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The potential role and design of asset risk metrics for water infrastructure asset health

Working paper (sponsored by Northumbrian Water)

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Summary

Background

Last year, Reckon produced a report for a group of water companies, which identified a set of concerns with Ofwat's regulatory approach to asset health investment, and considered potential reforms to address these concerns as part of the PR29 price review process. As a targeted follow-up to that report, this working paper considers the potential role and design of risk metrics for water and wastewater assets, building on the methodology for network asset risk metrics (NARMs) developed by Ofgem for energy network infrastructure in Great Britain.

In this working paper, we use the term "monetised asset risk metric" to refer to the type of metric used by Ofgem. Monetisation of risk is a key feature of Ofgem's NARM methodology, which enables different types of risk to be put into a common currency, for the purposes of aggregation into a company-level metric.

During our work last year, as our thinking evolved, we came to the view that developing monetised asset risk metrics for water and wastewater systems could bring two broad types of benefit for the economic regulation of water companies. First, the metrics themselves, once produced, could be used directly within the regulatory framework. In particular, they could play one or more of the following roles:

- As the basis for sophisticated forms of price control deliverables (PCDs) along the lines of the approach pioneered by Ofgem for energy network companies, with price control funding conditional on the delivery of specified amounts of reduction in asset risk.
- To enhance the information available on future risks relating to asset health, and water companies' management of these risks (and in turn to better align the financial and reputational incentives that water companies face with long-term performance and investment).
- As a key source of evidence to improve Ofwat's approach to price control cost assessment.

In addition to these specific roles, we also thought that the *process* to develop monetised asset risk metrics would bring broader indirect benefits for regulatory practice within the industry — for example by increasing the attention given to, and knowledge generated about, asset health and associated risks to outcomes and by spurring on the collection, organisation and interpretation of relevant data.

One of the next steps that we identified for the Infrastructure Health project was to start to develop arrangements for reporting asset risk metrics, drawing on Ofgem's NARM approach. This will need to involve detailed engineering and asset management expertise. We have sought to provide a foundation for that work through a number of actions that are intended to bridge the regulatory policy design work with the practical modelling of water infrastructure asset risk.

More specifically, in this working paper we have sought to:

- Clarify and elaborate on the key roles for monetised asset risk metrics for regulatory purposes.

- Identify a set of desirable features of these metrics, and the methodology used to produce them, taking account of the regulatory roles identified above.
- Specify the high-level modelling components that need to be developed to produce monetised asset risk metrics for water and wastewater assets.
- Identify how the metrics developed for water sector assets might differ from those used by Ofgem.

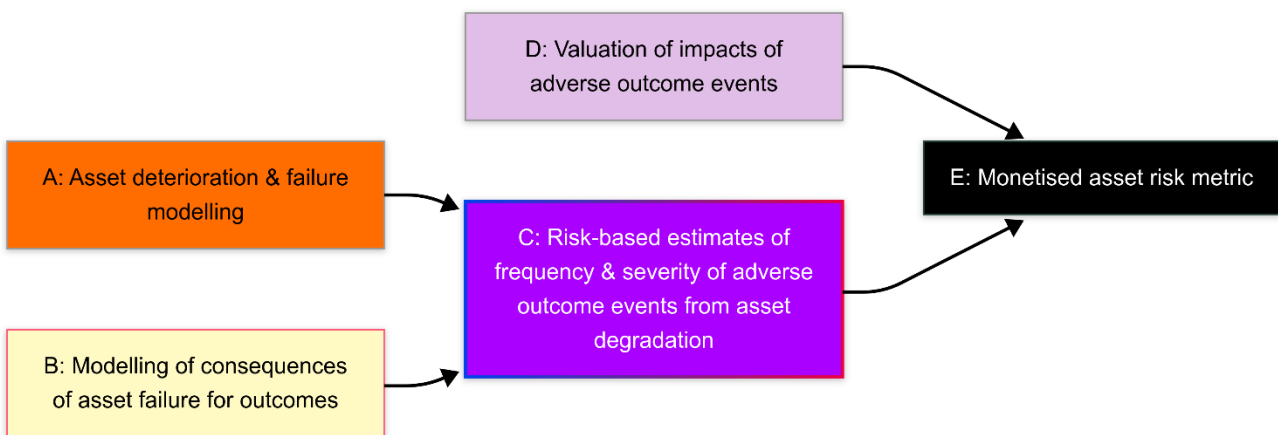
Monetised asset risk risks and outcome-level risk metrics

The monetised asset risk metric that we envisage would provide a measure of the risk, at a point in time, of adverse consequences arising from asset failures that are due to the condition of assets having degraded over time.

The methodology for calculating this metric would start by looking at the risks of individual assets experiencing failure (e.g. taking account of relevant information about the asset’s characteristics, such as age and condition, which affect its probability of failure, and of historical evidence on failures of similar assets in the past). It would then take account of how individual assets are used within the wider system of assets, and of operational resources and capabilities, to model how the failure of those assets could have adverse consequence in relation to outcomes (e.g. relating to aspects of customer service, workforce safety or the environmental impacts of water and wastewater service provision). This would be combined with valuations of the detriment from adverse outcome events that may arise, to produce estimates of monetised risk from asset failure, aggregated across all the assets and types of outcomes covered in the modelling.

At a high level we can represent the calculation of monetised asset risk, for a given year, as involving four intermediate steps, as shown in the diagram below.

Figure 1: High-level overview of calculation of monetised asset risk metric



We have given most attention to the type of aggregated monetised asset risk metrics used by Ofgem, and this has been our starting point. However, we have not been bound by Ofgem’s approach. In the

course of the work, we identified that there could be a role for metrics that draw on some of the same calculation steps but would not involve monetisation of risk.

On this basis, it is helpful to draw a distinction between two types of asset risk metrics that could be used for the future regulatory framework in the water sector:

- **Outcome-level asset risk metrics.** These metrics would be produced as the output from step C in the figure above. They are risk-based estimates of the frequency and severity of adverse outcome events, drawing on asset failure modelling and modelling of the consequences of asset failure for outcomes. Separate metrics would be calculated for different outcomes (e.g. metrics relating to risks of interruptions to water supplies would be kept separate from metrics relating to risks to the wholesomeness of water supplied).
- **Monetised asset risk metrics.** These are produced as the output from step E in the figure above. These are estimates of risk that are monetised (by applying valuations to potential adverse outcome events that may arise) and aggregated across all outcomes captured by the modelling.

The NARM methodology used by Ofgem focuses on the second of these, and this was the motivation for this working paper. However, a key finding from this paper is that outcome-level asset risk metrics could provide useful evidence by themselves, and play a valuable role in the regulatory framework.

Furthermore, drawing on Ofgem’s evolving approach, we see a role in the future regulatory framework for a **long-term monetised asset risk benefit** metric. This metric would itself be derived from projections of the monetised asset risk metric under certain scenarios. The long-term monetised asset risk benefit metric would apply to a set of actual or planned asset health investments. It would provide information on the benefit, in terms of long-term risk management, from that set of investments.

The contribution of the asset risk metrics to the regulatory framework

The relationship between the risk metrics outlined above is summarised in the following table.

Table 1 Key asset risk metrics and the links between them

Type of metric	Links to the other metrics
Outcome-level asset risk metric	Input to the calculation of the monetised asset risk metric but also has value in its own right
Monetised asset risk metric	Calculated by combining information from outcome-level asset risk metrics with monetised valuations of adverse outcome events and then aggregating risk across outcomes
Long-term monetised asset risk benefit metric	Calculated by comparing the NPV of monetised asset risk metrics over a long-term time horizon for scenarios with and without a defined set of investments

Both the outcome-level and monetised asset risk metrics would provide a snapshot of risk (over a 12-month period), which can be tracked over time and projected into the future. In contrast, the long-term

monetised asset risk benefit metric is defined for a set of investments and concerns the benefits to risk management, from those investments, over a long-term future time horizon. These asset risk metrics could provide various types of evidence for use as part of the future regulatory framework, as shown in the table below.

Table 2 Evidence provided by outcome-level and monetised asset risk metrics

Nature of evidence	Outcome-level asset risk metrics	Monetised asset risk metrics	Long-term monetised risk benefit metrics
Evidence on asset risk at a point in time (i.e. snapshot of the risk of adverse consequences from asset failure in that year)	✓	✓	-
Evidence on the evolution of asset risk over a historical period	✓	✓	-
Evidence on the factors driving the evolution of asset risk over a historical period	✓	✓	✓
Projection of levels of asset risk into future time periods (e.g. for scenarios for the asset health investment undertaken in future time periods)	✓	✓	✓
Estimation of the long-term benefits to asset risk from a company's actual investment in asset health during a previous year	-	-	✓
Estimation of the long-term benefits to asset risk from a company's proposed investment in asset health over a forthcoming period	-	-	✓

The nature of evidence provided by different types of metrics affects their potential role within the future regulatory framework. We summarise in the table below our initial view on the extent to which each of the metrics could contribute to the three key roles we identified.

Table 3 Contributions of asset risk metrics to specific regulatory roles

Potential regulatory role	Outcome-level asset risk metrics	Monetised asset risk metrics	Long-term monetised risk benefit metrics
1: Linking price control expenditure allowances to delivery of asset health investment	✓	✓	✓✓✓
2: Enhancing information on forward-looking asset risk management	✓✓✓	✓✓	✓✓
3: Supporting price control cost assessment	✓✓	✓✓✓	✓✓✓

We elaborate in this paper on how each of the asset risk metrics could contribute to the regulatory roles highlighted above. To give a flavour of the role the metrics could play, we give some examples below:

- If price control funding for asset health investment is to be tied to price control deliverables (PCD outputs), there are a number of benefits from setting deliverables based on monetised asset risk metrics, rather than more granular deliverables based on asset replacement volumes for specific asset categories (the approach Ofwat moved towards as part of its PR24 final determinations). Monetised asset risk metrics can help to better direct investment at what matters to customers and the environment, in terms of managing risks of adverse outcomes arising from asset failure. And monetised risk metrics would allow for greater flexibility — and opportunities for innovation over time — for companies in terms of how best to manage risk, subject to safeguards that this flexibility is not being used to deliver short-term solutions from funding levels intended for long-term investment.
- In our work last year, we identified an informational concern that there is not enough information available about the risks of service disruption and adverse environmental outcomes in the future that may arise from poor asset health, and how these risks are being managed by water companies. Outcome-level and monetised asset risk metrics, and projections of these metrics across future time periods under alternative scenarios, provide a key source of evidence to help address these informational gaps. Furthermore, improving the prominence and credibility of information relating to asset health and future outcomes performance could better align the financial and reputational incentives that water companies face with long-term performance and investment.
- In the case of price control cost assessment, consideration of asset risk metrics has helped shine a light on a key gap in the information that is available for Ofwat's cost assessment: information on the *long-term benefits* that companies have achieved as a result of the expenditure that they have incurred historically. Ofwat's established approach is compromised by taking limited account of the benefits that arise from the expenditure it is trying to analyse: the extent of these benefits may vary across companies and over time, and the scale of benefits delivered in the past may be more or less than what is needed in the future. The type of monetised asset risk modelling discussed in this paper seems to be an intuitive and direct way to plug this gap.

Our overall view is that, if it were to be possible to develop a reasonably good implementation of the risk metrics for water and wastewater systems, as envisaged in this working paper, this would be of great value for the regulatory framework. We can see the potential benefits more clearly now than at the conclusion of the first phase of work on the Infrastructure Health project last year.

The design and calculation of asset risk metrics

The development of monetised asset risk metrics for water and wastewater systems could benefit considerably from the methodologies developed, and insight gained, for GB energy network companies. At the same time, there are likely to be some significant differences when it comes to the application to water and wastewater systems, and we have started to expose these as part of this working paper.

We have made progress, as part of this paper, in setting out how asset risk metrics to fulfil the roles above could be designed and calculated. This includes work to:

- Set out a set of high-level steps for the calculation of monetised asset risk metrics for water and wastewater assets.
- Identify a number of desirable features of the asset risk metrics and the methodology used to produce them.
- Start to consider how the modelling of asset risk can be aligned with the four Rs of resilience. Our understanding is that the four Rs of resilience is a well-understood perspective within the water industry and it seems to offer a practical way to approach the link between asset failure risk and impacts on outcomes.

The table below summarises the desirable features that we have identified. These are an initial view and would benefit from further discussion and refinement with stakeholders.

Table 4 Overview of desirable features of the methodology and metric

Broad theme	Desirable features of the methodology and/or metric
Overall focus and scope	<ul style="list-style-type: none"> • Focuses on risks from degradation in asset condition • Outcomes-oriented as far as practical
Building on existing water industry concepts and data structures	<ul style="list-style-type: none"> • Builds on the four Rs of resilience • Draws on established asset and outcome categories as far practical • Can be related to other asset health metrics used in the industry as far practical
Contribution to regulatory analysis and arrangements	<ul style="list-style-type: none"> • Enables risk from asset degradation to be tracked over time • Enables risks from asset degradation to be projected into future time periods • Enables changes in risk over time to be decomposed across key drivers • Enables risk to be presented at the level of individual outcomes before monetisation • Enables risks from asset degradation to be reasonably compared across companies

Next steps

This working paper was developed before the publication of the final report from the Independent Water Commission (July 2025). The Commission found that the water sector is lacking a clear, consistent picture of long-term asset health and its associated risks and cliff edges. This finding fits closely with the informational concern identified in Reckon’s work last year, which has provided a foundation for this working paper. Furthermore, the Commission said that the regulator should develop a forward-looking asset health metric for use during price setting. This working paper provides a valuable contribution to the development of such a metric and addressing the informational gaps on risks related to asset health.

We have not sought to assess, as part of this working paper, whether it would ultimately be feasible to produce monetised asset risk metrics for water and wastewater assets. But the material set out in this

working paper should help to better explain what is intended, which can inform further stakeholder discussions about feasibility and proportionality.

In any event, our view is that there is a strong case for progressing with work to *try to* develop both outcome-level asset risk metrics and monetised asset risk metrics for water and wastewater infrastructure which could be used as part of the future regulatory framework.

There are good reasons for treating further work on the development of asset risk metrics as a priority. They are likely to be valuable across a range of different reforms to improve the regulatory approach to asset health. Furthermore, the development of these metrics is likely to take longer than other asset health metrics that might be considered, so prioritising work on them makes it more likely that they could play a useful role in the PR29 price review.

As part of this work, we suggest that particular focus should be given to the development of modelling of the consequences of asset failure for outcomes (i.e. step B in the high-level diagram introduced above). This modelling could be used for both outcome-level asset risk metrics and monetised asset risk metrics, so would be valuable even if the PR29 framework placed more emphasis on the former than the latter. This modelling is likely to be a particularly challenging task that seems more urgent than work under the monetisation and aggregation steps we identified.

More broadly, giving attention to the development of asset risk metrics at this early stage of the PR29 process can provoke healthy debate and consideration of what metrics/information relating to asset health and outcomes risk would ideally be desirable for use within the regulatory framework over the longer term — without being overly constrained by what metrics are most readily available for collection, or easy to calculate, in the near-term. A longer-term strategic perspective seems highly desirable, to help ensure that the regulatory framework evolves with sufficient ambition and coherence.

Section 1: Introduction

Background and scope

In January 2024, four water companies — Affinity Water, Anglian Water, Northumbrian Water and Wessex Water — commissioned Reckon to consider potential reforms to the regulatory framework for water companies, in relation to the treatment of capital maintenance and asset health. The work was intended to support the development of the regulatory approach to the PR29 price review and constituted workstream 2 within the first phase of a broader programme of work which we refer to as the Infrastructure Health project.¹ We refer to our main report from this phase of work as Reckon (2024).²

Alongside the workstream led by Reckon, the client companies commissioned a workstream from Jacobs (workstream 1). This identified and considered a range of metrics that could help to reveal current and future asset health risks, and track trends in asset health over time. This included metrics that could support potential changes to the regulatory framework identified in the work led by Reckon.

This working paper is a targeted follow-up to the first phase of the Infrastructure Health project. It was sponsored by Northumbrian Water and concerns the potential role and design of asset risk metrics for water and wastewater assets, building on the methodologies for the network asset risk metric (NARM) developed by Ofgem and the main energy network companies in Great Britain. It considers these metrics primarily from the perspective of regulatory design and regulatory policy, without getting into the more detailed engineering issues and data requirements that would arise if such metrics were to be implemented in the water sector. For the purposes of this paper, we agreed to cover the following:

- Clarification and elaboration of the potential roles of NARM-style metrics for regulatory purposes under the different policy packages presented as part of Reckon (2024), considering informational/incentive remedies, cost assessment and funding mechanisms.
- Specification of some essential (or higher priority) requirements/features of these metrics, taking account of the regulatory roles identified above.
- Consideration of timeframes to be covered by the metrics (e.g. in terms current and potentially historical time periods, and projections for future years under defined scenarios).
- Identification of key ways in which the metrics developed for water and wastewater assets might (need to) differ from those from Ofgem's NARM approach.
- Specification of the high-level modelling components that need to be developed to produce NARM-style metrics for water and wastewater assets, and description of how these relate to each other.

¹ Final reports from workstreams 1 and 2 can be found at: <https://www.water.org.uk/investing-future/infrastructure-health>.

² Reckon (2024) *Improvements to the regulatory framework for asset health and operational resilience: workstream 2: Main report*.

- Identification of what types of datasets and analysis might feed into different modelling components (without getting too far into the details at this stage).

This working paper provides an initial iteration across each of the areas above. It is intended as a working draft, for discussion, and we welcome feedback from stakeholders on all aspects of it.

As set out in Reckon (2024), there are good reasons for treating the development of monetised asset risk metrics as a priority area for the next phase of the Infrastructure Health project.³ These metrics are likely to be valuable across several preferred packages for regulatory reform identified in our report, and essential for one of them. Furthermore, the development of asset risk metrics is likely to take longer than other asset health metrics that might be considered, so prioritising work to develop asset risk metrics makes it more likely that they could play a useful role in the PR29 price review.

Our focus is on asset risk metrics that would capture risks relating to asset health (e.g. risks of asset failure from degradation in asset condition over time), and which could be used as part of a reformed regulatory framework that is designed to tackle concerns about the current regulatory treatment of asset health investment. Asset risk metrics could potentially play a broader role in the future regulatory framework, capturing other types of risks (e.g. risks to outcomes from capacity limitations or from external disruptions). This is outside the scope of this paper but may be a valuable area for future work.

This working paper was developed before the publication of the final report from the Independent Water Commission.⁴ The Commission found that the water sector is lacking a clear, consistent picture of long-term asset health and its associated risks and cliff edges. This finding fits closely with the informational concern identified in Reckon's work last year, which has provided a foundation for this working paper. Furthermore, the Commission said that the regulator should develop a forward-looking asset health metric for use during price setting. This working paper provides a valuable contribution to the development of such a metric and addressing the informational gaps on risks related to asset health. Going forwards, there is also likely to be value in further developing the material covered in this working paper in the light of the Commission's report.

Network asset risk metrics (NARM) for GB energy companies

The network asset risk metric (NARM) developed for GB energy network infrastructure companies can be outlined as follows:⁵

- The NARM is a monetised valuation of the asset failure risks associated with a defined scope of assets owned/operated by the network company.

³ Reckon (2024, pages 60 and 61).

⁴ Independent Water Commission (2025) *Final Report*.

⁵ Reckon (2024), page 37.

- In very broad terms, the NARM is computed by multiplying estimates of the probability of failure of each asset by the monetised consequences of that failure, and then aggregating across all assets within the scope of the NARM.
- In the absence of asset interventions such as asset replacement, the NARM would be expected to exhibit increasing monetised risk over time, due to modelling assumptions (e.g. informed by asset deterioration models) that failure risk for specific assets increases with asset age or usage.

Within Ofgem’s approach, the calculation of network asset risk metrics is used both to help determine expenditure allowances for the forthcoming price control period and to specify outputs that those allowances are tied to, such that under-delivery of benefits in terms of network asset risk would lead to funding being returned to customers. The way that monetised asset risk metrics are calculated, and the way that they are used as part of the regulatory framework, differs across the four energy network sectors regulated by Ofgem. For further information see Ofgem’s NARM handbook.⁶ In the box below, we reproduce the objectives for the NARM that Ofgem sets out in the handbook.

Figure 2 The objectives of GB energy network NARM

Ofgem specifies the objectives of the NARM methodology as follows:

- To allow Ofgem and other stakeholders to understand the links between the data that a network company collects and utilises and the asset management and investment decisions it makes. The NARM Methodology will therefore help provide assurance that any investment decisions are based on solid evidence and sound reasoning.
- To enable Ofgem to set outputs for the network company to deliver over a price control period and to ensure that what the network company actually delivers can be compared to the targets on a like-for-like basis.
- To enable the network company to estimate the Monetised Risk of its network assets both now and in the future.
- To enable the network company to estimate the Monetised Risk Benefit that would be delivered by different types of interventions on any given asset or group of assets. The objective is to be able to estimate both single-year snapshot risk benefit and long-term risk benefit.
- The estimated Monetised Risk Benefits should be suitable for use as inputs in Cost Benefit Analyses (CBA) in order to help network companies choose the best value for money investments, and to demonstrate to Ofgem, consumers, and other stakeholders that any investment plans have been optimised. This means that the Monetised Risk Benefits should be realistic with robust probability estimates and correctly valued consequences.
- To enable the identification and quantification of drivers of changes in Monetised Risk over time.
- To allow Monetised Risk comparisons to be made between different assets and different networks. In order for this objective to be achieved, the methodologies used for estimating Monetised Risk should be based as little as possible on subjectivity.

⁶ Ofgem (2025) *NARM Handbook Version 4.0*.

- To enable the network company to report to Ofgem and other stakeholders in a way that can be easily understood and unambiguously interpreted.

Source: Ofgem (2025) *NARM Handbook Version 4.0*

Potential monetised asset risk metrics for water and wastewater assets

Reckon (2024) referred to NARMs as part of a broader category of composite asset risk metrics. A composite asset risk metric can be understood as one that aggregates or synthesises more granular information on asset risk for the assets that it covers.

Jacobs' final report to workstream 1 of the first phase of the Infrastructure Health project reviewed a wide range of different metrics relating to asset health. It presented the energy industry NARMs within a high-level category of "risk indices", and within that a type of "asset risk / network risk" metric, while also highlighting these as a type of composite metric.

Annex 1 to Reckon (2024) summarised potential features of a potential composite asset risk metric that could be developed for water and wastewater systems, based on Ofgem's approach, as follows:⁷

- Risk would be considered from the perspective of potential adverse impacts on outcomes for customers and/or the environment that may arise from asset failure (e.g. supply interruptions or pollution events).
- Risk would be monetised, drawing for example on estimates of the potential adverse impacts on outcomes for customers and/or the environment that may arise from the failure of specific assets.
- The consolidated asset risk metrics would be built up from detailed estimates of the failure risk of individual assets, but the metrics would be designed to capture risk across a system of assets, rather than resulting in a large number of metrics which capture the risk for individual assets or asset groups at a granular level.
- As part of the consolidation, estimates of failure risk would be combined with information on the criticality of those assets to the network or system, taking account of other aspects of operational resilience (e.g. the extent of asset redundancy and the operational responses to mitigate the impacts of asset failure which affect the consequences of specific assets failing).

We do not propose to use exactly the same terminology as Ofgem (i.e. NARM) for the asset risk metrics that could be developed for water and wastewater systems. Using the same terminology as Ofgem risks tying the methodology too heavily to that which has been developed for energy network infrastructure, for which the context and purposes may differ in some significant ways to those applying to the water companies regulated by Ofwat. Furthermore, the emphasis given to "network" with the term NARM fits

⁷ Reckon (2024) *Improvements to the regulatory framework for asset health and operational resilience Annex 1: Further information on workstream 2 policy packages*, page 45.

better with the application to energy network infrastructure assets than it does to the relevant assets of the water companies, which cover network infrastructure (e.g. treated water distribution systems) as well as other types of assets (e.g. water abstraction assets and sewage treatment assets). Water companies' assets are better viewed as parts of systems rather than networks, and in some cases these systems might be discrete and localised (i.e. not interconnected across the area that the company serves).

Given the points above, we refer to versions of the energy industry NARMs that would be developed for the purposes of water companies' systems as "monetised asset risk metrics". This avoids an undue reference to network assets and gives emphasis to a key feature of the energy industry NARM methodology which is the use of monetisation as a means to aggregate information across a large number of assets, and outcomes / consequences, into a single metric.

Other types of composite asset risk metric

For the purposes of this paper, we have given most attention to monetised asset risk metrics, and this has been our starting point. However, we have not been bound by Ofgem's approach. In the course of the work, we recognised the potential value of outcomes-level asset risk metrics that would share some of the same calculation steps as monetised asset risk metrics, but would not involve monetisation and aggregation of risk across different outcomes. These outcomes-level asset risk metrics would be aggregated across assets (i.e. capturing risks across a system of assets rather than being granular asset-level metrics). But there would be separate metrics for the different dimensions of outcomes that can be affected by asset failure. We discuss these metrics further in sections 3 and 4. There may also be other types of aggregate or composite asset risk metrics that could be developed, beyond those covered in this paper.

Structure of this document

The remainder of this document is structured as follows:

- Section 2 provides an outline of the potential roles for monetised asset risk metrics within the regulatory framework for water companies, drawing on the work we produced for the Infrastructure Health project last year.
- Section 3 sets out our proposed design for the asset risk metrics, in the context of the potential roles for asset risk metrics identified in section 2, and discusses, at a high level, some key aspects of the calculation steps and methodology that could be used to produce them.
- Section 4 summarises how each of the proposed asset risk metrics from section 3 could contribute to the future regulatory framework for water companies.

The appendices to this paper provide further information in selected areas:

- Appendix 1 provides a more detailed explanation of the roles that monetised asset metrics could play within a reformed regulatory framework for water companies, elaborating on the roles identified in section 2 of the paper.

- Appendix 2 draws out some implications of the roles discussed in appendix 1 for the design of monetised asset risk metrics for water and wastewater systems, organised in terms of a number of desirable features of those metrics and the methodology used to produce them.
- Appendix 3 summarises how the approach to asset risk metrics for water company regulation might differ from that used for Ofgem's regulation of GB energy networks.

Section 2: Potential roles for asset risk metrics within a reformed regulatory framework

Introduction

We see three main ways in which asset risk metrics could play a role as part of the price control framework for water companies from PR29 and beyond. These are as follows:

1. Linking price control expenditure allowances to delivery of asset health investment.
2. Enhancing information on forward-looking asset risk management.
3. Supporting price control cost assessment.

We briefly elaborate on each of these roles below. We provide a more detailed explanation and discussion in Appendix 1. Further information on the types of reforms to the regulatory framework that we envisage is provided in Reckon (2024), including Annex 1 to that report.⁸

Role (1): Linking expenditure allowances to delivery of asset health investment

Perhaps the most obvious role for monetised asset risk metrics is that used by Ofgem for energy network regulation, building on the Network Asset Risk Metric (NARM) approach. Under this approach, all, or a large part of, the price control allowances for capital maintenance expenditure would be linked to a company's outturn delivery of asset health investment, measured using the monetised asset risk metric. A water company's price control funding would be adjusted if it delivers less, in terms of asset risk benefits, than it had been funded for (potentially with some scope for the funding to be adjusted upwards if it delivers more).

As with PCDs under Ofwat's PR24 framework, it would be made clear what part of the ex ante totex allowance set at the price control review is effectively hypothecated for delivery against the monetised asset risk metric, with the potential for some/all of that funding to be returned to customers if the company under-delivers against the asset risk benefits it had been funded for.

For PR24, Ofwat used the terminology of PCD "outputs" to refer to the specific level or volume that a company will be held to account for delivering through the PCD. For instance, the storm overflow PCD is defined in terms of a PCD metric, which is cubic metres of equivalent storage capacity delivered, and the PCD output for a specific company might be to deliver, for example, 500,000 cubic metres of equivalent storage capacity by 2030. In relation to capital maintenance allowances, PCDs could be based on monetised asset risk metrics, and the PCD output could be defined in terms of the expected benefits, in terms of risk reduction over the long term, from the capital maintenance expenditure that is funded at the price review.

⁸ Reckon (2024) *Improvements to the regulatory framework for asset health and operational resilience Annex 1: Further information on workstream 2 policy packages.*

This would be consistent with how Ofgem’s NARM approach has evolved to consider monetised asset risk over a long-term modelling time horizon. For example, in its NARM methodology, National Gas refers to “Long Term Monetised Risk Benefit (LTRB)” in recognition of the long-term horizon used when considering the benefits of asset replacement / refurbishment on monetised asset risk.⁹

This working paper is not intended to review in any detail the pros and cons of different options for the regulatory framework from PR29 onwards. But for our current purposes it seems useful to highlight a number of benefits of linking price control expenditure allowances to delivery against monetised asset risk metrics, rather than linking expenditure allowances to delivery against asset replacement volumes or to asset failure metrics for individual asset categories (the approach Ofwat moved towards as part of its PR24 final determinations):

- Company investment being better directed at what matters to customers and the environment, in terms of the estimated risk of adverse outcomes arising from asset failure.
- More flexibility — and opportunities for innovation and learning over time — for companies in terms of which assets to replace (or refurbish), and how best to achieve operational resilience, subject to safeguards that this flexibility is not being used to deliver short-term solutions from funding levels intended for long-term investment.
- Broad coverage of assets across the water and wastewater asset base (e.g. rather than PCDs being focused on specific asset categories for which data on asset replacement volumes is available and meaningful).
- Recognition of different types of asset intervention which differ in terms of the duration or scale of benefits delivered (e.g. asset replacement with long-life asset, asset replacement with short-life asset, asset refurbishment, etc).

Role (2): Enhancing information on forward-looking asset risk management

In Reckon (2024) we identified a concern that there is not enough information available about the risks of service disruption and adverse environmental outcomes in the future that may arise from asset deterioration or poor asset health, and about how these risks are being managed by water companies. Asset risk metrics provide a way to help address these informational gaps.

Furthermore, we identified that improving the prominence and credibility of information relating to asset health and future outcomes performance could better align the financial and reputational incentives that water companies face with long-term performance and investment. Rather than tying price control funding for capital maintenance expenditure directly to asset health investment deliverables (as under role (1) above) an alternative strategy for PR29 is to retain a regulatory focus on outcomes while enhancing the incentives of companies in respect of their long-term performance. Under this strategy, a range of complementary initiatives and modifications to the regulatory arrangements would be implemented to help to tackle both the behavioural and the informational concerns that arise under the

⁹ National Gas (2024) *Gas Transmission Network Asset Risk Metric (NARM) Methodology Main Overview Document*.

current regulatory approach. Enhancing information on forward-looking asset risk would be a key part of these initiatives. While these initiatives represent a potential alternative to the type of approach under role (1) above, they might also be applied in conjunction with that approach.

Asset risk metrics could make an important contribution to a number of the initiatives we identified to enhance information and asset risk management and to improve water companies' incentives for long-term performance, such as the following:

- **Long-term projections of outcomes performance under well-defined scenarios.** This would involve each water company providing long-term projections of its performance against common performance commitments, and potentially other areas of performance or impact that are important but not captured under common performance commitments (e.g. relating to workforce safety). A key factor to be captured under different scenarios is the assumptions on asset health investment in future periods. In addition, there may be scenarios for defined external conditions under different projections for climate change that may affect the risk to outcomes. Companies would explain their projections by reference to the modelling analysis, assumptions and judgements underpinning it, which they would make available to Ofwat and potentially other stakeholders.
- **Company-owned policies on the management of asset health and risks to future outcomes.** Each water company would publish key information about the policy and methodologies that it uses to manage asset health and control risks to outcomes in the future, and information about how it has applied its chosen policy and methodologies in practice. This would refer to the long-term projections and scenario analysis from the initiative above, as well as data on outturn performance.

As discussed further in appendix 1, asset risk metrics seem highly useful for these two initiatives. There would also be opportunity for other sources of information and judgement to be used in recognition of the potential limitations of these metrics (e.g. in terms of scope, known approximations or vulnerabilities affecting accuracy, or sensitivity to key assumptions).

For some of the informational and incentive remedies, estimates of asset risk before monetisation or aggregation could be equally important — or perhaps more important — than the final calculation of monetised asset risk aggregated across all assets and outcomes. For instance, a potential intermediate stage in the calculation of monetised asset risk would be to estimate the risks of specific adverse outcome events arising from asset failure risk (e.g. in terms of customer interruptions or sewer flooding events). As a source of information to convey to Ofwat, investors and other stakeholders about future risk, estimates at the level of individual outcomes might be more meaningful than a monetised aggregate metric, or it could help substantiate and explain the monetised and aggregated metric.

Role (3): Supporting price control cost assessment

Asset risk metrics could be used as part of regulatory cost assessment at price control reviews, to address some of the key limitations of Ofwat's existing approach and to bring a more forward-looking perspective to the cost assessment that is intended to cover asset health investment.

We use the term cost assessment in a broad way, consistent with its usage within Ofwat's current price review processes. It would include, where applicable, regulatory assessment of the appropriate quantum of asset health investment that companies should be funded for, as well as the costs of that investment.

Ofwat's current approach to cost assessment for base costs (which includes operating expenditure and capital maintenance expenditure) places a large weight on historical levels of *expenditure* (in cash terms) incurred by water companies.¹⁰ This approach is compromised by the lack of information on what has been achieved or delivered by that expenditure, especially in terms of the long-term benefits in relation to asset risk management. The extent of these benefits may vary across companies and over time, and the scale of benefits delivered in the past may be more or less than what is needed in the future. Asset risk metrics, and in particular evidence on the long-term benefits to monetised risk that companies have achieved in the time period covered by analysis of historical expenditure, would provide a means to help tackle this gap.

To the extent that data on the historical expenditure incurred by water companies is used to help assess companies' efficient expenditure requirements for the forthcoming price control period, it would be highly relevant to understand how asset risk has evolved over the timeframe covered by that expenditure. For instance:

- It would be relevant to understand whether monetised asset risk (calculated each year) has been stable, has improved or has worsened over relevant periods covered by the analyses.¹¹ For example, if monetised asset risk has worsened over the period then it may be inappropriate to set expenditure allowances at similar levels while expecting companies to maintain stable performance and asset risk.
- It would be relevant to understand what has driven the profile over time in overall asset risk given that different elements that contribute to overall risk (e.g. different aspects of operational resilience). For example, there may have been different trajectories for risk relating to underlying asset condition (e.g. reflecting the net effects of asset degradation over time and asset replacement / refurbishment) compared to the effects from operational practices/controls (e.g. changes in operating practices that have enabled reductions to risk). Understanding these changes seems important when setting cost allowances for future periods. Differences in the trajectory of risk from the various underlying elements may mean that the profile of overall risk in the future may differ from that in the past.¹²

¹⁰ This approach departs from more conventional economic analysis of costs which considers operating expenditure plus *depreciation*.

¹¹ Note that while Ofwat's base cost modelling at PR24 covered a historical data period from 2011-12 onwards, its application of an upper-quartile catch up adjustment, calculated over the last five years of data, means that the allowances it set give much more weight to the levels of expenditure (and the activities and delivery achieved) over that five-year period rather than the full historical data sample.

¹² Further to the elaboration of this issue in appendix 2 of this working paper (e.g. see subsection on desirable feature F8), this issue of risk trajectories is represented graphically and discussed in United Utilities (2021) *Asset health in the water sector: proposal for a framework*, page 10.

- It would be relevant to understand what benefits have been delivered from the expenditure incurred over the historical data period. Estimates of the longer-term benefits achieved, in terms of monetised asset risk over a long future time horizon, would be particularly useful.

In this context, asset risk metrics could provide valuable evidence to support a more informed and evidence-based way to use historical expenditure data to set cost allowances for a forthcoming price control period.

There is also a call for forms of cost assessment that are not based on water companies' historical data. Apart from the broader point about the future potentially differing from the past, there is a specific concern that, due to the behavioural concerns discussed in Reckon (2024), the historical expenditure data on base costs or capital maintenance may be polluted and not a good guide to efficient levels of expenditure in the future.

The modelling methodology developed for calculating monetised asset risk metrics might be viewed as a tool that could be used for forward-looking cost assessment. It could be used to produce long-term projections of monetised asset risk — and for individual outcomes before monetisation — for a series of user-defined investment programmes over the price control period. This might in turn be used, in conjunction with analysis of investment unit costs, to help calibrate or determine levels of funding for base costs or capital maintenance expenditure.

We have not sought at this stage to carry out a full review of the potential contribution to price control cost assessment of monetised asset risk metrics compared, to other metrics relating to water company asset health that might be available or be developed. But we highlight some aspects of monetised asset risk metrics that make them seem relatively desirable, in principle and leaving aside implementation challenges, compared to more granular metrics relating to investment volumes, asset age or asset condition:

- Monetised asset risk metrics can consolidate information across a large number of assets into a single metric, and a manageable source of evidence, that applies at the same level as that used for cost assessment (e.g. base costs or capital maintenance expenditure).
- Monetised asset risk metrics are more focused on the benefits of expenditure for outcomes (e.g. the benefits from investment in terms of impacts on risks to outcomes in the future) than metrics based on investment volumes, asset age or asset condition. For example, the overall costs to customers depend not simply on the unit costs of delivering specified asset replacement volumes but on the extent to which decisions on which assets to replace are well-targeted at reducing risks to future outcomes.
- Monetised asset risk metrics can take account of the interactions between operating expenditure and capital expenditure (e.g. the calculation of monetised asset risk should ideally take account of key ways in which operational practices might reduce the risk of asset failure, or provide response and recovery capabilities, that reduce the consequence of asset failure and, in turn, affect the efficient levels of asset replacement).

Section 3: The design and calculation of the proposed asset risk metrics

Introduction

This section sets our proposed design for the asset risk metrics, in the context of the potential roles for asset risk metrics identified in section 2 (and appendix 1), and discusses, at a high level, some key aspects of the calculation steps and methodology that could be used to produce them. We have given most attention to the type of aggregated monetised asset risk metrics used by Ofgem, and this has been our starting point. However, we have not been bound by Ofgem's approach. In the course of the work, we recognised the potential value of outcomes-level asset risk metrics that would share some of the same calculation steps but would not involve monetisation and aggregation of risk across all customer and environmental outcomes.

This section is organised as follows:

- High-level steps in the calculation of monetised asset risk metrics.
- Outcome-level asset risk metrics versus monetised asset risk metrics.
- Long-term monetised asset risk benefit metrics.
- Desirable features of the asset risk metrics and methodology.
- Decomposing the evolution of asset risk across the four Rs of resilience.
- Level of aggregation and scope of the calculation of asset risk.
- Modelling asset failure and the consequences of asset failure for outcomes.

In addition to this section, we elaborate in appendix 2 on the desirable features of the proposed asset risk metrics and methodology. We also summarise in appendix 3 how the metrics we envisage for water and wastewater systems might differ from the monetised asset risk metrics used by Ofgem for energy network infrastructure.

High-level steps in the calculation of monetised asset risk metrics

Before outlining the calculation of asset risk metrics, we briefly introduce two helpful terms that we make use of in this section:

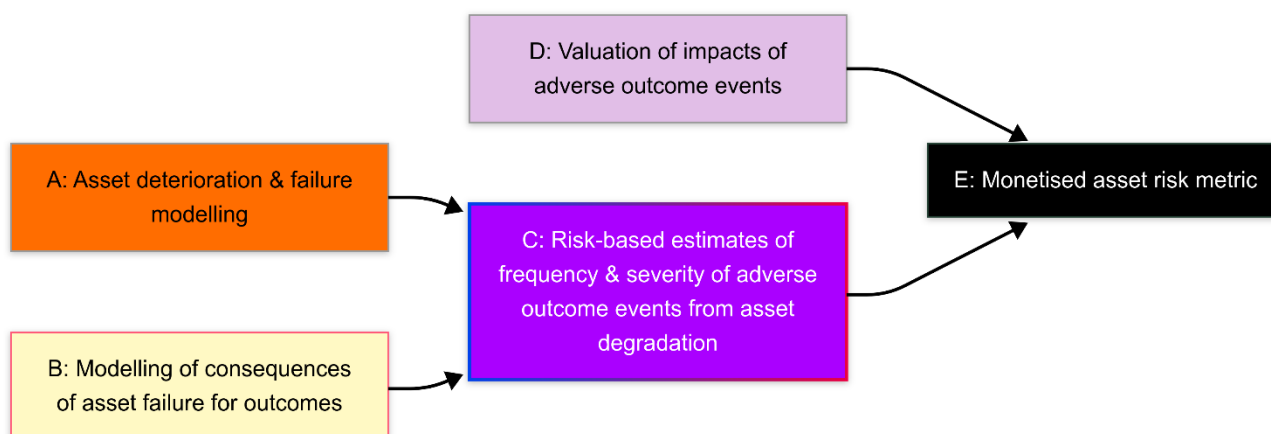
- **Failure mode.** A failure mode is a specific way in which an asset may fail to perform its intended functions, which may in turn (depending on other factors) have potential adverse impacts on outcomes. The relevant failure models will depend on the type of asset. For instance, failure modes for pumps on the water distribution system might be defined for the pump failing to operate at all as well as for other potential performance issues such as reductions in the effectiveness of the pump due to its degradation over time. For modelling purposes, a set of failure modes would be defined for

each asset type. Given the intended scope of the modelling, the focus would be on failure models associated with degradation in asset condition arising from usage or from the passage of time.¹³

- **Adverse outcome event.** An adverse outcome event is a specific type of adverse impact on outcomes that may arise from failure of assets within the system. For some adverse outcome events it may be relevant for the methodology to capture attributes such as duration and severity. There is likely to be considerable overlap between these events and those captured by the existing set of common performance commitments (e.g. water supply interruptions, serious pollution incidents, internal sewer flooding incidents). However, the asset risk modelling may need to use some modified definitions and it may need to cover outcome events that are not captured within the existing performance commitments (e.g. relating to workforce safety). And some current common PCs would not be directly relevant as they do not relate directly to adverse outcomes events (e.g. unplanned outages at water treatment works).

Drawing on these concepts, we can represent the calculation of monetised asset risk in a given year as involving four intermediate steps, as shown in the diagram below.

Figure 3: High-level overview of calculation of monetised asset risk metric



We now briefly summarise the steps shown in the figure above:

- **Step A: Asset deterioration and failure modelling.** This would use data on individual assets to estimate the probability of each asset in the scope of the modelling experiencing a specific failure mode in a given year. The data used may relate to range of factors such as the properties of assets (e.g. age, condition, cumulative historical usage); the environment in which the asset is used (e.g. soil type, weather conditions) and its operating conditions (e.g. usage levels, operational controls such as pressure management). Asset deterioration modelling is an established part of water company asset management, although the extent to which it is used in practice may vary across companies and across asset types.

¹³ For further discussion of the scope of asset risk modelling see material on feature F1 in appendix 2.

- Step B: Modelling of consequences of asset failure for outcomes.** This would use data on the role of individual assets within the system (e.g. in providing services to customers or protecting against environmental harm, health and safety risk, etc) to model the likelihood that the failure of a specific asset could have adverse consequences across a set of defined outcomes. This modelling would take account of the role of other assets in the system in providing redundancy and the role of operational practices and controls that act to reduce the probability of asset failure leading to adverse outcome events or to reduce the duration/severity of such events.
- C: Risk-based estimates of frequency & severity of adverse outcome events from asset degradation.** Steps A and B above would be combined to produce estimates of the risks of outcome events arising in a specified year. These estimates of risk would capture aggregations of risk across all assets in the company's system and, at the company level, might be expressed in terms of the estimated frequencies of adverse outcome events arising each year. At this point, the estimates of risk would be calculated separately for individual outcomes, with the specific metric used to capture risk varying by outcome (e.g. there might be estimates of the expectation value of the number of external sewer flooding incidents arising from failures due to asset degradation, across the total population served). For some outcomes there might be multiple dimensions in which the estimate of adverse outcome events is to be modelled (e.g. capturing the expectation values of the number of incidents and the average severity and/or duration of those incidents).
- Step D: Valuation of impacts of adverse outcome events.** This element would assign monetary values to the adverse outcome events that are modelled under step C. For some adverse outcome events, and reflecting how outcome-level risk under step C might be modelled, the valuation might be needed along multiple dimensions such as per incidents and according to the severity and/or duration of an incident. As a starting point the valuation exercise could potentially draw on the valuations that are implicit in the calculation of outcome delivery incentives (ODIs) set by Ofwat. But further consideration would be needed as to whether the ODIs capture an appropriate valuation of the impacts of adverse outcome events, and whether there are other sources of evidence or analysis to inform the valuation. In any event, there are likely to be relevant outcomes not captured by ODIs for which impacts would need to be valued. There may be some useful insight from valuation approaches used by energy network companies under their NARM methodologies.
- Step E: Monetised asset risk metric.** The estimates of risk of adverse outcome events from asset degradation from step C would be combined with the valuation of the impacts of adverse outcome events from step D to produce an estimate of monetised asset risk. This estimate would be aggregated across all outcomes (and aggregated across all assets by virtue of the aggregation across assets carried out for the purposes of step C), with monetary values used as a means to bring risks at the level of individual outcomes (from step C) into a common currency. If the valuation from step D is made in £ (or £m, etc) then the natural unit for the monetised asset risk would be £. Ofgem uses a special unit of measurement, "risk pounds" (R£), for the monetised asset risk metric which it says is used to differentiate this measure from financial monetary values.¹⁴ We leave open at this

¹⁴ Ofgem (2025) *NARM Handbook Version 4.0*.

stage whether the monetised asset risk metric would be defined in pounds or some conceptual variant such as risk pounds.

There are different ways that the calculation steps for monetised asset risk metrics might be organised, summarised and presented. We have chosen the presentation above with the following aims in mind:

- To help make the approach reasonably accessible to regulatory practitioners who are familiar with Ofwat's price control framework but do not have detailed understanding of the NARM methodology used by Ofgem for energy network companies or of water company asset management.
- To build on, but avoid being overly constrained by, the NARM methodology for energy network companies.
- To separate out steps that would call for quite different types of information and expertise.
- To expose how intermediate calculations used in the production of monetised asset risk metrics might themselves have value for regulatory purposes.

The last point above is particularly important and we elaborate on it in the next subsection.

Outcome-level asset risk metrics versus monetised asset risk metrics

In the summary of calculation steps set out above, step C involves estimation of risks to individual outcomes before monetisation and aggregation across outcomes. The results from this step could be used directly as part of the future regulatory framework (e.g. for the purposes of information and incentive remedies or to support cost assessment). This might be in conjunction with aggregated monetised asset risk metrics. But there is also a scenario where the results from step C are considered sufficient (recognising that monetisation brings additional complications).

On this basis, we make a distinction between two types of asset risk metrics that could be used for the future regulatory framework in the water sector:

- **Outcome-level asset risk metrics (OLAR metrics).** These metrics would be produced as the output from step C of the figure above. They are risk-based estimates of the frequency and severity of adverse outcome events, drawing on asset failure modelling and modelling of the consequences of asset failure for outcomes. Separate metrics would be calculated for different outcomes (e.g. metrics relating to risks of interruptions to water supplies would be kept separate from metrics relating to risks to the wholesomeness of water supplied).
- **Monetised (and aggregated) asset risk metrics (MAAR metrics).** These are produced as the output from step E of the figure above. These are estimates of risk that are monetised (by applying valuations to potential adverse outcome events that may arise) and aggregated across all outcomes captured by the modelling.

The NARM methodology used by Ofgem focuses on the second of these, and this was the motivation for this working paper. However, as indicated in section 4, outcome-level asset risk metrics could provide useful evidence by themselves, and play a valuable role in the regulatory framework.

A further potential type of metric would be to apply financial valuations to the outcome-level asset risk metrics but not proceed to aggregation across outcomes, so there would be a separate monetised risk metric for each relevant dimension of outcomes. Our current view is that this would not be as useful for the regulatory framework as the two types of metric highlighted above. Monetisation of adverse outcome events is a subjective and potentially controversial exercise, which may be tolerated, for some purposes at least, because it can provide a meaningful basis for aggregation of risk across different outcomes. In the context of these metrics, we primarily see monetisation as a tool for aggregation. Where we refer to monetised asset risk metrics in this paper, we mean metrics that involved both monetisation and aggregation across outcomes. That said, we do not want to rule out the idea that monetised outcome-level metrics could play some useful role in the future.

Long-term monetised asset risk benefit metrics

Further to the type of monetised asset risk metric introduced at the start of this section, Ofgem's NARM methodology has evolved in a way that recognises the importance of a related metric that is derived from it, which is intended to capture the estimated long-term *benefits* from historical or planned investment in asset health.

Ofgem's work has led to the creation of what it calls the Long Term (Monetised) Risk Benefit (LTRB) metric, which it summarises as follows:¹⁵

“When an intervention takes place, the asset’s monetised risk will be reduced in all years after the intervention up to the expected next replacement or refurbishment intervention. The LTRB is the sum of those risk reductions across a specified horizon.”

We summarise key aspects of Ofgem's approach to this metric in the box below.

Figure 4 Ofgem's long-term risk benefit metric

Ofgem's approach to using monetised risk metrics as price control outputs/deliverables has evolved over time. For the RIIO-1 price controls, although the network companies were expected to take into account longer-term views of risks when making their investment decisions, monetised risk outputs were defined using a single-year snapshot risk measure. Ofgem said that its aim for the RIIO-2 outputs was to define a longer-term risk measure.

For the RIIO-2 controls for electricity transmission and gas transmission networks, Ofgem set Baseline Network Risk Outputs for each company that are intended to capture the cumulative monetised risk benefits delivered by a set of interventions to be carried out by that company during the price control period, where the benefits are to be calculated over the full lifetime of the benefits (e.g. the lifetime might reflect the longest asset life of new assets to be installed within the set of interventions and might last 45 years in an example given by Ofgem). The cumulative monetised risk over the time horizon is calculated in net present value (NPV) terms using a chosen discount rate.

The risk benefits are calculated by comparing the cumulative monetised risk over the time horizon under two scenarios: (i) a scenario of no interventions (e.g. no asset replacement or refurbishment); and (ii) a scenario with the interventions that are to be funded during the price control period. The difference between the two is the reduction in long-term

¹⁵ Ofgem (2025) *NARM Handbook Version 4.0*, page 12.

monetised risk expected to be achieved by those interventions. Ofgem refers to the metric calculated as this difference as the Long Term (Monetised) Risk Benefit (LTRB) metric.

The transmission network companies are responsible for delivering the outputs specified in terms of long-term risk benefits but have flexibility (subject to some constraints) as to which specific interventions they carry out to achieve this.

Source: Ofgem (2025) *NARM Handbook Version 4.0*

Building on Ofgem’s approach, we see a role in the future regulatory framework for water companies for a “long-term monetised asset risk benefit” metric. This metric would itself be derived from projections of the monetised asset risk metric under certain scenarios.

The long-term monetised asset risk benefit metric would apply to a set of historical or planned asset health investments. It would be intended to provide information on the benefit, in terms of long-term risk management, from that set of investments. The table below shows, in broad terms, how we envisage the long-term monetised asset risk benefit metric being calculated.

Table 5 Key steps for calculation of long-term monetised asset risk benefit metric

Step	Summary of step
Step 1	Define the set of asset interventions and the historical / future investment period for which we want to estimate the benefits. For example, this might be defined to cover all asset replacement and refurbishment actually carried out in the previous financial year, or the set of asset replacement and refurbishment planned to be carried out in a forthcoming price control period.
Step 2	Define a time horizon that starts in the time period over which the set of investments from step 1 above was (or will be) undertaken, and stretches beyond that into the future for a period that is at least as long as the maximum asset life of the assets covered within that set of interventions.
Step 3	Calculate the monetised asset risk metric for each year over this time horizon for a hypothetical “counterfactual scenario” under which no asset interventions were (or will be) carried out during the investment period under consideration or during any subsequent years. Monetised asset risk would be expected to increase over time under this scenario, due to the assumed lack of any asset replacement or refurbishment activity to offset the increases in asset failure risk that are driven by increases to asset age or cumulative usage.
Step 4	Calculate the monetised asset risk metric for each year over this time horizon for the “investment scenario” where: (a) the actual (or planned) investments from step 1 have been (or will be) carried out during the investment period; and (b) there are no further asset interventions in any years subsequent to the investment period from step 1.
Step 5	Use the annual series from steps (3) and (4) to calculate a net present value (NPV) of monetised asset under the counterfactual scenario and the investment scenario. Then deduct the NPV under the counterfactual scenario from the NPV under the investment scenario. The result is an estimate of the long-term benefit to future asset risk that is attributable to the investments carried out (or planned) in the investment period.

A metric such as this, which captures benefits projected over a long period of time, would help address the concern that taking a snapshot of monetised asset risk at a single point in time would be unable to distinguish between the impacts on risk of: (a) operational or short-term measures that control or reduce risk for a short period of time only; and (b) long-term investment in asset replacement that brings benefits to the control of risk over many future years. For example, simply using a monetised risk snapshot as a PCD output could lead to a situation where a company could achieve the PCD outputs through short-term operational measures, and deliver a much smaller quantum of long-term benefits than had been expected, and funded, at the time of the price review.

We comment further on the potential role of the long-term monetised asset risk benefit metric in section 4. The remainder of this section turns back to the calculation of the monetised asset risk metric, which is a key building block for the calculation of long-term monetised asset risk benefit.

Desirable features of the asset risk metrics and methodology

In light the consideration in section 2, and appendix 1, of the potential roles of asset risk metrics as part of the future regulatory framework, we identified a set of desired features of monetised asset risk metrics (and of the methodology used to produce them). This is intended to help explain what is envisaged and to guide potential future work on the development of a methodology to produce such metrics. The table below presents a summary of the desired features that we identified. Each of these features is relevant to both outcomes-level asset risk metrics and monetised asset risk metrics.

Table 6 Overview of desirable features of the methodology and metric

Broad theme	Desirable features of the methodology / metric
Overall focus and scope	<ul style="list-style-type: none"> • Focuses on risks from degradation in asset condition • Outcomes-oriented as far as practical
Building on existing water industry concepts and data structures	<ul style="list-style-type: none"> • Builds on the four Rs of resilience • Draws on established asset and outcome categories as far as practical • Can be related to other asset health metrics used in the industry as far as practical
Contribution to regulatory analysis and arrangements	<ul style="list-style-type: none"> • Enables risk to be tracked over time • Enables risk to be projected into future time periods • Enables changes in risk over time to be decomposed across key drivers • Enables risk to be presented at the level of individual outcomes before monetisation • Enables risk to be reasonably compared across companies

We elaborate on each of these desirable features in appendix 2. In addition, we discuss in the following subsection one aspect that we consider particularly important, especially in terms of informing analysis of historical data on water companies' expenditure and outcomes performance. This concerns the ability to decompose changes in risk over time across key drivers of risk.

Decomposing the evolution of asset risk across the four Rs of resilience

As discussed in appendix 2, a critical feature of the asset risk metrics we envisage is that they enable comparisons of risk over time. Given the potential roles that such comparisons might play within the future regulatory framework, we consider it highly desirable (and perhaps essential for some purposes) that the modelling helps bring an understanding of the specific factors that have caused these changes.

In particular, it would be useful for the changes in asset risk calculated for a given company to be decomposed into changes that arise from:

- The effects of changes over time in the physical condition of assets that affect their asset failure risk (e.g. these changes may reflect the net impacts of asset deterioration over time and asset replacement and refurbishment).
- The effects of changes over time in operational controls that affect: (a) asset failure risk (e.g. pressure management systems to reduce risks of burst water mains); or (b) the consequences of asset failure for outcomes (e.g. response and recovery resources such as rapid response teams and tankering capabilities that act to reduce the duration of events caused by asset failure).

Further consideration will be needed as to the categories of individual drivers or effects that the decomposition would be made for. There would be value in aligning these categories, as far as possible, with the four Rs of resilience: resistance and reliability (potentially taken together); redundancy and response and recovery.¹⁶ The four Rs to relate the systems and controls operated by the water company.

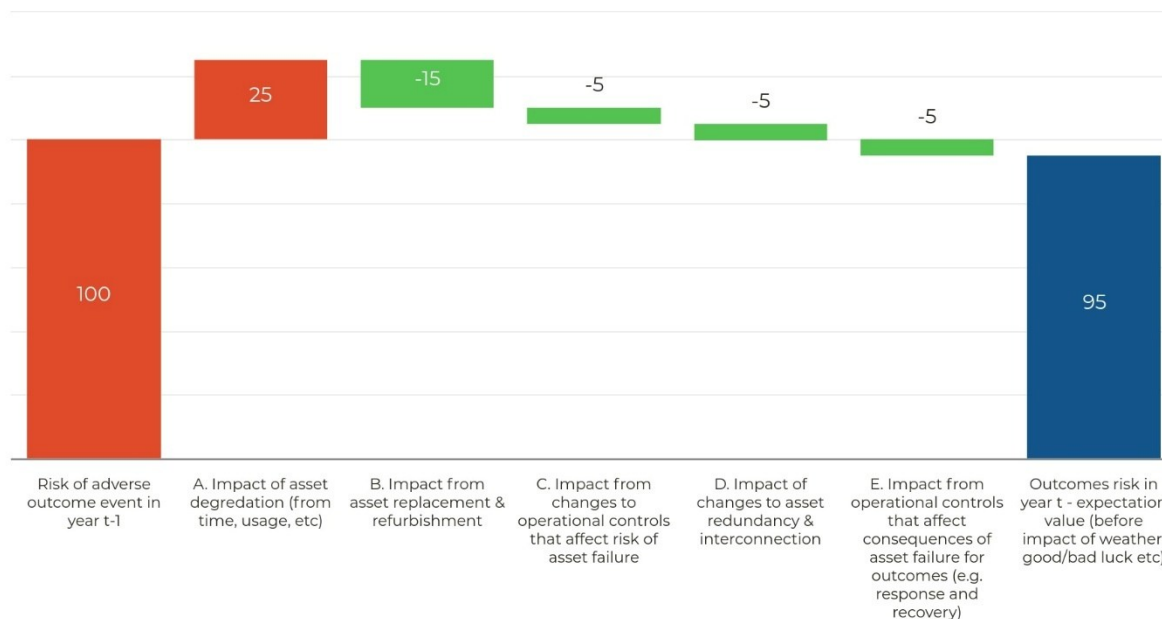
In addition to the different ways that water companies control risks from asset failure, it would be helpful for the decomposition to expose changes over time in asset risk that are driven by external factors (e.g. changes over time in risks from extreme weather events that are linked to climate change).

To provide an indication of what we envisage, the illustrative chart below shows a hypothetical improvement in a company's monetised asset risk from 100 to 95 unit from period t-1 to period t. In this hypothetical example, there has been an increase in monetised risk of 25 units attributed to increased risk of asset failure from degradation in asset condition (effect A in the diagram). This is partially offset by asset replacement and refurbishment reducing risk by 15 units (effect B). There are then a series of further reductions to monetised risk, of 5 units each, arising from: operational controls that reduce asset failure risk (effect C); greater redundancy and interconnection (effect D); and enhanced operational controls which mitigate the risk of asset failure leading to adverse outcomes (effect E).

In this example, we might say that the underlying physical condition of the asset base has deteriorated (the net effects of A and B) but that monetised asset risk has improved due to combination of operational improvements and greater asset redundancy (effects C to E).

¹⁶ See appendix 2 section F3 for further discussion of the relevance of the 4Rs of resilience.

Figure 5 Illustrative decomposition of drivers of changes over time in monetised asset risk



This type of decomposition indicated in the hypothetical example above could provide valuable information for the interpretation of historical data, including for cost assessment purposes. For instance, it could provide evidence on the extent to which the overall trajectory for monetised risk has been driven by long-term investment versus operational improvements, and whether underlying asset condition has improved or deteriorated. This decomposition would, in turn, provide evidence to help assess whether setting cost allowances for the next price control period based on historical levels of expenditure would be sufficient to enable an efficient company to maintain or reduce monetised risk.

Level of aggregation and scope of the calculation of asset risk

A key feature of the monetised asset risk metrics and outcome-level risk metrics that we envisage is that these would be designed to capture risk across a system of assets, rather than resulting in a large number of separate metrics which relate to individual assets or asset groups at a granular level.

This raises questions as to the level of aggregation at which the asset risk metrics would be calculated. At the most aggregated level, these could be calculated for each of wholesale water and for wholesale wastewater. Alternatively, these might be calculated in a way that is broken down into specific parts of each value chain: for example, by separating by price control, or within each control between categories of assets such as water treatment assets or treated water distribution assets. There may be benefits for regulatory purposes in aligning the metrics with price control boundaries, but this might not be essential (Ofwat’s base cost modelling for wholesale water is not separated by price control and instead the modelling results are allocated between the water resources and water network plus controls).

Furthermore, even if the overall metric is to be calculated and presented at a very aggregated level, there could be value for analytical purposes if, as part of the intermediate calculations, the implied monetised risk for parts of the value chain or categories of assets could also be presented at a lower level (e.g. tracking changes over time in parts of the system). But one challenge is that, because the risk to outcomes arises from systems of assets taken together rather than from individual assets in isolation, calculating risk metrics at a more granular level may cut across these systems which might raise implementation issues.

At this stage it seems premature to decide to target a specific level of aggregation. Our initial view is that it would be desirable (but not essential) if the methodology was designed so that monetised risk could be calculated and presented at different levels of aggregation. But as part of the development process, in light of what is learned, further consideration could be given to which levels of aggregation are practical.

A separate issue is whether specific categories of assets, or parts of water and wastewater systems, should be excluded altogether from the modelling of monetised asset risk. We did not, at this initial stage, see any reason to make such exclusions in principle. But it is possible that if work proceeds to implementation, practical issues arise that might suggest excluding or deprioritising certain sets of assets, at least for the initial phase of development. Not all energy network assets are covered by Ofgem's NARM methodology at present, though the scope of coverage may expand over time.

Modelling asset failure and the consequences of asset failure for outcomes

In this final part of section 3, we comment further on the modelling of asset failure (step A in the diagram at the start of the section) and the modelling of the consequences of asset failure for outcomes (step B). These are essential inputs to the calculation of both outcome-level asset risk metrics and monetised asset risk metrics.

Asset deterioration and failure modelling may be challenging in practice for a number of reasons, relating for example to data availability, the vast number of different asset types used in water and wastewater systems, and considerations around the most appropriate statistical or other estimation techniques. At the same time, our understanding is that this is a well-established area of asset management activity and we feel that it is reasonably well-defined conceptually.

One point of clarification is that the focus of asset failure modelling for step A would be failure associated with degradation in asset condition (e.g. degradation in condition that arises from asset usage over time or the passage of time), rather than all possible types of asset failure that might be relevant for broader asset management and operational purposes. Beyond that, it is not a priority for this working paper to elaborate on asset deterioration and failure modelling.

In contrast, we think that the modelling of the consequences of asset failure for outcomes would benefit from some further clarification in terms of what it is intended to do and what, in broad terms, might be involved. In doing so, we have been particularly mindful of our view that the methodology should build on the four Rs of resilience and enable changes in risk over time to be decomposed across key drivers (see appendix 2 for further discussion).

To help convey the broad approach we envisage we first introduce a number of high-level ingredients that could be used for modelling purposes:

- **Asset inventory.** The asset inventory would contain granular information on assets within the system, including characteristics of each asset that are relevant to probability of failure (e.g. physical condition, material, age, cumulative usage). To enable a sufficient level of granularity in the asset inventory, some data may need to be completed using sampling, extrapolation or other techniques.
- **Operational controls that mitigate risk of asset failure.** This would capture information on operational controls applied to assets in the asset inventory, such as periodic inspection and repair policies, or practices that limit the load/stress on the asset (e.g. policies on how pressure management systems are used), which mitigate or limit the risk of asset failure. There is value in specifying this information as input data, rather than reflecting directly within the asset deterioration and failure modelling, as the use of these operational controls may vary over time in important ways.
- **Asset systems.** We use the broad term information on asset systems to refer to information on the role of individual assets (covering the assets from the asset inventory above) within the broader system, which takes account of their roles in providing specific services to specific customers (or protecting against adverse environmental or other impacts) and on the extent to which other assets in the system provide redundancy in respect of those assets and roles.
- **Operational controls that mitigate the consequences of asset failure.** This would capture information on the operational controls that help reduce the likelihood of, or to reduce the severity of, adverse outcome events arising from asset failure events.

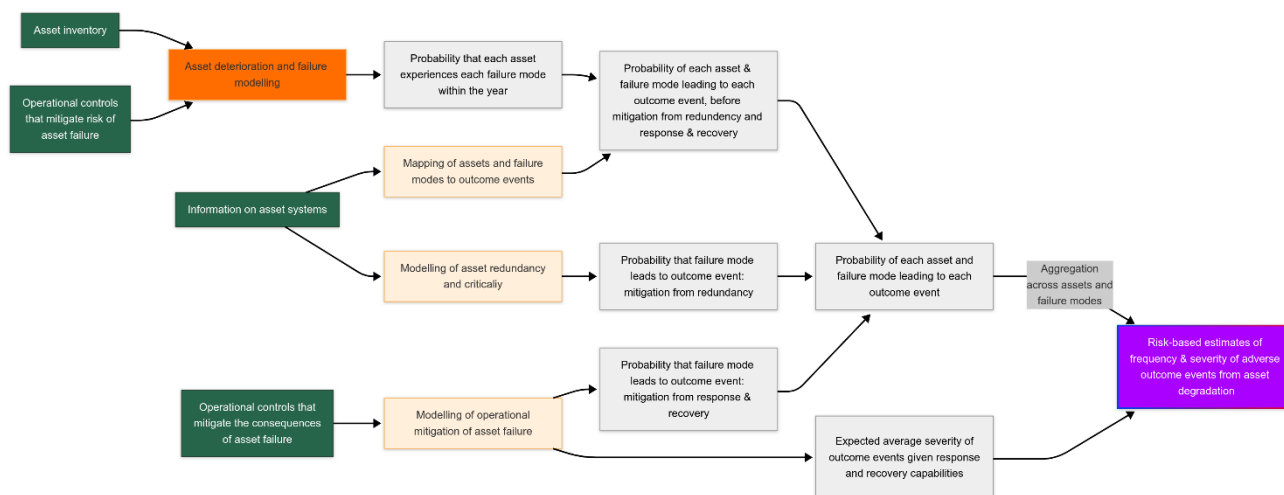
At a high level, the key modelling components or tools that we envisage for modelling the consequences of asset failure for outcomes are broadly as follows:

- **Mapping of assets and failure modes to outcome events.** This would draw on information about how assets are used to provide services to customers and the potential impacts of their failure, to map, for each asset, which adverse outcome events would arise from each potential failure mode of the asset, *before consideration of the protections and mitigations* provided by (a) other assets that provide redundancy and (b) operational controls which reduce the probability that the failure of that asset has consequences for outcomes. The mapping would also capture key aspects of the scale of adverse outcome events that might arise (e.g. how many customers might face water quality problems from the failure of a specific asset that serves them).
- **Modelling of asset redundancy and criticality.** This modelling would draw on information on the role of individual assets in the wider system to estimate the probability that a specific asset experiencing a specific failure mode would *not* lead to a specified outcome event due to the risk mitigation benefits from redundancy provided by other assets in the system which act to mitigate the risk that individual asset failure leads to adverse outcome events (but leaving aside the mitigation provided operational controls which is covered separately below).
- **Modelling of operational mitigation of asset failure.** This modelling would estimate, across failure modes and outcome events, the impact of the operational controls that mitigate the impacts of

specific asset failure scenarios on (a) the probability of adverse outcome events occurring and (b) the severity of their impact (e.g. reductions to their expected duration). This is essentially modelling of the response and recovery aspects of resilience.

The diagram below provides an illustration of how the modelling components set out above might fit together to enable the calculation of risk-based estimates of frequency and severity of adverse outcome events from asset degradation (i.e. step C in the high-level diagram above). This is intended as a simplified example of how things might work, focusing on key calculation flows and it does not necessarily capture all potential interactions across the various elements. To reduce complexity, this diagram focuses on what is covered by steps A to C from the high-level diagram at the start of section 3; it does not cover valuation of harm from adverse outcome events (step D) or calculation of monetised asset risk aggregated across all outcomes (step E).

Figure 6 Illustrative and simplified modelling structure



The diagram reflects an initial view intended to help outline a potential approach and to illustrate some broader points. Further consideration, including comparisons with the approaches to asset risk modelling used in practice by water companies, may suggest revisions and refinements. For instance, it is possible that the mapping of assets and failure modes to outcome events and the modelling of asset redundancy and criticality would make more sense in practice as an integrated modelling exercise drawing on common data. And there may be overlap in practice between the asset inventory and the information on asset systems.

The modelling outlined above could be used for both monetised asset risk metrics and for outcome-level asset risk metrics. Modelling of the consequences of asset failure for outcomes is likely to be a particularly challenging task that can usefully be separated from work on valuation and monetisation (though some alignment is needed on the set of outcomes to be modelled and potentially valued). The modelling of the consequences of asset failure for outcomes seems more urgent than work on monetisation and aggregation, if the type of asset risk metrics covered in this working paper are to be used as part of the PR29 regulatory framework.

Section 4: How the proposed metrics could contribute to the future regulatory framework

Introduction

In section 3 we proposed three related types of asset risk metric, which would draw on common underlying risk modelling. We recap these in the table below and comment on how they are related.

Table 7 Recap on asset risk metrics and the links between them

Type of metric	Links to the other metrics
Outcome-level asset risk metric	Input to the calculation of the monetised asset risk metric but also has value in its own right
Monetised asset risk metric	Calculated by combining information from outcome-level asset risk metrics with monetised valuations of adverse outcome events and then aggregating risk across outcomes
Long-term monetised asset risk benefit metric	Calculated by comparing the NPV of monetised asset risk metrics over a long-term time horizon for scenarios with and without a defined set of investments

Both the outcome-level and monetised asset risk metrics provides a snapshot of risk (over a 12-month period), which can be tracked over time (e.g. via reporting for each financial year) and projected into the future (under defined scenarios). In contrast, the long-term monetised asset risk benefit metric is defined for a set of investments (which may be investments carried out in the past or investments planned in a future year) and concerns the benefits to risk management, specifically from those investments, over a long future time horizon.

This section summarises how each of these related metrics could contribute to the future regulatory framework for water companies, drawing on the consideration of the potential roles of asset risk metrics provided in appendix 1 and taking account of differences between the three metrics. We first present a summary of the nature of evidence provided by each of the three asset risk metrics. We then present a summary of how these metrics could contribute to the regulatory framework.

The nature of evidence provided by the asset risk metrics

The asset risk metrics outlined above could provide various types of relevant evidence for use as part of the future regulatory framework. In the table below, we highlight a number of key types of evidence and indicate the potential contribution of each type of metric.

In all cases, it is important to recognise that there is likely to be approximation, subjectivity and inaccuracy in the calculation of monetised asset risk. This should be taken into account in the interpretation of evidence from the metrics. The degree of confidence in the calculation of an asset risk metric also has implications for how it is to be used in the regulatory framework and, in particular,

whether it is used mechanistically in a way that has large direct impacts or whether it is used, with judgement, as part of a broader evidence base.

Table 8 Evidence provided by outcome-level and monetised asset risk metrics

Nature of evidence	Outcome-level asset risk metric	Monetised asset risk metric	Long-term monetised risk benefit metric
Evidence on asset risk at a point in time (i.e. snapshot of the risk of adverse consequences from asset failure in that year)	Yes, evidence provided at the level of individual outcomes	Yes, evidence provided in a form that is aggregated across outcomes	Not directly
Evidence on the evolution of asset risk over a historical period	Yes, evidence provided at the level of individual outcomes	Yes, evidence provided in a form that is aggregated across outcomes	Not directly
Evidence on the factors driving the evolution of asset risk over a historical period	Yes, as long as the methodology is designed to enable decomposition of changes over time	Yes, as long as the methodology is designed to enable decomposition of changes over time	Some evidence especially in conjunction with the other two metrics
Projection of levels of asset risk into future time periods (e.g. for scenarios for the levels of asset health investment undertaken in future time periods)	Yes, evidence provided at the level of individual outcomes	Yes, evidence provided in a form that is aggregated across outcomes	This metric would be derived from projections of the levels of asset risk in future periods
Estimation of the long-term benefits to asset risk from a company's actual investment in asset health during a previous year	Not directly, but this metric is an input to long-term monetised risk benefit	Not directly, but this metric is an input to long-term monetised risk benefit	Yes, key role of this metric
Estimation of the long-term benefits to asset risk from a company's proposed investment in asset health over a forthcoming period	Not directly, but this metric is an input to long-term monetised risk benefit	Not directly, but this metric is an input to long-term monetised risk benefit	Yes, key role of this metric

How the asset risk metrics could contribute to the regulatory framework

The nature of evidence provided by the metrics affects their potential role within the future regulatory framework. In the table below, we list three high-level roles that the asset risk metrics might play in the regulatory framework (see section 2 and appendix 1 for further information on the use of asset risk metrics in each role). For each role we provide a view on the usefulness of these metrics for that role.

For the purposes of this table, we leave aside questions about the practicalities and costs of producing the relevant metrics, and the potential for inaccuracy arising from implementation, and focus on whether in principle the metric would be useful for the regulatory framework. This table provides an initial view which is likely to benefit from refinement over time as further work is carried out on these metrics and the future regulatory framework.

Table 9 Contributions of asset risk metrics to specific regulatory roles

Potential regulatory role	Outcome-level asset risk metrics	Monetised asset risk metrics (aggregated)	Long-term monetised risk benefit metrics
1: Linking expenditure allowances to delivery of asset health investment	No direct contribution identified (but this is an input to the long-term risk benefit metric)	No direct contribution identified (but this is an input to the long-term risk benefit metric)	Likely to be highly useful
2: Enhancing information on forward-looking asset risk management	Likely to be highly useful	Likely to be useful	Likely to be useful
3: Supporting price control cost assessment	Likely to be useful	Likely to be highly useful	Likely to be highly useful

By way of further explanation in the table above, we briefly highlight the following:

- Long-term monetised risk benefit metrics are much more suitable for linking expenditure allowances to delivery of asset health investment than the outcome-level and monetised asset risk metrics. The long-term monetised risk benefit is a more direct measure of the scale of delivery benefits achieved over a price control period, in a context where investments may bring benefits over many future years. Ofgem has been moving towards this role for long-term monetised risk benefit metrics for its energy network price control arrangements.
- In terms of enhancing information on forward-looking asset risk management, there is value in keeping visibility of future risks to individual outcomes (as under the outcome-level asset risk metrics), rather than collapsing information into a single monetised risk metric. This would draw on projections of the outcome-level asset risk metrics over a long-term future time horizon. The two metrics involving monetised risk could play a useful supporting role which, provides a more high-level perspective on the trajectory of risk and its drivers.
- For cost assessment, there is unlikely to be a simple mapping between expenditure categories and outcomes, with asset health investment in one area potentially bringing benefits across several outcomes. In this context, there is particular value in the two monetised metrics as these provide aggregate measures of risk (or risk reduction benefits) that can be compared against data (or projections) on water company expenditure. Nonetheless, outcomes-level metrics could play a useful supporting role, including where there is a case for targeting asset health investment at specific areas of risk.

The table above focuses on the three key roles discussed in section 2 which, in turn, reflect the key elements of the shortlisted policy packages from Reckon (2024). There may be other potential roles within the future regulatory framework. For instance, the outcome-level asset risk metric is likely to be useful, alongside other forms of analysis, to inform the setting of performance commitment levels (PCLs) as part of Ofwat’s price review process.

Finally, each of the three metrics might be useful as part of water companies' internal asset management activities. Indeed, versions of these metrics may already be used by water companies. More generally, the development of modelling to produce asset risk metrics for regulatory purposes is likely to overlap with the modelling that companies use internally, and it would benefit from alignment where practical. At the same time, we would expect there to be some limitations in the modelling that is used for regulatory purposes (e.g. due to requirements for consistency across companies in key aspects of the methodology and data structures, or due to requirements on the transparency of the modelling and input data). These limitations might mean that, even if asset risk metrics are established for regulatory purposes, water companies may use more sophisticated (but less transparent) internal modelling tools as part of their asset management activities.

Appendix 1: Elaboration on the roles that asset risk metrics could play

Introduction

This appendix elaborates on the potential roles for asset risk metrics within a reformed regulatory framework. It takes the following in turn:

1. Linking price control expenditure allowances to delivery of asset health investment.
2. Enhancing information on forward-looking asset risk management.
3. Supporting price control cost assessment.

In line with the overall focus of this paper on monetised asset risk metrics, the primary interest in this appendix is the use of monetised asset risk metrics across these three roles. However, we also comment on the use of outcome-level asset risk metrics where this is particularly relevant.

Role (1): Linking expenditure allowances to delivery of asset health investment

Perhaps the most obvious role for monetised asset risk metrics is that used by Ofgem for energy network regulation, building on the Network Asset Risk Metric (NARM) approach. In Reckon (2024), this role forms part of policy package P4.

Under this approach, all, or a large part of, the price control allowances for capital maintenance expenditure would be linked to a company's outturn delivery of asset health investment, measured using the monetised asset risk metric. A water company's price control funding would be adjusted if it delivers less, in terms of asset risk benefits, than it had been funded for (potentially with some scope for the funding to be adjusted upwards if it delivers more).

As with PCDs under Ofwat's PR24 framework, it would be made clear what part of the ex ante totex allowance set at the price control review is effectively hypothecated for delivery against the monetised asset risk metric, with the potential for some/all of that funding to be returned to customers if the company under-delivers against the asset risk benefits it had been funded for. For PR24, Ofwat used the terminology of PCD "outputs" to refer to the specific level or volume that a company will be held to account for delivering through the PCD. For instance, the storm overflow PCD is defined in terms of a PCD metric, which is cubic metres of equivalent storage capacity delivered, and the PCD output for a specific company might be to deliver, for example, 500,000 cubic metres of equivalent storage capacity by 2030.

In relation to capital maintenance allowances, PCD metrics could be based on monetised asset risk metrics, and the PCD output could be defined in terms of the expected long-term risk benefits from the capital maintenance expenditure over a long-term time horizon.

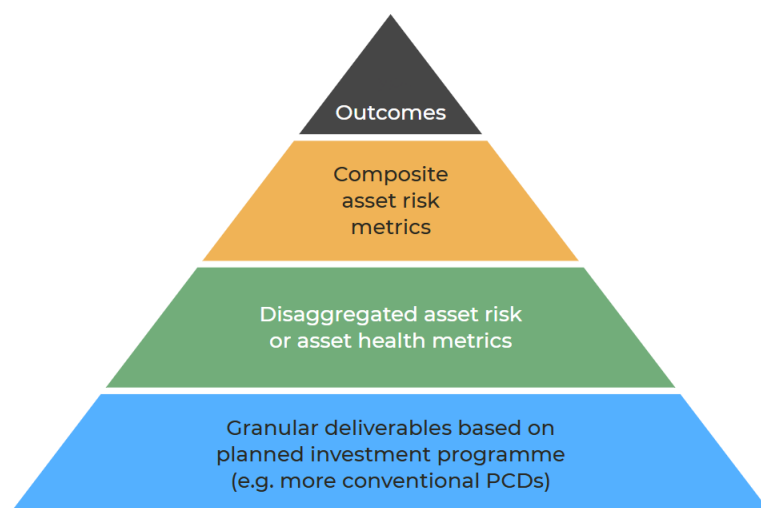
This would be consistent with how Ofgem's NARM approach has evolved to consider monetised asset risk over a long-term modelling time horizon. In its NARM methodology, National Gas refers to "Long

Term Monetised Risk Benefit (LTRB)” in recognition of the long-term horizon used when considering the benefits of asset replacement / refurbishment on monetised asset risk.¹⁷

Specifying the PCD output in a way that captures benefits projected over a long period of time would help address the concern that taking a snapshot of monetised asset risk at a single point in time would be unable to distinguish between the impacts on long-term risk of: (a) operational or short-term measures that reduces risk for a short period of time only; and (b) long-term investment in asset replacement that brings benefits to risk reduction over many future years. Simply using a monetised risk snapshot as the PCD output could lead to a situation where a company could achieve the PCD outputs but deliver a smaller quantum of long-term benefits than had been expected, and funded, at the time of the price review.

In our report last year, we identified that there are different levels of granularity at which deliverables used for capital maintenance expenditure might be specified. We reproduce a diagram from the report below.¹⁸ The monetised asset risk metrics that we envisage in this working paper would fit under the category of “composite asset risk metrics” in this diagram. The categories further down the diagram would involve more granular deliverables that are further removed from outcomes.

Figure 7 Different levels of granularity at which deliverables might be defined by reference to



This working paper is not intended to review in any detail the pros and cons of different options for the regulatory framework from PR29 onwards. But for our current purposes it seems useful to highlight a number of benefits of setting deliverables based on monetised asset risk metrics rather than granular deliverables based on asset replacement volumes or required asset condition grades:

¹⁷ National Gas (2024) *Gas Transmission Network Asset Risk Metric (NARM) Methodology Main Overview Document*.

¹⁸ Reckon (2024, page 36).

- Company investment being better directed at what matters to customers and the environment, in terms of the estimated risk of adverse outcomes arising from asset failure.
- More flexibility — and opportunities for innovation and learning over time — for companies in terms of which assets to replace (or refurbish), and how best to achieve operational resilience, subject to safeguards that this flexibility is not being used to deliver short-term solutions from funding levels intended for long-term investment.
- Broad coverage of assets across the water and wastewater asset base (e.g. rather than PCDs being focused on specific asset categories for which data on asset replacement volumes is available and meaningful).
- Recognition of different types of asset intervention which differ in terms of the duration or scale of benefits delivered (e.g. asset replacement with long-life asset, asset replacement with short-life asset, asset refurbishment, etc).

The realisation of the benefits above would depend on whether a sufficiently good (or good enough) implementation of monetised asset risk metrics for water and wastewater asset could be realised. We identified in Reckon (2024) that the implementation challenges with this type of approach are relatively high compared to other policy options. This is partly because of the complexity and sophistication of the modelling needed to produce monetised asset risk metrics for water and wastewater systems. It is also because of the direct role that the metrics would be playing in the calculation of deliverables that price control expenditure allowances would be tied to.

Nonetheless, it is important to keep in mind that, under package P4 from Reckon (2024), the deliverables based on monetised asset risk metrics would apply *alongside* the types of financial ODIs for customer service and environmental outcomes that apply today (subject to some refinement such as dropping the current “asset health” ODIs for sewer collapses and unplanned water treatment outages). Under this approach, we would expect companies’ decision-making in relation to asset health investment to be guided by both: (a) the expected impact of the investment on the company’s ability to meet the deliverables specified in terms of monetised asset risk metrics; and (b) the expected impact of the investment on the company’s performance against financial ODIs in the near-term and longer-term (as well as by other factors such as compliance with legal obligations). We see an important role for the financial ODIs in helping to mitigate the inevitable limitations in the design and implementation of monetised asset risk metrics for water and wastewater systems.

In any event, and given practical concerns, it may make sense for an approach to using monetised asset risk to determine PCD outputs to be complemented by a series of safeguards to help address potential risks of unintended consequences. These may relate, for example, to the extent to which any financial adjustments / non-adjustments for delivery against the PCD outputs are mechanistic or subject to some further arrangements or obligations which relate to the broader policy position on what has been funded than to the details of the metrics as calculated.

Role (2): Enhancing information on forward-looking asset risk management

In Reckon (2024) we identified a concern that there is not enough information available about the risks of service disruption and adverse environmental outcomes in the future that may arise from asset deterioration or poor asset health, and about how these risks are being managed by water companies. Asset risk metrics provide a way to help address these informational gaps.

Furthermore, we identified that improving the prominence and credibility of information relating to asset health and future outcomes performance could better align the financial and reputational incentives that water companies face with long-term performance and investment. Rather than tying price control funding for capital maintenance expenditure directly to asset health investment deliverables (as under role (1) above) an alternative strategy for PR29 is to retain a regulatory focus on outcomes while enhancing the incentives of companies in respect of their long-term performance. Under this strategy, a range of complementary initiatives and modifications to the regulatory arrangements would be implemented to help to tackle both the behavioural and the informational concerns that arise under the current regulatory approach. Enhancing information on forward-looking asset risk would be a key part of these initiatives. And while these initiatives represent a potential alternative to the type of approach under role (1) above, they might also be applied in conjunction with that approach.

In Reckon (2024), we refer to packages P2 and P3 as including an “Enhanced set of incentive and informational remedies” and we describe this package of remedies in more detail in Annex 1 to that report. In this section we elaborate on the role that monetised asset risk metrics (and the modelling that lies behind them) could play as part of this broader set of incentive and informational remedies. In short, monetised asset risk metrics as envisaged in this working paper, with a strong focus on the potential impacts of asset failure on outcomes, seem to be highly useful in principle for the implementation of the incentive and informational remedies.

In Annex 1 to Reckon (2024), we organised the potential incentive and informational remedies into five areas:

- Increasing the prominence and credibility of information relating to future outcomes performance.
- Use of financial ODIs applied to information on operational resilience.
- Steps to help avoid misleading inferences being drawn on companies’ current performance.
- Other targeted changes to reduce risks of undue incentives on short-term performance.
- Other targeted changes to support decision-making with a long-term perspective.

Monetised asset risk metrics could play a direct role under the first and second of these. But such metrics might have beneficial knock-on benefits in the other three areas.

Within the first area above, the underlying idea is that by exposing more information on companies’ current asset health, and their management of risks to outcomes in the future, companies would face enhanced financial and reputational incentives to: (a) better understand the risks to outcomes in the future that arise from the health of their assets (and the broader operational resilience of their systems);

and (b) take appropriate action today to better manage risks of adverse outcomes arising in the future (e.g. through long-term investment informed by an information on asset failure risk and the potential consequences of such failures for outcomes).

In the same document, we provide further information on a series of specific initiatives that could be used to increase the prominence and credibility of information relating to future outcomes performance. For the purposes of this section, we briefly highlight in the table below the contribution that monetised asset risk metrics could play as part of the initiatives from the first and second areas highlighted above.

Figure 8 Potential role of monetised asset risk metrics

Regulatory measure or initiative from Reckon (2024)	Comments on potential contribution of monetised asset risk metrics
Increasing the prominence and credibility of information relating to future outcomes performance	
Long-term projections of PC/outcomes performance under well-defined scenarios (using transparent modelling and assumptions and taking explicit account of asset failure risk)	<p>There is considerable overlap between the information and modelling needed to produce monetised asset risk metrics (and projections of these under defined scenarios) and the modelling that could help produce projections of a company's future performance against specific PCs or against other outcomes.</p> <p>Furthermore, because there are a large number of separate outcomes and PCs, there would also be value, for practical purposes, in a metric that consolidates projected performance across a range of outcomes/PCs and the monetised asset risk metric could play this role.</p>
Company-owned policies on the management of asset health and risks to future outcomes	<p>For this initiative to work well, it would be important for it to be based on evidence about asset risk and consequent risk to outcomes, rather than simply being a qualitative and high-level description of corporate policies. Monetised asset risk metrics could provide evidence, and the policies could also recognise and respond to any limitations of such metrics (e.g. in terms of scope or known shortcomings).</p>
Comparative evaluation of companies' outcome risk management	<p>If there was to be a comparative evaluation of companies' outcome risk management, there would be a need for greater information than available at present on asset health and risks to future outcomes. Ideally this would be on a basis that is comparable across companies. Asset risk metrics (and projections of these under defined scenarios) could provide a key piece of evidence to inform on companies' relative performance and could be taken into consideration alongside other evidence (e.g. evidence not captured by these metrics).</p>
Shadow RCV adjustments for scenarios of each company's future outcomes performance	<p>Monetised asset risk metrics (and projections of these under defined scenarios) could provide a key piece of evidence to determine shadow RCV adjustments under defined scenarios, while recognising that such metrics may not capture everything or be 100% reliable which suggests a role for other sources of evidence too.</p>
Use of financial ODIs applied to information on operational resilience	
Financial ODIs applied directly to metrics of asset health and operational resilience	<p>Our initial view is that it would not make sense to tie ODIs directly to companies' performance against monetised asset risk metrics; if such metrics are to be used in very mechanistic way, we think it would make more sense to use the monetised asset risk metrics to specify price control deliverables (see discussion under role (1) above). But at this stage we do not completely rule out this type of role.</p>

Regulatory measure or initiative from Reckon (2024)	Comments on potential contribution of monetised asset risk metrics
Financial ODIs apply to outcome of comparative evaluation of companies' outcome risk management referred to above	Monetised asset risk metrics could form part of the evidence base under the type of comparative evaluation of companies' outcome risk management referred to above but with financial ODIs applied depending on the results from that evaluation. This would allow account to be taken of the evidence from monetised asset risk metrics, without this being done mechanistically; the assessment could draw on broader set of evidence and take account of any limitations of such metrics (e.g. in terms of scope or known shortcomings).

There is also the potential for some of the initiatives above (particularly long-term projections of PC/outcomes performance under well-defined scenarios and company-owned policies on the management of asset health and risks to future outcomes) to be used as part of an extension and enhancement of water company's existing long-term delivery strategies (LTDS) to cover capital maintenance / asset health, and potential to be integrated with statutory planning process (e.g. drainage and wastewater management plans, DWMPs).

At this stage, we have drawn two key implications for use of monetised asset risk metrics under role (2):

- The informational and incentive remedies would generally not use monetised asset risk metrics in a mechanistic way, with potential for other sources and information and judgement to be used in recognition of the potential limitations of these metrics (e.g. in terms of scope, known approximations or vulnerabilities affecting accuracy, or sensitivity to key assumptions).
- For some of the informational and incentive remedies, estimates of asset risk before monetisation or aggregation could be equally important — or perhaps more important — than the final calculation of monetised asset risk aggregated across all assets and outcomes. For instance, a potential intermediate stage in the calculation of monetised asset risk would be to estimate the risks of specific adverse outcome events arising from asset failure risk (e.g. in terms of customer interruptions or sewer flooding events): this stage of modelling could be useful for the informational and incentive remedies before the monetisation and aggregation. While highly aggregated and monetised risk metrics could play a useful role as part of the informational and incentive remedies, these remedies could also make use of less aggregated metrics at the level of individual outcomes.

Role (3): Supporting cost assessment

Further to roles (1) and (2) above, monetised asset risk metrics could play a role as part of the cost assessment carried out at price reviews to determine ex ante allowances for base costs (or for capital maintenance expenditure, should this be assessed separately).

We use the term cost assessment in a broad way, consistent with its usage within Ofwat's current price review processes. It would include, where applicable, regulatory assessment of the appropriate quantum of asset health investment that companies should be funded for, as well as of the costs of that investment.

The approach to cost assessment might differ depending on whether or not monetised asset risk metrics are to be used for linking price control expenditure allowances to delivery of asset health investment, as under role (1) above. In the subsections below, we first discuss the potential use of monetised asset risk metrics in more general terms, including where the metrics are used for roles (1) and/or (2) above. We then turn to some more specific issues that arise for cost assessment in the specific case where monetised asset risk metrics are to be used for role (1).

Potential contribution of monetised asset risk metrics to cost assessment

Monetised asset risk metrics could play a valuable role under a number of different forms of analysis and analytical tools to support cost assessment.

Ofwat's current approach to cost assessment for base costs (which includes operating expenditure and capital maintenance expenditure) places a large weight on historical levels of *expenditure* (in cash terms) incurred by water companies.¹⁹ This approach is compromised by the lack of information on what has been achieved or delivered by that expenditure, especially in terms of the long-term benefits in relation to asset risk. The extent of these benefits may vary across companies and over time, and the scale of benefits delivered in the past may be more or less than what is needed in the future. Monetised asset risk metrics, and in particular evidence on the long-term benefits to monetised risk that companies have achieved in periods covered by analysis of historical expenditure, would provide a means to help tackle this gap.

To the extent that data on historical expenditure incurred by water companies is used to help assess companies' efficient expenditure requirements for the forthcoming price control period, it would be highly relevant to understand how monetised asset risk has evolved over the timeframe covered by that expenditure. For instance:

- It would be relevant to understand whether monetised asset risk (viewed as a snapshot at a point in time) has been stable, has improved or has worsened over relevant periods covered by the analyses.²⁰ For example, if monetised asset risk has worsened over the period then it may be inappropriate to set expenditure allowances at similar levels while expecting companies to maintain stable performance and asset risk.
- It would be relevant to understand what has driven the profile over time in overall monetised asset risk given that different elements that contribute to overall risk (e.g. different aspects of operational resilience). For example, there may have been different trajectories for risk relating to underlying asset condition (e.g. reflecting the net effects of asset degradation over time and asset replacement / refurbishment) compared to the effects from operational practices/controls (e.g. changes in operating

¹⁹ This approach departs from more conventional economic analysis of costs which considers operating expenditure plus *depreciation*.

²⁰ Note that while Ofwat's base cost modelling at PR24 covered a historical data period from 2011-12 onwards, its application of an upper-quartile catch up adjustment, calculated over the last five years of data, means that the allowances it set give much more weight to the levels of expenditure (and the activities and delivery achieved) over that five-year period rather than the full historical data sample.

practices that have enabled reductions to monetised risk). Understanding these underlying changes seems important when setting cost allowances for future periods as differences in the trajectory of risk from the underlying elements may mean that the profile of overall risk in the future may differ from that in the past.²¹

- It would be relevant to understand what benefits have been delivered from the expenditure incurred over the historical data period. Estimates of the longer-term benefits achieved, in terms of monetised asset risk over a long future time horizon, would be particularly useful.

In this context, analysis of monetised asset risk could provide evidence to support a more informed and evidence-based way to use historical expenditure data to set cost allowances for a forthcoming period.

For the purposes of the analysis above, we envisage in the first instance a strand of a quantitative analysis (using charts and other visual tools) that is carried out to complement analysis of companies' historical expenditure (e.g. econometric models that draw on historical expenditure data across companies). It would inform the interpretation of the outputs of the analysis of historical expenditure. It may also support quantification of adjustments to apply to cost estimates derived from analysis of historical data to fund a desired trajectory for monetised asset risk in the future.

In addition, there may be scope to use monetised asset risk metrics directly within econometric benchmarking modelling of historical expenditure, whether these are models of base costs or models that are more focused on capital maintenance expenditure. Further work would be needed to determine how best this could be done; our initial view is estimates of the benefits to long-term monetised asset risk delivered by each company in each year could be explored as a potential explanatory variable in the models. This may enable the econometric modelling to estimate and take account of the relationship between expenditure and these benefits. Doing so could help in three main ways:

- Enabling projections of modelled costs, derived from econometric benchmarking of historical data, to be made over the next price control period under desired scenarios for the trajectory for monetised asset risk across the industry (e.g. stable or improving). This in turn could help to better align price control expenditure allowances, at the industry level, with regulatory expectations/requirements on companies' management of risks.
- Potentially improving the broader quality (e.g. stability and explanatory power) of the econometric benchmarking models by controlling for an additional explanatory factor for expenditure levels that may vary across companies and over time.
- Reducing the risk that Ofwat's inferences about companies' relative efficiency are compromised by differences between companies in the benefits (short-term and long-term) that companies have delivered over the five-year historical period used by Ofwat to calculate its efficiency ratios.

²¹ Further to the elaboration of this issue in appendix 2 of this working paper (e.g. see subsection on desirable feature F8), this issue of risk trajectories is represented graphically and discussed in United Utilities (2021) *Asset health in the water sector: proposal for a framework*, page 10.

Further consideration of model specification and preliminary modelling results would be needed to assess whether this form of analysis is viable. It is possible that efforts to incorporate estimates of the benefits to long-term monetised asset risk as explanatory variables work would be more successful if the dependent variable in the econometric models is more focused on the costs of delivering such long-term benefits (such as capital maintenance expenditure and infrastructure renewals that are expensed) rather than the dependent variable being a broad measure of base costs that includes operating expenditure as well as other capital expenditure such as expenditure on network reinforcement. This is something that is best addressed through testing when data are available rather than seeking to prejudge.

In any event, it is important to stress at this stage that incorporating monetised asset risk metrics within econometric modelling of companies' expenditure is not essential in order for these metrics to provide useful evidence for cost assessment.

Beyond the analysis and interpretation of historical expenditure data as highlighted above, and as discussed in Annex 1 to our Infrastructure Health project report, there may be a role for forms of cost assessment that are not based on water companies' historical data. Apart from the broader point about the future potentially differing from the past, there is a specific concern that, due to the behavioural concerns discussed in Reckon (2024), the historical expenditure data on base costs or capital maintenance may be polluted and not a good guide to efficient levels of expenditure in the future.

The modelling methodology developed for calculating monetised asset risk metrics might be viewed as a tool that could be used for forward-looking cost assessment. It could be used to produce long-term projections of monetised asset risk, and for individual outcomes before monetisation, for a series of user-defined investment programmes over the price control period. This might in turn be used, in conjunction with analysis of investment unit costs, to help calibrate or determine levels of funding for base costs or capital maintenance expenditure. While this modelling of future costs might not be as sophisticated as that available from a water company's internal modelling systems (and expert judgement), it would have benefits for the purposes of price control cost assessment from the greater degree of transparency and from the use of common modelling methodologies.

Depending on the maturity of, and confidence in, the asset risk modelling, the outputs from this type of approach could be used in different ways, for example:

- As a source of evidence that is used, alongside other approaches, to apply forward-looking adjustments to cost estimates derived from benchmarking of historical expenditure data.
- As a self-standing means to set forward-looking estimates of companies' expenditure requirements for capital maintenance / asset replacement expenditure directly for each company (either by carrying out separate modelling for each company or by benchmarking the outputs from company-level modelling).

The investment costs under the approaches above might be derived by combining granular cost information (e.g. the average unit costs for specific asset replacement categories) with the volumes of investment under the assumed investment programme (e.g. investment volumes that reflect an optimised plan for maintaining stable monetised asset risk over time).

There is also the potential to calculate and use a broader concept of unit costs based on monetised asset risk: for example, the cost per unit of long-term risk benefit (drawing on the concept of the Unit Cost of Risk Benefit from Ofgem’s NARM methodology). For example, at the simplest level a cost per unit of long-term risk benefit for a given year and company might be obtained by dividing the estimate of the total value of monetised asset risk benefit achieved by the company in that year by the value of expenditure incurred contributing to that benefit (e.g. this might be capital maintenance expenditure plus asset renewals that are expensed). The cost per unit of long-term risk benefit might be informed by historical and/or forecast data from companies and potentially subject to cross-company benchmarking.

There are different ways that the cost per unit of long-term risk benefit might be used for cost assessment purposes, and we do not want to constrain these at this stage, but we briefly highlight the following examples:

- As a means to calibrate the scale of a sector-wide (or perhaps company-specific) adjustment to cost estimates derived from analysis of historical data (e.g. using econometric benchmarking of base costs or capital maintenance expenditure), in a context where separate analysis has indicated that the historical levels/trends in that expenditure would not be sufficient to support a sensible / desired trajectory for monetised asset risk in the future.
- Potentially to produce self-standing estimates of the expenditure requirements to fund a desired quantum of long-term benefit to monetised asset risk, which might be used more directly to set price control expenditure allowances for capital maintenance / asset health investment.

In Annex 1 to Reckon (2024), we described a number of different analytical tools and sources of evidence that might be used, as part of cost assessment, to help tackle concerns about asset health. The discussion above has sought to cover these where applicable. As a summary to this subsection, in the table below we briefly indicate whether monetised asset risk metrics could be useful under each of these tools or sources of evidence. This table focuses on the potential usefulness of monetised asset risk metrics, in principle, leaving aside the potential risks to cost assessment that might arise if the metrics produced in practice are inaccurate or misleading.

Figure 9 Potential contribution to analytical tools and sources of evidence for cost assessment

Potential analytical tool or source of evidence	Initial view on potential contribution of monetised asset risk metrics to the tool / source of evidence
1. Analysis of changes over time in expenditure and consideration of the factors driving these changes	Seems likely to be useful It would be especially useful if methodology enabled changes over time of monetised risk to be disaggregated across key drivers such as underlying asset condition, changes in operational practices, external factors etc
2. Analysis of historical data on asset health over the historical period covered by expenditure benchmarking Including analysis of what base buys (implicit allowances) as a means to understand what can reasonably be expected from expenditure allowances set based on historical expenditure levels	Seems likely to be useful Since monetised risk metric would capture operational changes as well as asset health it would be especially useful if, as above, changes over time in monetised risk is disaggregated across key drivers

Potential analytical tool or source of evidence	Initial view on potential contribution of monetised asset risk metrics to the tool / source of evidence
	Useful role for long-term monetised asset risk benefit metrics (see section 3 of this paper).
3. Estimates of expenditure requirements based on asset inventories and asset life estimates	No direct contribution identified at this stage This type of approach might be viewed as a simpler way to model forward-looking expenditure requirements, based on asset age versus assumed asset life, compared to the more risk-based approaches such as under (4) below
4. Projections for asset health and outcomes under defined investment scenarios drawing on asset deterioration modelling	Seems likely to be useful
5. Econometric benchmarking models of base-plus expenditure with time trend explanatory variables	No direct contribution identified at this stage (but may be relevant in conjunction with (6) and (7) below)
6. Econometric benchmarking models of capital maintenance expenditure	Potential to be useful, though uncertain at this stage whether this type of modelling would work well in practice
7. Econometric benchmarking models of base-plus expenditure with explanatory variables relating to asset health	Potential to be useful, though uncertain at this stage whether this type of modelling would work well in practice
8. Econometric benchmarking models using company expenditure forecasts as input data	No direct contribution identified at this stage (but may be relevant in conjunction with (6) and (7) below)
9. Analysis of costs per unit of monetised asset risk reduction (e.g. cost per unit of long-term risk benefit)	Likely to be useful / essential: this type of cost analysis from Annex 1 to Reckon (2024) is defined to use monetised asset risk metrics. Useful role for long-term monetised asset risk benefit metrics (see section 3 of this paper).

We have not sought at this stage to carry out a full review of the potential contribution of monetised asset risk metrics compared to other metrics relating to water company asset health that might be available or be developed. But we highlight some aspects of monetised asset risk metrics that make them seem relatively desirable, in principle, compared to more granular metrics relating to investment volumes or measures of asset age, asset failure rates or asset condition for specific categories of assets:

- Monetised asset risk metrics consolidate information across a large number of assets into a single metric and manageable source of evidence that applies at the same level as that used for cost assessment (e.g. wholesale base costs or total capital maintenance expenditure).
- Monetised asset risk metrics are more focused on the benefits of expenditure for outcomes (e.g. the benefits from investment in terms of impacts on risks to customer and environmental outcomes in the future) than metrics based on investment volumes, asset age, asset failure rates or asset condition.
- Monetised asset risk metrics can take account of the interactions between operating expenditure and capital expenditure (e.g. the monetised asset risk metrics envisaged in section 3 of this paper would take account of key ways in which operational practices might reduce the risk of asset failure or

provide response and recovery capabilities that reduce the consequence of asset failure which in turn affects the efficient levels of asset replacement).

Further considerations for cost assessment in the case where monetised asset risk metrics are also used to link price control expenditure allowances to delivery of asset health investment

There are some further considerations that may be relevant to cost assessment in the case where monetised asset risk metrics are also used to link price control expenditure allowances to delivery of asset health investment, as envisaged under role (1) discussed earlier in this appendix.

Under Ofwat's totex and outcomes approach to base costs, introduced as part of major reforms at PR14 and refined at PR19, there has been considerable flexibility for water companies as to what scale of long-term investment in asset health, or what scale of long-term benefits to future outcome risk management, companies have been required (or been expected) to deliver in any single five-year price control period (and corresponding ambiguity about the scale of long-term benefits that companies have been funded to deliver).²²

However, if the bulk of the price control allowances for capital maintenance expenditure were to be tied to PCD outputs that are defined by reference to monetised asset risk metrics then this would involve a more precise regulatory specification of what scale of long-term investment in asset health water companies have been funded to deliver.

We identified under role (1) above that if PCD outputs are to be specified in terms of monetised asset risk metrics, it would make sense for these to be defined in terms of the estimated long-term benefits to monetised risk delivered rather than the value of monetised asset risk metrics at a point in time (e.g. the level of risk at the end of the price control period). More specifically, PCD outputs might be specified in terms of the estimated long-term benefits to monetised asset risk to be achieved / delivered over the price control period (e.g. where the benefits delivered in practice are to be calculated by comparing the net present value of monetised risk over a long future time horizon in the light of the specific asset replacement (/refurbishment, etc) delivered during the price control period against a counterfactual with no asset replacement in that period).

Specifying PCD outputs in this way would naturally call for a more precise approach to the consideration of investment benefits as part of base cost assessment. For instance, in the interests of internal consistency, the upfront funding that is provided at the price review in respect of base costs or capital maintenance expenditure ought to be calibrated by reference to estimates of the costs of delivering the

²² The PR24 final determinations are somewhat different. First, there are PCDs for water mains replacement which, while not focused on the benefits of asset replacement, do place requirements on the scale of water mains asset replacement and in turn reduce the flexibility for companies on both the overall scale and focus of asset replacement activity within the price control period. Second, Ofwat made statements which might suggest that there are — and indeed have been in previous price control periods — other delivery requirements in respect of cost allowances or capital maintenance expenditure. This is a complex and potentially controversial issue, which we leave aside for the purposes of this paper.

scale of long-term benefits specified for the PCD outputs (or conversely, the scale of long-term benefits specified for the PCD outputs ought to be calibrated by reference to the level of upfront funding).

Seeking consistency in this regard would fit, in broad terms, with the approach taken by Ofwat at PR24 with regards to interactions between PCDs for enhancements and cost assessment for enhancements: for instance, the delivery metrics used for PCDs are generally aligned with the metrics used as cost drivers in the models used for enhancement cost assessment (albeit with some additional delivery obligations applying beyond those cost drivers in some cases). This alignment means that the upfront allowances are calibrated by reference to an assessment of the costs of the PCD outputs that are to be delivered and, in addition, to the financial adjustments that apply in the event of under-delivery of those outputs.

Drawing on the discussion in the subsection above, there are a number of ways in which estimates of the efficient costs of a company delivering a defined quantum of long-term benefits to monetised asset risk might be derived for the purposes of this type of alignment or calibration. For example:

- Cross-company benchmarking of the unit costs of long-term benefits to monetised asset risk, using historical and/or forecast data, whether through unit cost analysis or econometric models that have the unit cost as a dependent variable and explanatory variables relating to potential exogenous cost drivers (e.g. for customer density or topography).
- Incorporation of monetised asset risk metrics into econometric models of historical and/or forecast expenditure, in which measures of base costs or capital maintenance expenditure are the dependent variable.
- Using the same underlying models to calculate both the amount of long-term risk to be delivered and the costs of delivering that scale of risk benefit, by combining the granular investment programme that is modelled as producing the intended risk benefit with unit cost assumptions (e.g. from benchmarking) applicable to the elements of that programme.
- As a more substantial departure from Ofwat's current approach to cost assessment for capital maintenance expenditure, an alternative would be for Ofwat's cost assessment to be based on a series of deep dive reviews of the detailed bottom-up costing of an investment programme which has been put forward by each company to achieve a scale of long-term risk benefits that corresponds to the proposed PCD outputs.

However, in practice, given both the complexity of the monetised asset risk metrics and their novelty, it may be impractical, in the near term at least, to rely entirely on monetised asset risk metrics either for the upfront cost assessment or for the adjustments in the event of under- (and potentially over-) delivery.

The approach to cost assessment may evolve over time as more data become available. For instance, the absence of historical data on monetised asset risk metrics (and associated long-term benefits achieved in historical years) may mean that the most suitable approaches for cost assessment in the near-term differ from those available at subsequent price reviews.

Appendix 2: Desirable features of the asset risk metrics and methodology

Introduction

In light of the consideration in section 2, and appendix 1, of the potential roles of asset risk metrics as part of the future regulatory framework, we identified a set of desired features of monetised asset risk metrics (and of the methodology used to produce them). This is intended to help explain what is envisaged and to guide potential future work on the development of a methodology to produce such metrics.

The table below presents a summary of the features that we identified. These features relate either to monetised asset risk metrics themselves or to the methodology used to produce them. For ease of cross referencing, we denote each of the features with a code from F1 to F10. Each of the features is relevant to both outcomes-level asset risk metrics or monetised asset risk metrics.

Table 10 Overview of desirable features of the methodology and metric

Broad theme	Desirable features of the methodology / metric
Overall focus and scope	<ul style="list-style-type: none"> • F1: Focuses on risks from degradation in asset condition • F2: Outcomes-oriented as far as practical
Building on existing water industry concepts and data structures	<ul style="list-style-type: none"> • F3: Builds on the four Rs of resilience • F4: Draws on established asset and outcome categories as far as practical • F5: Can be related to other asset health metrics used in the industry as far as practical
Contribution to regulatory analysis and arrangements	<ul style="list-style-type: none"> • F6: Enables risk to be tracked over time • F7: Enables risk to be projected into future time periods • F8: Enables changes in risk over time to be decomposed across key drivers • F9: Enables risk to be presented at the level of individual outcomes before monetisation • F10: Enables risk to be reasonably compared across companies

In this appendix, we briefly elaborate on each of these desirable features. This set of features should be seen as part of an initial specification that can be used as the basis for discussion and refinement.

In addition to the features listed above, a possible further desirable feature would be that the methodology aligns, where practical, with current approaches to risk modelling for asset health, resilience and outcomes/ODIs that are used by water companies. Going forwards, there would be value in seeking to understand the extent of overlap and divergence between what is set out in this working paper and the models/tools/software that companies use, and the extent to which this differs across companies.

F1: Focuses on risks from degradation in asset condition

The development of monetised asset risk metrics for water companies is likely to be a challenging exercise, and the challenges are likely to increase with the scope of risks that the metrics are intended to cover.

Our interest in monetised asset risk metrics primarily comes from our earlier report Reckon (2024), which is concerned with the regulatory approach towards asset health and capital maintenance. For these purposes, capital maintenance could be interpreted broadly, for example covering activities such as asset replacement and asset refurbishment as well as maintenance activities that provide benefits to assets that last longer than a single year (without being bound by whether or not the expenditure on these activities is capitalised for accounting purposes).

In this context, our proposal is that, in the first instance, the risks to be covered by the monetised asset risk metrics are those that relate to asset health and, more specifically, to asset failure arising from degradation over time in the condition of assets. Assets may degrade over time due to factors such as aging, the stresses placed on them through usage, and the external environment (e.g. weather).

We have chosen to refer here to risks from degradation in asset condition, rather than risks from asset health, for two reasons. First, it makes more sense linguistically to refer to risks from degradation in asset condition rather than risks from asset health. Second, from phase 1 of the Infrastructure Health project we found the term asset health to be used in a number of different ways, some of which can be quite broad, and that this might be unhelpful for the purposes we have in mind here. That said, there is generally a close link between asset degradation (or deterioration) and asset health concepts. For instance, Ofwat's asset management maturity assessment lexicon said the following: "*Poor asset health is when assets are allowed to deteriorate to a point where the risk of failures (which will impact on customers, the environment and wider society) exceeds the company's risk tolerance*".²³

Examples of relevant risks under this scope would be the risks that an asset breaks and fails to function at all, and the risks that an asset does not perform as well as it used to (e.g. a pump becoming less effective over time).

The focus on risks relating to asset degradation means that the monetised asset risk metrics would not cover all of the risks faced by water companies that matter to customers, the environment, and the wider public. For instance, the monetised asset risk metrics would not be intended to cover the following sources of risk to a water company's service provision or environmental performance:

- Risks that may arise from the company not having sufficient protection against external events that threaten the functioning of its operations (e.g. assets failing to function properly due to cyber security or terrorist attacks).

²³ Ofwat (2021) *Asset management maturity assessment lexicon*, pages 4-5.

- Risks that may arise from the company not having sufficient capacity to meet the needs of its customers and/or to avoid harm to the environment (e.g. risks from not expanding capacity to accommodate growth in the number of customers it serves).
- Risks that may arise from the company not having put in place adequate technologies, processes and capabilities to meet customer and environmental expectations or requirements (e.g. the risk to water quality from inadequate water treatment processes at a specific location).
- Risks that may arise from the company not having sufficient financial resource (e.g. to maintain an adequate workforce of staff and contractors and to pay the suppliers that the company relies on).
- Risks that may arise from the company having poor leadership and making bad decisions.

Some of these wider risks might be viewed as relevant to broader concepts of resilience, without arising primarily from deterioration in asset condition. Further work might be needed at some stage to clarify the scope more precisely. For instance, it may be appropriate in most cases to exclude risk relating to third party damage from the methodology, but in some cases this might be relevant if the risk from third party damage is linked in a significant way to asset degradation over time.

In practice, we recognise the boundaries between different types of risks may not be straightforward and there may be some overlap. For instance, a lack of financial resource might act to reduce capital maintenance expenditure and, in turn, create risks associated with asset deterioration. But this linkage has greater practical relevance when it comes to the work to project future scenarios for risks associated with asset deterioration than it does for the specification of the asset risk metrics themselves.

Finally, we recognise that asset risk metrics could potentially play a broader role in the future regulatory framework, capturing other types of risks (e.g. risks to outcomes from capacity limitations or from external disruptions). This may be a valuable area for future work. Indeed, a coherent regulatory approach across different types of risk (especially where they overlap) would seem attractive for the development of the regulatory framework. However, there is a concern that if the methodology for the risk metrics is intended to cover a wide range of risks from the outset, rather than being targeted on priority areas (such as asset health) this could reduce chances of successful implementation in time for the PR29 price review.

F2: Outcomes-oriented as far as practical

When considering risk for the purposes of the monetised asset risk metrics, the intention would be to capture, as far as practical, risks to the achievement of good outcomes. A specific asset failing to function properly due to a deterioration in its condition is not a concern in itself, but a potential concern because it *may* have adverse consequences for outcomes that matter to the regulatory framework.

In Reckon (2024), we set out a possible position on what the desirable outcomes under the regulatory framework are *at a high level*. This covered the following:

- Good customer service, across a range of areas.
- Good environmental outcomes, across a range of areas.

- Affordable bills that represent value for money.
- Public trust in the water industry.
- Fairness between current and future customers.
- Fair remuneration of equity investors.

This list is indicative and not necessarily as well-expressed as it might be. For instance, the first item on good customer service would need to be understood in a broad sense, which captures for example potential impacts on customer wellbeing (e.g. from risks of poor water quality). And there might be other outcomes that are relevant. For instance, there may be relevant outcomes relating to the health, safety and wellbeing of workers engaged in the water industry value chain and of the wider public (further to people's role as consumers of water and wastewater services).

Focusing for now on outcomes relating to customer service and the environment, the interest in risks of asset failure arises from a concern that asset failure may have adverse consequences for these outcomes. But the failure of a specific asset does not necessarily lead to a material impact on customers or the environment. The existence and severity of any impact on outcomes will depend on a range of factors, especially those which are captured under the idea of operational resilience, which we discuss further under feature F3 below.

From a practical perspective, it may make sense for initial development of monetised asset risk metrics to focus on a subset of outcomes and, once progress has been made on these, to extend the scope.

At this stage, there seems to be an open question about whether risks relating directly to customer bills should be captured as part of the outcomes for which risk would be modelled and, in turn, covered the monetised asset risk metrics. We elaborate on this issue in the box below.

Figure 10 Need for further consideration of the treatment of bill impacts and costs

One of the relevant high-level outcomes identified above is “affordable bills that represent value for money”. At a broad level, customer bills (and the levels of costs feeding into these) are highly relevant to the outcomes for customers. Furthermore, we understand that the NARM methodologies used for some GB energy network companies take account of some risks relating to costs (e.g. reactive costs for repairs captured as part of the coverage financial risks under National Gas's methodology).

However, there is an argument that for the purposes of the monetised asset risk metric, and given the roles envisaged in section 2 of this paper, any potential impacts of asset failure (including consequent asset repairs and maintenance) relating directly to customer bills, affordability and/or water company costs should be excluded from scope.

This is primarily because we would expect the metric to be used, as part of the price review process (and potentially as part of company's internal asset management activities), in conjunction with analysis of costs and/or impacts on bills. Including monetisation of the risks of cost increases from asset failure could lead to double counting, depending on the way that the metric would be used. And there are potential concerns about treating different types of costs differently within the regulatory framework, if some are captured as risks through the monetised asset risk metric and some are not.

Another source of problem is that customer bills will be affected by ODIs which in turn will reflect companies' performance against performance commitments relating to customer service and environmental outcomes. Furthermore, and from a practical perspective, seeking to include impacts on costs or bills in the metric might raise quite challenging issues relating to the choice of counterfactuals.

This issue would benefit from further discussion, and we have not sought to take a firm view on it at this stage.

F3: Builds on the four Rs of resilience

In looking to understand the relationship between asset failure and the impacts on customer and environmental outcomes it can be helpful to make use of the four Rs of infrastructure resilience. This perspective was put forward by the Cabinet Office in 2011 and subsequently drawn on in the context of the water industry in Jacobs' report to WS1, Ofwat's discussion paper on operational resilience,²⁴ and other stakeholder contributions.²⁵

The four Rs as defined by the Cabinet Office and adopted by Ofwat are as follows:

Figure 11 Four elements (or Rs) of infrastructure resilience



Source: Cabinet Office (2011), page 15.

Of the four elements, the reliability element relates most directly to risks of asset failure (or asset under-performance) arising from degradation in asset condition. The redundancy and response and recovery elements affect both the likelihood and severity of any impact on outcomes arising from asset failure.

The resistance element may be relevant in some cases (e.g. because measures to improve resistance may reduce the risks that assets that have deteriorated in some way fail under stress). But it is important

²⁴ Ofwat (2022) *Operational resilience discussion paper*.

²⁵ See for example, United Utilities (2021) *Asset health in the water sector Proposal for a framework: Proposal for a framework*, page 3.

to recall that, given the scope set out above under F1, the proposed monetised asset risk metric is not intended to capture all risks relating to infrastructure assets (e.g. risks to services from malicious threats or natural hazards that could arise even if existing assets were in perfect condition).

Our impression is that the four Rs of resilience is a well-understood perspective within the water industry and it seems to offer a practical way to approach the link between asset failure and outcomes impacts. This perspective also helps emphasise the importance of operational resources and capabilities in a context where there is the potential for asset risk modelling to be overly focused on assets.

On this basis, it seems highly desirable that the methodology for the monetised asset risk metrics is structured in a way that explicitly takes account of: (a) redundancy and (b) response and recovery, insofar as these enable the impacts from asset failure (that are associated with asset deterioration) to be mitigated. Further work may suggest benefits from some refinement of the 4Rs for the purpose of the methodology for monetised asset risk metrics, rather than treating these as a hard constraint.

F4: Draws on established asset and outcome categories as far practical

A considerable amount of the work to develop the monetised asset risk metric will concern the way that assets are to be categorised and organised for the purposes of determining the input used to calculate the metric. A desirable feature of the methodology is that it draws on the asset categories that are already established for the purposes of water companies' data reporting, or which are being developed as part of Ofwat's broader work on operational resilience and asset health.

We would expect the asset categories that are already established to be a starting point, but they would probably not be sufficient on their own. For instance, more granularity on asset categories might be needed for the purposes of the monetised asset risk metric. As an example from a related area, the asset categories that were developed as part of work for Ofwat on bioresources asset valuation, carried out by Jacobs and Reckon in 2017, were more granular than Ofwat's established asset categories for bioresources but fitted within the structure of those categories.²⁶

For outcomes, the set of common PCs used for PR24 final determinations is a useful starting point for the outcome categories for the monetised asset risk metric. But these are not comprehensive of all potentially relevant areas of outcomes that may be affected by asset failure, and there may be some additional areas that are important to include. In any event, we would expect that the scope of outcomes covered by the monetised asset risk metric to be expanded and refined over time.

F5: Can be related to other asset health metrics used in the industry as far practical

As reflected in Reckon (2024), there is a wide range of metrics available that relate to asset health. Monetised asset risk metrics, drawing on Ofgem's NARM approach, are just one type.

In its PR24 final determinations, Ofwat set out a plan to collate more information relating to asset health. In the near-term, the priority seems to be on what Ofwat refers to as workloads, such as data on asset

²⁶ Reckon and Jacobs (2017) *Support to allocate the bioresources RCV*, pages 16-18.

replacement volumes, and on granular data on asset condition (e.g. with individual assets assigned a condition grade following surveys).

Asset condition data is evidence of asset health. Beyond the granular condition data for each asset, it might be aggregated across assets with the same or similar category. For example, at PR24, as part of its cost assessment, Ofwat gave weight to evidence on the proportion of each company's water mains in "condition grades" 4 and 5, and how it thought this had evolved since PR09. However, our understanding is that Ofwat's data on water mains conditions grades is not data on asset condition, but rather data on asset failure rates, and that Ofwat's assessment of changes over time in asset condition is not reliable.²⁷

Monetised asset risk metrics would give more explicit attention to risk, both in terms of the risk of assets failing and the risks that such asset failure gives rise to adverse consequences or adverse outcomes (e.g. for customers or the environment). And monetised asset risk metrics would involve a greater degree of aggregation, across different types of assets and different types of outcomes.

If monetised asset risk metrics are to be developed alongside Ofwat's plans for more extensive collection of asset condition data, it would be helpful if links between the two could be made clear and, where possible, made use of. For example:

- Observed asset condition data might be an input to the modelling of asset failure risk. The extent to which observed asset condition is used to model failure risk would vary by asset type.
- Some of Ofwat's data on "asset condition" is actually data on asset failure rates rather than data on observed (or modelled) asset condition.²⁸ Asset failure risk may depend on the physical condition of assets as well as other factors, such as operational practices that affect the risk of asset failure as well as the external environment that an asset operates in (e.g. affected by soil conditions and the weather). It may be possible to relate Ofwat's asset failure metrics to the outputs from asset failure modelling that is used for monetised asset risk metrics.

In the early stages of its path towards monetised asset health metrics, Ofgem's work in the electricity distribution sector placed emphasis on more granular data on the condition or health of individual assets (e.g. for the DPCR5 review). Taking account of assets' criticality (e.g. in terms of the risks of adverse consequences for customers) and then proceeding to monetise and aggregate risk were subsequent developments. This shows how data on asset condition can provide part of the foundation for the development of asset risk metrics.

²⁷ Ofwat's "condition grade" data for water mains at PR24 FD was actually based on data on water mains burst rates, which is not a measure of asset condition but rather a measure of (detected) asset failures. Changes over time in the rates of asset failure that are detected may provide a misleading guide to changes over time in asset condition, given the influence of other factors, besides asset condition, on the rates of asset failure that are detected.

²⁸ See footnote above.

F6: Enables risk to be tracked over time

In the light of the potential roles of monetised asset risk metrics in the regulatory framework, it seems a critical feature of the metric that it is constructed in a way that enables risks from degradation in asset condition to be tracked over time.

At a very basic level, this means that the metrics should be calculated annually and should draw on information about assets that relate to the ways that these change over time. In particular:

- Degradation in assets over time (and corresponding increases in asset failure risk) due to the effects of usage and/or the passage of time.
- Improvement in assets (and corresponding reductions in asset failure risk) arising from asset replacement and asset refurbishment.

In addition, there may be other factors, such as changes over time in operating conditions for an asset, which act to either increase or decrease its risk of failure.

We envisage that the monetised asset risk metric would, in its basic form, be calculated and reported annually, where the monetised risk reported for year t reflects the probabilities of asset failures in year t (e.g. given the prevailing asset base and operating conditions in that year) and the consequences of such failures for outcomes (recognising that the harm from an asset failure in year t could in some cases persist for a longer period of time). Furthermore, as discussed in section 3, for some regulatory applications it may be appropriate to consider not simply the monetised asset risk metric for a specific year, but the net present value of the monetised asset risk over a long-term future modelling horizon (under specified assumptions about the future).

As a minimum, the metrics would be reported from the time the methodology was introduced onwards. For some potential regulatory purposes, especially cost assessment, it would also be desirable if the metrics could be reported for a historical period of time (even if on a more approximate basis). Ofwat sometimes refers to this as backcasting. However, at this stage it is difficult to gauge whether this would be practical or proportionate.

Figure 12 Managing risks to comparability over time

It would be natural for the methodology used to produce monetised asset risk metrics to evolve over time, starting with something practical as an initial iteration and then being strengthened and refined in light of experience and as ideas for improvements emerge.

The need to make comparisons over time raises some issues for the development of the methodology. There is potential for a tension to arise between the desire to improve the methodology (e.g. drawing on practical experience and new ideas) and the desire to understand changes over time in asset health. If the methodology keeps changing, data reported in one year may not be comparable to that reported in previous years.

One potential way to address this concern is to adopt shadow reporting. If the methodology changes in a major way then, for a transitional period, companies could report under both the old and new versions of the methodology so as to enable like-for-like comparisons. However, shadow reporting would come with additional administrative cost and

complexity, and may not be practical in all circumstances (e.g. after a series of successive changes to the methodology).

Given these issues, we see value in trying to anticipate, as far as practical, how the methodology might be developed and improved over time (e.g. in terms of sophistication, granularity, data used and scope) and looking for opportunities to enable the initial iterations of the methodology to be adaptable to these changes, both in terms of facilitating improvements and enabling improvements without undermining the ability to make comparisons over time.

F7: Enables risk to be projected into future time periods

Across the three main roles for asset risk metrics discussed in appendix 1, we see a need to be able to make projections of monetised asset risk metrics into the future, based on well-defined assumptions and/or scenarios.

At a broad level, these scenarios might include the following, for example:

- No asset replacement (or refurbishment) over the timeframe of the projection.
- Volumes of asset replacement that reflect those carried out in recent years.
- Volumes of asset replacement that are funded by specified levels of expenditure (e.g. expenditure in line with historical expenditure, proposed price control allowances or a company's business plan).

Where asset age is taken into account in modelling asset failure risk, then the projections based on no asset replacement would naturally lead to an increase in asset failure risk over the projected future timeframe. Similarly, if asset failure risk is modelled to take account of asset usage, then risk would tend to increase over time without asset interventions.

There may be other factors to take into account when making projections, such as:

- Changes over time in the size and composition of the asset base (e.g. reflecting growth in customer numbers, enhancements to systems to improve environmental performance, etc).
- Changes over time that affect asset failure risk and/or outcomes risk (e.g. changes to operating conditions or changes in estimated weather conditions due to climate change).

For the purposes of making projections into the future, projections of the monetised asset risk metric would make most sense when presented alongside assumed expenditure projections (or perhaps customer bills) that are coherent (e.g. expenditure projections that involve capital maintenance / asset replacement expenditure that is consistent with the evolution of asset failure risk over time). The trajectory of monetised asset risk into the future will be highly dependent on the investment undertaken in the past and future, and the operational resources available in the future periods.

Indeed, we do not think that it is meaningful or helpful to make projections of future asset risk without some clarity on the assumptions about the assumed asset interventions (or assumed expenditure to fund those asset interventions) over the future period to which the projection applies.

F8: Enables changes in risk over time to be decomposed across key drivers

As highlighted above a critical role of the monetised asset risk metrics is to enable comparisons over time. Given the potential roles that such comparisons might play within the regulatory framework, we consider it highly desirable (and perhaps essential for some purposes) that the metric is constructed in a way that allows for some decomposition of the factors that have caused these changes. Understanding the drivers of changes over time might be important in its own right and, in addition, might provide for a valuable way to sense check the implied changes over time in the overall metric.

Especially for cost assessment purposes we expect that it would be useful for the changes in the value of the metric calculated for a given company to be decomposed into changes that arise from:

- the effects of changes over time in the physical properties of assets that affect their asset failure risk (e.g. reflecting the net impacts of asset deterioration and asset replacement and refurbishment);
- the effects of changes over time in operational controls that affect asset failure risk (e.g. pressure management) and/or the consequences of asset failure for outcomes (e.g. response and recovery resources such as rapid response teams and tankering solutions that act to reduce the duration of events caused by asset failure).

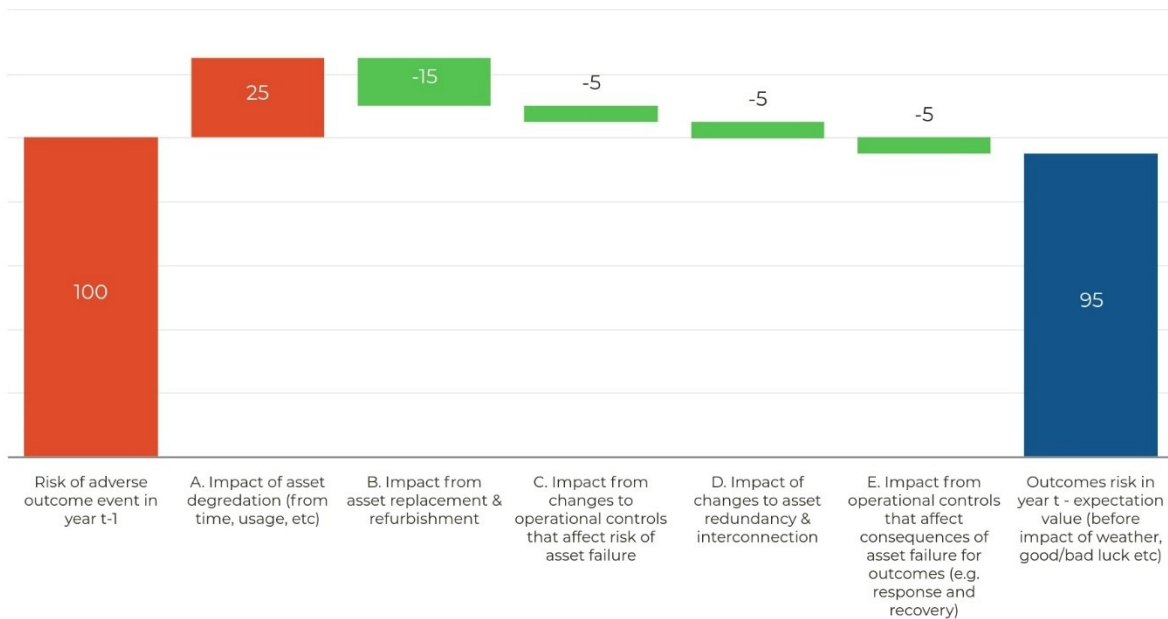
Further consideration will be needed as to the categories of individual drivers or effects that the decomposition would be made for. On this:

- In line with F3 above, there would be value in aligning these categories with the four Rs of resilience: resistance and reliability (potentially taken together); redundancy and response and recovery. The four Rs relate to the systems and controls operated by the water company.
- In addition to the different ways that companies may control risks from asset failure, it may be helpful to be able for the decomposition to expose changes over time in monetised asset risk that are driven by in external factors (e.g. changes over time in risks of extreme weather events).

To provide an indication of what we envisage, the illustrative chart below shows a hypothetical improvement in a company's monetised asset risk from 100 to 95 unit from period t-1 to period t. In this hypothetical example, there has been an increase in monetised risk of 25 units attributed to increased risk of asset failure from degradation in asset condition (effect A in the diagram). This is partially offset by asset replacement and refurbishment reducing risk by 15 units (effect B). There are then a series of further reductions to monetised risk, of 5 units each, arising from: operational controls that reduce asset failure risk (effect C); greater redundancy and interconnection (effect D); and enhanced operational controls which mitigate the risk of asset failure leading to adverse outcomes (effect E).

In this example, we might say that the underlying physical condition of the asset base has deteriorated (the net effects of A and B) but that monetised asset risk has improved due to combination of operational improvements and greater asset redundancy (effects C to E).

Figure 13 Illustrative decomposition of drivers of changes over time in monetised asset risk



This type of decomposition indicated in the hypothetical example above could provide valuable information for the interpretation of historical data, including for cost assessment purposes. For instance, it could provide evidence on the extent to which the overall trajectory for monetised risk has been driven by long-term investment versus operational improvements, and whether underlying asset condition has improved or deteriorated. This decomposition would, in turn, provide evidence to help assess whether setting cost allowances for the next price control period based on historical levels of expenditure would be sufficient to enable an efficient company to maintain or reduce monetised risk.

It is possible that the monetised asset risk metric could be constructed in a way that means that it is built up from calculations covering the individual categories of drivers/effects discussed, which could then either be added together to produce the overall metric or presented at the level of these categories.

However, given the likely nature and complexity of the methodology, this may not be practical (at least without compromising other parts of the methodology). An alternative approach to achieve the decomposition envisaged above would be to have functionality to enable the calculation of the metric for different versions of the input data over the timeframe under consideration (e.g. input data that reflects the actual data on assets but in which the input data relating to operational controls and/or extreme weather events is held constant at the level that applied at the start of the period under consideration). This could be used to produce different versions of the monetised asset risk metric which each capture different elements of the changes experienced over time. This highlights that what is likely to be needed is not so much a series of calculations to produce a metric, but a more sophisticated model that is capable of presenting different types of outputs.

F9: Enables risk to be presented at the level of individual outcomes before monetisation

We see value in the methodology for the monetised asset metric enabling outcomes risk to be presented at the level of individual outcomes, before monetisation and aggregation across outcomes. To take a practical example, the methodology could produce estimates in year t of the expected volume of water supply interruptions that arise from asset failure (e.g. burst pipes) insofar as failure is attributable to degradation in asset condition (e.g. rather than third party damage). At this level, risk would be expressed in units that are applicable to the dimension of performance under consideration (e.g. metrics of the number, severity and/or duration of adverse outcome events), prior to monetisation.

The key benefits we see at this stage from exposing risk at the level of individual outcomes and before monetisation is as follows:

- As discussed further in section 4 and appendix 1, for some regulatory purposes there may be value in presenting evidence on risk at the level of individual outcomes, before monetisation and aggregation.
- Regardless of which role monetised asset risk metrics would play in the regulatory framework, evidence on adverse outcome events that have arisen in practice could be used to help calibrate, test and/or refine the methodology and assumptions used to calculate monetised asset risk.

We briefly elaborate on the second point. More specifically, it would be useful, as a means to help calibrate, test and refine the assumptions and methodology used for the calculation of monetised asset risk, to be able to compare:

- the predicted level of adverse outcome events that the methodology predicts for a given year in relation to a specific dimension of outcomes (e.g. the number of external sewer flooding incidents or pollution incidents); and
- the outturn level of outcome events that the company reports for that dimension of outcome in that year, *insofar as these are attributed to asset failure from asset degradation* (e.g. rather than to lack of capacity or third-party damage).

In any single year, these would not be expected to match. The outturn level of adverse outcome events will be affected by external factors (e.g. the weather differing from that assumed explicitly or implicitly for the purposes of the metric) as well as good luck or bad luck in relation to asset failure and its consequences (e.g. if an asset of given characteristics has an expected probability of failing in a given year that is greater than zero and smaller than one, then it is partly a matter of chance whether the asset fails in that year). Nonetheless, when looking across multiple assets, years, outcome types and perhaps companies, such comparisons would be useful, and evidence of systematic divergences might suggest that changes to the assumptions used (or the methodology itself) could, on the information available, improve the modelling. This reflects the broader point that we would expect the modelling to evolve over time, including refinements in light of outturn data.

Furthermore, where this is particular uncertainty about parameters needed for the modelling, it may make sense to calibrate these in a way that helps to align the estimates of the risk / frequency of adverse outcome events from the model with what has been observed in practice historically.

Given the above, it seems desirable for the model to be structured in a way that facilitates comparisons between (a) data relating to companies' outturn performance for specific performance commitments (or other aspects of performance that are observed in practice) and (b) intermediate calculations used within the model that produce measures of risk for individual area of performance. This also has implications for the data that companies report about outturn performance (e.g. there is value in data that enables a distinction between impacts on outcomes that is attributed to degradation in asset condition from those driven by other factors such as capacity or external events).

F10: Enables risk to be reasonably compared across companies

It seems a highly desirable feature of the metric that it enables reasonable comparisons to be made across companies. This seems particularly important for cost assessment, given the emphasis that Ofwat's regulatory approach places on cross-company benchmarking of costs. But, more generally, Ofwat's regulatory approach makes extensive use of comparisons between companies and it would be unhelpful if asset risk metrics were developed for regulatory purposes which were not reasonably comparable across companies.

Several types of comparison seem particularly useful:

- Comparisons between companies as to the level of monetised asset risk at a given point in time.
- Comparisons between companies as to the trajectory of monetised asset risk (e.g. whether this is stable, deterioration or improving) that they have each experienced in the past or are projected to experience in the future under specified scenarios.
- Comparisons between companies as to the scale of benefits to long-term monetised risk that they have delivered in the past or are expected to deliver in the future.

To make such comparisons, a reasonable degree of consistency across companies in the methodology applied would be needed. It would not be helpful if companies had a large amount of discretion to pursue different modelling methodologies or to use very different modelling assumptions without good reason.

That said, the existence of some differences between companies in terms of the methodology itself or the application of that methodology would not necessarily undermine the use of comparisons, but the potential for such differences should be taken into account in the interpretation and use of the results from such comparisons.

In making comparisons under the first and third examples above, it may be necessary to take account of other factors beyond the monetised asset risk metrics in order to make reasonable comparisons between companies. For example, two companies might have different levels of monetised risk in £m simply because they operate at very different scales (e.g. in terms of number of customers or the geographic

area served), and a method to take account of such scale differences is likely to be needed at a minimum. Ofwat's existing regulatory framework uses a range of approaches to take account of differences in companies' scale and operating environment, including econometric modelling (e.g. in the case of base cost assessment) and expressing performance against a scale variable (e.g. number of interruptions over 3 hours per 100,000 people served, or net ODI impacts expressed as a proportion of notional regulatory equity).

The method to be used to take account of differences in scale and operating environment between companies may need to reflect the way that the monetised asset risk metrics are calculated and the roles that cross-company comparisons are to play. But our initial view is that the methodology for construction of the monetised asset risk metrics does not, itself, need to be incorporate these methods or to be designed by reference to them. At this stage, we view the choice of methods that might be used to take account of differences in company scale and operating environment when making comparisons of monetised risk across companies as outside the scope of the design of the methodology or metric.

Appendix 3: Potential differences in approach compared to the NARM for energy networks

In this appendix we briefly summarise our initial views on areas in which the methodology for modelling monetised asset risk metrics might differ for use in the regulation of water companies in England and Wales compared to Ofgem’s regulation of energy network companies in Great Britain. We highlight a number of issues in the table below. These are not intended to be exhaustive but should help convey important points for the development of the approach for water and wastewater assets. We also note that Ofgem’s methodology, and the methodologies implemented by the network companies, varies across the different energy network sectors.

Table 11 Potential differences versus approach for regulation of GB energy network companies

Area	Potential differences between approach for water companies vs energy network NARM
Role and purpose within the regulatory regime	<ul style="list-style-type: none"> For GB energy networks the monetised asset risk methodology has been developed with emphasis on the production of metrics which can be used to tie price control allowances for asset replacement/refurbishment expenditure to, such that those allowances are conditional on achieving baseline outputs that are specified by reference to these metrics. This involves using the monetised asset risk metrics playing quite a major and mechanistic role with the regulatory arrangements for funding asset health investment. A similar approach is one possible option for water company regulation (in which case the metric would form the basis for a type of PCD output) but it is not the only way that monetised asset risk metrics could play a major role in the regulatory arrangements relating to asset health investment. An alternative (o additional) regulatory approach would be to use the monetised asset risk metrics as part of a package of informational and incentive remedies intended to provide enhanced incentives for companies to carry out appropriate long-term investment in asset health while retaining a regulatory focus on outcomes. As with the approach for GB energy networks the monetised asset risk metrics could also play a key role as part of price control cost assessment, although there could be significant differences in the ways that the metric is used for cost analysis used, reflecting both whether or not the metric is to be used as a PCD as well as broader differences between Ofwat and Ofgem in the regulatory approach to cost assessment.
Scope and nature of consequences covered by the modelling	<ul style="list-style-type: none"> Given the discussion of feature F2 in appendix 2 the methodology for water and wastewater systems may need to be more focused on outcomes when it comes to modelling the potential consequences of asset failure. And there may be a larger number of different dimensions of outcomes / consequences than in the case for GB energy network companies. This reflects in part that the water and wastewater assets cover more stages of the value chain than the GB energy network companies (which are more focused on transmission/transportation/distribution activities) and have a more direct relationship with final consumers than energy network companies.
Scope of assets covered	<ul style="list-style-type: none"> Not all assets are covered at present in the implementation of the NARM methodology in the four energy network sectors (electricity transmission, electricity distribution, gas transmission and gas distribution) and the development and implementation of the NARM approach has reflected prioritisation in each case. The scope of assets covered varies by sector, and is expected to expand over time.

Area	Potential differences between approach for water companies vs energy network NARM
	<ul style="list-style-type: none"> We see no reason at present why asset risk metrics cannot be applied to all water and wastewater asset types (insofar as these are material to risk) but the timeframe and proportionality of achieving this may vary across asset types.
Links to four Rs of resilience	<ul style="list-style-type: none"> As discussed under desirable feature F3 in appendix 2, we consider it likely to be useful for the methodology to build on the four Rs of resilience. This would help to link the methodology to established concepts relating to asset management and operational resilience that have been given attention as part of the regulatory arrangements and discussions in the water industry. Beyond this, an emphasis on the 4Rs of resilience helps to highlight the need to look beyond assets and take account operational controls and operational resources that affect the risk and severity of adverse outcome events, and to allow for decomposition of changes over time in monetised risk across different aspects of resilience (see desirable feature F8 in appendix 2). This seems important for water company regulation because there are some views within the industry that underlying asset risk has deteriorated over time, but this has been masked, in the short term at least, by increased mitigation from operating practices and operational resources. Our impression is that the methodologies for calculation of monetised asset risk used for energy network companies are less developed and sophisticated when it comes to the treatment of operational controls and operational resources than they are for the modelling of physical assets.
Exposure of risk at the level of individual outcomes	<ul style="list-style-type: none"> As discussed in section 3 and appendix 2, we consider it a desirable feature of the methodology for water companies that it enables risk at the level of individual outcomes to be presented. This does not necessarily change the overall modelling and data requirements in a substantial way, but it may affect the order in which specific calculations are carried out and how the results from intermediate calculations are presented. From what we can tell, there seems to be less emphasis in the methodologies for GB energy network companies in exposing risk at the level of individual outcomes (or areas of performance) before monetisation.
Role of asset health scores and criticality scores within the calculation methodology	<ul style="list-style-type: none"> There are some significant differences across the GB energy networks sectors in terms of the methodology for calculating monetised asset risk metrics, some of which reflect legacy issues rather than underlying differences between the sectors. One issue is that, as we understand it, for electricity distribution companies there is an explicit use of asset health scores/indices in the calculation of the probability of failure. In contrast the methodology for electricity and gas transmission proceeds more directly to calculation of probability of asset failure. We understand that this difference reflects historical/legacy regulatory arrangements for the electricity distribution companies. In the past, before the development of monetised risk metrics aggregated across assets and consequences, the more granular asset health indices were themselves a key part of the regime for electricity distribution. Our initial view is that the approach used for electricity distribution does not seem a good guide for water companies, as the estimation of probability of failure is not helped (and might be hindered) through the use of asset health scores / indices. While this is a point of detail on the calculation methodology, it helps to illustrate how the approach seen in practice for GB energy network companies might reflect legacy constraints or considerations that are not applicable for water companies, and an alternative approach might be available and preferable.