Wastewater Asset Management: the Implications of the Proposed UKWIR Common Framework

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Acknowledgement and Disclaimer

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1 Introduction

A collaborative project is currently underway to develop an improved Common Framework for capital maintenance planning (CMP) within the UK water industry. The project has been commissioned by UKWIR in association with Ofwat, the Drinking Water Inspectorate (DWI), the Environment Agency (EA), the Water Industry Commissioner for Scotland and the Department for Environment, Food and Rural Affairs (DEFRA).

The project has been initiated against the background of the 1999 Periodic Review of Prices within the water industry in England & Wales (PR99), and subsequent criticisms [2,3,4,5] of the approaches adopted by both Ofwat and the Companies to the assessment of capital maintenance requirements. In addition, there has been concern to provide a framework within which the requirements of the Ofwat letter MD161 [6] may be addressed, particularly the need "to demonstrate how the flow of services to customers can be maintained at least cost in terms of both capital and operating expenditure, recognising the trade off between cost and risk".

The following tasks are being undertaken:

- key concepts are being defined and an overall framework identified for the application of good practice approaches to medium term capital maintenance planning
- an improved set of serviceability indicators are being formulated and tested (in the light of concurrent studies in the area of water quality and environmental quality involving Ofwat jointly with the DWI and the EA respectively)
- techniques are being identified for the forecasting of likely future asset performance and serviceability, reflecting both past trends and the impacts of relevant asset criteria
- a strategic approach for assessing the economic level of maintenance activity is being identified, to assist the identification of the optimum mix between capital maintenance and operating expenditure
- the scope for the economic appraisal is being defined

The research contractors for the project are Tynemarch Systems Engineering Ltd, with Stone & Webster Consultants Ltd and Strategic Management Consultants Ltd as sub-contractors.

2 Overview of the Proposed Common Framework

The Common Framework proposed is based on the approach applied by Ofwat at PR99 in that capital maintenance (CM) requirements will continue to be assessed using a set of indicators which reflect the service provided to customers and the environment.

The PR99 approach has been extended to allow a more structured and detailed assessment of expected service changes within the future review periods in response to changing levels of CM. This assessment will involve forecasting of service levels to customers and the environment and will allow

explicit account to be taken of the implications of historical investment cycles, the one-off requirements of large and unusual assets, and the additional CM relating to recent quality schemes.

In recognition of recent direction provided by DETR (now DEFRA) [5] and Ofwat [6], the Common Framework is based on the analysis of risk (specifically the probability and consequences of asset failure) and encompasses an economic approach to the assessment of both capital and operational interventions. This allows an assessment of the economic level of capital maintenance with due regard to the costs associated with asset failure, and (where appropriate) the value placed by customers on service improvements.

Within England & Wales, the Common Framework is intended to facilitate an improved consensus at the 2004 Periodic Review, whilst allowing sufficient flexibility for the integration of existing good practice and the furtherance of Companies' wider business objectives.

Figure 1 shows the components of the proposed Framework, and these will be outlined in the remainder of this paper.

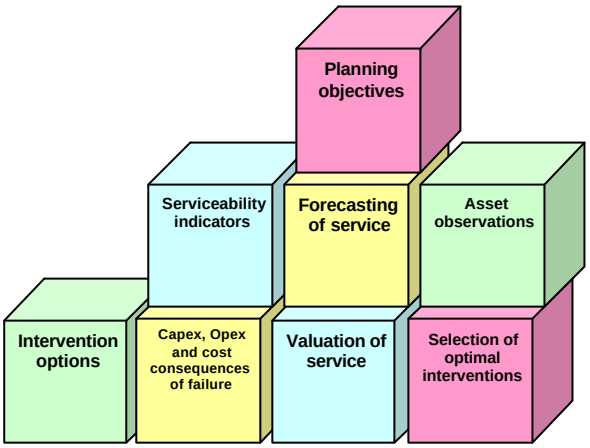

Figure 1 – Common Framework Components

3 Planning Objectives

The Common Framework provides a basis for Water Service Providers (WSPs) to plan their future CM requirements to meet one of two possible objectives:

(i) To provide steady or improving service to customers and the environment at minimum cost to the WSP. (The **cost-effectiveness objective**, to be used to justify CM for base service provision.)

(ii) To provide the level of service to customers and the environment which represents an economic balance between the value of the service provided and the associated costs to the WSP. (The **cost-benefit objective**, to be used to justify CM to achieve enhanced levels of service.)

These two objectives provide the basis for an assessment of the economic level of capital maintenance, and are expressed diagrammatically in Figure 2. The selection and clear definition of the planning objective is an essential first step to the CMP process, since it will determine the scope of the subsequent analysis.

Both objectives are expected to have their place at the 2004 Periodic Review within England & Wales, with the selection of objective being a matter for individual companies in consultation with Ofwat. All WSPs will estimate the CM requirements to achieve the cost-effectiveness objective, while some may also wish to apply the cost-benefit objective as a means of justifying additional CM to achieve enhanced levels of service. This application need not cover the full range of serviceability indicators, but could be restricted to selected service areas where there is concern that current levels of service may be below the economic optimum.

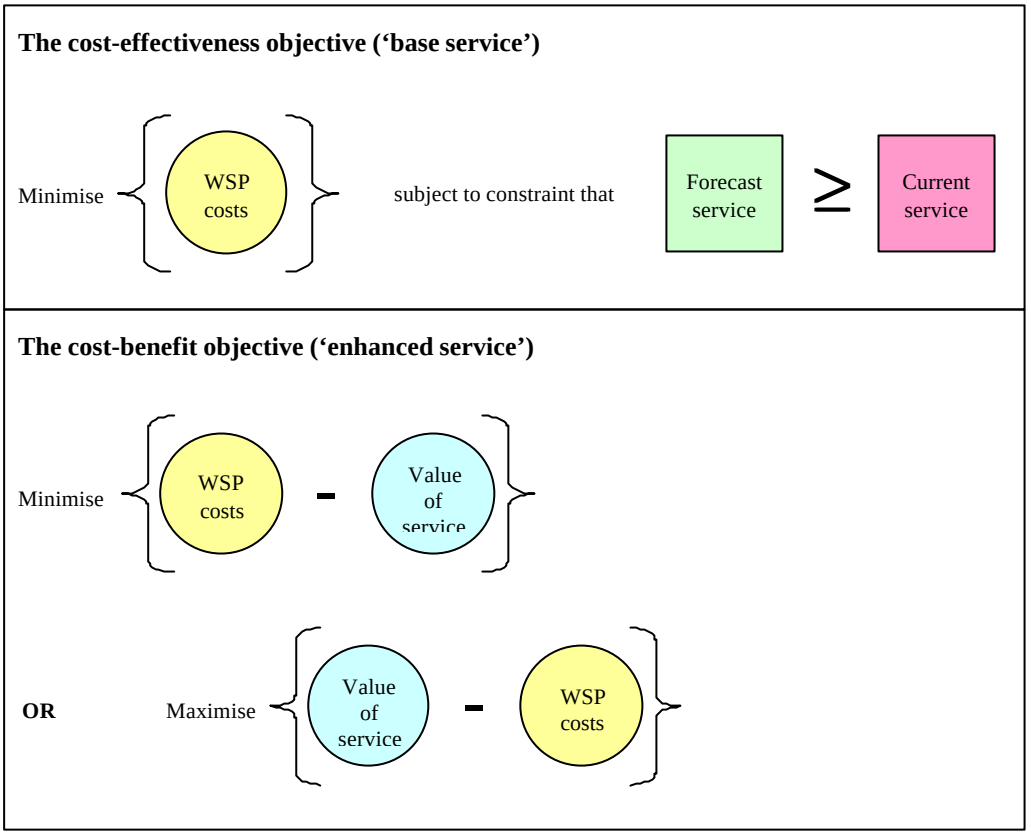

Figure 2 – The principal planning objectives

4 Serviceability Indicators

4.1 Concepts

The use of serviceability indicators remains a central element of the proposed Framework. Although termed 'serviceability' indicators, it is proposed that the principal objective of these indicators is to reflect the level of service provided to customers and the environment.

At PR99 capital maintenance allowances were determined with the aim of maintaining a stable or improving trend in the serviceability indicators. It is expected that this approach will continue at the 2004 Periodic Review, and this is reflected in the first planning objective above.

Within this context, indicators of service to customers and the environment are preferred to indicators of the service potential of assets (and similarly to indicators of asset performance) for the following reasons:

- It is service to customers and the environment that matters, rather than the service potential of assets.
- An economic approach to capital maintenance (as required by Ofwat letter MD161) will involve comparison of capital and operational approaches to service provision. If CM requirements are planned with the aim of maintaining a stable or improving trend in an indicator of the service potential of assets, then this introduces a bias in favour of capital solutions.

Having said this, asset performance indicators will have an important role in the forecasting of service to customers and the environment, and their use in this way will help to ensure that service is provided in a manner which is sustainable in the long term.

Serviceability indicators are useful for CMP purposes only where they are significantly influenced by CM activity, and where the CM expenditure is expected to be large enough to justify the analysis

required. It is recognised that serviceability indicators may be influenced by operational factors where this reflects their influence on service to customers and the environment.

4.2 Proposed modified and additional serviceability indicators

Proposed modifications and additions to the set of serviceability indicators are currently under development. Table 1 and Table 2 summarise the preliminary proposals relevant to wastewater services.

Current serviceability indicator	Recommendations
Properties flooded because of insufficient sewer capacity (DG5)	• retain • modify to include properties affected by flooding incidents irrespective of cause
Sewer collapses per 1000 km	• re-classify as asset performance indicator
Number of pollution incidents arising from wastewater systems	• retain • include Category 3 incidents
Percentage of sewage treatment works failing numeric consents	• retain • include failures with respect to all consent types, and all conditions
Percentage of equivalent population served by non-compliant works failing look-up table consents	• remove (PE weighting not considered appropriate; otherwise duplicates previous indicator)

Table 1 – Preliminary proposals for modifications to current serviceability indicators

Proposed indicator
wastewater
External property flooding
Properties affected by restricted discharge to sewer (e.g. restricted toilet use)
Wastewater treatment works headroom indicator
Compliance of sludge disposal to agricultural land
general
Traffic disruption (using New Roads and Street Works Act reporting)
Health & safety (using Health & Safety Executive reporting)

Table 2 – Preliminary proposals for new indicators

The new indicators proposed will be tested by three volunteer WSPs within Phase 2 of the project. Additional indicators are also being proposed by parallel studies commissioned by Ofwat in association with the DWI and EA. The proposals of all three projects will be reviewed by Ofwat during their review of June Return reporting requirements scheduled for December 2001.

The set of serviceability indicators should ideally encompass all areas of service to customers and the environment requiring significant CM investment, including all relevant regulatory requirements. If this aspiration is to be achieved it will be necessary for the development of improved serviceability indicators to be seen as an ongoing task extending beyond the current projects.

Within the Common Framework it is proposed that serviceability indicators are used to assess trends in service for individual WSPs, but not for making inter-company comparisons. It is accepted that Regulators will wish to make inter-company comparisons, but the design of indicators suitable for this purpose is not an objective of this project.

It is recognised that no set of serviceability indicators can fully reflect all aspects of water services, and that WSPs may at times need to present a case for CM expenditure based on broader arguments

regarding the avoidance of a future deterioration in service to customers and the environment, including compliance with regulatory requirements.

5 Forecasting of Service to Customers and the Environment

The Common Framework for CMP involves a modification to the way in which serviceability indicators were applied at PR99. It is proposed that the assessment of historical service is supplemented by the forecasting of future service taking account of the estimated impact of proposed CM interventions and operational changes.

5.1 General approach

The current serviceability indicators characterise service in terms of failure (eg sewage flooding, pollution events, etc.). Service failures can result from an asset failure, an operational failure, or from some cause outside WSP control such as extreme weather or unexpected source water quality.

It is proposed that the forecasting of service within the Common Framework is undertaken using a structured analysis of key modes of asset failure, involving the estimation of both the probability (or frequency) of future asset failure and the consequences of failure in terms of both service to customers and the environment and WSP costs. The best known example of this kind of analysis is Failure Mode and Effect Analysis (FMEA), a technique in common use within the UK water industry.

In many cases the failure modes considered will be failures of individual assets occurring in a particular manner in the absence of other failures. Where there is concern regarding coincident or overlapping asset failures, care must be taken to take correct account of any correlation or dependency between the individual failures considered.

The probability and consequences of each identified failure mode should be assessed for each asset or asset type, with consequences being quantified in terms of the impact of the failure on the serviceability indicators, and on WSP costs. The assessment of the probability of failure should be clearly distinct from the assessment of consequences, and vice versa.

Probabilities of failure should be derived from the analysis of historical failure data wherever feasible and appropriate. Where suitable data are not available, probability estimates may be derived from expert judgement and checked where possible against recent experience and observations.

In many cases there will be a need to define probability and/or consequence ‘functions’ for a given failure mode, to take account of variations with time or on the basis of observations relating to the asset and its environment or operation.

Probability and consequence functions may take any form which can be identified from the data available (or failing that from expert judgement). Examples include:

- statistical models fitted to observed failure data
- multi-criterion models elicited from experts [7]
- consequence modelling (eg process or hydraulic modelling, optimisation)

5.2 Validation of forecast service functions

One of the most common criticisms of “bottom-up” CMP approaches is that they over-estimate investment requirements. Although risk-based methods represent an improvement in this respect over the simplistic use of ‘remaining life’, care must be taken to avoid the under or over-estimation of probabilities and/or consequences of failure, particularly where the primary source is expert judgement.

It is important that this issue is addressed by validating the functions used to estimate future service against observed service wherever feasible, recognising where possible the influence of unusual conditions or events. This process of validation (and to some degree ‘calibration’) should be seen as a central part of the Common Framework CMP process, and should be documented and open to Reporter review.

6 Asset Observations

The probability and consequences of the failure of a given asset will depend on various attributes of the asset, termed here the 'asset observations'. These observations may include anything that is known or can be measured, judged or estimated regarding the asset and its operation, environment and performance, and which is useful for estimating the probability and/or consequences of failure.

Whilst many of their component observations will continue to be important, the current grading systems for Condition and Performance assessment are not considered to provide a suitable basis for asset observations within the Common Framework.

It is proposed that the Framework should not prescribe specific asset observations since WSPs have differing views, experience and records regarding the relationship between various asset observations and the probability and consequences of failure. Observations should be recorded separately at the point of survey, rather than being combined within a composite grading system.

It is proposed that within the Common Framework asset observations will not in general provide a basis to assess an asset's CM requirements in isolation. Rather, the identification of future CM will take place following the estimation of future service, on the basis of observations of all assets contributing to a particular service area.

7 Identifying, Costing and Selecting the Intervention Options

7.1 Identifying the intervention options

Having estimated future service, it is necessary to identify a range of intervention options to be considered for use in meeting the chosen planning objective. These should include both CM schemes and operational changes, and appropriate phasing and timing variations.

Assets and groups of assets where interventions should be considered may be identified from a review of the results of the service forecasting analysis.

7.2 Costing

All intervention options considered should be costed taking full account of capital costs, operational costs, and any expected savings in the costs which would have resulted from service failure (eg clean-up costs, compensation payments and the cost of reactive maintenance).

Where the cost-benefit objective is being applied, there is an additional requirement to take account of the value of any resulting improvements in service to customers and the environment.

To allow comparison of capital and operational interventions, all costs and benefits are to be evaluated as present values using an appropriate discount rate and planning horizon.

7.3 Selection of optimal interventions

The interventions (capex and opex) required to meet the chosen planning objective should be identified using an appropriate decision algorithm, based on an assessment of the comparative costs and service benefits of each alternative.

Interventions may be included within the optimal selection on purely economic grounds, in the absence of any service benefits.

8 Implications for the Asset Management of Sewerage Networks

This section describes in outline how the asset management of sewerage networks might be considered within the structure of the proposed Common Framework.

The principal serviceability indicators of relevance to sewerage networks are properties affected by internal flooding and number of pollution incidents. New indicators relating to external flooding, restricted discharge to sewer and traffic disruption (e.g. due to sewer collapses) may also be proposed.

8.1 Failure modes

First, the failure modes associated with each asset type should be identified. For example, the principal failure modes associated sewers include sewer collapses and blockages, and the failure modes associated with sewage pumping stations may be categorised as pump failure, structural failure and control or alarm failure.

For both asset types, the consequences of failure may be expressed in terms of the identified serviceability indicators and the costs to the WSP associated with responding to a failure incident and undertaking any reactive maintenance required.

8.2 Probability of failure

For sewer collapses and blockages there may be sufficient historical failure data available for use in the development of a probability of failure function. Analysis of these data should pay due regard to the likely censored and truncated nature of the data, [8]. Where suitable data are not available, expert judgements can be applied, to derive multi-criterion functions which express expert judgements in a structured manner to derive a best estimate of the probability of failure, [7].

8.3 Consequence of failure

Consequences will be assessed where possible using hydraulic modelling, but this is unlikely to be feasible for all failure modes. Instead, there will be a need to identify attributes of the network and location which can be obtained from analysis of GIS network data. Attributes to be identified are those which are judged to influence the consequences of failure.

Functions for estimating the cost of failures should be derived in a similar manner. These will be required if companies are to be able to demonstrate that an economic level of capital maintenance is being applied. Costs estimated should include all incident costs, any associated compensation payments and the full cost of any reactive maintenance required.

8.4 Expected future service

The future service in the absence of capital maintenance may be estimated by combining the probability and consequence functions. This level of service should be compared with what is considered from recent history as current service.

Where a deterioration in service is forecast, proactive schemes and operational policies should be identified which will correct the shortfall. Wherever possible, attempts should be made to identify both capital and operational approaches to service improvement. For example, flooding and pollution may be addressed by capital maintenance to reduce sewer collapses and/or proactive jetting to reduce blockages.

8.5 'Optimal' interventions

Each intervention option should be costed and its impact on the probability and consequences of failure estimated, including any impact on the cost consequences of failure.

If sufficient intervention options are considered it will become evident that there are many alternative combinations of schemes and operational changes which could be selected in order to achieve the requirement to maintain or improve service. For example there may be a large number of sewers which are candidates for rehabilitation, and there may be several options being considered for a proactive jetting policy. In order to meet the requirement of MD161 to identify an economic level of capital maintenance, Ofwat will wish to see the set of interventions identified which achieves the required service at least cost.

For companies where the number of options is likely to be large, optimisation techniques will be required in order to identify the least cost solution. The technique applied will need to be capable of accounting for schemes with multiple service benefits.

In order to ensure that a long-term approach is applied to the maintenance of assets, intervention options should be considered to cover the next three Review periods. Planning horizons applied in the

evaluation of discounted costs should be sufficiently long to reflect the lifetimes expected of the various sewerage assets.

9 Conclusion

The Common Framework proposed is intended to address the requirements of Ofwat letter MD161 and to provide an agreed basis for the assessment of CM requirements at future Periodic Reviews. Its foundation within the current 'serviceability' approach is intended to address the concern of Ofwat for continuing efficiency in the provision of service to customers and the environment. Its recognition of the added value provided by an asset-based forward-looking analysis of future requirements is intended to address WSP concerns regarding the limitations of a largely retrospective approach.

In view of the continuing need for engineering judgement to be exercised in the implementation of the Common Framework by WSPs, there will remain considerable scope for regulatory discretion in the setting of price limits. However, it is intended that the Framework should provide a shared basis for the justification of CM requirements, with the potential to facilitate increased transparency in the Periodic Review process.

The proposed Framework is intended to provide sufficient flexibility to allow considerable variation in analysis effort according to the importance of the asset area, the size of the WSP and the availability of suitable data.

For most WSPs the analysis required to justify a substantial CM programme will be significant, but need not be in excess of that undertaken at PR99. Guidance is provided within the Interim Report [1] on opportunities to focus and simplify the analysis where appropriate.

The feasibility of the proposed capital maintenance planning process is currently being tested by three volunteer companies, one of which (United Utilities) is working within the Framework to consider CM requirements for sewerage assets.

In addition to its use within a regulatory context, the approach proposed provides a suitable basis for the development of WSP internal asset management strategies.

10 References

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