For example, a small project, equivalent to fencing or tree works, would be worth 1 project unit. Whereas a large project, such as weir removal or re-meandering, would be worth 2 project units. The units can also be added cumulatively, for example a project which delivered a weir removal, fencing and tree works would equate to 4 project units.

The other relevant Ofwat performance commitment is the Water Industry National Environment Programme (WINEP) reputational performance commitment. This ensures all activities identified under WINEP are delivered in line with the Environment Agency agreed deadlines. The river restoration programme falls under the WINEP; therefore, river restoration projects need to be delivered on all 14 chalk streams by the end of AMP7 to meet this performance commitment.

The costs for the river restoration programme and projects are based on bottom-up calculations based on project cost data captured over AMP6 and AMP7 to date. Each line in the outturn cost report for projects is assigned to an activity grouping, ranging from optioneering, outline design, detailed design, and construction etc. The activity grouping for each project has been divided by the number of project units achieved or forecast that the project will achieve. This ensures the standardisation of a unit cost across for each river restoration project for each activity grouping.

The average activity grouping cost for one unit could then be calculated and used to build up a cost per river restoration unit delivered for a project. This includes the average activity grouping unit cost for all activities which make up the river restoration project lifecycle. For example, the average unit cost for optioneering, outline design, detailed design, early contractor involvement (ECI), and construction combined provides the river restoration unit cost. This river restoration unit cost has then been used to calculate the high-level budget for the AMP8 and AMP9 river restoration programme. We have proposed the delivery of 108 project units across 20 chalk streams, 62 to be achieved in AMP8 and the remaining 46 to be achieved in AMP9 subject to regulatory approval.

A river restoration project lifecycle can take on average take 18 months due to extensive stakeholder engagement being required. This is because most of these projects take place on third party land and Affinity Water have no powers to enforce the delivery of river restoration projects. These projects are highly complex and often involve managing; ecological constraints, archaeological constraints, avoidance of other utilities, consideration of flood risk, permitting delays, complex site access, and weather to avoid construction during time of high river flows. The high-level unit costs are reviewed through each stage of the project lifecycle (optioneering, design development and ECI) to ensure we are getting the best value for money and increase confidence in the project and programme budgets.

3. Ensuring Sustainable Asset Health

3.1 Overview

We operate a wide range of assets within the process of abstracting water from sources, treatment, storage, and distribution to our customers. It is essential that the health of these assets is assessed and understood to ensure that customers do not receive a bad service, e.g., an interruption to their supply. Through improved understanding of an assets' health, we can determine the optimum point to intervene - refurbish or replace. Considering performance, risk, and cost, we can make the optimal investment decision and deliver greatest value for customer bills. In the development of the PR24 business plan, we have matured our processes for understanding the health of our assets, through deterioration modelling and investment optimisation using PIONEER, and the creation of a process for understanding our base asset health (BAH). These processes are described further within this section of the appendix.

3.2 PIONEER Overview

For PR24, we've enhanced our portfolio optimiser, PIONEER (Proactive Investment Optimisation by Evaluating Expenditure and Risk), originally developed by Ovarro (formerly Servelec Technologies Ltd during PR19). PIONEER is a web-based tool designed to find the best investment and operational strategies to achieve optimal serviceability at the lowest cost, considering resource and capacity constraints. It uses asset data, deterioration curves, and cost calculations to identify the ideal investment portfolio based on customer priorities.

PIONEER optimises all production assets, including pumps, drives, buildings, telemetry, distribution mains, communication pipes, and trunk mains. It covers approximately 73,000 above-ground assets and over 17,000km of mains, addressing most infrastructure and non-infrastructure maintenance needs for AMP8.

Our in-house Asset Strategy Team has made significant improvements and data restructuring, building on our investment modelling expertise. This enhances our understanding of the PIONEER system, reducing its "black box" nature as our staff are already trained and familiar with its use. We've created a customised configuration tailored to our specific needs and standardised production asset data for consistent, semi-automated consequence likelihood calculations for each asset.

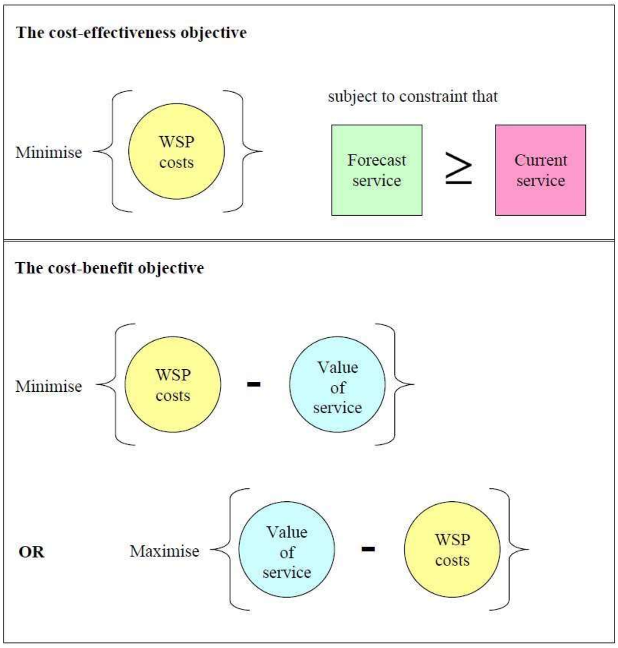
We have made significant strides in our business-wide portfolio optimisation by seamlessly integrating both above and below-ground operational assets. Since PR14, we've invested in an integrated burst rate modelling module called "Model Builder," which combines burst data from PIONEER and pipe attributes from our GIS system. This tool automates multivariable regression modelling of burst rates over time, segmented by cohort, for PIONEER's forecasting.

We have also used Model Builder to examine the acceleration and deceleration of burst rates per pipe in recent years, using Pipe Level Conditional Probability (PLCP) adjustment. Furthermore, we have leveraged Model Builder to automatically group distribution pipes based on material and soil corrosivity, creating practical schemes for implementation through our mains renewals program.

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.

Both the Cost effectiveness and cost beneficial objectives as defined in the Common Framework have been used in maintenance investment planning, where we follow the most advanced techniques as identified in the Common Framework Review of Current Practice[3], (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 within Figure 16, and explanations on both objectives are explained within the following sections.



[3] UKWIR, Capital Maintenance Planning Common Framework: Review of Current Practice, Ref: 05/RG/05/14

Figure 16 - The Two Optimisation Objectives

3.2.1 Cost Effectiveness Objective

The cost effectiveness objective (minimise costs while maintaining service) has been used for most optimisation scenarios. The prime objective of optimisation was to achieve target levels of service for each of the key customer expectations defined within the infrastructure and non-infrastructure Business Plan, which define expected levels of service at least cost. These are set as constraints to the optimisation process. An example of the target levels is shown below within Figure 17, which shows the serviceability targets for Scenario 2 – Stated Ambition. The constraints used during the PR24 process can be found in Section 3.5.

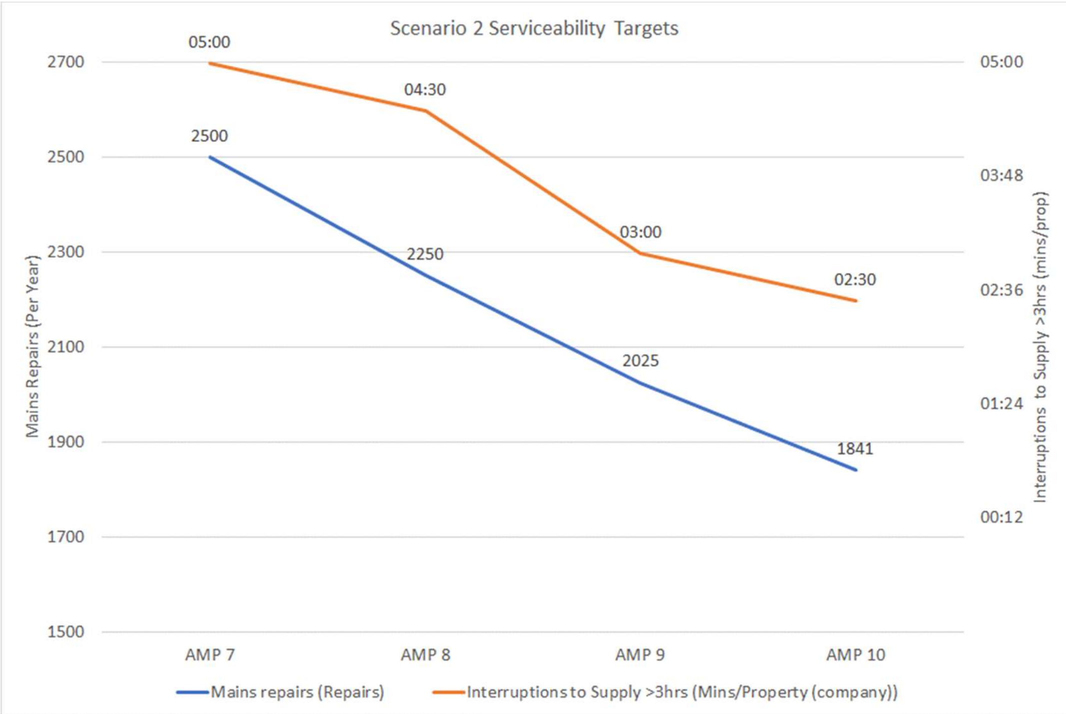


Figure 17 - Serviceability Targets for Scenario 2 - Stated Ambition

Further details of the consultation process, customer outcomes and willingness to pay work can be found in our main Business Plan.

3.2.2 Cost Benefit Objective

Though not used in our final plan, the cost benefit objective is used to test the sensitivity to Willingness to Pay (WTP) valuations. Willingness to pay has been used elsewhere, within the service measure framework in relation to customer benefits. The WTP values are used in PIONEER against the matching service measure to offset the costs identified in previously within the costs section of this appendix. Details of the various scenarios and sensitivity tests run can be found in the next section.

3.3 PIONEER Process

The PIONEER process is shown within the flow chart below in Figure 18. The following sections define the numbered boxes and the lettered arrows.

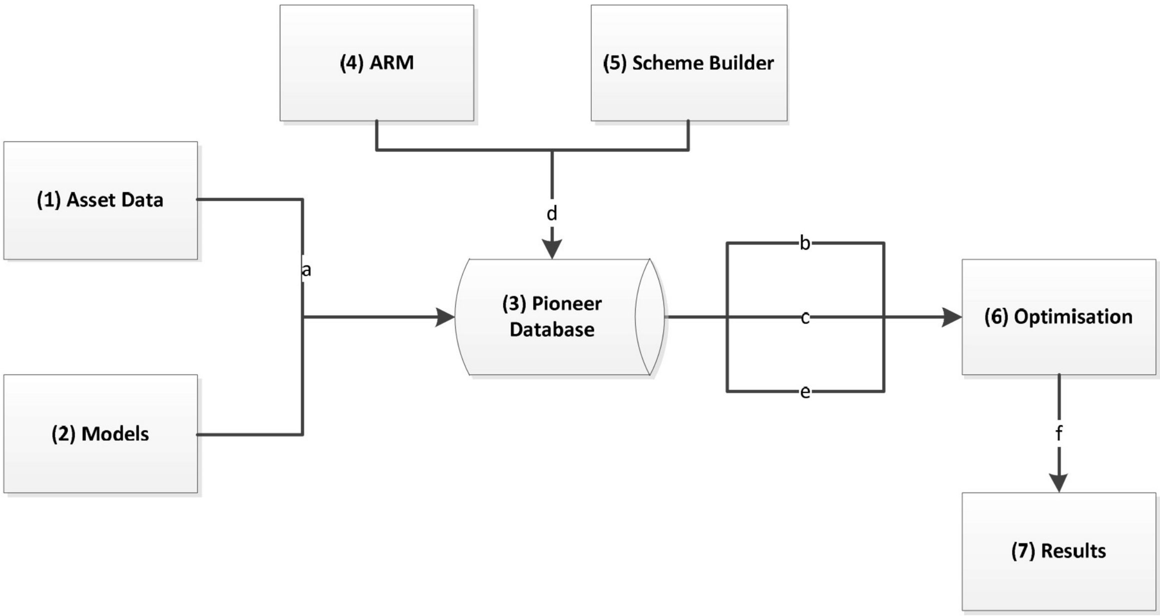


Figure 18 - The Pioneer System

3.3.1 [1] 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.

[a] The data 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.

3.3.2 [2] 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. For example, the calculation tree for the Hazard Based on Weibull Survival Fit uses a calculation tree which is a calculation of two coefficients:

Name	(B/(A^B))*(E^(B-1))
Min Limit	Not Specified
Max Limit	Not Specified
Interpreter Model Type Name	Multiply
Interpreter Model Type Description	
Node Formula	[B/(A^B)]*[E^(B-1)]

Figure 19 - The Calculation Tree for the Hazard Based on Weibull Survival Fit Model

- **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.

We can combine these models to create more complex ones for in-depth analysis. Controlling the models involves setting model coefficients, which are essential for building specific models from the lists mentioned earlier. Various types of model coefficients can be applied based on the specific model's requirements, including asset attributes, outputs from other models, information about the current year in optimisation, and static values.

Static values can be incorporated in two ways: directly inputting them into the PIONEER system or using the Excel Add-In module, which enables the addition or editing of many coefficients at once. The Excel Add-In has been extensively utilised, and previous sections provide examples of its usage. In the case of distribution mains likelihood models, coefficients are automatically populated by the Model Builder module.

In Table 9 below, we provide a break-down of the methods 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 –	-	Direct input (Global variable)

Unit Type	Model	Model Type	Model Coefficients
	Consequence probability		
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 9 - Summary of the Main Affinity Water PIONEER Configurations

* Different functions were combined into a single equation for the cost model, including constant, linear, power, quadratic, cubic, exponential, and logarithmic functions.

3.3.3 [3] PIONEER Database

This is the primary storage for all model data, including failure modes, interventions, and results, managed by the optimiser.

[b] PIONEER employs failure modes to assess the impact of asset failures. 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.

Likelihood measures the expected number of failures for a specified time-period (one year was used); they are calculated from the models, derived from 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[4], which has been illustrated within Figure 20 below.

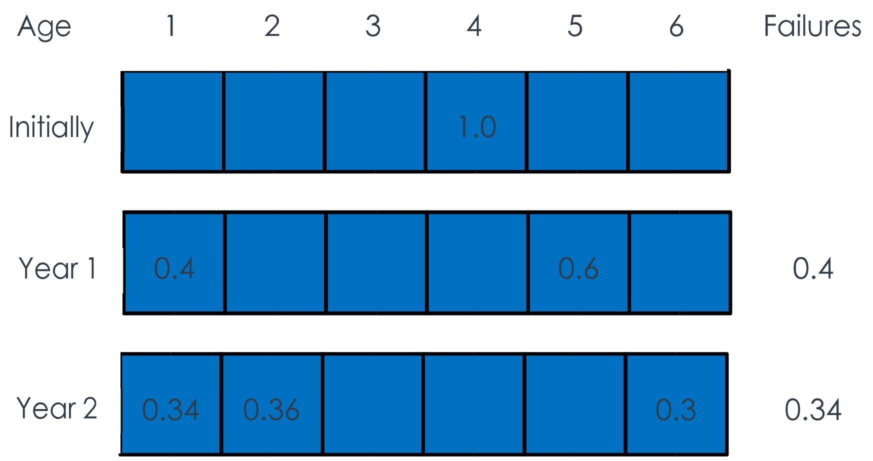


Figure 20 - Age Profile of a Pump Using Bayes Theorem

(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

[4] (Joyce, 2003)

given asset failure and the quantity of consequence. The calculation for the Service Measure Consequence is shown in Equation 2 below.

Service Measure Consequence = Likelihood of Failure X Consequence Probability X Consequence Quantity

Equation 2 - Calculation for the Service Measure Consequence

For instance, consider a burst in the distribution mains leading to a supply interruption. In this case, the consequence probability reflects the likelihood of a burst causing an interruption, and the quantity represents the number of properties impacted by the interruption.

Each service measure has a cost per unit of failure as described in Section 2.7. The total cost of failure is the cost of failure plus the consequential cost of failure. The 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 proactive actions selected by the optimisation engine to alter failure modes and, consequently, service measures. Unlike failure modes, an intervention affects only one unit type, although multiple interventions can impact each unit type. These interventions primarily result in three types of effects: attribute changes, failure mode alterations, and costs.

Typically, interventions adjust the installation date of the unit, influencing subsequent failure likelihood. They can also modify other asset attributes, affecting service measure impact or cost of repair. Additionally, interventions may change the model used to calculate failure mode likelihood, allowing for different deterioration curves after partial replacements or refurbishments.

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 interdependencies may be a requirement for 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.

3.3.4 [4] Asset Risk Manager (ARM)

Sometimes assets deviate from expected and modelled behaviour. This can occur due to failures differing from predictions or unexpected consequences. When a field engineers encounter these differences, they can be added into the optimisation using the Asset Risk Manager (ARM) module.

ARM, an add-on module for PIONEER, facilitates the inclusion of new risks into the capital maintenance programme. It comprises two primary sections: a risk section, akin to a failure mode, and associated solutions, resembling interventions. When multiple solutions are available for a risk, the optimisation engine selects the most suitable and cost-effective one.

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 resolved 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.

Additionally, the ARM module allows ongoing monitoring of risks during everyday operations. This enables managers to assess risks in their area, ensuring consistent use of risk framework in maintenance and business planning.

3.3.5 [5] Scheme Builder

Scheme Builder simplifies the creation of complex schemes, which serve various purposes in both capital planning and daily project analysis. It enables the input of intricate solutions, such as non-like-for-like replacements when resizing assets is necessary. These schemes can be linked to ARM risks for optimisation purposes.

You can create prospective projects 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. Pricing is achieved using the PIONEER unit cost database and allows Scheme Builder to be used as a project cost prediction tool.

[d] We convert ARM and Scheme Builder values into the relevant PIONEER values and store them 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.

3.3.6 [6] Optimisation

PIONEER optimisation relies on constraints defined 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 achieves this by calculating the benefits each intervention provides over the benefit period and selects the most cost effective one that meets the targets.

Initially, the optimiser executes all mandated interventions and assesses their effects on service measures. It subsequently computes the net cost for each intervention. Any interventions with a negative net cost (where the cost of intervention is less than the benefit costs) are automatically included in the selected intervention list.

The optimiser compares the other interventions by calculating a "Z factor", as shown below within Equation 3.

$$Z_i = \frac{\sum_{j=1}^{n} p_j s_{ij}}{q_i}$$

Equation 3 - Calculation of the Cost Effectiveness Index

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*.

3.3.7 [7] Output of Results

The overall process for extraction and analysis of PIONEER results is summarised below in Figure 21.

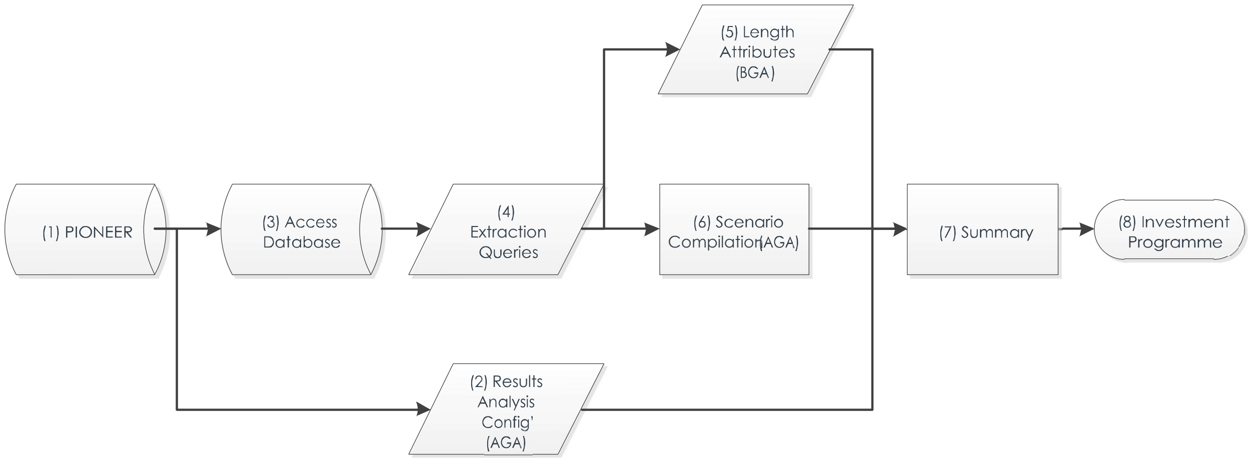


Figure 21 - Outputs and Post-Processing

1. **PIONEER**

The key source of information is the PIONEER system. The system has several preconfigured reports accessed via the integrated SQL Report Manager. Results from optimisations in PIONEER are stored in underlying database tables.

2. **Results Analysis Configuration Report**

PIONEER has a standard reporting feature called the Results Analysis Configuration Report. It serves to extract results for a chosen optimisation scenario. This report allows for the visualisation of costs or service measures in both graphical and tabular formats. Additionally, it provides the option to compare these results with the baseline repair-on-failure scenario. This comparison is particularly useful for calibration to ensure that baseline service levels align with historical levels. Furthermore, the report facilitates the export of forecasted above-ground service measures and costs through the Microsoft Excel export feature.

The costs to the business in this report are double discounted and annuitized. 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 (2022/23 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 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.

3.4 Service Measures

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.

3.4.1 Focusing the Analysis

For maintenance planning, two of the four customer outcome expectations apply:

- 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. Except for 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 are shown within Table 10.

Outcome	Service Measures	PC
Supplying high quality water, you can trust	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 10 - Outcomes, Service Measures and PCs

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 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.

3.4.1.1 Number of Mains Bursts

The results of a 'do nothing' forecast shows that the maximum number of bursts predicted in AMP 8, if no investments took place, would be 2618 bursts per year. The current average number of bursts is approximately 2500 bursts per year. The network plan aims to keep the number of bursts below 2500 per year. Bursts however can fluctuate each year and can be largely dependent on weather.

The average frequency of trunk main bursts is approximately 151 bursts per year based on historical data. This has been set as a stable target across all scenarios.

3.4.1.2 Compliance Risk Index (CRI)

The Compliance Risk index consists of 3 components; compliance in water supply zones, compliance at water treatment works and compliance at storage facilities.

In 2022, we achieved a CRI index of 1.086. For AMP8 we aim to maintain a stable CRI score of < 2.

3.4.1.3 Interruptions more than 3 hours (property minutes)

This common PC comprises two components, planned and unplanned interruptions.

A target has been set for interruptions to supply for the network scenarios, however the target for mains bursts drives the investment for mains renewals and as a result, the resulting interruption to supply remains below the target for all scenarios.

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.

3.4.1.4 Unplanned Outage

For unplanned outage, we have used a surrogate measure of production asset failures at our non-infrastructure sites. This serves as an indicator for appropriate maintenance and long-term asset health. Our goal is to maintain numbers stable across AMP8.

3.4.2 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[5] 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 early view of WACC.
- Costs are annuitized 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.

[5] 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).

3.5 Options and Scenarios Run

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 within Section 3.6.

3.5.1 PIONEER Optimisation 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.

3.5.1.1 Affinity Water Selected Serviceability

As part of the development of the PR24 plans, Affinity Water comprised six scenarios, five regarding the network strategy and one regarding the non-infrastructure assets. These serviceability scenarios are highlighted in Table 11 below:

Scenario	PC/Measure	Units	AMP 7	AMP 8	AMP 9	AMP 10
Network Strategy Sc 1 - Optimisation of Stable Service (unconstrained)	Interruptions to Supply >3hrs	Mins/Property (company)	03:00	03:00	03:00	03:00
	Mains repairs (relates to BGA asset health)	Repairs	2500	2500	2500	2500
	Mains repairs (TMs)	Repairs	151.7	151.7	151.7	151.7
Network Strategy Sc 2 - Optimisation for	Interruptions to Supply >3hrs	Mins/Property (company)	05:00	04:30	03:00	02:30

Scenario	PC/Measure	Units	AMP 7	AMP 8	AMP 9	AMP 10
stated ambition (unconstrained)	Mains repairs (relates to BGA asset health)	Repairs	2500	2250	2025	1841
	Mains repairs (TMs)	Repairs	151.7	151.7	151.7	151.7
Network Strategy Sc 3 - Stated ambition less 10 percent (unconstrained)	Interruptions to Supply >3hrs	Mins/Property (company)	05:00	04:57	03:18	02:45
	Mains repairs (relates to BGA asset health)	Repairs	2500	2475	2228	2025
	Mains repairs (TMs)	Repairs	151.7	151.7	151.7	151.7
Network Strategy Sc 4 - Stated ambition - plus 10 percent (unconstrained)	Interruptions to Supply >3hrs	Mins/Property (company)	05:00	04:05	02:43	02:16
	Mains repairs (relates to BGA asset health)	Repairs	2500	2046	1841	1674
	Mains repairs (TMs)	Repairs	151.7	151.7	151.7	151.7
Network Strategy Sc 5 - Upper Quartile	Interruptions to Supply >3hrs	Mins/Property (company)	05:00	03:24	02:00	02:00
	Mains repairs (relates to BGA asset health)	Repairs	2,500	1162	1040	969
	Mains repairs (TMs)	Repairs	151.7	151.7	151.7	151.7
Network Strategy Sc 6 - Non-Infra Baseline	Water quality compliance (CRI)	# (Company level)	0.47	0.47	0.47	0.47
	Unplanned outage (relates to AGA asset health)	%	2.34	2.34	2.34	2.34

Scenario	PC/Measure	Units	AMP 7	AMP 8	AMP 9	AMP 10
	Mains repairs (relates to BGA asset health)	Repairs	2500	2500	2500	2500
	Mains repairs (TMs)	Repairs	151.7	151.7	151.7	151.7

Table 11 – Affinity Water's Selected Serviceability Scenarios

Scenario 1 is the optimisation for maintaining stable service. The focus for this optimisation was to understand the investments required to maintain the service levels modelled for the end of AMP 7. The serviceability targets constrained for this optimisation was for interruptions to supply and mains repairs.

Scenario 2 is the optimisation for the stated ambition for the company. The focus of this optimisation was to understand the investments required to reduce the quantity of yearly mains repairs by 10% each AMP. The serviceability targets constrained for this optimisation was for interruptions to supply and mains repairs.

Scenario 3 is a sensitivity test based on the stated ambition for the company (Scenario 2). This optimisation was designed to reduce the number of bursts less in AMP 8 in comparison to Scenario 2 but drives an increased reduction of bursts within AMP 9. The serviceability targets constrained for this optimisation was for interruptions to supply and mains repairs.

Scenario 4 is a sensitivity test based on the stated ambition for the company (Scenario 2). This optimisation was designed to reduce the number of bursts 10% more in AMP 8 and AMP 9, than in comparison to Scenario 2. The serviceability targets constrained for this optimisation was for interruptions to supply and mains repairs.

Scenario 5 is an optimisation to understand the investments required to meet the upper quartile of the UK water industry standards. The serviceability targets constrained for this optimisation was for interruptions to supply and mains repairs.

Scenario 6 is an optimisation to understand the investments required to maintain a stable level for CRI and above ground assets repairs, whilst maintaining stable network serviceability (matching scenario 1).

3.5.1.2 Further Service Scenarios Optimisations

Following the optimisations of Affinity Water's selected serviceability scenarios, some additional serviceability scenarios were suggested to be modelled. The further serviceability scenarios are highlighted below in Table 12:

Scenario	PC/Measure	Units	AMP 7	AMP 8	AMP 9	AMP 10
Network Strategy Scenario 2a - Optimisation for stated ambition (unconstrained)	Interruptions to Supply >3hrs	Mins / Property (company)	05:00	03:00	02:30	02:30
	Mains repairs (relates to BGA asset health)	Repairs	2500	2250	2025	1841
	Mains repairs (TMs)	Repairs	151.7	151.7	151.7	151.7
Network Strategy Sc 6 - Non-Infra Baseline (£0 Planned Investment in AMP 8)	Water quality compliance (CRI)	# (Company level)	Unconstrained	Unconstrained	Unconstrained	Unconstrained
	Unplanned outage (relates to AGA asset health)	%	2.34	2.34	2.34	2.34
	Mains repairs (relates to BGA asset health)	Repairs	2500	2500	2500	2500
	Mains repairs (TMs)	Repairs	151.7	151.7	151.7	151.7
	Planned Non-Infrastructure Investment Monetary Constraint	(£m)	0	Unconstrained	Unconstrained	Unconstrained

Table 12 - Further Serviceability Constraint Scenarios

Scenario 2a is an alternative to the optimisation for the stated ambition for the company. The focus of this optimisation was to understand the investments required to reduce the quantity of yearly mains repairs by 10% each AMP. The other focus of the optimisation is to reduce the interruptions to supply to 3 minutes by the end of AMP

8. The serviceability targets constrained for this optimisation was for interruptions to supply and mains repairs.

Scenario 6 – (£0 planned investment in AMP 8) is an alternative to the optimisation for the non-infrastructure assets. This optimisation was designed to review the effect of having £0 million investments for planned above ground assets with serviceability indicator for CRI unconstrained. The purpose of this is to investigate the effect of only replacing the assets which the optimisation predicts will need to be replaced reactively within the AMP. Like in the original scenario 6, the infrastructure serviceability indicators are set to maintain stable serviceability. The number of production failures has been kept stable for the expected service levels modelled for the end of AMP 7.

3.5.1.3 Monetary Constraint Optimisations

Following the results of the service scenario optimisations, Affinity Water completed analysis using monetary constraints, focused only on the infrastructure costs for AMP 8 (and therefore the non-infrastructure serviceability targets and investment results have been removed). All these scenarios include the burst benefits from the network calming business case. This began as a 95.3 burst benefit, but with restructuring to the network calming programme, this reduced to an 87-burst benefit. These scenarios, including the network calming benefits, has been highlighted below in Table 13.

Scenario	Network Calming Burst Benefit	Network Calming Base Capex Investment (million)	Distribution Mains Capex Investment (million)	Trunk Main Capex Investment (million)	Total Investment (Mains Renewals + Base Network Calming) (million)
100%	95.3	£2.06	£174.74	£29.05	£205.85
75%	95.3	£2.06	£123.28	£29.05	£154.39
50%	95.3	£2.06	£71.82	£29.05	£102.93
31%	95.3	£2.06	£32.71	£29.05	£63.81
0%	95.3	£2.06	£0	£0	£2.06
£25,000,000	95.3	£2.06	£10.25	£14.75	£27.06
£25,000,000 – 87 NC Bursts Benefit	87	£0	£10.25	£14.75	£25.00

Table 13 - Monetary Constrained Optimisations

3.5.2 Intervention Options

For all the scenarios above, the investment portfolio optimisation considers different intervention options depending on the type of asset, as shown in Table 14.

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 14 - 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.

3.6 Results and Assurance

In this section, the results and analysis of the portfolio optimisation process using PIONEER are explained. The section should be read in conjunction with Section 3.5 which defines the scenarios run and the reasons for them, 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.

3.6.1 PIONEER Optimisation Results

3.6.1.1 Selected Serviceability Scenario Results

The results for each of the selected serviceability scenario optimisations are highlighted below in Table 15 and Figure 22. As the targets for the optimisation was based on serviceability targets, the results are shown for the resulting investments required for the targets to be achieved.

Scenario	**Distribution Mains (£m)**	**Trunk Mains (£m)**	**Planned Non-Infrastructure (£m)**	**Reactive Non-Infrastructure (£m)**	**Total AMP 8 (£m)**
Network Strategy Sc 1 - Optimisation of Stable Service	50.33	28.78	3.75	179.41	262.27
Network Strategy Sc 2 - Optimisation for stated ambition	217.57	29.47	3.75	179.41	430.19
Network Strategy Sc 3 - Stated ambition less 10 percent	61.64	28.92	3.75	179.41	273.72
Network Strategy Sc 4 - Stated ambition - plus 10 percent	402.46	29.47	3.75	179.41	615.09
Network Strategy Sc 5 - Upper Quartile	1,618.01	33.72	3.75	179.41	1,834.89
Network Strategy Sc 6 - Non-Infra Baseline	146.42	59.71	18.73	176.31	401.17

Table 15 - Service Scenario Results

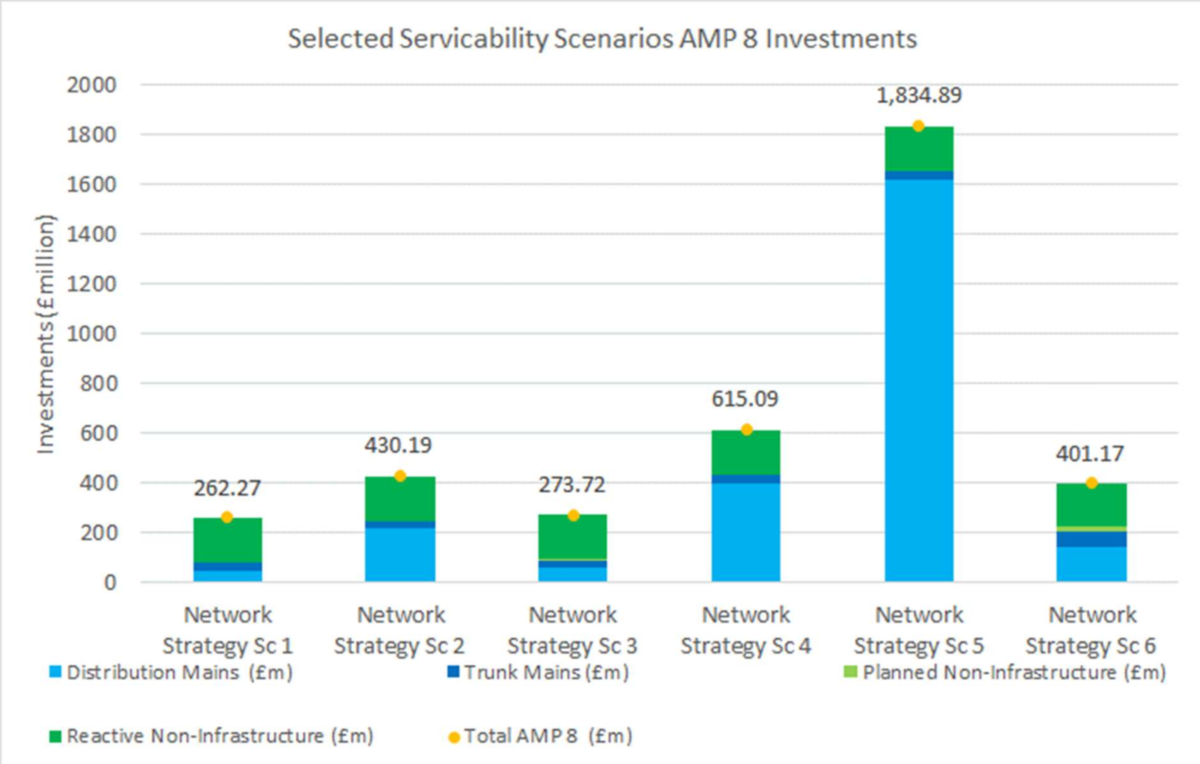


Figure 22 - Selected Serviceability Constrained Scenarios Investment Results

Scenario 1 is the optimisation for maintaining the modelled end of AMP 7 infrastructure serviceability levels. The result of this optimisation shows that the total investment in AMP 8 to maintain the serviceability levels is £262.27 million. Of this the infrastructure investment required is £79.11 million, which comprises of a distribution main investment of £50.33 million and a trunk main investment of £28.78 million. The non-infrastructure investment required is £183.16 million, which comprises of a £3.75 million planned investment and a £179.41 million reactive investment.

Scenario 2 is the optimisation for Affinity Water's stated ambition. The stated ambition is to reduce the modelled end of AMP 7 infrastructure serviceability indicator, for the number of bursts annually, by 10% by the end of AMP 8. The result of this optimisation shows that the total investment in AMP 8 to maintain the serviceability levels is £430.19 million. Of this the infrastructure investment required is £247.04 million, which comprises of a distribution main investment of £217.57 million and a trunk main investment of £29.47 million. The non-infrastructure investment required is £183.16 million, which comprises of a £3.75 million planned investment and a £179.41 million reactive investment.

Scenario 3 is a sensitivity test which is based on a less harsh version of the stated ambition for the company (Scenario 2). The result of this optimisation shows that the total investment in AMP 8 for this sensitivity test scenario is £273.72 million. Of this the infrastructure investment required is £90.56 million, which comprises of a distribution main investment of £61.64 million and a trunk main investment of £28.92 million. The non-infrastructure investment required is £183.16 million, which comprises of a £3.75 million planned investment and a £179.41 million reactive investment.

Scenario 4 is a sensitivity test which is based on a harsher version of the stated ambition for the company (Scenario 2). The result of this optimisation shows that the total investment in AMP 8 for this sensitivity test scenario is £615.09 million. Of this the infrastructure investment required is £431.93 million, which comprises of a distribution main investment of £402.46 million and a trunk main investment of £29.47 million. The non-infrastructure investment required is £183.16 million, which comprises of a £3.75 million planned investment and a £179.41 million reactive investment.

Scenario 5 is the optimisation to understand the investment requirements for Affinity Water to be considered within the upper quartile of the UK water industry. The result of this optimisation shows that the total investment in AMP 8 to promote Affinity Water into the upper quartile for mains bursts is £1,834.89 million. Of this the infrastructure investment required is £1651.73 million, which comprises of a distribution main investment of £1,618.01 million and a trunk main investment of £33.72 million. The non-infrastructure investment required is £183.16 million, which comprises of a £3.75 million planned investment and a £179.41 million reactive investment.

Scenario 6 is an optimisation to understand the investments required to maintain a stable level for CRI and above ground assets repairs, whilst maintaining stable network serviceability (matching scenario 1). The result of this optimisation shows that the total investment in AMP 8 to maintain the serviceability levels is £401.17 million. Of this the infrastructure investment required is £206.13 million, which comprises of a distribution main investment of £146.42 million and a trunk main investment of £59.71 million. The non-infrastructure investment required is £195.04 million, which comprises of a £18.73 million planned investment and a £176.31 million reactive investment.

3.6.1.2 Further Service Scenario Optimisation Results

The results for each of the selected serviceability scenario optimisations are highlighted below in Table 16 and Figure 23. As the targets for the optimisation was based on serviceability targets, the results are shown for the resulting investments required for the targets to be achieved.

Scenario	**Distribution Mains (£m)**	**Trunk Mains (£m)**	**Planned AGA (£m)**	**Reactive (£m)**	**Total AMP 8 (£m)**
Network Strategy Scenario 2a - Optimisation for stated ambition (unconstrained)	275.64	49.47	3.75	179.41	508.26
Network Strategy Sc 6 - Non-Infra Baseline (£0 Planned Investment in AMP 8)	50.68	28.78	0	182.60	262.06

Table 16 - Further Serviceability Constrained Scenarios Optimisation Results

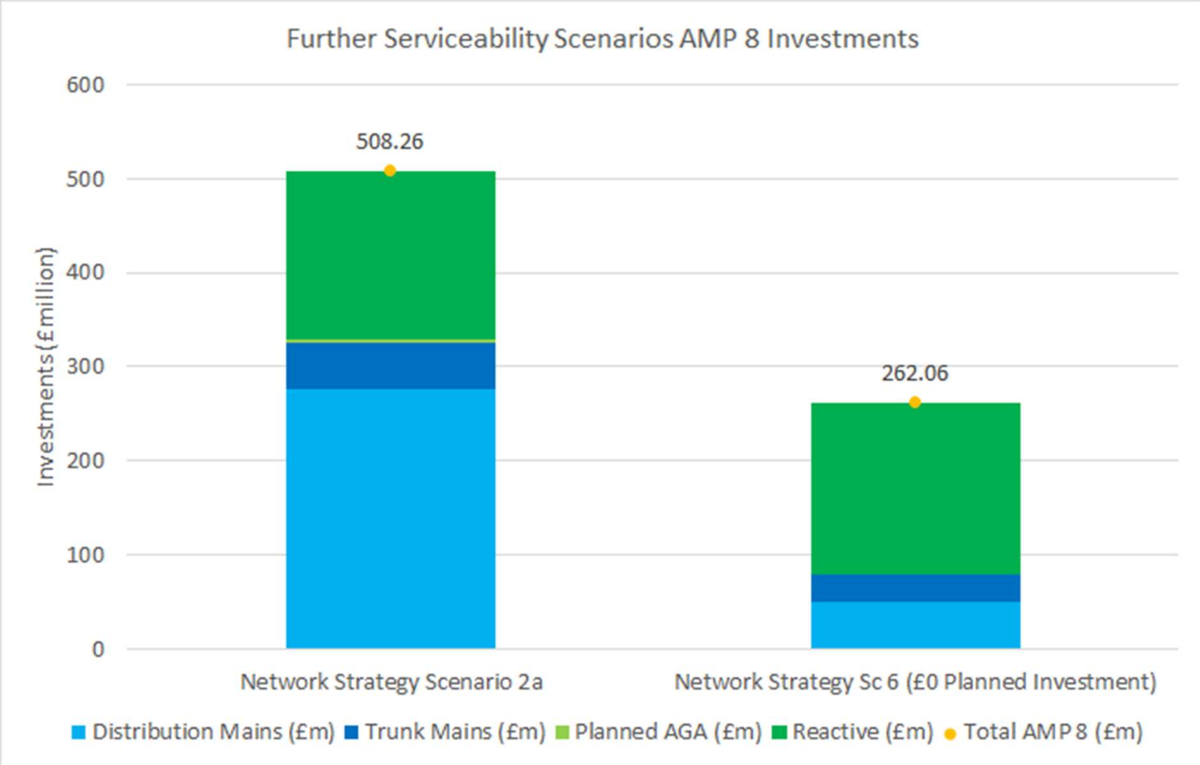


Figure 23 - Further Service Scenario Optimisation Results

Scenario 2a is an alternative to the optimisation for the stated ambition for the company, whereby the number of mains bursts reduces by 10% per AMP, whilst reducing the interruptions to supply to 3 minutes by the end of AMP 8. The result of this optimisation shows that to meet these targets, the total investment in AMP 8 is £508.26 million. Of this the infrastructure investment required is £325.11 million, which comprises of a distribution main investment of £275.64 million and a trunk main investment of £49.47 million. The non-infrastructure investment required is £183.16 million, which comprises of a £3.75 million planned investment and a £179.41 million reactive investment.

Scenario 6 (£0 Planned Investment in AMP 8) is an optimisation to review the impact of not replacing any non-infrastructure assets proactively, and only replacing reactively. The infrastructure, and the production failures, serviceability targets were set to maintain a stable level from the modelled end of AMP 7 levels. The results for the total investment in AMP 8 to maintain the serviceability levels is £262.06 million. Of this the infrastructure investment required is £79.46 million, which comprises of a distribution main investment of £50.68 million and a trunk main investment of £28.78 million. The non-infrastructure investment required is £182.60 million, which comprises of a £0 million planned investment and a £182.60 million reactive investment.

As a result of removing planned investments for non-infrastructure assets, the optimisation results in an increase in CRI. This has been shown below in Figure 24.

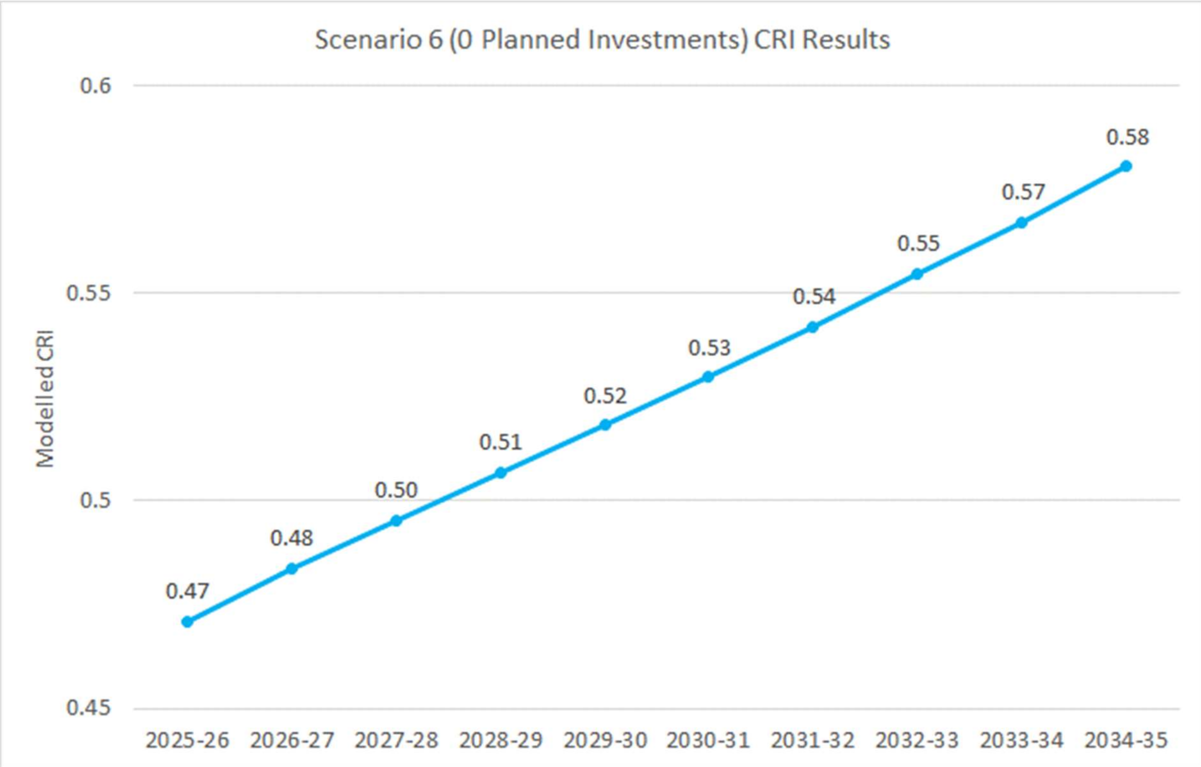


Figure 24 - Increase in CRI Due to the No-Planned Investments

3.6.1.3 Monetary Constraint Optimisations Results

The results for each of the monetary constraint optimisations are highlighted below in Table 17, Figure 25 and Figure 26. As the investments were constrained, unlike the previous optimisations which had serviceability targets, the results are a comparison of the resulting serviceability levels for each scenario.

Scenario	Network Calming Burst Benefit (Bursts per Annum)	AMP 8 Total Mains Bursts (Bursts Per Annum)	AMP 8 Trunk Mains (Bursts Per Annum)	AMP 8 Mains Renewals (km)	AMP 8 Mains Renewals (% of the Network)
100%	95.3	2251.3	151.78	848.8	4.96
75%	95.3	2321.9	151.78	613.7	3.59
50%	95.3	2403.0	151.78	377.5	2.21
31%	95.3	2477.2	151.78	204.1	1.19
0%	95.3	2565.2	160.59	0.0	0.0

£25,000,000	95.3	2527.3	156.09	80.6	0.47
£25,000,000 – 87 Network Calming Bursts Benefit	87	2584.5	155.51	74.22	0.43

Table 17 – Monetary Constraints Scenarios Serviceability Indicator Results

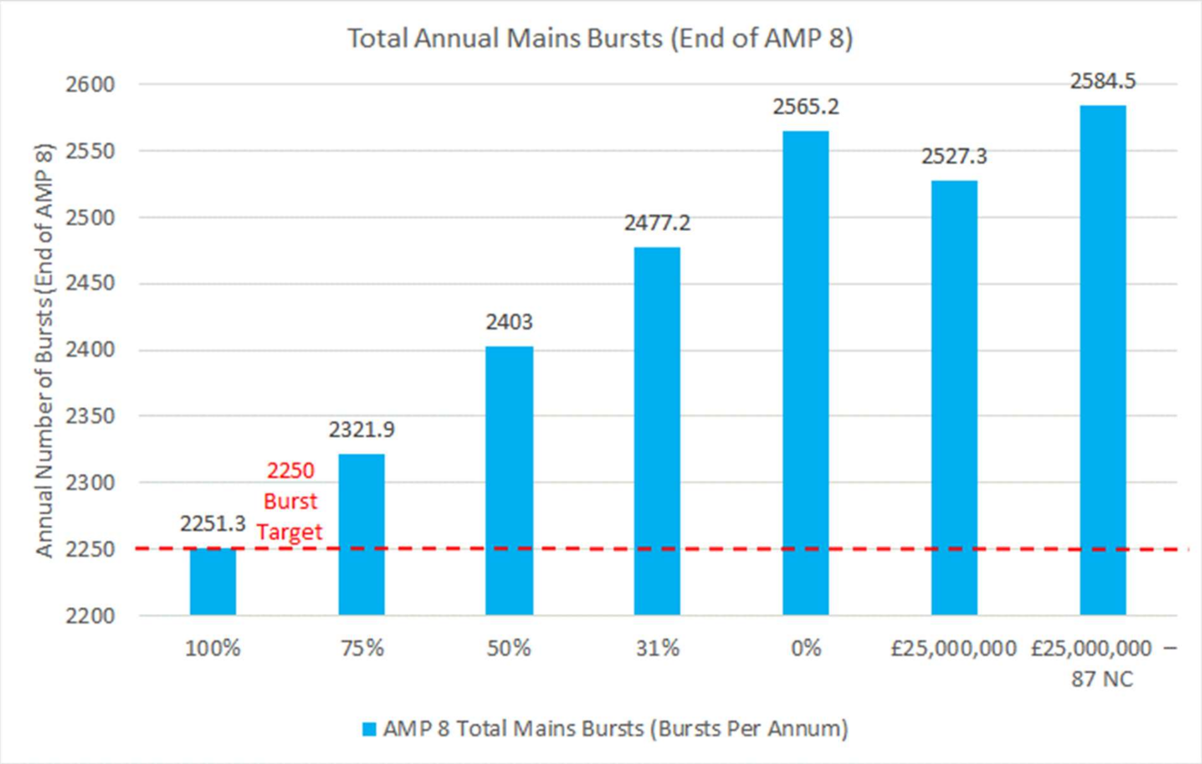


Figure 25 - Total Annual Mains Bursts Results for the Monetary Constrained Scenarios

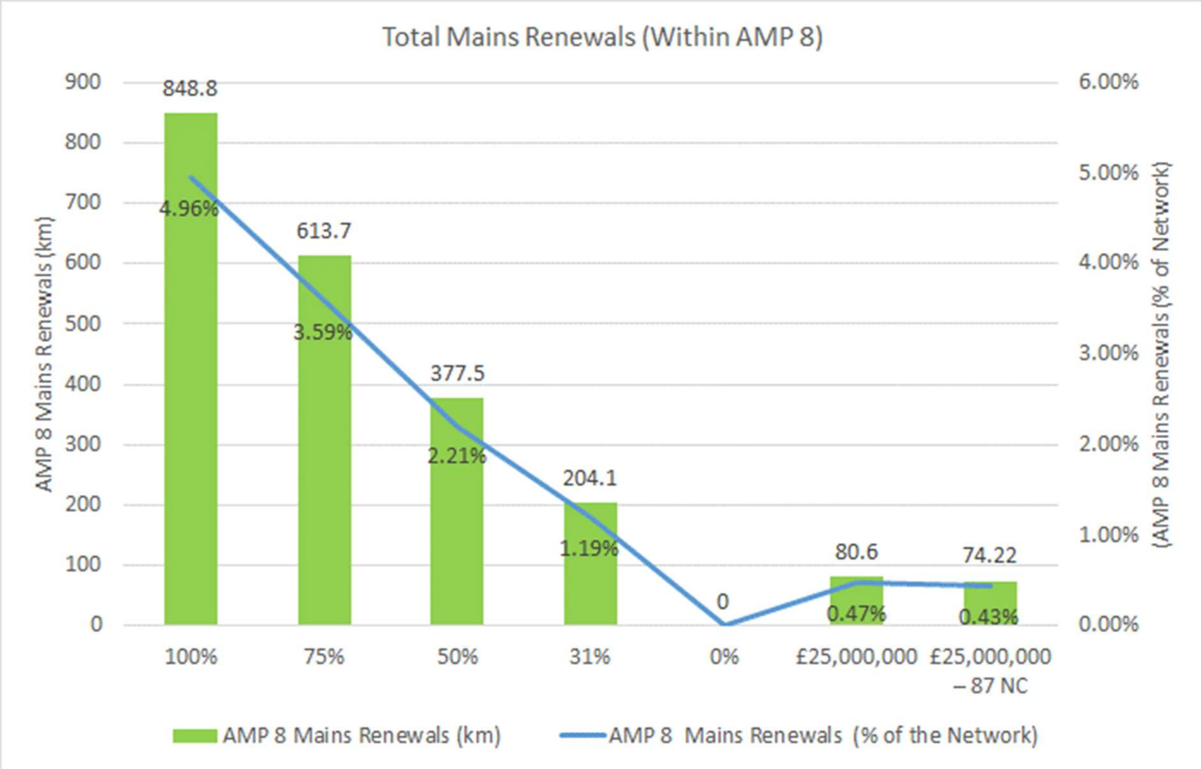


Figure 26 - Total In-AMP Mains Renewals Results for the Monetary Constrained Scenarios

100% is the scenario, which is based on ensuring that 100% of the modelled investment required to meet the companies Scenario 2 – Stated Ambition. The modelled investments total £205.85 million. This is made up of an investment breakdown of £2.06 million network calming base Capex, £174.74 million distribution mains Capex and a £29.05 million trunk main investment. This optimisation also had the drawback effect of climate change and a network calming benefit of 95.3 bursts applied to it.

The modelled results of the optimisation, in terms of serviceability indicators indicates that the investment would meet the serviceability targets for the stated ambition. The annual number of total bursts modelled for the end of AMP 8 is 2251 bursts, and the modelled number of trunk main bursts is 151.78. In terms of mains renewals, this equates to 848.8 km of mains renewals, which is 4.96% of Affinity Water's network.

75% is the scenario, which is based on ensuring that 75% of the modelled investment required to meet the companies Scenario 2 – Stated Ambition. The modelled investments total £154.39 million. This is made up of an investment breakdown of £2.06 million network calming base Capex, £123.28 million distribution mains Capex and a £29.05 million trunk main investment. This optimisation also had the drawback effect of climate change and a network calming benefit of 95.3 bursts applied to it.

The modelled results of the optimisation, in terms of serviceability indicators indicates that the investment would meet the serviceability targets for the stated ambition. The annual number of total bursts modelled for the end of AMP 8 is 2321.9 bursts (71.9 bursts over target), and the modelled number of trunk main bursts is 151.78. In terms of mains renewals, this equates to 613.7 km of mains renewals, which is 3.59% of Affinity Water's network.

50% is the scenario, which is based on ensuring that 50% of the modelled investment required to meet the companies Scenario 2 – Stated Ambition. The modelled investments total £102.93 million. This is made up of an investment breakdown of £2.06 million network calming base Capex, £71.82 million distribution mains Capex and a £29.05 million trunk main investment. This optimisation also had the drawback effect of climate change and a network calming benefit of 95.3 bursts applied to it.

The modelled results of the optimisation, in terms of serviceability indicators indicates that the investment would meet the serviceability targets for the stated ambition. The annual number of total bursts modelled for the end of AMP 8 is 2403.0 bursts (180 bursts over target), and the modelled number of trunk main bursts is 151.78. In terms of mains renewals, this equates to 377.5 km of mains renewals, which is 2.21% of Affinity Water's network.

31% is the scenario, which is based on ensuring that 31% of the modelled investment required to meet the companies Scenario 2 – Stated Ambition. The modelled investments total £63.81 million. This is made up of an investment breakdown of £2.06 million network calming base CAPEX, £32.71 million distribution mains Capex and a £29.05 million trunk main investment. This optimisation also had the drawback effect of climate change and a network calming benefit of 95.3 bursts applied to it.

The modelled results of the optimisation, in terms of serviceability indicators indicates that the investment would meet the serviceability targets for the stated ambition. The annual number of total bursts modelled for the end of AMP 8 is 2477.2 bursts (227.2 bursts over target), and the modelled number of trunk main bursts is 151.78. In terms of mains renewals, this equates to 204.1 km of mains renewals, which is 1.19% of Affinity Water's network.

0% is the scenario, which investigates the effect of investing £0 in infrastructure in AMP 8. The modelled investments total £2.06 million. This is made up of an investment breakdown of £2.06 million network calming base Capex, £0 million distribution mains Capex and a £0 million trunk main investment. This optimisation also had the drawback effect of climate change and a network calming benefit of 95.3 bursts applied to it.

The modelled results of the optimisation, in terms of serviceability indicators indicates that the investment would meet the serviceability targets for the stated ambition. The annual number of total bursts modelled for the end of AMP 8 is 2565.2 bursts (315.2 bursts over target and 65.2 bursts over the predicted start of AMP 8), and the modelled number of trunk main bursts is 160.59 (8.81 trunk main bursts over target). In terms of mains renewals, this equates to 0 km of mains renewals, which is 0% of Affinity Water's network.

£25,000,000 is the scenario, which is based on constraining the investment to £25 million. The modelled investments total £27.06 million. This is made up of an investment breakdown of £2.06 million network calming base Capex, £10.25 million distribution mains Capex and a £14.75 million trunk main investment. This optimisation also had the drawback effect of climate change and a network calming benefit of 95.3 bursts applied to it.

The modelled results of the optimisation, in terms of serviceability indicators indicates that the investment would meet the serviceability targets for the stated ambition. The annual number of total bursts modelled for the end of AMP 8 is 2527.3 bursts (277.3 bursts over target and 27.3 bursts over the predicted start of AMP 8), and the modelled number of trunk main bursts is 156.09 (4.31 trunk main bursts over target). In terms of mains renewals, this equates to 80.6 km of mains renewals, which is 0.47% of Affinity Water's network.

£25,000,000 – 87 Network Calming is the scenario, which is based on constraining the investment to £25 million, with the updated benefits for network calming. The modelled investments total £25 million. This is made up of an investment breakdown of £0 million network calming base Capex, £10.25 million distribution mains Capex and a £14.75 million trunk main investment. This optimisation also had the drawback effect of climate change and a network calming benefit of 87 bursts applied to it.

The modelled results of the optimisation, in terms of serviceability indicators indicates that the investment would meet the serviceability targets for the stated ambition. The annual number of total bursts modelled for the end of AMP 8 is 2584.5 bursts (334.5 bursts over target and 84.5 bursts over the predicted start of AMP 8), and the modelled number of trunk main bursts is 155.51 (3.73 trunk main bursts over target). In terms of mains renewals, this equates to 74.22 km of mains renewals, which is 0.43% of Affinity Water's network.

3.6.2 Selection of Our Plan

As the development for the PR24 plan progressed, and the affordability challenges facing our customers became clearer, our optimisations sought to account for this in the balance between long-term asset health, short-term performance and affordability.

For the infrastructure plan, initially scenario 2 (stated ambition) was the preferred option for the business. Scenarios 1-6 were optimised using PIONEER, the results of which shows the need for a large investment within AMP 8 for mains renewals. Following these optimisations, the effects of network calming and climate change were applied to scenario 2, which became the 100% investment scenario. Using the monetary costs of the 100% investment scenario, further scenarios for 75%, 50% and 31% investments were developed and optimised.

For the non-infrastructure plan, one scenario (scenario 6) was developed to investigate the investment required to maintain the modelled end of AMP 7 serviceability levels for production failures and CRI score. The results of the optimisation showed that a significant investment would still be required within AMP 8 on non-infrastructure. This identified, we then undertook detailed risk and value analysis of each asset class to refine this modelling output to ensure costs remain affordable.

The serviceability and investment results from all the scenarios optimised with PIONEER were used to build a wealth of options that were inputted into Copperleaf. This allows for the portfolio to be optimised, the assess the benefits and risks associated with limiting the investments to individual business cases. More information on how Copperleaf was used during the investment decision making process can be found within Section 6.

3.7 Development of the Base Asset Health Indicator

3.7.1 Overview

For PR24, we have developed a process to understand the health of our assets. The Base Asset Health (BAH) indicator provides valuable predictions for the remaining economic life of our assets, which is derived from a calculation between factors such as the asset life expectancy, effective age, and the modern equivalent replacement costs. The BAH indicator offers us the flexibility to assess the asset health at various levels, including individual asset classes, processes, the whole company, or specific regions.

The insights derived from BAH models play a critical role in developing Asset Class Management Frameworks (ACMF). These frameworks encompass various elements within similar asset classes and outline our approach to asset replacement, refurbishment, and metadata requirements essential for informed investment decision-making. Additionally, the BAH models are instrumental in targeting maintenance, inspection, and replacement activities for our below-ground assets, with a focus on critical asset types presenting the highest risk. This proactive approach allows us to optimise asset management strategies, enhance asset longevity, and ensure efficient resource allocation.

By utilising the BAH indicator and ACMFs, we empower our organisation to make data-driven decisions that align with long-term asset management goals, fostering a sustainable and resilient infrastructure for the future.

3.7.2 Calculation of the Base Asset Health Indicator

To determine the BAH we use asset data information from Maximo, including the age of the asset (or assumed age if not known), the condition of civil assets, the performance of mechanical assets and mains, and failure analysis comprising common failure reasons and trends. This data is used to develop asset deterioration curves, which establish the typical economic life for each asset type. For individual assets, their specific data (performance, condition, or failure rate) is utilised to calculate their effective age.

The BAH indicator is then calculated using Equation 4:

$$BAH = \frac{\Sigma\left(\frac{Effective\ Age}{Economic\ Life} \times GMEAV\right)}{\Sigma\, GMEAV}$$

Equation 4 - Calculation for the Base Asset Health (BAH) Indicator

Where:

Effective age = The age of the asset

Economic life = Expected end of life

GMEAV = Gross Modern Equivalent Asset Value, representing the current cost to replace an asset of this type with its modern equivalent.

4. Identification of Investment Needs & Evaluation

4.1 Identification of Needs

Investment needs originate across our business from different teams, covering all our service commitments. We have an established process for raising and capturing investment needs as well as a defined approach for carrying out an initial evaluation. Needs originate from various sources, including:

- Statutory and regulatory requirements
  - Water Resources Management Plan (WRMP)
  - Water Industry National Environment Plan (WINEP)
  - Drinking Water Safety Plans (DWSPs)
  - Security and Emergency Measures Direction (SEMD)
- Asset and corporate risk registers
- Performance Commitment delivery strategies (to achieve our 2050 ambition, informed by Customer Research)
- Asset and Network Strategies (to maintain Asset Health at an acceptable level)
- Deterioration Models

Each potential need is provisionally assessed to determine whether investment is likely required within the 2025-30 period, examining the consequence of non-investment for those needs that are not obligatory. All needs determined to potentially require investment are progressed through to optioneering.

4.2 Options Analysis

Needs requiring investment are then assigned to appropriate owners to lead in optioneering of solutions. A panel of subject matter experts are then brought together to identify a comprehensive list of potential solutions, with the panel size varying dependent on the inherent complexity of the need and diversity of potential solutions. These panels often included representatives from our supply chain and relevant operational teams, led by our asset planning team.

Optional analysis consistently included consideration of partnership with third parties and adopting nature-based solutions, to ensure we have considered a full range of options. An initial more qualitative assessment of the full list of options was then undertaken to shortlist feasible options that could dependably meet the need. These were then economically assessed to identify best value and lowest cost solutions.

Both stages of the optioneering process were presented to our cross-functional Red Team, to provide challenge and assure the quality of the optioneering undertaken.

4.3 Building Our Business Cases

In building our business cases for investment, we set out to follow industry best practice. We drew guidance from a wide variety of sources including the HM Treasure Green Book, the Environment Agency's WINEP guidance, and the Office for National Statistics (ONS). Importantly, we also sought to carefully replicate Ofwat method for economic assessments, including using the Ofwat valuations released as part of the Willingness to Pay (WtP) study.

The key messages from this section are:

1. We fully comply with Ofwat method for economic assessments, including using Ofwat benefit valuations where possible.
2. We have supported this with our own customer research to confirm the priorities, options, and benefits.
3. We have used economic assessments to support our decision-making, accounting for other parameters such as affordability and deliverability.
4. We have used a risk-based approach to forecast investment benefit over time, enabling us to compare dissimilar investment cases.
5. We have taken a conservative, and consistent approach to economic assessments; focusing on major benefits only, using conservative benefit estimates, and being prudent in our assessment of High Impact Low Consequence events.
6. Most of our enhancement cases are required to meet our statutory obligations. However, we have used an economic analysis to understand the costs and benefits of all key investments where we are able to.
7. The enhancement programme has been optimised based on a combination of statutory requirements, stakeholder engagement, customer preferences and the outputs from our economic assessments.

The remainder of this section will provide additional detail on how we have built our business cases for our PR24 business plan, and how it aided our decision-making as well as providing the foundations for our enhancement cases. We have made substantial improvement to our process since PR19, including improving our certainty around how we assess investment benefit. The assumptions we have used are fully compliant with Ofwat, WINEP, WRMP and the HM Treasury Green Book methodologies. As well as seeing how we have used these methodologies for PR24 in the remainder of this section, we will provide a case study throughout to show these methodologies in practice. The same methodologies have also been used in developing parts of our Long-Term Delivery Strategy (LTDS). The approach presented has been independently assured and we have employed robust internal governance procedures for every stage of the process. Sensitivity analysis has been carried out where possible and the results factored into our decision-making.

The business case development process is shown in Figure 28Figure 27.

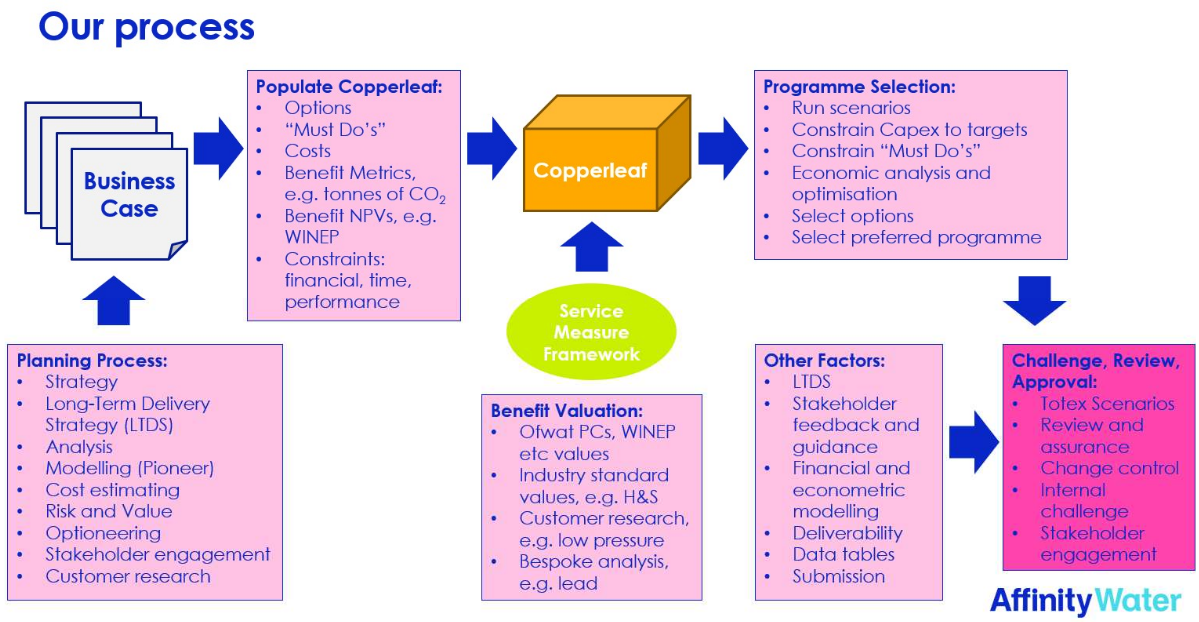


Figure 27 - Our Business Case Process, the Inputs and Outputs and Flow Through to Our TOTEX Plans.

4.4 Risk and Value process

4.4.1 Overview

Risk and Value (R&V) is a process that we apply throughout the asset investment planning cycle from the original need or risk recognition through to outline design and development of the detailed solution. Our R&V process identifies solutions that achieve efficiency savings through a structured process based upon an assessment of risk, opportunity, and proposed cost for mitigating the risk. R&V is applied to all areas of our investment programme.

The first phase of R&V is to fully determine the risks/opportunities for the service to our customers. Once a risk is fully defined, comprehensive root cause analysis is applied to determine the right source of the asset failures and the impact these have on the business/service.

R&V follows a defined and templated process to achieve robust, best value decision making. We have developed different R&V runways to apply the level of rigour and challenge appropriate to the risk and level of investment required. For example, our 'full' R&V process is delivered through facilitated face-to-face workshops with the relevant stakeholders and used to investigate the risks with the highest consequence costs and investment options, while our 'desktop' process is more agile and suits smaller investment needs. All runways follow the same five-step process, as presented in Figure 28.

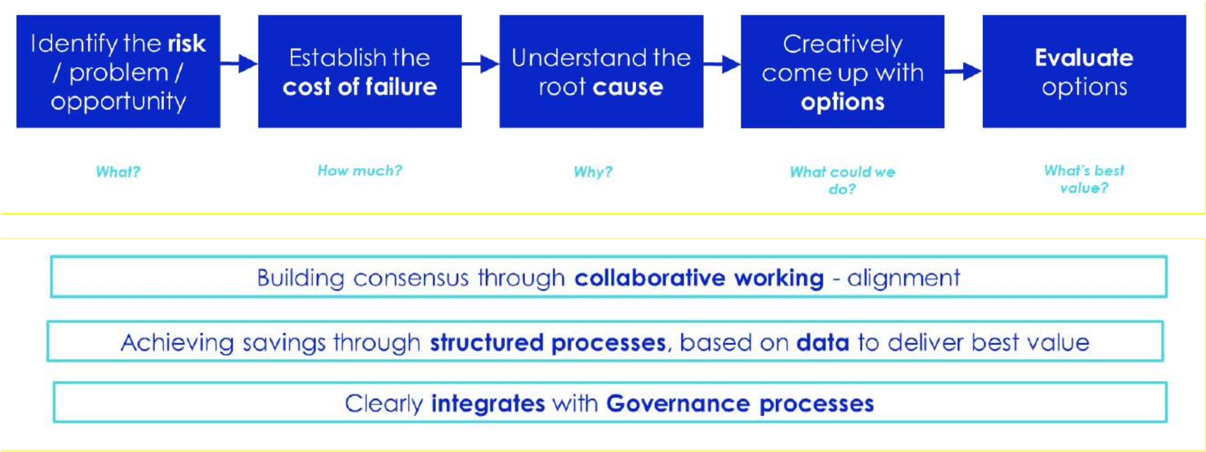


Figure 28: Our R&V process

4.4.2 Identify the risks

The objective of this step is to ensure that all workshop attendees have a shared understanding of the issue at hand. This includes the following:

- The nature of the issue
- The current state of the problem
- The potential impact of the problem
- Data analysis

4.4.3 Cost of failure

Our Opportunity and Risk Assessment summary tool is used to assess the risks associated with a particular risk or initiative. We use this tool to analyse the likelihood of different failure modes occurring, as well as the potential impact of those failures to our customer service. Impacts are monetised to enable an assessment of the risk cost and the value in mitigation.

4.4.4 Root cause

Bringing together relevant stakeholders who have connection to the asset and its impact on the operations, customers, environment, water quality, regulatory obligations etc. to collectively analyse and agree the root cause of the problem.

4.4.5 Solution Optioneering

Our optioneering identifies alternative solution options to fully or partially mitigate the identified risks and opportunities. The Whole Life Cost (WLC) and potential solutions are evaluated using techniques including historic cost outputs and our unit cost library, together with our subject matter experts' and supply chain insights.

The WLC is the total cost of owning and operating an asset over its lifetime. It is calculated by adding the initial capital expenditure to the operating expenditure over a time period of typically 25 years, to allow a common basis for assessment.

4.4.6 Option evaluation

Risk reduction scores and the risk index are two important metrics used to evaluate the options for mitigating risks.

The risk reduction quantifies the amount of risk that is removed by a given solution. It is calculated by subtracting the percentage of risk removed by the identified solution from the initial risk identified in the cost of failure section.

The risk index is a measure of the cost effectiveness of a proposed solution. It is calculated by dividing the WLC of the solution by its residual risk. It is used to compare different solutions to see which one is the most cost effective and therefore best value. The best value option is not always the cheapest WLC as the magnitude of risk reduction is a factor in the calculation. Each of our investment business cases propose lowest risk index solution, which is the best value option.

4.5 Our Approach to Economic Analysis

We continually develop and refine our approach to economic analysis as part of our business-as-usual approach to investment decision-making. We maintain an approach to economic analysis that is compliant with guidance from industry bodies including; Ofwat, the Environment Agency (EA) and HM Treasury. An economic analysis of our investment options is central to our business cases, and we ensure that these assessments are as accurate as possible at the time of decision-making. We follow a consistent approach to analysis for strategic planning (LTDS), business planning (our AMP8 Totex plan), and near-term planning (our investment plan).

Several parameters are kept consistent in our approach. For PR24 we have assumed:

- Weighted Average Cost of Capital: 2.92%
- Net Present Value (NPV) period: 30 years
- 2022/23 price base for all costs
- Consumer Price Index (CPIH) indices
- Depreciation Period: 45 years
- Industry Standard Consequence Values (e.g., Health & Safety)

We also employ several governance checks and steps to ensure consistent application of our Service Measures Framework and investment costs:

- Encourage conservative estimation of benefits and performance improvements, using data to support the benefit estimate as far as possible.
- Our economic analysis method is embedded within our decision support tool, Copperleaf, to ensure close control over parameters used.
- Detailed review and challenge sessions with a group of our people who are experienced in carrying out these assessments.

4.6 Case Study – River Catchment Restoration

4.6.1 Catchment and Nature-based Solutions (Including River Restoration) Programme Overview

In this section we will present a short case study for our Catchment and Nature-based Solutions (including River Restoration) Programme. This programme, like the rest of our Totex plan, has been through our rigorous option development and economic appraisal process.

- The need for this investment was established through existing statutory planning frameworks (in this case – the Water Framework Directive).
- Options were developed following the Water Industry National Environment Programme (WINEP) methodology and associated supporting driver guidance.
- Costs were built up and estimated using the tools and techniques discussed in Chapter 1 of this document.
- Benefits were evaluated using our Service Measures Framework and were inputted into our economic appraisal spreadsheet and Copperleaf solution.
- A summary document was then produced for presentation at challenge groups and PR24 steering committees.

4.6.2 Business Case Solution Option Selection

The river restoration programme was divided into catchment areas. Each catchment area has its own business case, which aims to provide solutions to issues specific to each area. The 'WINEP Dour and Little Stour Catchments' business case[6] can be used as an example of how the solutions have been developed, considered and compared throughout the business case development.

Initially 21 options were proposed, which included a combination of combination of land management focused C&NBS referred to as Resilient Chalk Catchments (RCC) and a river restoration / river improvement works options referred to as Revitalising Chalk Rivers (RCR). These options were then assessed and screened into three categories; Proceed, Reject or Clarify. Options that were rejected were due to them not meeting the Statutory and Non-Statutory requirements.

Of the initial 21 options, 7 options were proceeded through to the next round of assessment. In this round, each option was assessed as to whether it would meet the following criteria:

- Expected to meet statutory or non-statutory requirements.
- Contribute to the WINEP wider environmental outcomes.
- Technical Feasibility.
- Deliverability.

[6] (Affinity Water, 2023)

The results of the assessment are shown below within Table 18.

Option	Expected to meet statutory obligation(s) or meet non-statutory requirements	Contribute to the WINEP wider environmental outcomes *	Technically feasible	Deliverability
Resilient Chalk Catchments (RCC) C&NBS option B (Spatial targeting using SERT ProWater outputs and DWSP WQ heat maps)	N	YY	YYY	YYY
Revitalizing Chalk Rivers (RCR) option 1 - Standard (1 small and 1 large project on each river) and Resilient Chalk Catchments (RCC) C&NBS option B (Spatial targeting using SERT ProWater outputs and DWSP WQ heat maps)	Y	N	YYY	YYY
Revitalizing Chalk Rivers (RCR) option 1 - Standard (1 small and 1 large project on each river) and Resilient Chalk Catchments (RCC) C&NBS option C (Spatial targeting plus wider landscape measures upstream of River restoration (RCR) schemes)	Y	YY	YYY	YYY
Revitalizing Chalk Rivers (RCR) option 2 - Enhanced (1 small project and 1 large project on the Little Stour and 2 small and 2 large projects on the Dour) and Resilient Chalk Catchments (RCC) C&NBS option B (Spatial targeting using SERT ProWater outputs and DWSP WQ heat maps)	YYY	YY	YYY	YYY
Revitalizing Chalk Rivers (RCR) option 2 - Enhanced (1 small project and 1 large project on the Little Stour and 2 small and 2 large projects on the Dour) and Resilient Chalk Catchments (RCC) C&NBS option C (Spatial targeting plus wider landscape measures upstream of River restoration (RCR) schemes)	YYY	YYY	YYY	YYY
Revitalizing Chalk Rivers (RCR) option 3 – Enhanced + (delivering 3 small and 3 large projects on each river) and	YYY	Y	NN	NN

Resilient Chalk Catchments (RCC) C&NBS option B (Spatial targeting using SERT ProWater outputs and DWSP WQ heat maps)				
Revitalizing Chalk Rivers (RCR) option 3 – Enhanced + (delivering 3 small and 3 large projects on each river) and Resilient Chalk Catchments (RCC) C&NBS option C (Spatial targeting plus wider landscape measures upstream of River restoration (RCR) schemes)	YYY	YY	NN	NN

Table 18 – Seven Option Assessment for the Dour and Little Stour Catchment Solutions

The assessment of the seven solutions resulted in three scenarios that met the four criteria. The three feasible options which progressed through to further analysis were:

1. Revitalising Chalk Rivers (RCR) option 1 - Standard (1 small and 1 large project on each river) and Resilient Chalk Catchments (RCC) C&NBS option C (Spatial targeting plus wider landscape measures upstream of River restoration (RCR) schemes).
2. Revitalising Chalk Rivers (RCR) option 2 - Enhanced (1 small project and 1 large project on the Little Stour and 2 small and 2 large projects on the Dour) and Resilient Chalk Catchments (RCC) C&NBS option B (Spatial targeting using SERT ProWater outputs and DWSP WQ heat maps).
3. Revitalising Chalk Rivers (RCR) option 2 - Enhanced (1 small project and 1 large project on the Little Stour and 2 small and 2 large projects on the Dour) and Resilient Chalk Catchments (RCC) C&NBS option C (Spatial targeting plus wider landscape measures upstream of River restoration (RCR) schemes).

The costs and benefits of each option was then assessed and compared, to then decide which option was to be continued. This was completed using an economic assessment, with the benefits being weighed up against cost by using the service measure framework. The resulting 4 options were:

Option 0 – Do Nothing

Option 1 – Preferred Option (Revitalizing Chalk Rivers (RCR) option 2 - Enhanced (1 small project and 1 large project on the Little Stour and 2 small and 2 large projects on the Dour) and Resilient Chalk Catchments RCC C&NBS option C (Spatial targeting plus wider landscape measures upstream of River restoration (RCR) schemes).

Option 2 – Least Cost Option (Revitalizing Chalk Rivers (RCR) option 1 - Standard (1 small and 1 large project on each river) and Resilient Chalk Streams (RCC) C&NBS option C (Spatial targeting plus wider landscape measures upstream of River restoration (RCR) schemes).

Option 3 – Alternative Option (Revitalizing Chalk Rivers (RCR) option 2 - Enhanced (1 small project and 1 large project on the Little Stour and 2 small and 2 large projects on the Dour) and RCC C&NBS option B (Spatial targeting using ProWater outputs and DWSP WQ heat maps).

The costs and benefits of this business case is then inputted into Copperleaf, as explained later within the cost appendix, for the options to be 'weighed up' against the other business cases to ensure that we have an optimal portfolio of investments for PR24.

4.6.3 Benefit Assessments

We have focused our benefit quantification on the use of the WINEP environmental and community benefit metrics and have used the associated benefit valuations published in the WINEP methodology.

We screened each feasible option to understand the potential benefits. These are captured in the following table and then used in the analysis. The benefits are either monetised if they are WINEP benefits, or not monetised if not. This is shown below in Table 19.

Benefit	Commentary
WINEP Benefits	
Biodiversity	Considered but not measured
Water purification by habitats	Not applicable
Water quality	Monetised as per WINEP and impacted by the river restoration investments
Water supply	Not applicable
Climate regulation	Monetised as per WINEP and impacted by the natural capital investments
Recreation	Applicable but not monetised
Recreation – angling	Applicable but not monetised
Food – shellfish	Not applicable
Air quality	Monetised as per WINEP and impacted by the natural capital investments
Hazard regulation – flood	Applicable but not monetised
Volunteering	Applicable but not monetised

Education	Applicable but not monetised
Other Benefits	
Food production (ha)	Applicable but not monetised
Livestock (dairy and meat) (ha)	Applicable but not monetised
Timber production (ha)	Applicable but not monetised
Social health (ha)	Applicable but not considered

Table 19 - Benefits Considered During the Development of the Business Case

The catchment and nature-based solutions considered are shown in Table 20 below.

Outcome	Option	Included
Option includes a catchment and nature-based solution	**Preferred Option**	**Yes**
	Least Cost Option	**Yes**
	Alternative Option 1	**Yes**
	Alternative Option 2	**N/A**

Table 20 - Catchment and Nature Based Solutions Considered

We have also considered other benefits such as cost savings, and other performance metrics where they are applicable. In most cases we have not attempted to monetise the additional benefits for two reasons: firstly, to ensure no double counting of benefits; and secondly, because many of these are difficult to quantify. We have however discussed these qualitatively in our assessment.

The supporting metrics for the benefits quantification have been determined using the WINEP methodology or based on an assessment of studies from similar projects. In some areas, we have had to estimate the metrics. If these have a material impact on the analysis, then we have undertaken sensitivity studies. Where the benefits are less material, we have, where possible, qualitatively assessed the benefits rather than include them in the economic analysis.

For each benefit, we have considered the timing of the benefit realisation and duration of the benefits over time. For example, is there is any lag before the benefit will start to materialise? Is there is a phased benefit realisation? And will the benefits diminish over time? As such, we have developed a profile for each benefit over time.

For the river water quality improvement valuations, we have used the original source data values for specific rivers, rather than the averaged values quoted in the WINEP methodology. This is because the rivers that we are restoring are unique in nature and therefore of higher environmental value to society.

5. Portfolio Optimisation

5.1 Overview

A key element of our Totex plan development methodology is cross-portfolio optimisation, which entails the optimisation of options for investments between numerous portfolios as a part of the over-arching Business Plan. This ensures that the proposed Plan is affordable to customers, satisfactory to stakeholders and that investment is optimally balanced between risk, cost, and value across both infrastructure and non-infrastructure. The tools and methodologies that we have used to develop our optimally balanced and thoroughly challenged Totex plan are described in this section.

5.1.1 Whole-Life Cost Assessment

We have completed Net Present Value (NPV) calculations to assess options and select efficient, best-value whole-life solutions through our business case development process. Each business case 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. Further details on the NPV approach used during the portfolio optimisation can be found within Section 4.4.

5.1.2 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.

5.1.3 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 econometric 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.

To further ensure consistent assessments of the business cases, and to avoid bias in the decision-making process, the plan has undergone scrutiny from external stakeholders, such as audits by Atkins and Baringa.

5.1.4 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 contribute to, 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 and aligns with the long-term delivery strategy.

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. The weightings are only used to aid strategic mapping and do not affect the NPV/CBA assessments. 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 investment programme impacts. It has also enabled us to ensure that the achievement of each PC is supported by relevant investment.

5.1.5 Risk Assessment

To understand the deliverability of the Totex plan and to test the optimum balance of expenditure across programmes, we have assessed the risk of not delivering an investment at a programme, sub-portfolio, and portfolio level. The first step in this exercise was to determine the relative impact of the various planned investment programmes.

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.

5.1.6 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 e.g., if 100%, 75%, 50%, etc., of the preferred funding was made available. PR24 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.

5.1.7 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.

5.1.8 WRMP Economic Modelling

The WRMP produces enhancement expenditure required to maintain the supply demand balance (SDB) from 2025/26 to 2074/75. To ensure the supply demand deficits are met in all zones, under a range of likely future scenarios, a regional adaptive model was developed by Water Resources Southeast. To determine the most suitable sequence of options to meet the SDB, while also meeting the Water Resource Planning Guidance, throughout the planning period, Best Value Planning practices were adopted.

The 'least cost' programme that is generated by the model is based on the use of a Genetic Algorithm to find the lowest NPV solution across all the potential futures, whilst including a common pathway until key adaptive points in 2035 and 2040. The Best Value Planning methodology then incorporates numerous metrics such as Cost, Carbon Costs, Resilience etc. to select the most appropriate supply and demand schemes. Further sensitivity testing takes place at a regional level to ensure the suitability of the strategy. The selected schemes are further developed through peer reviewed business cases and subjected to the same tests and challenges as all other business cases.

5.1.9 PIONEER

We have optimised our capital maintenance investment by using PIONEER. The methodology is described in detail in Section 3.3.

5.1.10 Copperleaf

Using the results from PIONEER, Net Present Value from the economic assessments and benefits for each business case, we have used Copperleaf to optimise our portfolio. The details of this are explained within the following section, Section 6.

6. Copperleaf

6.1 Overview

The following section details the processes and procedures in how we have used Copperleaf Portfolio (CP) to support investment decision making for Affinity Waters PR24 Business Plan.

6.1.1 Copperleaf Portfolio Overview

CP is an investment decision support tool which is used to conduct a cross portfolio optimisation. Our aim is to search for the best combination of investments, alternatives and timings that meet our long-term objectives of cost, performance, and risks.

CP achieves the cross-portfolio optimisation by conducting a Total Net Present Value Calculation (NPV) for each alternative associated with an investment need, which is then double discounted as per Ofwat/NJUG CBA method. This calculation is defined below in Equation 5.

$$\textit{Investment Value (£)} = \textit{NPV (Costs – Benefits)}$$

Equation 5 – Calculation for the Investment Value

Investment costs used in this optimisation were whole life Capex and Opex associated with the Capex intervention. Base Opex costs have not been considered in this calculation.

The benefits for each investment are assessed for the whole life of the asset. They are calculated from converting risks or benefits into a common monetary currency which then allows service measures of dissimilar metrics to be scored against each other. These calculations stored in each value model and are not available to the evaluator. Value models are stored and configured within the CP Value framework. This means that there is no bias against any investment and that costs and benefits have been combined to give a total NPV.

6.1.2 Copperleaf Optimisation Focus

The portfolio being optimised includes all the investment needs and associated alternatives with competing benefits from across the business including base and enhancement investments. The portfolio, defined by the PR24 team, was agreed, and formed as detailed in the previous section.

The portfolio is usually placed into various planning groups which will determine whether the optimiser will be applied to them, this is for ease of management of the portfolio and to separate those non-discretionary. Such as accelerated programs with committed spend or contractually tied. Each scenario run will have its own definition of the planning groups, which will help set up the constraints of the scenario. For instance, for a leakage focused scenario, leakage investments or those delivering on leakage benefits will be labelled 'leakage mandated projects, and 'mandated, such that they must be completed to meet our leakage ambitions and vice versa.

6.1.3 Base Investment Portfolio

Capital maintenance investments have been modelled and tested across a range of scenarios in PIONEER as detailed in the previous section. Outcomes (Intervention costs, service performance outcomes, cost of failure etc) of the various scenario runs have been replicated in copperleaf and tested across the entire portfolio. Other Base investment needs not arisen from PIONEER runs, such as ARM, scheme builder and long-term known investment options are all also replicated in copperleaf, though populated CBA sheets, R&V impact costs and expert judgement from subject matter experts.

6.1.4 Enhancements Investment Portfolio

Cost benefit analysis for all options associated with enhancement schemes are conducted outside of copperleaf. Their expenditure and benefits valuations have been replicated in CP to allow for analysis. Enhancement schemes will be mandated as they are typically optimised with the relevant regulatory body and subsequently prescribed such as WINEP and the WRMP through consultations etc. Although these will be included in CP for analysis of the entire portfolio.

6.1.5 Optimisation Algorithm and Example

The optimiser is designed to find the combination of investment alternatives and start dates with the highest possible value, which also meets the constraints that have been set.

When a scenario is optimised the first thing that is calculated is the total whole life investment value for all possible alternatives and start dates. The optimiser will then compare all the different combinations and begin eliminating combinations with a lower value, until a single solution with the highest value which meets all the constraints is found. This result is and must be deterministic, meaning no matter how many runs a scenario is optimised (with the same inputs and constraints), the same answer will be produced, otherwise the optimisation would fail.

It is useful to understand how the optimiser works for the benefit of those trying to understand the outputs of an optimisation. Take a scenario where you only have one constraint: maximum yearly Capex investment expenditure for a number of years. However, your original portfolio plan might exceed this value in some years and underspend in other years. By setting this constraint and optimising you are effectively allowing the optimiser to propose a different project start date from the original plan and thus when spend occurs. Additionally, the optimiser may also select a different alternative or investment route entirely, if necessary, for example, to select a lower cost option as opposed to the submitted plan. A successful optimisation will save the outputs to a new scenario, different to the original plan which is used for comparison of the different aspects of each scenario, i.e., expenditure, total value, service performance levels etc.

The optimiser has been set up to alter the start dates of the investments to a monthly resolution. Where Capex forecast is only yearly, the optimiser would distribute the spend linearly across the year.

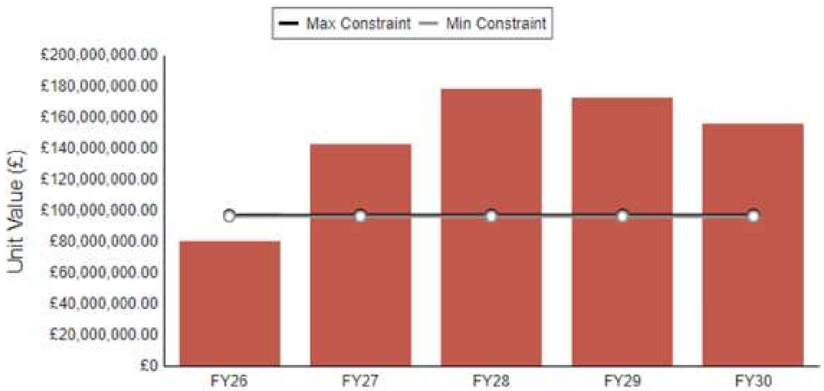


Figure 29 – Non-Optimised Portfolio with Capex Exceeding Constraints

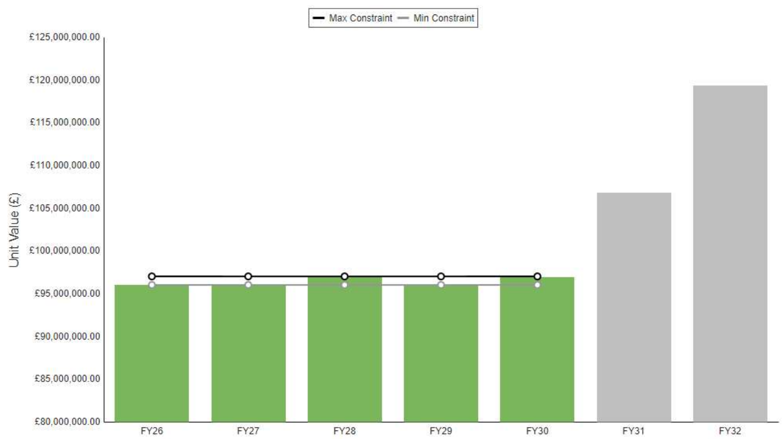


Figure 30 - Successfully Optimised Portfolio with Capex Within Target Condition and Deferred Expenditure

Figure 29 shows an example Capex forecast for each year in an un-optimised example, with expenditure clearly exceeding in FY27,28,29 and 30 But underspending in FY25. Figure 30 shows how the optimiser has deferred investments and brought forward investment to meet Capex constraints in all years that constraints are set. It also demonstrates how the monthly resolution allows the optimiser to successfully optimise to a tight envelope. Please note this simple example is included to show the optimisation process and does not represent a 'real' scenario for the development of our PR24 plan.

6.1.6 Copperleaf Constraints

Setting a constraint on a portfolio is the cornerstone of an optimisation process and is what fundamentally sets it apart from a simple prioritisation process (to rank a list of investments from best value to least value). Typically, a set of constraints will be used to define the conditions the optimiser must satisfy to successfully optimise. The outcome of optimised scenarios is a combination of investments alternatives and start dates that best satisfy the conditions set. This may not necessarily include the highest valued investments solely (which produces the highest value) but should instead consider all the available value measures/metrics that the investment has. It is important to note that finding the highest value then becomes the secondary objective when enforceable constraints are set. A fundamental example of a constraint could simply be a yearly investment budget we must not exceed as mentioned above, however in real life scenarios, there are usually, various, sometimes contradictory set of constraints which results in more complex optimisations. Constraints can be applied yearly, monthly, or cumulatively.

Despite this, it is also a useful exercise to conduct an unconstrained scenario optimisation to understand the implicit behaviours of the portfolio, which is hidden once constraints are set. This would then give you a further understanding which may initiate more scenario optimisations due to the need to understand the portfolio from another perspective. It is useful to understand here, some of the scenario constraints used in the optimisations later discussed. The constraints used for the scenarios are shown within Table 21.

Constraint	Value Measure (Units)	Target Condition
End of AMP 8 Capex Cumulative expenditure	£/AMP	Min/Max
Yearly Capex expenditure	£/Year	Min/Max
Water Demand Reduction (Leakage, PCC, Business)	Ml/d	Min
Mains Bursts	Number/Year	Max
Interruption To Supply	Minutes Per Property	Max
Environmental Benefits	Value (£) /Year	Min
Recreational Net Gain	Value (£) /AMP	Min
Water Quality CRI, ERI	Score	Max

Table 21 - Examples of Constraints Used for The Scenarios

6.2 Value Framework

6.2.1 Value Models

The CP value framework comprises of 27 value models, each computing background calculations with relevant formulas necessary to calculate the risk, value and/or service measure outcome, private consequence costs and social value which all contributes to the total net value calculation. Each value model is also mapped to a 6 Capitals category which can then be used to report in the IRCC standards. Please see Table 21 for an outline of the value measures that are available in CP.

6.2.2 Valuation of Risks and Benefits

This requires the business case owner and subject matter expert to provide the relevant information required to answer the questions stipulated by the value models impacted by their investment. Value calculated is based on the change in risk following the completion of the investment and is evaluated over whole economic life of the asset. Following the initial evaluation process, each investments risk and value is peer reviewed and adjusted by the investment programme team alongside members of Affinity Water's executive. This is to ensure that the evaluations are coherent and consistently assessed across the portfolio.

6.2.3 Value Lenses Perspective

As above, private, and social values are computed for each value model in CP. During the defining stages of the optimisation process, it is necessary to define what perspective the optimiser should consider. For the PR24 planning, the 'regulatory' lens, which considers private and social value has been used. Private consequence costs are based on directly incurred costs to the business and are modelled based on historical data and significance to the business. These costs are managed and updated by the cost and value team and are entered into copperleaf. Social costs where available are provided by the relevant organisations such as ICS, Owat and WINEP. The library of private and social costs is held in a document named service measure framework (SMF) manged by the PR24 team. It is important to note that PIONEER, R&V and CBA workbooks all share the same private and social costs values. This ensures that the value analysed across the different processes and workstreams are all aligned.

6.2.4 Example Value Model Calculation

The inputs required for a value calculation is a combination of investment specific questionnaire answers, system configured values, such as consequence unit cost rates and location specific system values, such as the output in ML/d of a specific site.

Q1. How many events per year?

Q2. How many properties impacted by these interruptions?

Q3. What is the expected duration (in minutes) of these interruptions?

Water Supply Interruptions [mins] = A1 * A2 * A3

Water Supply Interruptions [min/property] = Water Supply Interruptions [min] / Total Company Properties**.** If duration < 180 mins, then value service measure is zero.

Water Supply Interruptions – Societal [£] = Water Supply Interruptions [min] * Societal Interruption Cost [£/min]

Water Supply Interruptions – Private [£] = Water Supply Interruptions [min] * Consequence unit Cost [£/min]

Manufactured Capital [£] = Water Supply Interruptions – Societal + Water Supply Interruptions – Private

The details of the Suite of Value Models Available in CP Value Framework are shown within Table 22.

Value Model	Description	Six Capitals
Financial Risk	Captures arbitrary directly incurred financial value	Financial
Safety Risk	Health and Safety risk, aligned to HSE risks and hazard suggested impact	Human
C-MeX and D-MeX and BR-MeX	Complex models capturing Ofwat various measure of experience performance commitments	Social
Compliance Risk Index (CRI), Event Risk Index (ERI)	Complex models capturing DWI water quality measures	Social
Employee Experience Benefit	Drop down menu with various of impact on employee productivity and talent acquisition	Intellectual
Embodied Carbon, Operational Carbon	Carbon impact in TCO2e, unit benefit values are profiled with values suggested in BEIS	Natural
Per Capita Consumption (PCC), Business Demand, Leakage Reduction	Three separate simple models, capturing water demand reduction in Ml/d	Natural
Mains Repair	Captures the number of mains repairs required on the network	Manufactured
Risk of Severe Restrictions During Drought	Evaluates the impact on a population, during a drought event	Social
Interruption to Supply	Complex model obtaining the minutes of interruption per company population	Manufactured
Unplanned Outage	Assesses the water production impact of a site-specific location	Social
Abstraction Reduction	Impact on exceeding abstraction license	Natural
Natural Capital Net Gain	Simple value model capturing the Natural capital net gain benefits	Natural
Recreation Net Gain	Simple value model capturing social value in improved recreational activities	Social

Value Model	Description	Six Capitals
Social Health Net Gain	Simple value model capturing all social health benefits	Human
Business Continuity Benefit	Captures the impact in the company's ability to operate during an emergency event	Human
Disruption	Simple value model capturing the impact of traffic and related disruption	Social
Customer Contacts for Water Quality Aesthetics	Impact of dealing with complaints in the	Social
Average Time Properties Experience Low Pressure	Simple model appraising the impact on average time customers received low pressure per company property	Manufactured
Biodiversity	Simple value model capturing the biodiversity net gain per unit	Natural

Table 22 - Details of the Suite of Value Models Available in CP Value Framework

6.3 Procedure

The steps describe how Copperleaf fits within the wider invest planning process. As CP is being used as an optimiser for a developed plan, the CP procedure falls at the end of the investment planning procedure, as shown below in Figure 31. An explanation of each of these process numbers can be found following the Figure.

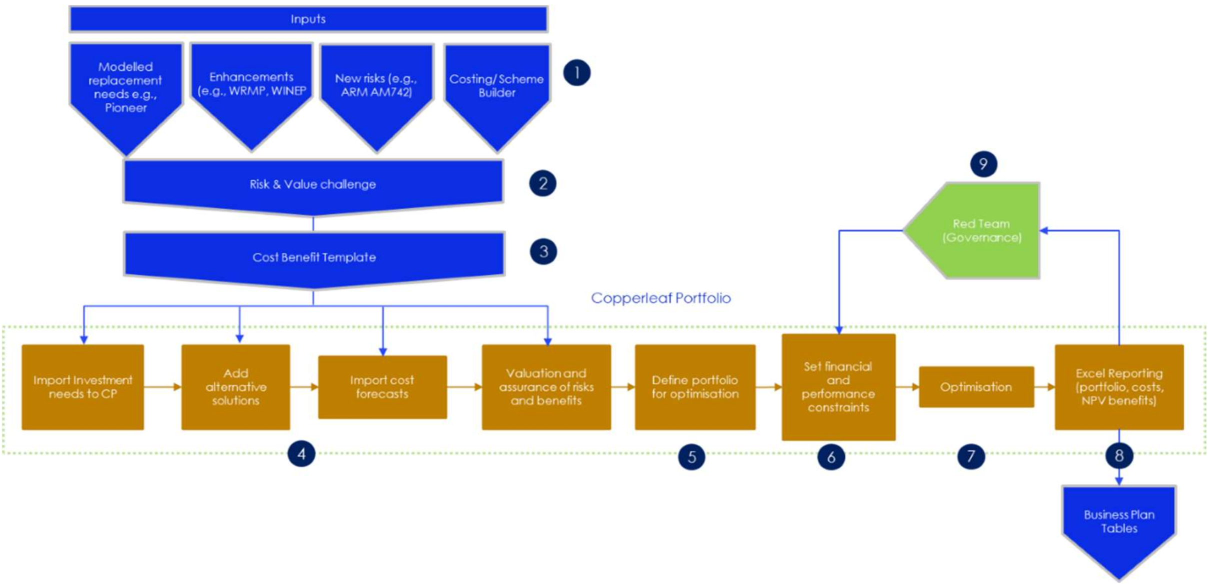


Figure 31 - Copperleaf Procedure (Coloured Bronze) within the wider investment planning process

6.3.1 [1] Investment Needs

Business cases for investment have been developed by individual business case owners. These may arise from prescriptive methodologies defined by regulators, such as the Water Resources Management Plan or WINEP methodology, or modelled outputs from capital maintenance planning e.g., PIONEER, or emerging risks/opportunities. Solution options set out in each of the business cases are costed (including initial Capex, Opex, capital maintenance etc).

6.3.2 [2] Risk and Value Process

Each business case has undergone a risk and value (R&V) challenge. This may be a formal structured risk and value workshop, or an evaluation of root cause, alternative options and costs and benefits. Subsequent rounds of risk and value challenges have been required following 'red' team reviews (see item 9) of early drafts of some business cases to strengthen the case for investment and identify more options.

6.3.3 [3] CBA Template

A cost benefit analysis template, populated by the SAM team in conjunction with business case owners, has been completed for every enhancement project or programme in the investment portfolio. These contain cost forecasts of capital and operational expenditure, and an evaluation of benefits against our suite of performance measures, plus additional measures required by the EA, for every alternative solution to the need. Each line of expenditure or cost saving will be allocated a Table, line number, financial year, business unit and enhancement driver. The CBA template was developed by the Copperleaf Team with SAM and to allow automated import into Copperleaf Portfolio (CP).

In the cases of base investments, particularly with capital maintenance, these would not have an associated CBA sheet, because the investment data would have come from PIONEER outputs indirectly. I.E., investment cost forecasts and service measure outcomes, for a given scenario defined in PIONEER and converted and aligned into the CP Value Models in the CP Value Framework.

6.3.4 [4] Investment Data Input

Details of the investment need, each alternative solution and forecast of Capex and Opex along with valuation of risks and benefits have been imported or added into CP. Base Investment forecasts were imported directly into CP by the Copperleaf team using a bulk loading template based on the 'Lumpy Capex' workbook supplied by SAM. Valuations of base investments were based on from business cases and R&V outputs and entered manually.

6.3.5 [5] Including 6,7,8,9 Optimisation Outputs and Review Process

At this stage investment should be approved for inclusion into a portfolio with all the previous input's steps having been reviewed. A scenario will then pick up the portfolio being considered. Investments within the portfolio will then be placed into various planning groups with optimisation rules placed on each group, including to optimise or whether it is a must do investment.

Affordability and performance constraints are now placed on the scenario before the optimisation will be run to find the highest value combination of investment start dates and alternatives which meet the performance and affordability targets. In the PR24 optimisation runs affordability and performance constraints have been placed on AMP8 years; however, CP will consider the total investment value double discounted using the WACC and STPR rates over the life of the asset. Which means that longer term benefits are still considered, even though constraints are only focused on interventions starting in AMP 8.

Multiple outputs were reviewed by the ‘red’ team comprising experienced executives and subject matter experts, who challenged the results and consider which mix of benefits provides the best value, lowest cost, and alternative portfolios.

Further optimisation with revised constraint levels following the review process might be required and steps 5-9 repeated until a scenario that has the correct expenditure amounts, alternative options and benefits outcomes is found. Following this, Standard Microsoft Excel reports are run to export the results of the scenario costs and benefits over 30 years to align with the Ofwat tables.

6.4 Scenarios

6.4.1 Initial Base Scenarios

Initial testing was conducted for eight different performance preferences set at four different affordability levels, giving a total of thirty-two different scenarios. The outcomes for these scenarios have been outlined in Table 23 below. Due to the large numbers of optimisations conducted, initial testing was placed on the Base Investments portfolio consisting of eighty investment lines. Enhancement investments was added to the portfolio after a recommended portfolio was concluded.

6.4.2 Affordability

Based on preliminary runs without performance constraints, it was agreed that £390m, £420m, £450m and £480m base Capex was a suitable basis. Yearly base Capex constraints were applied with a minimum and maximum target to create a target envelope of £2m. This was suitable as for a large majority of projects fall between the £500k and £1.5m Capex forecast. This is to ensure that there is enough movement and highest chance of successful optimisation as possible. A flat-line target was used (Capex constraint/5 years) to ensure a bill friendly profile. The details of the scenarios run are shown in Table 23.

Scenario Name	Description/Objective	Capex Constraints
1. Low Pressure	Mandate all investment projects contributing to our low-pressure target but allowing CP to choose any alternative.	
2. WQ Customer contacts Aesthetics	Mandate all investment projects which contributes to lowering the number of customer contacts received due to WQ Aesthetics. Allow CP to choose best alternative.	
3. Mains Bursts	Mandate all investment projects impacting mains repairs caused by mains burst for the lowest cost option for the lowest Capex constraint but allow CP to decide other alternatives for all other Capex constraints.	
4. C-MeX	Mandate all investment projects which contribute to C-MeX benefits and allow CP to choose best alternatives for all constraints.	
5. Leakage	Mandate all investment projects which contribute to leakage reduction and allow CP to choose best alternatives for all constraints. Note Enhancements will have contributions to this performance.	£390m, £420m, £450m and

Scenario Name	Description/Objective	Capex Constraints
6. Interruptions to Supply	Mandate all investment projects contributing to I2S benefits. Allow CP to select alternative.	£480m @ ± £1m
7. CRI	Mandate all CRI investments and allow CP to select any alternative, regardless of the costs.	
8. Unplanned Outage	Mandate all CRI investments and allow CP to select any alternative, regardless of the costs.	

Table 23 - Details of The Scenarios Run for the Base Portfolio

6.4.3 Constraint Settings

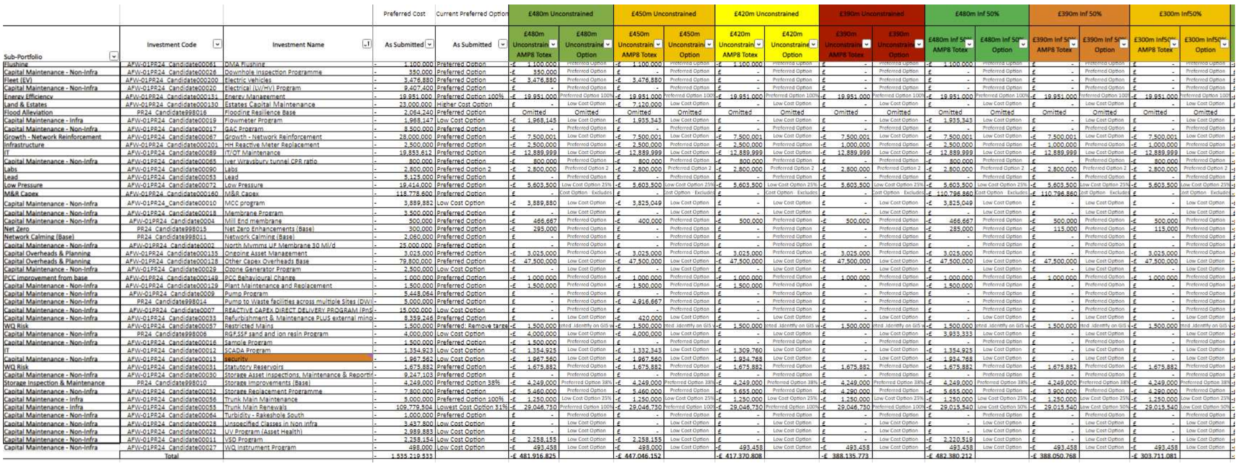
Given the basic optimisations performed at this stage (singular constraints), constraints on Capex were set to enforceable for all scenarios. This is the most stringent level of optimisation and must be satisfied to successfully optimise. Relaxed or override rules were used at a later stage where more than one constraint was used.

6.4.4 Sensitivity Analysis

Following the initial runs based on yearly Capex constraints with a £2m envelop, this was increased to £4m to assess the sensitivity of the outputs. Yearly Capex constraints were also changed to end of AMP cumulative spend to understand the significance of the Capex profile across AMP 8.

6.5 Optimisation Results

Each scenario objective was successfully optimised, and the results tabulated into excel sheets and analysed. Scenarios with and without specific performance and Capex based preferences have been run, and depending on the Capex constraints, a proportion of the portfolio will fall outside of the optimised plan (deferred). Where schemes have not been selected in their respective scenarios, their start dates have been deferred and pushed into AMP 9 with a start date showing 1st April 2031 on the outputs.



Sub-Portfolio	Investment Code	Investment Name	Preferred Cost As Submitted	Current Preferred Option As Submitted
Flushing	AFW-01PR24_Candidate00061	DMA Flushing	1,100,000	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00026	Downhole Inspection Programme	350,000	Preferred Option
Fleet (EV)	AFW-01PR24_Candidate000200	Electric Vehicles	3,476,880	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00020	Electrical (LV/HV) Program	9,407,400	Preferred Option
Energy Efficiency	AFW-01PR24_Candidate000131	Energy Management	19,951,000	Preferred Option 100%
Land & Estates	AFW-01PR24_Candidate000130	Estates Capital Maintenance	23,000,000	Higher Cost Option
Flood Alleviation	PR24_Candidate998016	Flooding Resilience Base	2,064,240	Preferred Option
Capital Maintenance - Infra	AFW-01PR24_Candidate00019	Flowmeter Program	1,968,147	Low Cost Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00017	GAC Program	8,500,000	Preferred Option
Growth - Network Reinforcement	AFW-01PR24_Candidate00067	Growth - Network Reinforcement	28,000,000	Preferred Option
Infrastructure	AFW-01PR24_Candidate000201	HH Reactive Meter Replacement	2,500,000	Preferred Option
IT	AFW-01PR24_Candidate00089	IT/OT Maintenance	19,853,612	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00065	Iver Wraysbury tunnel CPR ratio	800,000	Preferred Option
Labs	AFW-01PR24_Candidate00090	Labs	2,800,000	Preferred Option 2
Lead	AFW-01PR24_Candidate00053	Lead	5,125,000	Preferred Option
Low Pressure	AFW-01PR24_Candidate00072	Low Pressure	19,414,000	Preferred Option
M&R Capex	AFW-01PR24_Candidate000160	M&R Capex	118,778,600	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00010	MCC program	3,889,882	Low Cost Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00018	Membrane Program	3,500,000	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate0004	Mill End membrane	500,000	Preferred Option
Net Zero	PR24_Candidate998015	Net Zero Enhancements (Base)	300,000	Preferred Option
Network Calming (Base)	PR24_Candidate998011	Network Calming (Base)	2,060,000	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate0002	North Mymms UF Membrane 30 Ml/d	25,000,000	Preferred Option
Capital Overheads & Planning	AFW-01PR24_Candidate000135	Ongoing Asset Management	3,025,000	Preferred Option
Capital Overheads & Planning	AFW-01PR24_Candidate000128	Other Capex Overheads Base	79,800,000	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00029	Ozone Generator Program	2,500,000	Low Cost Option
PCC improvement from base	AFW-01PR24_Candidate000149	PCC Behavioural Change	1,000,000	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate000129	Plant Maintenance and Replacement	1,500,000	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate0009	Pump Program	5,448,064	Preferred Option
Capital Maintenance - Non-Infra	PR24_Candidate998014	Pump to Waste facilities across multiple Sites (DWI	5,000,000	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate0007	REACTIVE CAPEX DIRECT DELIVERY PROGRAM (PnS	15,000,000	Low Cost Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00033	Refurbishment & Maintenance PLUS external mino	8,359,246	Preferred Option
WQ Risk	AFW-01PR24_Candidate00057	Restricted Mains	1,500,000	Preferred: Remove targe
Capital Maintenance - Non-Infra	PR24_Candidate998006	RGF,SSF sand and ion resin Program	4,000,000	Low Cost Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00016	Sample Program	1,500,000	Preferred Option
IT	AFW-01PR24_Candidate00012	SCADA Program	1,354,923	Low Cost Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00013	security	1,967,562	Low Cost Option
WQ Risk	AFW-01PR24_Candidate00031	Statutory Reservoirs	1,675,882	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00030	Storage Asset Inspections, Maintenance & Reportir	9,247,103	Preferred Option
Storage Inspection & Maintenance	PR24_Candidate998010	Storage Improvements (Base)	4,249,000	Preferred Option 38%
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00032	Storage Replacement Programme	7,800,000	Preferred Option
Capital Maintenance - Infra	AFW-01PR24_Candidate00056	Trunk Main Maintenance	5,000,000	Preferred Option 100%
Capital Maintenance - Infra	AFW-01PR24_Candidate00055	Trunk Main Renewals	109,779,504	Lowest Cost Option 31%
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00064	Turbidity - Rakeshole South	1,000,000	Preferred Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00028	Unspecified Classes in Non Infra	3,437,800	Low Cost Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00022	UV Program (Asset Health)	2,989,883	Low Cost Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00011	VSD Program	2,258,154	Low Cost Option
Capital Maintenance - Non-Infra	AFW-01PR24_Candidate00027	WQ Instrument Program	498,000	Low Cost Option
	Total		1,535,219,533	

Figure 32- Example Raw Data Output Following the Successful Optimisation Runs

Performance outcomes and selected schemes for each scenario were presented in a similar format shown in Figure 32. The PR24 team alongside experienced members of the board have evaluated the findings.

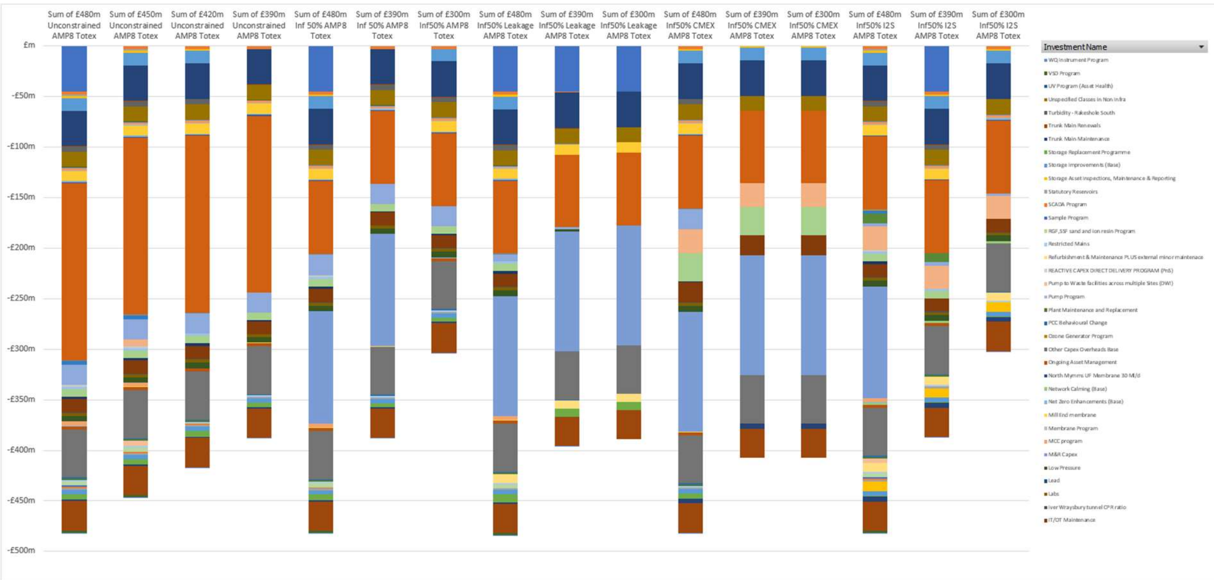


Figure 33- Pivot Table Showing the Make-Up of The Selected Schemes of Each Scenario in Comparison to An Unconstrained Scenario

Figure 33 was constructed to allow for an efficient view of various constraints and breakdown of each optimised portfolio. Non-cost-effective programmes such as capital maintenance projects are generally deferred the most, which is not unexpected since the optimisation value looks to maximise value.

Following the completion of the initial base runs, prescribed enhancement investments were added to the portfolio, where we can then get a full view of the benefits that any of the scenarios are expected to deliver in AMP 8.

Figure 34- Example of The AMP 7 Service Measure Outcomes Expected from A Particular Scenario Created Using Microsoft Powerbi with The Outputs of The Scenario.

CP has supported the development of the PR24 base portfolio by providing the basis required in making an informed decision particularly with finding the balance between cost, performance, and service risk across the entire portfolio under different scenarios. It has in many ways, been used to confirm our understanding of our initial portfolio developed prior to optimisation. But has also brought several new perspective and subsequent discussions to more complex questions, following the evaluation of the CP outputs provided by the executive team and those with expert knowledge of the portfolio. CP requires a continuous iteration of input and output between what the company wants to understand and what CP requires to do so.

7. Bibliography

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8. Figures

9. Tables

10. Equations