Structures Asset Management Planning Toolkit

Part A: Methodology

Version 2.01

March 2015

This document is supported, endorsed and recommended by:

Department for Transport

CIPFA The Chartered Institute of Public Finance & Accountancy

ADEPT Association of Directors of Environment, Economy Planning and Transport

BRIDGES UK Bridges Board

HAMFIG Highway Asset Management Financial Information Group

Document Control

DOCUMENT DETAILS:

NAME:	Structures Asset Management Planning Toolkit – Part A: Methodology
VERSION:	2.01
OWNER:	UK Bridges Board
PREPARED BY:	Atkins ATKINS
DATE OF ISSUE:	2015

VERSION HISTORY:

Version	Purpose Description	Date
0.1	Draft for client comment	09 October 2009
0.2	Draft for client comment	16 November 2009
0.3	Working draft for internal review	18 November 2009
0.4	Draft for client comment	01 July 2011
0.5	Draft for client comment	2 September 2011
0.6	Draft – Realised for consultation	16 September 2011
0.7	Draft for UKBB endorsement	28 November 2011
\\\	Draft – Released for pilot	16 December 2011
0.9	Draft for Internal Review	05 January 2012
1.01	Final for Release	08 May 2012
1.02	Update for 2013: • References to valuation period and toolkit version amended • References to rates updated • Appendix B inserted	05 April 2013
1.03	Update for 2014: • References to valuation period and toolkit version amended • References to rates updated • Reference to 2013 CIPFA Code added	09 June 2014
2.01	Update for 2015: • References to valuation period and toolkit version amended • References to rates updated	31 March 2015

Acknowledgements

This revision of Structures Asset Management Planning Toolkit (SAMPT) is based on work undertaken for previous version of SAMPT released in June 2014. The project has been undertaken by Atkins and overseen by a steering group:

Haydn Davies	Department for Transport
Steve Berry	Department for Transport
Chris Allen-Smith (Chair)	Hertfordshire County Council
Mandy Bretherton	Chartered Institute of Public Finance and Accountancy
Chris Brain	Chartered Institute of Public Finance and Accountancy
Shaun Darcy	Bournemouth Borough Council
Steve Mead	Derbyshire County Council
Clive Griffiths	Hampshire County Council
Geoff Lewis	Hertfordshire County Council
Keith Harwood	Hertfordshire County Council
Harry Godwin	Leicestershire County Council
Neil Eglintine	Newcastle City Council
Paul Boss	Staffordshire County Council
Colin Jenkins	Warrington Borough Council
Graeme Ferguson	SCOTS/SRMCS/Perth & Kinross
Duro Basic	Transport for London
Lila Tachtsi	Atkins
Andy Woolley	Atkins
Dr Ray Hickey	Atkins
Pat Haley	Atkins
John Paterson	Atkins

Project Team

Lila Tachtsi	Atkins
Andy Woolley	Atkins
Dr Ray Hickey	Atkins
Oriana Hesketh	Atkins
Pat Haley	Atkins
John Paterson	Atkins
Sergey Mikhaylov	Atkins
Jonathan Gamble	Atkins

Contents

Section Page

List of Tables

List of Figures

Appendices

Glossary of Terms

Asset	Whole system, structure or a component or part
Asset Management[1]	A strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure in order to meet the needs of current and future customers.
Asset Management Plan[1]	A plan for managing the asset base over a period of time in order to deliver the agreed levels of service and performance targets in the most cost effective way. This may be referred to as a highway asset management plan (HAMP) or transport asset management plan (TAMP) in other guidance documents and Codes of Practice.
Asset Management Planning	The activity of producing an Asset Management Plan
Asset Value[1]	The calculated current monetary value of an asset or group of assets. 'Asset value' in this document is synonymous with depreciated replacement cost.
Componentisation[1]	Where an asset can be broken down into identifiable components (or elements) with different useful lives, those components (or elements) are accounted separately.
Asset Whole Lifecycle	The asset whole lifecycle comprises all stages from design, construction, operation and maintenance to the end of life, including decommissioning, deconstruction and disposal.
Depreciated Replacement Cost (DRC)[1]	A method of valuation which provides the current cost of replacing an asset with its modern equivalent asset less deductions for all physical deterioration and all relevant forms of obsolescence and optimisation.
Depreciation[1]	The systematic allocation of the depreciable amount of an asset over its useful life arising from use, ageing, deterioration or obsolescence.
Deterioration[1]	The physical wear and tear on the asset; damage due to time, weather, etc., that can be observed and measured through condition surveys.
Discount Rate[1]	The annual percentage rate at which the present value of a future pound, or other unit of account, is assumed to decrease through time.
Discounted Cost	The resulting cost when the total costs of maintenance and renewals are discounted by the application of the discount rate.
Discounting[1]	A technique used to convert costs or benefits that occur in different time periods to 'present values', so that they can be compared on a consistent basis. It is a separate concept from inflation, and is based on the principle that, generally, people prefer to receive goods and services now rather than later.

Finite Life[1] Length of life at the end of which the assets will need to be replaced.

Gross Asset Value See **Gross Replacement Cost**.

Gross Replacement Cost[1] The total admissible cost of replacing either the whole of an existing highway network or some part of it with an equivalent new asset.

Heritage Asset[1] A listed asset or an asset that, due to its construction form or character, is considered to be important to the heritage and/or character of an area.

Indefinite Life[1] Those assets that, given the necessary maintenance, will last indefinitely.

Inflation The rise in the general level of prices of goods and services in the economy over a period of time.

Inflation Rate A measure of inflation; it is the percentage rate of increase in the level of consumer prices or the percentage rate of decrease in the purchasing power of money.

Note: Provided that inflation for all costs included in the lifecycle plan is approximately equal, it is normal practice to exclude inflation effects from a whole lifecycle cost/value analysis. However, inflation should be applied when the outputs from the analysis are used for budgeting purposes.

Lifecycle Plan A long-term strategy for managing an asset, or a group of similar assets, with the aim of providing the required performance while minimising whole life costs.

Modern Equivalent Asset An asset that provides the same potential performance as the existing asset but takes account of up-to-date technology.

Net Present Cost (NPC) The discounted 'present cost' of all future costs, e.g. work, access, traffic management, etc. It is calculated as:

$$\mathrm{NPC} = \sum_{t=0}^{T} \frac{C_t}{(1+r_t)^t}$$

where

T = the time horizon in years

t = the current year, with t = 0 in the base year

C_t = costs incurred in year t, i.e. labour, plant and material.

r_t = the discount rate for year t, expressed as a fraction

Net Present Value (NPV) The discounted 'present value' (normally monetised) of all future costs, benefits and dis-benefits (e.g. service disruption, environmental impact, carbon footprint, etc.). It is calculated as:

$$NPV = \sum_{t=0}^{T} \frac{M_t}{(1+r_t)^t}$$

where

T = the time horizon in years

t = the current year, with t = 0 in the base year

M_t = monetised costs, benefits and dis-benefits in year t

r_t = the discount rate for year t, expressed as a fraction

Shortfall Shortfall refers to the financial value of the maintenance works that are required – but, due to limited funding, not undertaken – to restore to "as-new" condition all components that have reached or exceeded their intervention threshold. Shortfall is carried forward from one year to the next until the required work can be undertaken. The shortfall associated with a particular component may increase over time if the component continues to deteriorate and the value of work required to restore it to "as-new" condition increases as a result.

Special Structures[1] Structures that due to a combination of their size, construction and character, are not suitable to be valued using standardised unit rates and gross replacement cost models.

Time Horizon[1] The period covered by the analysis; typically, this is between 30 and 120 years.

Total Element Replacement Cost The total admissible cost of replacing the whole of the highway asset, when each element is replaced individually. It is used in conjunction with GRC to normalise the value of Accumulated Depreciation. The application of total element replacement cost ensures the value of assets is retained whilst in service.

Uncertainty Lack of certain, deterministic values for the variable inputs used in a whole lifecycle cost analysis of an asset.

Unit Rates[1] The cost per unit measure (number/length/area/volume) to replace an asset or a part of an asset.

Whole Life Cost[3] The cost of all items/activities that need to be considered in a whole lifecycle cost analysis, such as the costs of acquiring (including design and construction costs), operating and maintaining an asset over its whole lifecycle through to its eventual disposal.

Whole lifecycle costs are used to calculate a net present cost (NPC).

Whole Lifecycle Costing A technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. Being able to compare the future costs of alternatives allows selection of the most effective overall solution and helps to plan and control the cost of ownership.

Whole Lifecycle Value[3] A balance of the stakeholders' aspirations, needs, requirements and whole lifecycle costs, i.e. a balance between risks, performance, cost of interventions and interventions.

Whole lifecycle value is used to calculate a net present value (NPV).

Whole of Government Accounts[1]	Full accruals based accounts covering the whole of the public sector. They consolidate the accounts of around 3,800 bodies from within the central government, local government, health service and public corporation sectors.

Abbreviations

AADT	Annual Average Daily Traffic
ADEPT	Association of Directors of Environment, Economy, Planning and Transportation
AMP	Asset Management Plan
CIPFA	Chartered Institute of Public Finance and Accountancy
CSS	County Surveyors Society (currently known as ADEPT)
CV	Commercial Vehicles
DC	Design Cost
$DC_{Component\_i}$	Design Cost apportioned to Component i
DRC	Depreciated Replacement Cost
ECI	Element Condition Index
Ext_{Si}	Extent for Severity i
f_1, f_2, f_3	Weighting coefficients used in calculating the maintenance prioritisation score
f_D	Uplift factor for Design Cost
f_O	Uplift factor for Other Cost
f_p	Uplift factor for Preliminary Cost
FR	Fixed Rate
GPG	Good Practice Guide
GRC	Gross Replacement Cost
LIP	Local Improvement Plan
LoBEG	London Bridges Engineering Group
LTP	Local Transport Plan
MEA	Modern Equivalent Asset
NPC	Net Present Cost
NPV	Net Present Value
OBS_f	Factor based on the obstacle crossed by the route served
OC	Other Cost
$OC_{Component\_i}$	Other Cost apportioned to Component i
PC	Preliminaries Cost
$PC_{Component\_i}$	Preliminaries Cost apportioned to Component i
P_R	Prioritisation Score
R_f	Factor based on the importance of the route served
SC	Scheme Cost
$SC_{Component\_i}$	Scheme Cost apportioned to Component i

SF	Component or Structure Size
ST_f	Factor based on the structure type
SWD	The sum of the duration of works on individual components of a structure, or group of structures, which are to be treated under the same traffic management arrangement
TEoD	Total Extent of Defects
T_f	Factor based on traffic on route served
TERC	Total Element Replacement Cost
TMC	Traffic Management Cost
$TMC_{Component\_i}$	Traffic Management Cost apportioned to Component i
TMD	Duration of a traffic management arrangement
TMR	Unit cost of a traffic management arrangement
UR_C	Constant Unit Rate
UR_{Si}	Unit Rate for Severity i
$WC_{Constant}$	Works Cost where the treatment cost type is *Constant*
WC_{Fixed}	Works Cost where the treatment cost type is *Fixed*
$WC_{Variable}$	Works Cost where the treatment cost type is *Variable*
$WD_{Component\_i}$	Duration of works to be carried out on Component i
WGA	Whole of Government Accounts
WLC	Whole Life Cost
$\sum WC$	Total Works Cost

1. Introduction

1.1 General

1.1.1 This document constitutes one part of the *Structures Asset Management Planning Toolkit*. The custodian of this document is the *UK Bridges Board*.

1.1.2 The Structures Asset Management Planning Toolkit comprises:

- Part A: Methodology
- Part C: Supporting Information

1.2 Purpose of the Structures Asset Management Planning Toolkit

1.2.1 The purpose of the *Structures Asset Management Planning Toolkit* is to support bridge engineers and managers in their management and other related activities, for example, financial planning, prioritisation of needs, lifecycle planning and asset valuation. It is anticipated that the toolkit will enable what-if scenarios to be analysed, which would support the decision maker in identifying the appropriate level of funding required for future maintenance, and in doing so, ensuring that the pre-defined performance targets for the structures stock are met.

1.2.2 This version of the toolkit (Version 2.01, March 2015) primarily focuses on long-term asset management and financial planning and asset valuation/depreciation for highway structures.

1.3 Objectives of the Structures Asset Management Planning Toolkit

1.3.1 The objectives of the toolkit, and the requirements and principles that underpin it are:

- To clearly explain the overall methodology and supporting rationale;
- To identify the data and supporting information, i.e. rule sets and algorithms, required to support the methodology;
- To ensure the methodology is standalone when read with the suite of accreditation documents and independent of any computerised tool, thereby enabling the toolkit to be adopted by different commercial software/systems;
- To enable the methodology, where appropriate, to be adopted in part or in whole to suit the functionality of different commercial software/systems;
- To clearly define the minimum requirements of the methodology;
- To enable the methodology, where appropriate, to be applied so that the minimum requirements are met by the analysis; and
- To enable the methodology, where appropriate, to be refined to support evolving practices over time.

1.4 Background

Asset Management

1.4.1 Asset management is accepted good practice for infrastructure assets. In recent years a number of high profile publications have emphasised the importance of adopting an asset management approach for infrastructure assets, including:

- *Code of Practice on Transport Infrastructure Assets, CIPFA, 2013*
- *Code of Practice on Transport Infrastructure Assets: Guidance Notes, CIPFA, 2015*
- *Management of Highway Structures: A Code of Practice, TSO, 2005 (currently under revision)*

- *What Should Councillors Know About Asset Management?, UKRLG & HMEP, 2013*
- *International Infrastructure Management Manual (International Edition), National Asset Management Support Group (NAMS limited), 2011*
- *ISO 55001:2014 Asset Management, BSI, 2014.*
- Highway Infrastructure Asset Management Guidance Document, *UKRLG & HMEP*, 2013

1.4.2 In recognition of this, the UK Bridges Board has introduced this toolkit to support asset management activities for highway structures.

Accounting Requirements

1.4.3 The UK Government introduced the Whole of Government Accounts (WGA) process to produce a consolidated set of financial statements for the UK public sector. It consolidates around 3,800 bodies, including central government departments, local authorities, devolved administrations, the health service, and public corporations. It is prepared using accounting standards (International Financial Reporting Standards), as adapted and interpreted for the public sector, and is similar in presentation to private sector accounts.

1.4.4 The aim of WGA is to enable Parliament and the public better to understand and scrutinise how taxpayers' money is spent. By presenting the public finances in a framework familiar to the commercial and accountancy professions, WGA increases transparency and accessibility of information about public finances.

1.4.5 CIPFA, on behalf of HM Government, has produced financial planning and accounting guidance for local authority transport infrastructure. CIPFA's *Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting*[1] supports and aligns with recognised good practice in asset management, providing synergy between asset management, financial planning and accounting. The Code moves the valuation of infrastructure assets from a historic cost basis to a depreciated replacement cost valuation, which is consistent with the accounting policy adopted for WGA. An updated version of the Code was published in December 2013[1].

1.4.6 The Structures Asset Management Planning Toolkit meets the accounting requirements presented in the CIPFA Code[1].

1.5 Purpose of Part A

1.5.1 The purpose of this document is to describe in detail the methodology that has been developed for highway structures to meet specific asset management (and financial reporting) requirements. The document sets out the assumptions, rationale, algorithms, the minimum data requirements and how the methodology can, where appropriate, be further refined.

1.6 Layout of Part A

1.6.1 The layout of Part A is summarised in Table 1.

Table 1: Layout of the Report

Section	Contents Description
2. Asset Management Planning	Provides a detailed description of the Structures Asset Management Planning Process along with its component parts
3. Calculating Gross Replacement Cost	Provides guidance for calculating gross replacement cost
4. Calculating Depreciation	Provides guidance for calculating accumulated depreciation at both component and structure level
5. References	Lists relevant documents referred to for the purpose of this study
Appendices	Provide supporting information

2. Asset Management Planning

2.1 General

2.1.1 Asset Management Planning is used to assess current and future needs of a stock of structures, enabling 'what-if' analyses to be performed, for example, impact of different levels of spend on performance. The methodology uses standard inventory, inspection and work programme data, alongside data on deterioration rates, service lives and treatment types/effects.

2.2 Hierarchy of Asset Management Functions

2.2.1 *Management of Highway Structures: A Code of Practice*[2] recommends that the asset management functions within an organisation should align with integrated planning and decision-making at the three levels, into which management processes in large organisations are typically categorised, namely: Strategic, Tactical and Operational.

2.2.2 The scope of the asset management functions in the three levels is illustrated in Figure 1 and summarised below.

- ***Strategic: Where are we going and Why?*** – At the strategic level organisations establish, in consultation with stakeholders, the overall long-term direction for transport, e.g. policy, goals and objectives, vision, mission statement and performance targets. The strategic vision is often encapsulated in the Business Plan, e.g. Strategic Transport Plan (e.g. LTP and LIP), and/or Asset Management Policy.
- ***Tactical: What is worth doing and When?*** – At the tactical level, the overall Strategic Transport Plan (goals and objectives) is translated into specific plans, objectives and performance targets for individual asset types. The tactical level involves undertaking a performance gap analysis and adopting and implementing a formal asset management planning process to identify the required, most beneficial and cost effective activities and when they should be carried out. Particular emphasis is drawn to the role of asset management planning which, although a tactical programming activity, is heavily relied upon to support strategic planning, i.e. informs budget setting and can be used to demonstrate the delivery of performance targets.
- ***Operational: How to do the right things?*** – At the operational level detailed work plans and schedules that have a short-term outlook but take account of the work volumes and phasing arising from tactical planning are developed and implemented. Engineering processes include inspection, structural assessment, routine maintenance, scheme design, work scheduling and implementation. Their focus is on choosing the right techniques, Value Engineering of schemes and carrying out the work in the most efficient way.

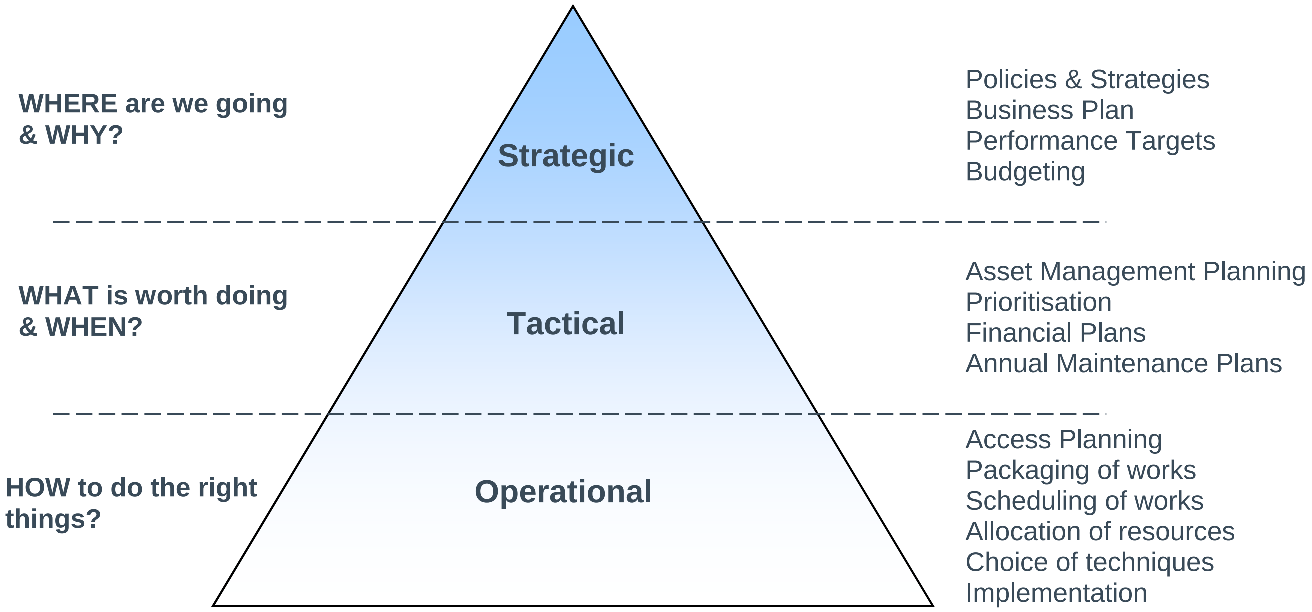


Figure 1: Hierarchy of Asset Management Functions[6]

2.3 Overview of Asset Management Planning Process

2.3.1 The approach is based on that described in *Management of Highway Structures: A Code of Practice*[6]; extending and refining steps 5 to 9 to provide a detailed step-by-step methodology for asset management planning. Figure 2 provides an overview of the asset management planning process for structures; the main steps in the process are:

- ***Inventory Data and Groups*** – e.g. structure type, dimensions, materials, components and the criteria used to group similar structures;
- ***Condition Data*** – element level condition and defect data, e.g. standardised severity and extent ratings are used for highway structures.
- ***Programmes of Work*** – defined programmes of work that typically address specific needs or issues, e.g. strengthening, parapet upgrade, scour susceptible bridges.
- ***Identify Needs*** – identify maintenance needs based on defined intervention levels, triggers and programmes of work.
- ***Select Treatments and/or Strategies*** – select the appropriate treatment, and/or long-term strategy, to address the need.
- ***Calculate Costs and Penalties*** – evaluate the costs (e.g. labour, plant, material, access etc.) and penalties (e.g. traffic disruption) of doing or not doing work.
- ***Prioritise Identified Needs*** – prioritise competing maintenance needs using an appropriate set of weighted criteria;
- ***Maintain and/or Deteriorate*** – improve/restore the condition of those structures or components that have been treated and deteriorate others.
- ***Evaluate Expenditure and Condition*** – evaluate the total annual expenditure and the condition of the structure stock after maintenance.
- ***Outputs*** – the key outputs from the lifecycle planning process, across the full analysis period (i.e. time horizon) and for each scenario analysed (e.g. Do Minimum, defined budget and target condition), include:
    - Expenditure, condition and shortfall profiles;
    - The expected life of each finite life component;

- The treatment cycle/life of each indefinite life component;
- The timing, cost and effect of each intervention (be it a replacement of a finite life component or capital maintenance of an indefinite life component).

2.3.2 The following sections provide a detailed description of each step in the process.

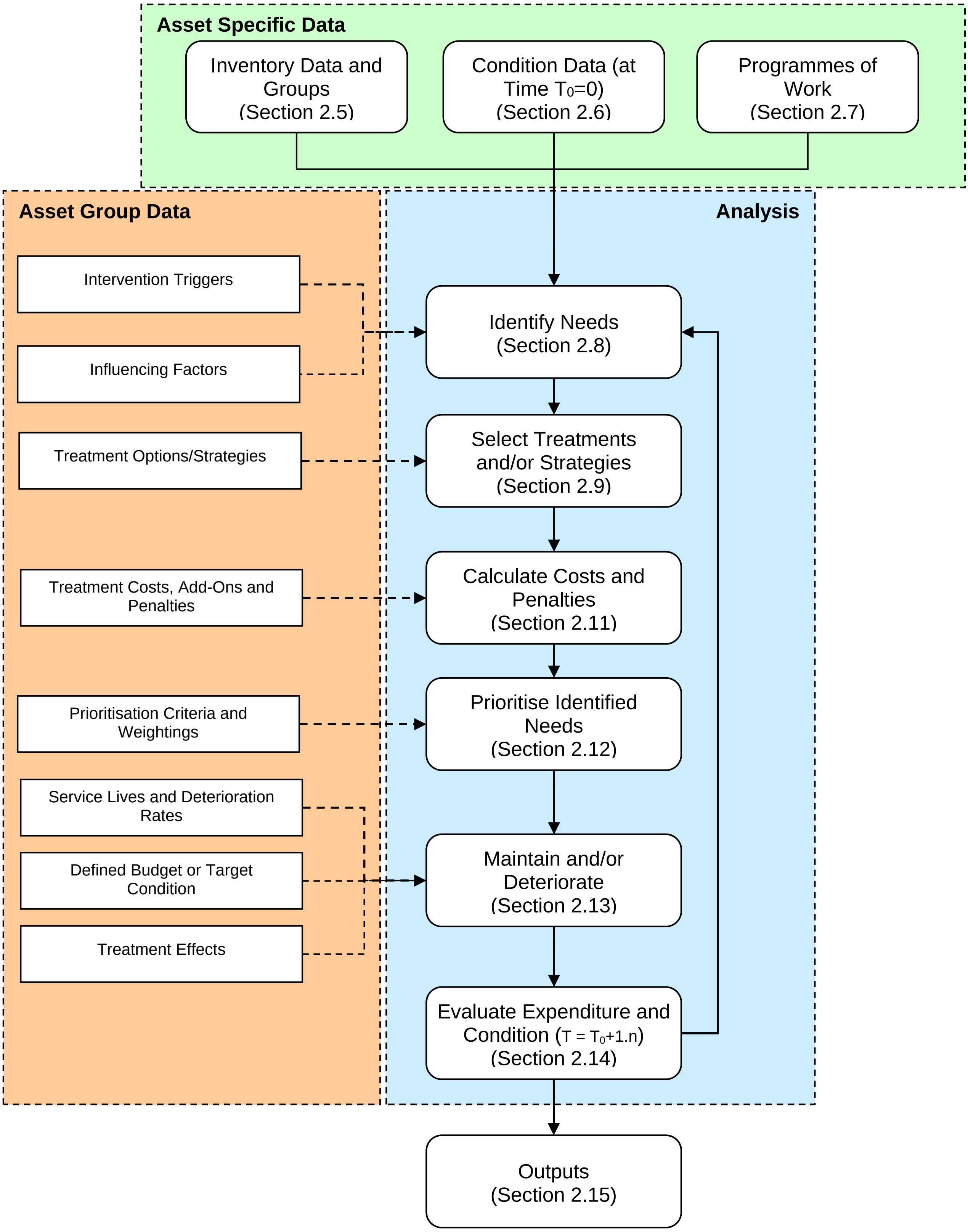


Figure 2: Overview of Structures Asset Management Planning Process

2.4 Process Logic

Time Dependent Deterioration

2.4.1 Deterioration of highway structures may trigger specific maintenance needs and expenditure. Therefore, the appropriate representation of deterioration through time is a fundamental part of the asset management planning process. This requires service lives and deterioration rates to be defined which inform the analysis and support profiling of deterioration through time in the following sequence of events:

(1) Starting condition is provided for the year of the last inspection T_0, i.e. $T_0 = -3$ meaning last inspection occurred 3 years ago.
(2) Needs are identified and/or prioritised before available funding is allocated.
(3) Structures and/or components that have been allocated funding are maintained/treated and their condition is reset for use in the following year ($T = T_0+1$) of the analysis.
(4) Structures and/or components that have not been allocated funding are deteriorated further. Their deteriorated condition is used to support the analysis undertaken for the following year ($T = T_0+1$) in the analysis period.
(5) Repeat Steps 2 to 4 for each year in the evaluation, i.e. from $T = T_0+1$ to T_0+n.

Homogeneous Groups

2.4.2 Asset management planning can be streamlined by categorising the assets into homogeneous groups. A homogeneous group is a collection of assets that are considered to have similar attributes and behave in a similar manner, e.g. rate of deterioration. However, where this categorisation is not possible, i.e. due to the unique characteristics of some structures, lifecycle data should be defined on an individual structure basis. Also, where relevant information is readily available for individual structures, it is recommended that these structures are not categorised into homogeneous groups and that lifecycle data should again be defined on an individual structure basis.

2.4.3 The criteria used to determine homogeneous groups should be those that have a significant influence on the lifecycle behaviour or Level of Service requirements of the assets. Criteria that should be considered when defining homogeneous groups for highway structures include:

- Structure type, e.g. bridge, culvert, retaining wall, etc.;
- Location, e.g. urban, rural, environmentally sensitive area, same route corridor, etc.;
- Structure usage, e.g. route supported, obstacle crossed, traffic, etc.;
- Structure size, e.g. number of spans and dimensions;
- Level of Service requirements, e.g. high visual standard required, loading requirements;
- Construction type, material and condition of components.

Important Note: It is considered that the primary drivers for deterioration and interventions are the structure type, construction type and construction material as these would determine whether a group of structures behave in a similar or different manner with regard to deterioration. It is not recommended to group structures with different deterioration behaviour, i.e. 'location' should not be used as the sole or most significant criterion for grouping structures because, for example, structures on the same route corridor but of different construction and material type (e.g. a simply supported concrete bridge and a masonry arch) will not deteriorate in the same manner.

Data and Analysis

2.4.4 Figure 2 shows there are three key areas in the asset management planning process. These are:

- ***Asset Specific Data*** – Inventory, condition, etc.;
- ***Asset Group Data*** – Lifecycle and other data and information typically defined at group level; and
- ***Analysis*** – Analysis performed at group, structure and/or element level.

2.4.5 As discussed in the previous section, for strategic asset management planning, it is only necessary to define lifecycle data at group level. However, the analysis will be performed at group, structure or element level, i.e. for complex structures (e.g. bridges, tunnels) the individual components will be analysed but for more straightforward structures (e.g. culverts, retaining walls, etc.) it will be possible to perform the analysis at either group or structure level (as element level data may not be readily available for structures such as culverts, retaining walls, etc.).

2.4.6 It is noted that the analysis is only performed for assets that are under the stewardship of an organisation.

2.5 Inventory Data and Groups

Inventory Data

2.5.1 The minimum inventory data required are:

- ***Structure Type*** – as per those listed in Table 2;
- ***Dimensions*** – the relevant dimensions for the structure type, see Table 2;
- ***Structure Breakdown*** – an appropriate breakdown of the structure, see Table 3;
- ***Structure Usage*** – the route carried or supported (e.g. rail, salted road, etc.), the obstacle crossed (e.g. rail, unsalted road, watercourse, etc.);
- ***Structure Location*** – Urban, rural, marine/estuarial; and
- ***Traffic Category*** – a category used as an indication of traffic levels associated with a structure, e.g. 'severe', 'moderate' or 'mild'; the actual values of AADT, CV, speed limit, traffic type, etc. are not required.

2.5.2 The complete list of required data is contained in Section 15 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

Table 2: Structures Dimensions[1]

Structure Types	Description	Dimensional Requirements Minimum	Dimensional Requirements Refined
Bridge: Vehicular	A structure with a span of 1.5m or more spanning and providing passage for vehicular traffic over an obstacle, e.g. watercourse, railway, road	Number of spans Overall length (m) Average width (m)	Average critical headroom (m)
Bridge : Non-Motorised User	As for vehicular bridge, but provides passage for pedestrians, cyclists or other non-motorised users		
Underbridge	A bridge supporting the road that is the point of reference and allowing traffic to pass over an obstacle		
Overbridge	A bridge that enables a route to pass over the road that is the point of reference		
Cantilever road sign	A structure with a single support that projects over the network in order to carry a traffic sign	Number	
Chamber/cellar/vault	An underground room or chamber with a plan dimension of 1.5m or more	Average length (m) Average width (m)	Average critical headroom (m)
Culvert	A drainage structure with a span of 0.9m or more passing beneath a network embankment that typically has a proportion of the embankment, rather than a bridge deck, between its uppermost point and the road running courses	Length (m) Average width (m)	Average critical headroom (m)
High mast lighting	Lighting columns over 20m in height	Number	
Retaining wall	A wall associated with the network where the dominant function is to act as a retaining structure (>1.35m)	Length (m)	Average retained height (m) **Note:** Excludes the depth below ground.
Sign/signal gantry	A structure spanning the network, the primary function of which is to support traffic signs and signalling equipment	Length (m)	Height (m) Width (m)
Structural earthworks - reinforced/strengthened soil/fill structure	A structure associated with the network where the dominant function is to stabilise the slope and/or retain earth. All structures with an effective retained height of 1.5m or greater.	Length (m) Plan width (m)	
Subway: Pipe	Subways that provide passage for utility service pipes and cabling	Length (m) Average width (m)	Average height (m)
Tunnel	An enclosed length of 150 metres or more through which vehicles passes	Length (m) Average width (m)	Average critical headroom (m)
Underpass (or subway): Pedestrian	A short (1.5m – 150m) passage for pedestrians under an obstacle typically characterised by retaining walls and tunnel construction form	Length (m) Average width (m)	Average critical headroom (m)
Underpass: Vehicular	As for pedestrian underpass, but provides passage for vehicles	Length (m) Average width (m)	Average critical headroom (m)

Structure Types	Description	Dimensional Requirements	
		Minimum	Refined
Special structure	For example, moveable bridges, Millennium Bridge, Tower Bridge	As appropriate	As appropriate

Table 3: Component Breakdown for Asset Management Planning[1]

Structures Type	Minimum Breakdown	Refined Breakdown
Bridge: Vehicular	CSS Bridge Inspection Elements[1]	Sub-division of major inspection components, e.g. abutments divided into East and West
Bridge: Non-Motorised User		
Cantilever road sign	Structure	CSS Sign/Signal Gantry Inspection Elements[1]
Chamber/cellar/vault	Structure	CSS Bridge Inspection Elements[1]
Culvert	Structure	CSS Bridge Inspection Elements[1]
High mast lighting	Structure	CSS Sign/Signal Gantry Inspection Elements[1]
Retaining wall	Structure	CSS Retaining Wall Inspection Elements[1]
Sign/signal gantry	Structure	CSS Sign/Signal Gantry Inspection Elements[1]
Structural earthworks - reinforced/strengthened soil/fill structure	Structure	-
Subway: Pipe	Structure	CSS Bridge Inspection Elements[1]
Tunnel	CSS Bridge Inspection Elements[1]	Sub-division of major inspection components, e.g. abutments divided into East and West
Underpass (or subway): Pedestrian		
Underpass: Vehicular		
Special structure		

Finite and Indefinite Life Components

2.5.3 Lives of components can be considered in two ways:

- Finite Life – those components that typically need to be replaced at the end of their service life, for example, expansion joints, bearings, some types of parapets, paint system, etc.; and
- Indefinite Life – those components that, given necessary maintenance, are maintained in perpetuity, e.g. abutments, primary/secondary deck elements, foundations, etc.

2.5.4 Appendix A provides the default classification of components into finite and indefinite life. However, it is recognised that these may differ on a case-by-case basis. As such, bridge engineers/managers should review and amend the default classification as appropriate.

Groups

2.5.5 As described in Paragraphs 1.1.1 to 2.4.3, homogeneous groups may be defined to reflect the key characteristics of the structure stock, enabling key drivers/influencers of lifecycle activities to be identified. It is important to bear in mind that the more refined the grouping the more effort will be involved in setting up the lifecycle data, i.e. data required for each homogeneous group.

Example 1: Groups

'Crude' Group – 100 Composite Bridges

This group comprises 100 'concrete/steel composite bridges' and has been formulated by interrogating only the drivers considered key to deterioration and interventions, i.e. structure type, construction type and construction material. This means that the criteria adopted for the formulation of this group are:

- Structure type = bridge; and
- Bridge Type Code = 04E 24A, i.e. a bridge composed of a reinforced concrete deck slab supported by longitudinal steel beams.

'Refined' Group – 5 Composite Bridges

This group comprises 5 'concrete/steel composite bridges' and has been formulated using the same criteria as the 'Crude' Group above as well as additional criteria as follows:

- Location = Urban
- Route supported = A road
- Obstacle crossed = Railway line
- Number of spans = 3 – 4 spans
- Average Structure Condition = Fair
- Critical Structure Condition = Good

2.6 Condition Data

2.6.1 Condition data for highway structures is primarily collated through General and Principal Inspections, typically undertaken at 2- and 6-year intervals but extendable to 12 year intervals. These datasets along with the year of the last inspection form the foundation for all asset management planning activities and in particular act as the starting point from which predictions can be made on how the condition (or performance) of assets changes over time. When the analysis is undertaken for groups or individual structures that do not have condition data at element level, a structure (e.g. a culvert) is regarded to be a 'component'.

Component/Sub- element level Analysis for Structures – Refined Level

2.6.2 Defect code types can be used to support a more refined level of analysis. These should be in the format described in the *Inspection Manual for Highway Structures*[1]. The current methodology does not support this level of refinement.

Currency of Condition Data

2.6.3 The analysis utilises the date of the last inspection to support the updating of condition data where this is deemed to be 'out-of-date'. Condition data are considered to be appropriate for the analysis when an inspection regime in accordance with *Management of Highway Structures: A Code of Practice*[6] is identified and implemented. If organisations do not comply with the data collection recommendations provided in *Management of Highway Structures: A Code of Practice*[6] they should fully document the assumptions and rationale to justify that the condition data used for the analysis are suitable.

2.7 Programmes of Work

2.7.1 Programmes of work provide details (i.e. work type, cost, etc.) of activities scheduled to address specific needs or issues. These should be used, where possible, to inform the analysis and may include the following:

- ***Routine maintenance regime schedules*** – minor work carried out on a regular or cyclic basis that helps to maintain the condition and functionality of the structure and reduce the need for other, often more expensive, maintenance works;
- ***Inspection programme*** – inspections, e.g. General Inspections and Principal Inspections, that are undertaken for the purpose of providing the most up-to-date and comprehensive data on the condition of structures;
- ***Assessment programme*** – structural assessments that are undertaken in order to identify sub-standard structures;
- ***Upgrade programmes*** – work that brings an existing structure up to the appropriate current standard, e.g. strengthening, upgrading parapets, waterproofing, etc.;
- ***Improvement programmes*** – work that entails changing certain features of an existing structure, e.g. increasing the width or headroom of an existing structure; and
- ***Lifecycle plans*** – long-term strategies for managing an asset, or a group of similar assets, with the aim of providing the required performance while minimising whole life costs.

2.7.2 Further information on the classification of work types is provided in *Management of Highway Structures: A Code of Practice*[6].

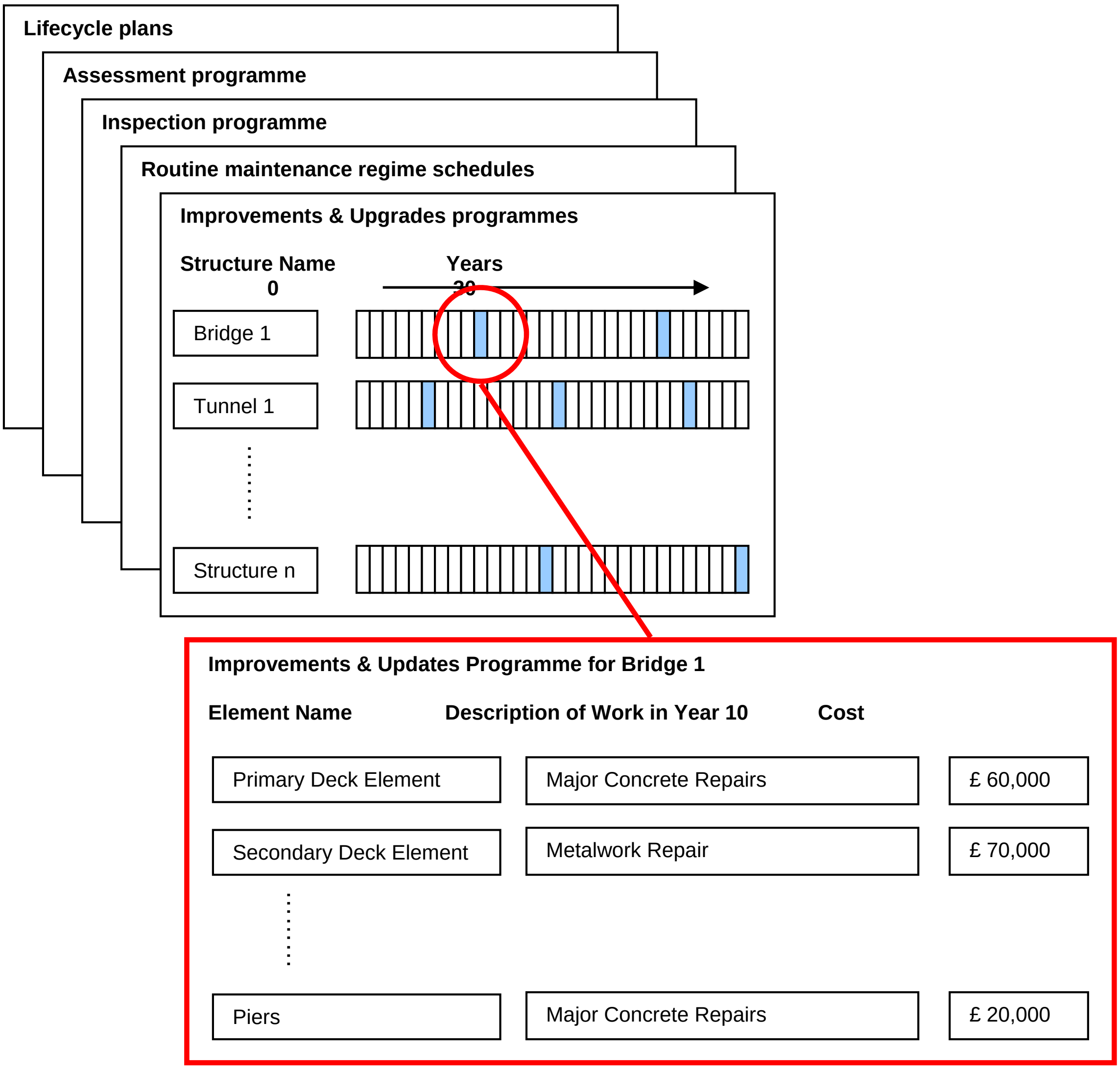
2.7.3 When programmes of work are used to inform the analysis, work types should be clearly classified into either Capital or Revenue expenditure. It is noted that Capital or Revenue expenditure relates to the type of activity and not to the source of funding. Further guidance on costs that may be capitalised is provided in:

- CIPFA's *Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting*[1]; and in
- *CIPFA's Practitioners' Guide to Capital Finance in Local Government*[13].

<u>NOTE:</u> For the purposes of WGA returns for 2014/2015, no Capital programmes of work should influence the determination of Depreciated Replacement Cost.

Example 2: Programmes of Work

Programmes of work are generated for structures that have specific maintenance and/or other needs. Programmes of work provide schedules and details of when and how these needs will be addressed as depicted below. For example 'Bridge 1' has a 30-year 'Improvements and Upgrades' programme; in year 10 of this programme, several treatments (i.e. concrete repairs and metalwork repairs to the deck elements, concrete repairs to the piers, etc) are planned and costed. Other activities are also planned on specific components on the bridge for subsequent years. Similarly, 'Improvements and Upgrades' and other programmes are created for other structures in the stock.



2.8 Identify Needs

2.8.1 Maintenance needs per group and/or individual structure are identified using intervention levels, triggers and programmes of work. These are typically the condition/performance levels at which treatments may be applied or that trigger the need for work, the setting of which is driven by the level of service required (at group/structure and element level) both now and in the future and by the type of treatment. The following issues are considered key drivers for the setting of intervention triggers:

- Condition – Are there any specific condition/aesthetic requirements that need to be satisfied?
- Loading – What loading regime needs to be satisfied?
- Height – What vehicle height clearance is required?
- Width – What width clearance is required (e.g. a single vehicle or number of lanes provided)?
- Users – What facilities are required for users (vehicular and pedestrian)?
- Safety – What safety criteria need to be satisfied, e.g. condition to prevent concrete spalling?

Condition Intervention Triggers

2.8.2 Default condition based intervention levels and triggers that can be used in the analysis are contained in Section 6a and Section 6b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

2.8.3 The intervention levels and triggers are influenced by factors such as traffic and exposure environment. These are defined in Section 1 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

2.8.4 For structural components, the default exposure classification can be determined by considering the factors that relate to the type, location and usage of the component and the condition of other key adjacent components, i.e.

- Route supported;
- Obstacle crossed;
- Proximity to the traffic spray zone; and
- Failures of relevant components (e.g. failure of the waterproofing impacts the exposure environment of bridge deck).

2.8.5 A simplified calculation is used to determine exposure of structural components in HAMFIG DRC analysis module. The calculation considers the factors determined in paragraph 2.8.4 of the *Structures Asset Management Planning Toolkit, Part A: Methodology,* apart from the failures of relevant components. The exposure level defined at year 0 is assumed to be constant thereafter.

2.8.6 For groups/structures, the default exposure classification can be determined by considering the factors that relate to the type, location and usage of the structure, i.e.

- Location, e.g. urban, rural, marine/estuarial;
- Route supported;
- Obstacle crossed; and
- Proximity to the traffic spray zone.

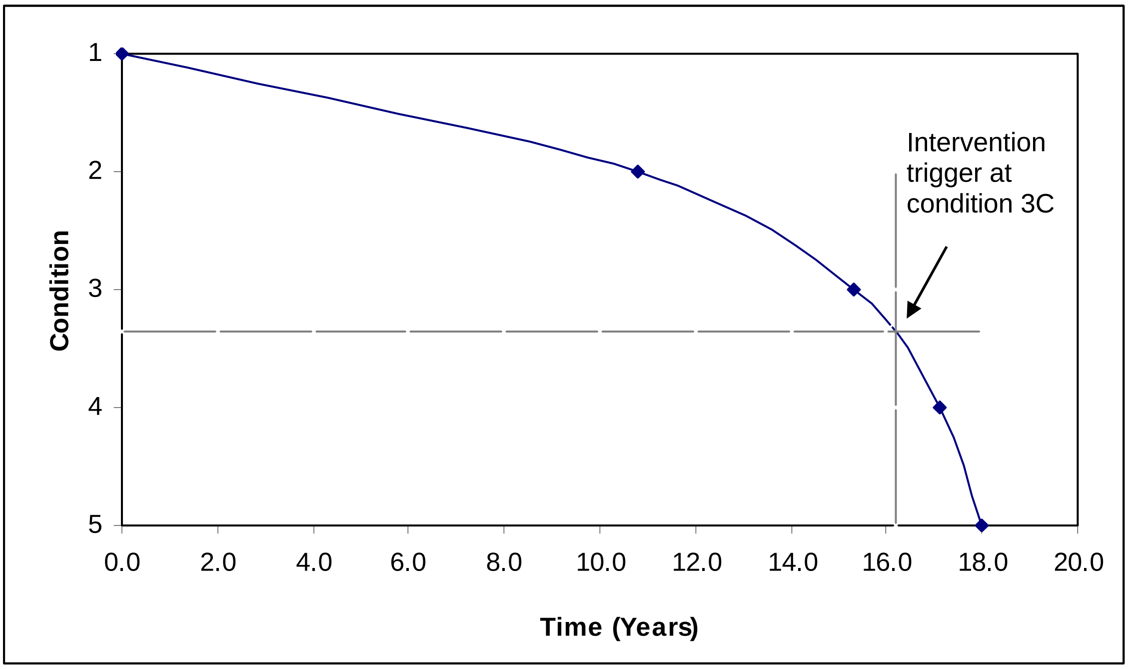
2.8.7 The default exposure classifications are presented in Section 2 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

Performance Intervention Triggers

2.8.8 Performance intervention triggers, i.e. relating to load-carrying capacity, minimum height/width, safety and other similar requirements, are addressed through the use of appropriate programmes of work (Section 2.7).

Example 3: Intervention Triggers

A buried joint exposed to 'Moderate' traffic (Section 1 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]) has the deterioration profile shown below. One intervention type, i.e. expansion joint replacement, is triggered when this type of component reaches condition 3C[1].



2.9 Select Treatments and/or Strategies

2.9.1 To address the identified needs (Section 2.8), appropriate maintenance treatments and/or strategies need to be assigned to groups, individual structures and/or components of structures.

Treatment Options

2.9.2 Different treatment options are appropriate for different structure types and different components. A list of suitable treatment options that are currently used for the maintenance of highway structures is provided in Section 5 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]. Maintenance activities are classified into either Capital or Revenue expenditure. Guidance on costs that may be capitalised is provided in:

- CIPFA's *Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting*[1];
- *CIPFA's Practitioners' Guide to Capital Finance in Local Government*[13]]; and in
- *CIPFA's Code of Practice on Transport Infrastructure Assets: Guidance Notes.*

NOTE: For the purposes of WGA returns for 2014/2015, the default treatment options should be used to determine Depreciated Replacement Cost.

2.10 Treatment Selection

2.10.1 Treatment selection depends on which treatment options are deemed to be appropriate or can be suitably applied depending on the construction material, exposure environment and condition of a group, individual structure and/or component of a structure.

2.10.2 Default treatment application triggers are provided in Section 6a and Section 6b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

Strategies

2.10.3 A minimum of three strategies should be analysed:

- ***'Planned Do Minimum' Strategy*** – the minimum required to sustain safety across the analysis period, e.g. infrequent but major interventions to satisfy minimum safety and performance targets;
- ***'Planned Preventive' Strategy*** – regular and frequent minor interventions that slow down the rate of deterioration; and
- ***'Planned Targeted' Strategy*** – interventions aimed towards delivering a required target condition.

2.10.4 Although default intervention triggers associated with the aforementioned strategies are provided in Section 6a and Section 6b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12], organisations should review and, where appropriate, revise these based on local targets, knowledge and engineering judgement. **NOTE:** For the purposes of WGA returns for 2014/2015, the default intervention levels, triggers and effects should be used to determine Depreciated Replacement Cost.

2.10.5 Furthermore, and despite the fact that this would be a very unlikely situation in practice, an **'Unplanned Reactive' Strategy** can also be analysed. Under this strategy, all components irrespective of their importance and irrespective of the available budget are treated when they reach condition 5B (i.e. failure) and action is mandatory (even if it is just to close the structure). The purpose of this strategy is to demonstrate the consequences of a zero-budget. It is anticipated that, if no funding is available, the stock condition and value would decline over the analysis period, while restrictions and traffic delay would increase ('Calculate Penalties' in Section 2.11).

Example 4: Treatment Selection and Strategies

The components listed below (along with other components) are present on a reinforced concrete bridge. Given the exposure and the material type of each component, the treatment types listed below have been identified as suitable treatment options. The selection of specific treatment options depends on the maintenance strategy for which the analysis will be performed and the pre-defined condition based intervention triggers.

							Intervention Triggers			
Element	Exposure	Material	Treatment Type	Applicable to Condition Band			Planned Preventive	Planned Targeted	Planned Do Minimum	Unplanned Reactive
01 - Primary deck element	Moderate	Concrete	Concrete Repairs	2B	-	5E	3C	3C	4D	5B
			Component Replacement	3B	-	5E	-	-	-	-
08 - Abutments	Mild	Concrete	Concrete Repairs	2B	-	5E	3C	3C	4D	5B
			Component Replacement	3B	-	5E	-	-	-	-
13 - Bearings	Severe	Roller	Bearings: Replacement	2B	-	5E	3C	3C	4D	5B
18 - Expansion Joints	High	Asphaltic Plug	Expansion Joint: Replacement	2B	-	5E	3C	3C	4D	5B

2.11 Calculate Costs and Penalties

2.11.1 Once a suitable treatment has been selected, costs are derived for:

- ***Maintenance activities*** – the actual cost for doing work on a specific component or structure;
- ***Add-Ons*** – costs associated with work enablers, i.e. traffic management, design costs, access, preliminaries, etc.; and
- ***Penalties*** – an indicative monetary value representing the risks and penalties associated with not undertaking and/or significantly delaying intervention(s).

Cost of Maintenance Activities

2.11.2 Each identified work activity is assigned a base unit rate (i.e. rate for works only). For this purpose, a set of typical unit rates should be compiled for each intervention. A set of default unit rates is presented in Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12] against each work activity along with the following:

- ***Unit*** – the unit against which base cost is defined, e.g. number, m, m^2;
- ***Maintenance Activity Cost Type*** – cost types can be set as Fixed, Constant or Variable, which are defined as:
    - Fixed – a unit rate applied under specified conditions and/or a point in time. The activity has a fixed cost per item/time period.
    - Constant – a unit rate that remains the same regardless of condition and is normally applied to the full size of the structure or component, e.g. component replacement, application of impregnants, etc.
    - Variable – a unit rate that is dependent on the condition of the structure or component to which a maintenance treatment is applied, e.g. concrete repairs, masonry repairs, metalwork repairs, etc.
- ***Unit Rate*** – default unit rates are rates from the second quarter of 2010, indexed to the second quarter of 2014 using Road Project Index. Guidance on indexation is provided in Section 13 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

NOTE: For the purposes of WGA returns for 2014/2015, the default costs of maintenance activities should be used to determine Depreciated Replacement Cost.

2.11.3 The works cost for a maintenance activity that may be required for a component at a given time is evaluated based on the quantity of work required, i.e. taking into account the component's dimensions and the severity and extent of defects, and the maintenance activity cost type and unit rates. When the analysis is undertaken for groups or structures that do not have condition data at element level, a structure (e.g. a culvert) is regarded to be a 'component'.

1. When the maintenance activity cost type is *Fixed*, the works cost is evaluated using the following equation:

$$\mathbf{WC_{Fixed} = FR}$$

Equation 1

Where:

WC_{Fixed} = Works cost for the maintenance activity cost type *Fixed*

FR = Fixed rate (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12])

2. When the maintenance activity cost type is *Constant*, the works cost is evaluated using the following equation:

$$\mathbf{WC_{Constant} = SF \times UR_C}$$

Equation 2

Where:

$WC_{Constant}$ = Works cost for the maintenance activity cost type *Constant*

SF = Component or structure size (Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12])

URC = Constant unit rate (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12])

3. When the maintenance activity cost type is *Variable*, the deterioration sequence defined in Table 4 is applied. This describes the expected percentage of the component or structure in each condition band. For example, when a component is in condition 3C, it is assumed that 7.5% of the structure/component is in Severity 3 and 12.5% is in Severity 2. These percentages are used along with the corresponding maintenance activity unit rates listed in Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12] to calculate the works cost.

Table 4: Extent of Severity

Primary Condition		Lesser Conditions Also Present						Total Extent of Defects (TEoD)
1A	0.00%	-		-		-		0.00%
2B	2.50%	-		-		-		2.50%
2C	7.50%	-		-		-		7.50%
2D	12.50%	-		-		-		12.50%
2E	15.00%	-		-		-		15.00%
3B	2.50%	2D	12.50%	-		-		15.00%
3C	7.50%	2D	12.50%	-		-		20.00%
3D	12.50%	2E	10.00%					22.50%
3E	15.00%	2E	10.00%	-		-		25.00%
4B	2.50%	3D	12.50%	2E	10.00%	-		25.00%
4C	7.50%	3D	12.50%	2E	10.00%	-		30.00%
4D	12.50%	3D	12.50%	2E	10.00%	-		35.00%
4E	15.00%	3E	12.50%	2E	10.00%	-		37.50%
5B	2.50%	4D	12.50%	3D	12.50%	2E	10.00%	37.50%
5C	7.50%	4D	12.50%	3D	12.50%	2E	10.00%	42.50%
5D	20.00%	4D	12.50%	3D	12.50%	2E	12.50%	57.50%
5E	50.00%	4D	20.00%	-		-		70.00%

This information is used to calculate the works cost using the following equation:

$$\mathbf{WC_{Variable} = SF \times [(UR_{S2} \times Ext_{S2}) + (UR_{S3} \times Ext_{S3}) + (UR_{S4} \times Ext_{S4}) + (UR_{S5} \times Ext_{S5})]}$$

Equation 3

Where:

$WC_{Variable}$ = Works cost for the maintenance activity cost type *Variable*

SF = Component or structure size (Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12])

UR_{Si} = Unit rate for Severity i (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12])

Ext_{Si} = Extent for Severity i (Table 4)

Add-Ons

2.11.4 A scheme is a combination of all the activities undertaken on all components of an individual structure or a group of structures at a specific time step. Thus, the total scheme cost includes a summation of the cost of all the works undertaken on an individual structure or a group of structures within the time step. The total scheme cost can also be significantly influenced by the following:

- ***Traffic Management Cost*** – the cost of traffic management required to do the work;
- ***Preliminaries Cost*** – including items such as establishment of site facilities for the employer/overseeing organisation and the contractor;
- ***Design Costs*** – planning the scheme, i.e. programming the works, and preparing designs and drawings; and
- ***Other Costs*** – including costs associated with access, site clearance, minor earthworks, fencing, retaining wall repairs, etc.

2.11.5 The above costs are calculated by applying a suitable uplift factor to the total works cost at a given time. The total scheme cost can be calculated using Equation 4 to Equation 9.

$$\mathbf{SC = \sum WC + TMC + PC + DC + OC}$$

Equation 4

$$\mathbf{TMC = \sum (WD \times TMR)}$$

Equation 5

$$\mathbf{WD = SF / WDR}$$ (if the maintenance activity cost type is *Fixed* or *Constant*)

or

$$\mathbf{WD = (SF \times TEoD) / WDR}$$ (if the maintenance activity cost type is *Variable*)

Equation 6

$$\mathbf{PC = f_P \times \sum WC}$$

Equation 7

$$\mathbf{DC = f_D (\sum WC + TMC + PC + OC)}$$

Equation 8

$$\mathbf{OC = f_O \times \sum WC}$$

Equation 9

Where:

SC	=	Scheme cost
∑WC	=	Total works cost in a given time step, i.e. a summation of the cost of all the works undertaken on an individual structure or a group of structures within the time step
TMC	=	Traffic management cost
PC	=	Preliminaries cost
DC	=	Design cost
OC	=	Other costs
WD	=	Works duration
TMR	=	Unit cost of a traffic management arrangement
∑ (WD x TMR)	=	a summation of the cost of all the traffic management arrangements required to undertake the scheme
SF	=	Component or structure size (Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12])
WDR	=	Works duration rate (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12])
TEoD	=	Total extent of defects (Table 4)
f_P	=	Uplift factor for preliminaries cost
f_D	=	Uplift factor for design cost
f_O	=	Uplift factor for other costs

2.11.6 Traffic management arrangements are combined during the Asset Management Planning Analysis. This is a two-step process:

1. The duration of each required traffic management arrangement in a particular works location (e.g. above or below the bridge deck) is evaluated. This is taken as the maximum works duration for an individual component on which maintenance is to be carried out under that traffic management arrangement, as shown in Equation 10.

$$\mathbf{TMD = max\,(WD_{Component\_1}, WD_{Component\_2}, \ldots, WD_{Component\_n})}$$

Equation 10

Where:

TMD	=	Duration of the traffic management arrangement
$WD_{Component\_i}$	=	Duration of works on component i to be carried out under the traffic management arrangement
n	=	Number of components being maintained as part of the scheme

2. Where possible, simple traffic management arrangements are combined with more onerous traffic management arrangements. This is best illustrated by Example 5.

Example 5: Consider Asset Management Planning Analysis of 6 components that are located above a bridge deck and are scheduled for maintenance with the following individual traffic management requirements:

Traffic management arrangement for $Component_1$ = 5 days of Contraflow

Traffic management arrangement for $Component_2$ = 15 days of Contraflow

Traffic management arrangement for $Component_3$ = 8 days of Lane Closure

Traffic management arrangement for $Component_4$ = 24 days of Lane Closure

Traffic management arrangement for $Component_5$ = 10 days of Hardshoulder Closure

Traffic management arrangement for $Component_6$ = 30 days of Hardshoulder Closure

<u>Duration of Traffic Management Arrangements</u>

Works on $Component_1$ and $Component_2$ require that contraflow is in place. Since works on $Component_2$ will take longer than works on $Component_1$, the works can be combined under one arrangement of contraflow for the duration of works on $Component_2$.

$$TMD_{Contraflow} = max(WD_{Component\_1}, WD_{Component\_2}) = 15 \text{ days}$$

Works on $Component_3$ and $Component_4$ require that a lane closure is in place. Since works on $Component_4$ will take longer than works on $Component_3$, the works can be combined under one arrangement of lane closure for the duration of works on $Component_4$.

$$TMD_{Lane\ Closure} = max(WD_{Component\_3}, WD_{Component\_4}) = 24 \text{ days}$$

Works on $Component_5$ and $Component_6$ require that a hardshoulder closure is in place. Since works on $Component_6$ will take longer than works on $Component_5$, the works can be combined under one arrangement of hardshoulder closure for the duration of works on $Component_6$.

$$TMD_{Hardshoulder\ Closure} = max(WD_{Component\_5}, WD_{Component\_6}) = 30 \text{ days}$$

<u>Final Traffic Management Durations for the Scheme</u>

For this scheme, the simple traffic management arrangements can now be combined with the more onerous traffic management arrangements as follows:

Contraflow (the most onerous of the arrangements required) for 15 days:

$$TMD_{Contraflow\_Final} = TMD_{Contraflow} = 15 \text{ days}$$

Lane closure for 9 days:

$$TMD_{Lane\ Closure\_Final} = TMD_{Lane\ Closure} - TMD_{Contraflow\_Final} = 24 \text{ days} - 15 \text{ days} = 9 \text{ days}$$

Hardshoulder closure (the least onerous of the arrangements required) for 6 days:

$$TMD_{Hardshoulder\ Closure\_Final} = TMD_{Hardshoulder\ Closure} - TMD_{Contraflow\_Final} - TMD_{Lane\ Closure\_Final}$$
$$= 30 \text{ days} - 15 \text{ days} - 9 \text{ days} = 6 \text{ days}$$

2.11.7 A simplified calculation is used for evaluation of traffic management cost in HAMFIG DRC Analysis, involving summation of costs of required traffic management arrangements and application of a reduction factor to this summation.

2.11.8 Default unit costs of traffic management arrangements and default uplift factors are listed in Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]. **<u>NOTE:</u>** For the purposes of WGA returns for 2014/2015, the default unit costs of traffic management arrangements and default uplift factors should be used to determine Depreciated Replacement Cost.

Example 6: Calculation of Scheme Cost

Consider a 2-span bridge carrying an A class road and crossing a navigable watercourse. The total length of the structure is 17m and the average width is 8m. The spans are supported on elastomeric bearings and the central pier is located in the river bed. The clearance of the bridge to water surface is 4.7 m. Given their condition and exposure environment, the following components require maintenance in the same year:

Bearings – the reported condition of the bearings is 3C and they are in a severe exposure environment (assuming that the expansion joints on the structure are not functioning). 'Bearings Replacement' is triggered as an appropriate intervention under a preventive maintenance strategy.

Expansion Joints – the reported condition of the nosing joints is 4C and they operate in a mild environment (i.e. low traffic). 'Expansion Joint Replacement' is triggered as an appropriate intervention.

Abutments – the reported condition of the reinforced concrete abutments is 3C and they are in a severe exposure environment (assuming that the expansion joints on the structure are not functioning). 'Concrete Repairs' are triggered as an appropriate intervention under a preventive maintenance strategy.

The works cost (WC) for each component is calculated below:

<u>Bearings – Replacement – Works Cost</u>

Maintenance activity cost type = Constant (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

Therefore, Equation 2 is used $\mathbf{WC_{Constant} = SF \times UR_C}$

Component size for bearings is **SF = Average Width x (Number of Spans + 1) x Number of Structures in the Group** (Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

SF = Average Width x (Number of Spans + 1) x Number of Structures in the Group
= 8 x (2 + 1) x 1 = 24 m

The unit rate for bearing replacement is £1037/m (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

Therefore, the works cost for bearing replacement is:

$\mathbf{WC_{Constant} = SF \times UR_C = 24\ m \times £1037/m = £24,888}$

<u>Expansion Joints – Replacement – Works Cost</u>

Maintenance activity cost type = Constant (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

Therefore, Equation 2 is used: $\mathbf{WC_{Constant} = SF \times UR_C}$

Component size for expansion joints is **SF = Average Width x (Number of Spans + 1) x Number of Structures in the Group** (Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

SF = Average Width x (Number of Spans + 1) x Number of Structures in the Group
= 8 x (2 + 1) x 1 = 24 m

The unit rate for the replacement of a nosing joint is £763/m (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

Therefore, the works cost for expansion joint replacement is:

$\mathbf{WC_{Constant} = SF \times UR_C = 24\ m \times £763/m = £18,312}$

Abutments – Concrete Repairs – Works Cost

Maintenance activity cost type = Variable (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

Therefore, Equation 3 is used: $\mathbf{WC_{Variable} = SF \times [(UR_{S2} \times Ext_{S2}) + (UR_{S3} \times Ext_{S3}) + (UR_{S4} \times Ext_{S4}) + (UR_{S5} \times Ext_{S5})]}$

Component size for abutments is **SF = Average Critical Headroom x Average Width x Number of Structures in the Group x 2** (Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

SF = Average Critical Headroom x Average Width x Number of Structures in the Group x 2 = 4.7 m x 8 m x 1 x 2 = 75.2 m²

The reported condition for the abutments is 3C. From Table 4, 12.5% of the total area is in Severity 2 (in condition 2D) and 7.5% of the total area is in Severity 3 (in condition 3C). No part of the abutment is in Severity 4 or Severity 5. Therefore, the extent of each severity is:

Ext_{S2} = 0.125

Ext_{S3} = 0.075

$Ext_{S4} = Ext_{S5}$ = 0

The unit rate for concrete repairs for each severity (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]) is:

UR_{S2} = £346/m^2

UR_{S3} = £1,383/m^2

UR_{S4} = £2,075/m^2

UR_{S5} = £2,685/m^2

Therefore, the works cost for concrete repairs on the abutments is:

$\mathbf{WC_{Variable} = SF \times [(UR_{S2} \times Ext_{S2}) + (UR_{S3} \times Ext_{S3}) + (UR_{S4} \times Ext_{S4}) + (UR_{S5} \times Ext_{S5})]}$

$\mathbf{WC_{Variable} = 75.2\ m^2 \times [(£346/m^2 \times 0.125) + (£1,383/m^2 \times 0.075) + (£2,075/m^2 \times 0) + (£2,685/m^2 \times 0)] = £11,053}$

Total Works Cost

The total works cost is equal the sum of the costs of all the works undertaken on the structure:

$\mathbf{\sum WC = £24,888 + £18,312 + £11,053 = £54,253}$

Traffic Management Cost

Two types of traffic management arrangement are required to carry out the works. These are a lane closure for replacing the expansion joints and a watercourse possession for replacing the bearings and carrying out concrete repairs to the abutments (Section 7 and Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

Traffic management cost is calculated using

Equation 5: **TMC = ∑ (WD x TMR)**; and

Equation 6:

WD = SF / WDR (if the maintenance activity cost type is *Fixed* or *Constant*)

or

WD = (SF x TEoD) / WDR (if the maintenance activity cost type is *Variable*)

Lane Closure – Traffic Management Cost

The works duration rate for expansion joint replacement is 1 m/hr (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]). Therefore:

WD = SF / WDR = 24 m / (1 m/hr) = 24 hours

The unit cost of a lane closure is £259/hr (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]), so:

$TMC_{Lane\ Closure}$ = WD x TMR = 24 hours x £259/hr = £6,216

Waterway Possession – Traffic Management Cost

The works duration rate for bearing replacement is 0.35 m/hr (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]). Therefore:

WD = SF / WDR = 24 m / (0.350 m/hr) = 68.6 hours

The works duration rate for concrete repairs is 0.7 m^2/hr (Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]). The reported condition for abutments is 3C and, from Table 4, the total extent of defects is 20%. Therefore:

WD = (SF x TEoD) / WDR = 75.2 m^2 x 0.2 / (0.7 m^2/hr) = 21.5 hours

Works on the bearings and the abutments can be combined under one waterway possession lasting 68.6 hours.

The unit cost of a waterway possession is £305/hr (Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]), so:

$TMC_{Waterway\ Possession}$ = WD x TMR = 68.6 hours x £305/hr = £20,923

Total Traffic Management Cost

The total traffic management cost is the sum of the costs for individual traffic management arrangements:

TMC = $TMC_{Lane\ Closure}$ + $TMC_{Waterway\ Possession}$ = £6,216 + £20,923 = £27,139

Preliminaries Cost

The preliminaries cost is calculated using Equation 7: **PC = f_P x ∑WC**

The uplift factor for preliminaries cost f_p is 0.2 (Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]). Therefore:

PC = f_P x ∑WC = 0.2 x £54,253 = £10,851

Other Costs

Other Costs are calculated using Equation 9: **OC = f_O x ∑WC**

The uplift factor for other costs f_O is 0.2 (Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]). Therefore:

OC = f_O x ∑WC = 0.2 x £54,253 = £10,851

Design Costs

Design cost is calculated using Equation 8: **DC = f_D (∑WC + TMC + PC + OC)**

The uplift factor for Design Costs f_D is 0.2 (Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]). Therefore:

DC = f_D (∑WC + TMC + PC + OC) = 0.2 x (£54,253 + £27,139 + £10,851 + £10,851) = £20,619

Total Scheme Cost

Equation 4 is used to calculate the total scheme cost:

SC = ∑WC + TMC + PC + DC + OC = £54,253 + £27,139 + £20,619 + £10,851 + £10,851+ £9,354 = £123,713

Calculate Penalties

2.11.9 A 'penalty' refers to an indicative monetary value representing the risks and penalties associated with not undertaking and/or significantly delaying intervention(s). This typically takes account of:

- Loss of service:
  - *Impact on availability:* In extreme circumstances, it may become necessary to close a lane or an entire structure for safety reasons. Where appropriate, penalty costs associated with the closure of lanes or structures could be quantified by vehicle delay costs.
  - *Impact on other routes:* Not undertaking and/or significantly delaying an intervention may impact the route supported and/or crossed by a structure, i.e. pose a risk to:
    - railways, thereby disrupting service;
    - waterways, e.g. pollution;
    - traffic flow (over or under a structure); or
    - farm access, etc.
  - *Impact on utilities:* Disruption of utility services, e.g. gas, water, telecommunication, etc.
- Safety risk:
  - *Risk to public safety:* If some components are permitted to deteriorate to an unacceptable level (e.g. expansion joints, bearings) they may cause vehicle accidents due to their impact on the running surface. Where appropriate, associated penalty costs, e.g. accident/casualty costs, should be calculated and taken into consideration while developing lifecycle plans.
  - *Risk to structural integrity:* In extreme circumstances structural failure may occur, e.g. a load bearing component reaches condition 5B (i.e. failure). Where appropriate, associated penalty costs, e.g. vehicle delay costs, reconstruction costs, etc., should be calculated and taken into consideration while developing lifecycle plans.

- Environmental impacts may include pollution (e.g. air, noise) due to traffic delays or carbon footprint associated with re-construction, etc. Where appropriate, such costs should be quantified and taken into consideration while developing lifecycle plans.

2.11.10 Penalty costs can be calculated based on the following:

- ***Structure[*] with Safety or Performance at Risk*** – A structure's safety or performance is considered to be at risk if at least one component with a "very high importance" rating has a condition score[†] of 4.0 or more (the Condition Performance Indicator procedure describes which components are classified as having a very high, high, medium and low importance[14, 15, 16]). By definition, a condition score of 4.0 or more describes a significant loss of functionality.
- ***Traffic Delay Cost*** – Every structure[*] for which safety or performance is at risk incurs a traffic delay cost. If at least one component with a "very high importance" rating on a structure has a condition score of 4.0 or more, but less than 5.0, then the traffic flow is assumed to be restricted on one lane in each direction. The length of time over which the restriction applies is dependent on structure length:
    - For structures with a length of 10m or less, the restriction applies for 5 days.
    - For structures with a length greater than 10m and less than or equal to 20m, the restriction applies for 10 days.
    - For structures with a length greater than 20m, the restriction applies for 15 days.

  However, if at least one component with a "very high importance" rating on a structure has a condition score of 5.0 or more, the entire structure is assumed to be closed to all traffic for 30 days.

2.11.11 The default traffic delay rates are listed in Section 10 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

> **Example 7: Penalties**
>
> The primary deck element of a 15 m long bridge has reached condition 4D. There are no available funds to undertake any maintenance work. The structure carries an A class road with high traffic.
>
> The bridge is flagged as having its safety or performance at risk and a restriction is applied for 10 days (Section 10 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).
>
> The traffic delay cost resulting from this restriction is calculated by multiplying the Daily Traffic Delay Rate given in Section 10 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12] by the duration of the restriction, i.e. 10 days. Therefore:
>
> **Traffic Delay Cost = £996/day x 10 days = £9,960**

2.12 Prioritise Identified Needs

2.12.1 In the analysis, it is likely that a large number of components will reach their maintenance intervention threshold simultaneously and the level of funding may not be sufficient to meet all maintenance requirements. A prioritisation process is used to allocate the budget, in a logical and consistent manner, to where it is needed most. The prioritisation method reflects a streamlined and fully automated Value Management process that operates on readily available data. The prioritisation method is based on:

[*] "Structure" in this context refers to all structure types which contribute to the condition of the structure stock as bridges, small culverts or tunnels. Please refer to Appendix B.
[†] Please refer to Appendix B for how condition is evaluated.

- ***Element Condition Index*** – a combination of the component's physical condition (severity and extent of defect) and its importance (very high, high, medium or low) to the overall structure[14, 15, 16]; where:
  - *Element Condition* – components or structures in poorer condition receive higher priority because they are deemed to represent a greater risk to the public and the service. Also, deferred maintenance on components in poorer condition is considered to lead to proportionally larger maintenance costs when further deterioration occurs.
  - *Element Importance* – components that have a greater impact on functionality, durability and/or strength receive a higher priority. When the analysis is undertaken for groups or individual structures that do not have condition data at element level, a structure (e.g. a culvert) is regarded to be a 'element' and the Element Importance is set at a default value of 'very high'.
- ***Structure Importance*** – reflects the importance of the structure to the network by taking account of the structure type (as per those listed in Table 2), the route classification, the traffic category of the route supported and the type of obstacle crossed (e.g. railway, local road, watercourse or farmland). More important structures have a higher priority of maintenance because deferred maintenance work or structural failure results in greater consequences.

2.12.2 The equation used for calculating the prioritisation score is shown below:

$$\mathbf{P_R = f_1(ECI) + f_2(T_f + OBS_f + R_f) + f_3(ST_f)}$$

Equation 11

Where:

ECI	=	Element Condition Index[14, 15, 16]
T_f	=	Factor based on the traffic on the route served
OBS_f	=	Factor based on the obstacle crossed by the structure
R_f	=	Factor based on the importance of the route served
ST_f	=	Factor based on the structure type
f_1, f_2, f_3	=	Weighting coefficients

2.12.3 The default weighting coefficients and the other factors used by the prioritisation algorithm are listed in Section 11 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

2.13 Maintain and Deteriorate Components

2.13.1 Once the identified needs have been prioritised, there are two possibilities:

- Structures or components are not maintained, i.e. further deterioration is allowed to take place; or
- Structures or components are maintained, i.e. an intervention is applied and the condition is restored to a pre-defined level.

2.13.2 This utilises the following, as described in subsequent sections:

- Service lives and deterioration rates;
- Treatment effects;
- Defined budget or target condition.

Service Lives and Deterioration Rates

2.13.3 A set of default service lives and deterioration rates was compiled for the analysis. The datasets cover all components and materials and seek to reflect the key factors that influence the rate of deterioration or length of service life. These are listed in Sections 3, 4a and 4b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]. It is recognised that this is not an exact science and typically the best source of information is local knowledge, especially as some defects take many years to develop to the point where they require maintenance. **NOTE:** For the purposes of WGA returns for 2014/2015, the default service lives and deterioration rates should be used to determine Depreciated Replacement Cost.

2.13.4 The exposure environment has significant influence on deterioration rates and service lives of materials and components. The default exposure classifications are presented in Section 2 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

2.13.5 The appropriate representation of deterioration through time is a fundamental part of the asset management planning process. In order to achieve this, i.e. calculate deterioration profiles through time, it is firstly necessary to define and compile data on the following:

- Factors influencing the service life and rates of deterioration of components, e.g. exposure environment; and
- Service lives and deterioration rates for components, and how these may differ by material type, exposure environment and other relevant factors.

2.13.6 In general, the starting position for future deterioration would be taken as the condition, with the rate of deterioration influenced by exposure. The analysis supports the creation of profiles that describe how condition changes over time given no maintenance intervention, such as that shown in Figure 3. Figure 3 shows a profile that describes how a component deteriorates from condition 1A to condition 5E. To represent uncertainty in deterioration rates and service lives, times to failure are defined as uniform distributions.

2.13.7 A uniform distribution allowing for uncertainty of ± 20% about the mean value for time to failure is applied to the service lives and deterioration rates of all components. This distribution was selected because experience indicates that diverse deterioration rates and service lives occur across a network due to the wide range of exposure environments and construction qualities present. A random time to failure is selected for each component from the respective distribution.

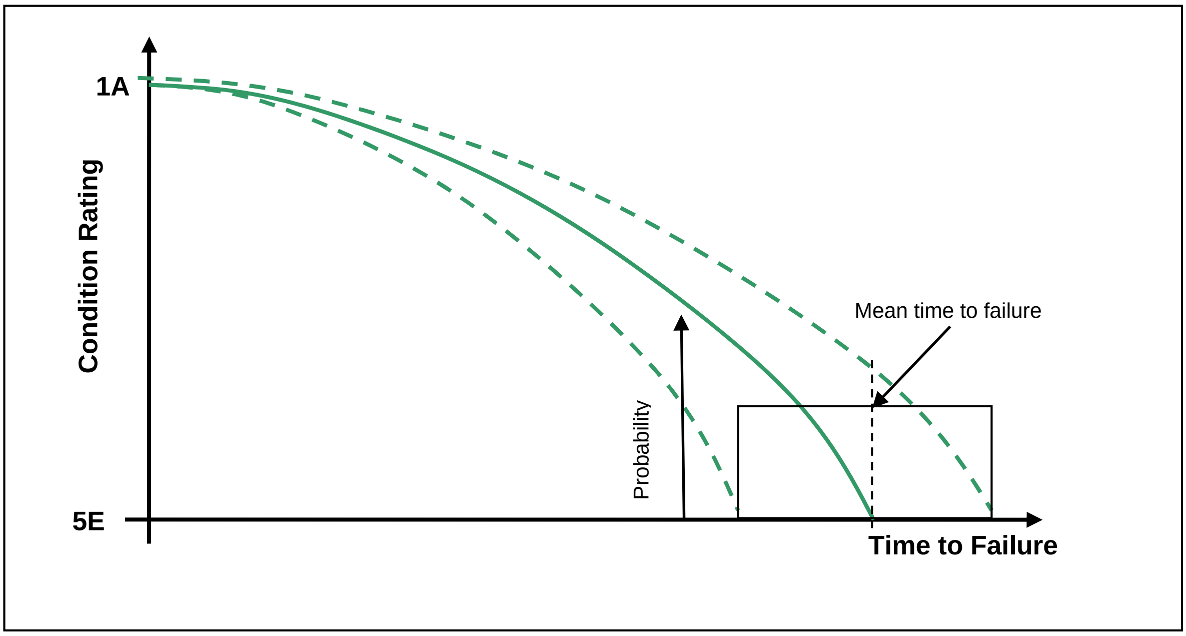


Figure 3: Deterioration Profiling

NOTE: For the purposes of WGA returns for 2014/2015, only the mean service lives and deterioration rates should be used to determine Depreciated Replacement Cost. That is, no uncertainty should be included in the determination of Depreciated Replacement Cost for the purposes of WGA returns for 2014/2015.

Treatment Effects

2.13.8 Applied treatments have one or more of the following effects on components or structures:

- Change exposure classification;
- Reset condition to a defined level;
- Change the time to failure; or
- Change the deterioration profile.

2.13.9 These effects are listed in Section 6a and Section 6b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12].

Define Budget or Target Condition

2.13.10 The analysis requires the annual budget and/or target condition to be defined.

2.13.11 Where an annual budget is defined, the analysis enables assessment of how the budget changes the condition, and future funding requirements, for the structure stock.

2.13.12 Where a target condition is defined, the analysis suggests the level of funding required to achieve or maintain the target condition.

2.14 Evaluate Expenditure and Condition

2.14.1 The total annual expenditure and condition are evaluated for each component, structure and group in each year of the analysis period based on the applied maintenance interventions. In addition, the number of structures with safety or performance at risk and associated traffic delay costs are calculated depending on whether or not maintenance interventions are applied.

Shortfall

2.14.2 Shortfall refers to the financial value of the maintenance works which are required – but, due to limited funding, not undertaken – to restore to “as-new” condition all components that have reached or exceeded their intervention threshold. Shortfall is evaluated for each year in the analysis period for each of the structure types listed in Table 2. Therefore, shortfall is carried forward from one year to the next until the required work can be undertaken. The shortfall associated with a particular component may increase over time if the component continues to deteriorate and the value of work required to restore it to “as-new” condition increases as a result.

Work Volume

2.14.3 Work volume is defined as the financial value of the maintenance works carried out, as permitted by the available budget, on components that have reached or exceeded their intervention threshold. Work volume is evaluated for each year in the analysis period classified as Capital or Revenue for each of the structure types listed in Table 2.

2.15 Outputs

2.15.1 The analysis provides the following functionality and output:

1. Performance of “what if” scenarios to interrogate:
    - How the structure stock’s condition changes due to different levels of funding;
    - How shortfall changes due to different levels of funding;
    - How penalties change due to different levels of funding e.g. number of propped structures, number of weight restricted structures, etc.; and

- The ‘optimum’ level of funding to maintain the condition and functionality of the structures stock.

NOTE: For the purposes of WGA returns for 2014/2015, an unlimited annual budget should be used to determine Depreciated Replacement Cost.

2. Time dependant condition and funding profiles for the structure stock and sub-groups of the stock e.g. bridges, retaining walls, culverts, etc.;
3. Expenditure profiles for routine maintenance and inspections;
4. The total (discounted) whole life cost for each scenario, including works and penalty costs;
5. The expected life of each finite life component;
6. The treatment cycle and life of each indefinite life component;
7. Expenditure profiles associated with finite life and indefinite life components; and
8. Profiles of gross replacement cost and depreciated replacement cost.

2.16 Apportioning Scheme Add-Ons at element level for Asset Management Planning Analysis

2.16.1 In order to calculate the contribution of an individual element to scheme cost and therefore the element’s annual depreciation, add-ons evaluated at scheme level in Equation 5 to Equation 9 should be apportioned at element level.

Traffic Management

2.16.2 For the purpose of Asset Management Planning analysis, the duration of each required traffic management arrangement is evaluated as the maximum works duration for an individual component on which maintenance is to be carried out under that traffic management arrangement. Where possible, simple traffic management arrangements are combined with more onerous traffic management arrangements.

2.16.3 A simplified calculation is used for evaluation of traffic management cost in HAMFIG DRC Analysis, involving summation of costs of required traffic management arrangements and application of a reduction factor to this summation.

2.16.4 The following sequence is applied to identify the appropriate traffic management cost to be apportioned to each element in a given time step:

1. Sum the works duration for all maintenance activities that would be utilising the same traffic management arrangement in the same location in a given time step, as shown in .

$$\mathbf{SWD = \sum(WD_{element\_1}, WD_{element\_2}, \ldots, WD_{element\_n})}$$

Equation 16

Where:

SWD = Sum of all work durations for elements on which maintenance is to be carried out under the same traffic management arrangement in the same location

$WD_{element\_i}$ = Works duration for element i, calculated using Equation 6

n = Number of elements on which maintenance is to be carried out under the same traffic management arrangement in the same location

2. The equation used for apportioning the scheme’s traffic management cost to each element is 17.

$$TMC_{element\_i} = TMC \times WD_{element\_i} / SWD$$

Equation 17

Where:

$TMC_{element\_i}$ = Traffic management cost of a particular traffic management arrangement apportioned at element level

TMC = Final cost of the traffic management arrangement for the scheme, calculated using Section 2.11.6 and Equation 5

$WD_{element\_i}$ = Works duration for element i, calculated using Equation 6

SWD = Sum of all works durations for elements on which maintenance is to be carried out under the same traffic management arrangement in the same location, calculated using 16

Preliminaries Cost and Other Costs

2.16.5 8 and 9 are used to apportion a scheme's preliminaries cost and other costs, respectively, to individual elements.

$$PC_{element\_i} = WC_{element\_i} \times f_P$$

Equation 18

Where:

$PC_{element\_i}$ = Preliminaries cost apportioned at element level

$WC_{element\_i}$ = Works cost at element level calculated using Equation 1 to Equation 3, as appropriate

f_p = Uplift factor for preliminaries cost at scheme level (Section 2.11)

$$OC_{element\_i} = WC_{element\_i} \times f_O$$

Equation 19

Where:

$OC_{element\_i}$ = Other costs apportioned at element level

$WC_{element\_i}$ = Works cost at element level calculated using Equation 1 to Equation 3, as appropriate

f_o = Uplift factor for other costs at scheme level (Section 2.11)

Design Cost

2.16.6 20 is used for apportioning the scheme's design cost to individual elements.

$$DC_{element\_i} = (WC_{element\_i} + TMC_{element\_i} + PC_{element\_i} + OC_{element\_i}) \times f_D$$

Equation 20

Where:

$DC_{element\_i}$ = Design cost apportioned at element level

$WC_{element\_i}$ = Works cost at element level calculated using Equation 1 to Equation 3, as appropriate

$TMC_{element\_i}$ = Traffic management cost apportioned at element level, calculated using

$PC_{element\_i}$ = Preliminaries cost apportioned at element level, calculated using

$OC_{element\_i}$ = Other costs apportioned at element level, calculated using 9

f_D = Uplift factor for design cost at scheme level (Section 2.11)

Maintenance Cost

2.16.7 1 is used for apportioning scheme cost at element level.

$$SC_{element\_i} = WC_{element\_i} + TMC_{element\_i} + PC_{element\_i} + OC_{element\_i} + DC_{element\_i}$$

Equation 21

Where:

$SC_{element\_i}$ = Scheme cost apportioned at element level

$TMC_{element\_i}$ = Traffic management cost apportioned at element level, calculated using 7

$PC_{element\_i}$ = Preliminaries cost apportioned at element level, calculated using 18

$OC_{element\_i}$ = Other costs apportioned at element level, calculated using 9

$DC_{element\_i}$ = Design cost apportioned at element level, calculated using

2.16.8 This is best illustrated in Example 13 below:

Example 13: Consider the bridge presented in Example 6 (Section 2.11.7).

Works Cost at element level ($WC_{element\_i}$)

The works cost for each element identified as needing maintenance has been calculated as follows:

Replacement of bearings: $WC_{Bearings}$ **= £21,456**

Replacement of expansion joints: $WC_{Expansion\ Joints}$ **= £15,792**

Concrete repairs on abutments: $WC_{Abutments}$ **= £ 9,524**

Works Duration at element level ($WD_{element\_i}$)

The works duration for each element has been calculated as follows:

Works duration of replacement of bearings: $WD_{Bearings}$ **= 68.6 hours**

Works duration of replacement of expansion joints: $WD_{Expansion\ Joints}$ **= 24.0 hours**

Works duration of concrete repairs on abutments: $WD_{Abutments}$ **= 21.5 hours**

Traffic Management Arrangements

The traffic management arrangements required to carry out works have been identified as follows:

Lane closure: Applicable to the replacement of expansion joints

Waterway Possession: Applicable to the replacement of bearings and concrete repairs on abutments

Traffic Management Cost (TMC)

The traffic management cost for individual arrangements has been calculated as follows:

Cost of lane closure: $TMC_{Lane\ Closure}$ **= £ 5,352**

Cost of waterway possession: $TMC_{Waterway\ Possession}$ **= £18,042**

Uplift Factors at Scheme Level

Uplift factor for preliminaries cost: $f_P = 0.2$

Uplift factor for other costs: $f_O = 0.2$

Uplift factor for design cost: $f_D = 0.2$

Preliminaries Cost at element level
The scheme's preliminaries cost is apportioned to individual elements using 8:
Preliminaries cost for bearings: **$PC_{Bearings}$ = £21,456 x 0.2 = £4,291**
Preliminaries cost for expansion joints: **$PC_{Expansion\ Joints}$ = £15,792 x 0.2 = £3,158**
Preliminaries cost for abutments: **$PC_{Abutments}$ = £ 9,524 x 0.2 = £1,905**

Other Costs at element level
The scheme's other costs are apportioned to individual elements using 9:
Other costs for bearings: **$OC_{Bearings}$ = £21,456 x 0.2 = £4,291**
Other costs for expansion joints: **$OC_{Expansion\ Joints}$ = £15,792 x 0.2 = £3,158**
Other costs for abutments: **$OC_{Abutments}$ = £ 9,524 x 0.2 = £1,905**

Traffic Management Cost at element level
The final durations for individual traffic management arrangements have been calculated as:
Final duration of lane closure: **$TMD_{Lane\ Closure}$ = 24.0 hours**
Final duration of waterway possession: **$TMD_{Waterway\ Possession}$ = 68.6 hours**

The sum of works durations for all maintenance activities using the same traffic management arrangement is calculated using 6.
Sum of works durations for lane closure: **$SWD_{Lane\ Closure}$ = 24.0 hours**
Sum of works durations for waterway possession: **$SWD_{Waterway\ Possession}$ = 68.6 hours + 21.5 hours = 90.1 hours**

Traffic management cost can be apportioned to individual elements using 7:
$TMC_{element\_i} = TMC \times WD_{element\_i} / SWD$

Traffic management cost for bearings: **$TMC_{Bearings}$ = £18,042 x 68.6 / 90.1 = £13,712**
Traffic management cost for expansion joints: **$TMC_{Expansion\ Joints}$ = £ 5,352 x 24.0 / 24.0 = £5,352**
Traffic management cost for abutments: **$TMC_{Abutments}$ = £18,042 x 21.5 / 90.1 = £4,330**

Design Cost at element level
Design cost can be apportioned to individual elements using 20:
$DC_{element\_i} = (WC_{element\_i} + TMC_{element\_i} + PC_{element\_i} + OC_{element\_i}) \times f_D$

Design cost for bearings: **$DC_{Bearings}$ = (£21,456 + £13,712 + £4,291 + £4,291) x 0.2 = £8,750**
Design cost for expansion joints: **$DC_{Expansion\ Joints}$ = (£15,792 + £5,352 + £3,158 + £3,158) x 0.2 = £5,492**
Design cost for abutments: **$DC_{Abutments}$ = (£9,524 + £4,330 + £1,905 + £1,905) x 0.2 = £3,533**

Total Maintenance Cost at element level
Scheme cost can be apportioned to individual elements using 1:
$SC_{element\_i} = WC_{element\_i} + TMC_{element\_i} + PC_{element\_i} + OC_{element\_i} + DC_{element\_i}$

Maintenance cost for bearings: **$SC_{Bearings}$ = £21,456 + £13,712 + £4,291 + £4,291 + £8,750 = £52,500**
Maintenance cost for expansion joints: **$SC_{Expansion\ Joints}$ = £15,792 + £5,352 + £3,158 + £3,158 + £5,492 = £32,952**

Maintenance cost for abutments:	$SC_{Abutment}$	**= £9,524 + £4,330 + £1,905 + £1,905 + £3,533** **= £21,197**

3. Calculating Gross Replacement Cost

3.1.1 The gross replacement cost (GRC) is calculated as shown in Equation 12. This is replicated here from *CIPFA's Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting*[1]*:*

GRC = Dimensions x Unit rate x Adjustment factor(s)

Equation 12

Where:

Dimensions – those relevant to the structure type, e.g. number, m, and m^2 (Table 2)

Unit rate – the cost per dimension relevant to the structure type, e.g. £/m^2

Adjustment factor(s) – these reflect criteria that have a significant impact on GRC

3.1.2 The structure types and associated sub-divisions listed in Table 2 are used for calculating GRC. Unit rates were derived using the concept of modern equivalent asset (MEA) as described in CIPFA's *Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting*[1]. Default unit rates are listed in Section 12 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]. **NOTE:** For the purposes of WGA returns for 2014/2015, the default unit rates should be used to determine Gross Replacement Cost.

3.1.3 Heritage and special structures may require an alternative approach for deriving appropriate unit rates for GRC evaluation as described in CIPFA's *Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting*[1].

3.1.4 Unit rates are adjusted, where appropriate, to take account of criteria that have a significant impact on replacement costs. Factors that may have a significant impact and their associated values are listed in Section 12 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]. **NOTE:** For the purposes of WGA returns for 2014/2015, the default adjustment factors should be used to determine Gross Replacement Cost.

4. Calculating Depreciation

4.1.1 Depreciation for structures is calculated as follows:

- ***finite life structures/components*** – depreciation is based on the cost of replacing the component plus any interim capital expenditure needed to allow it to achieve its life.
- ***indefinite life structures/components*** – depreciation is based on the cost of any capital treatments needed to maintain the component to the required standard over the life of the treatment. If a component does not normally require treatment to maintain its life indefinitely, no depreciation applies. However, should it begin to show signs of measurable deterioration that will require capital treatment to restore service potential then it needs to be treated from that point as a finite life asset.

4.1.2 Annual depreciation between treatments is calculated for each component as:

$$\textbf{Annual Depreciation} = \frac{\textbf{cost of capital treatment or replacement}}{\textbf{number of years in the intervention cycle} - \mathbf{1}}$$

Equation 13

See worked examples for more information.

4.1.3 Depreciated replacement cost (DRC) for a structure is calculated as:

$$\textbf{DRC}_{\textbf{for the structure}} = \textbf{GRC}_{\textbf{for the structure}} - \sum_{i=1}^{i=n} (\textbf{accumulated depreciation of component i})$$

Equation 14

Where:

n = the number of components on the structure

Accumulated depreciation = annual depreciation of component i multiplied by a number of years component i's intervention cycle consumed so far. Please refer to section 4.2 for more details.

Note that the cost of the treatment is always the cost of an intervention at the condition of element failure for the purposes of calculating DRC.

4.1.4 However, if the accumulated depreciation of component i is greater than the GRC for a structure, the Total Element Replacement Costs (TERC) should be used to normalise the DRC, which in this case is calculated as:

$$\textbf{DRC}_{\textbf{for the structure}} = \textbf{GRC}_{\textbf{for the structure}} - \frac{\textbf{GRC}}{\textbf{TERC}} \times \sum_{i=1}^{i=n} (\textbf{accumulated depreciation of component i})$$

$$\frac{\textbf{GRC}}{\textbf{TERC}} \times \sum_{i=1}^{i=n} (\textbf{accumulated depreciation of component i})$$

Equation 15

Where:

TERC = is a total cost of replacing each element individually.

The application of total element replacement cost ensures the value of assets is retained whilst in service.

4.1.5 Figure 4 illustrates how annual and accumulated depreciation are calculated for a component.

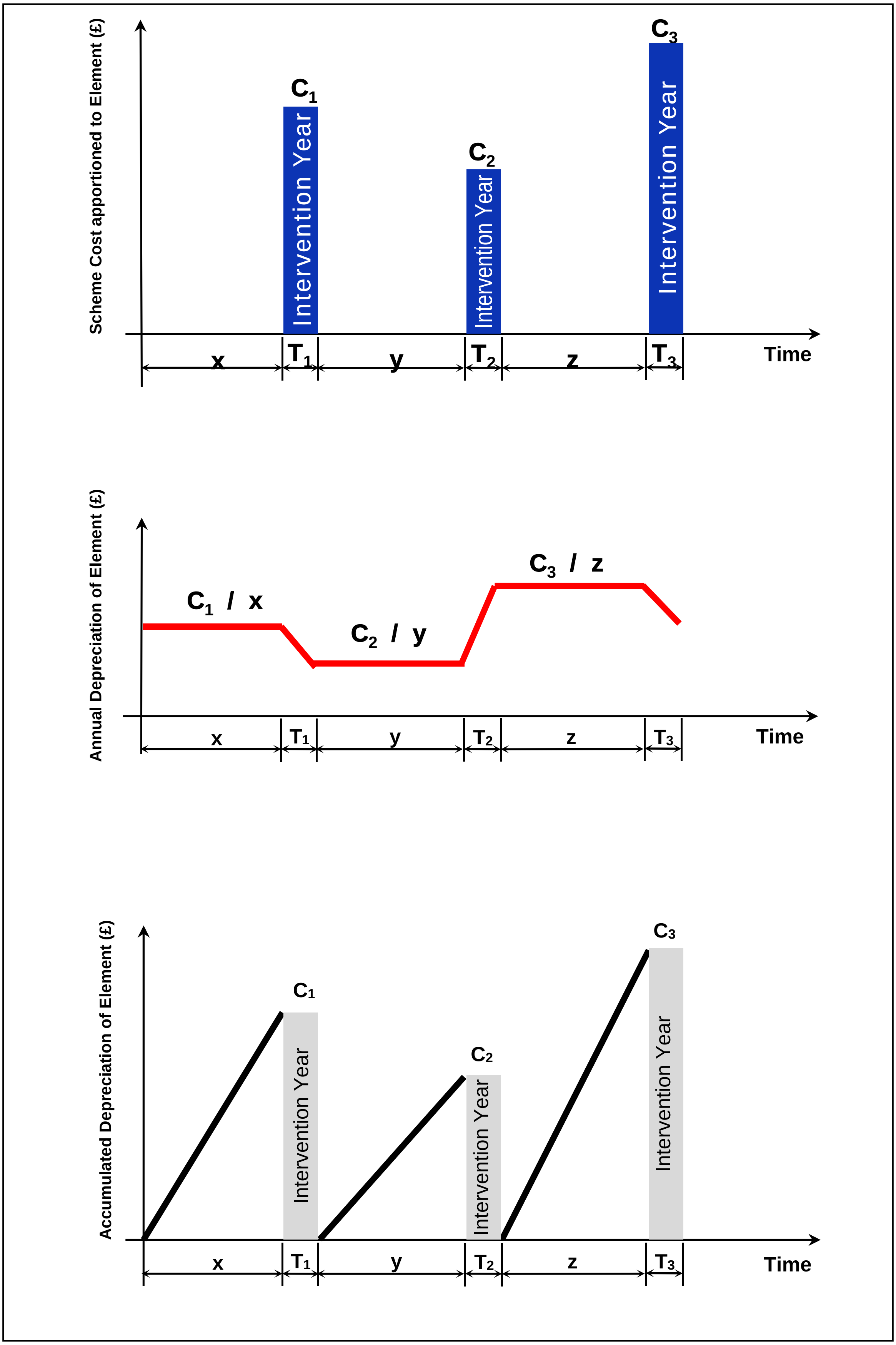
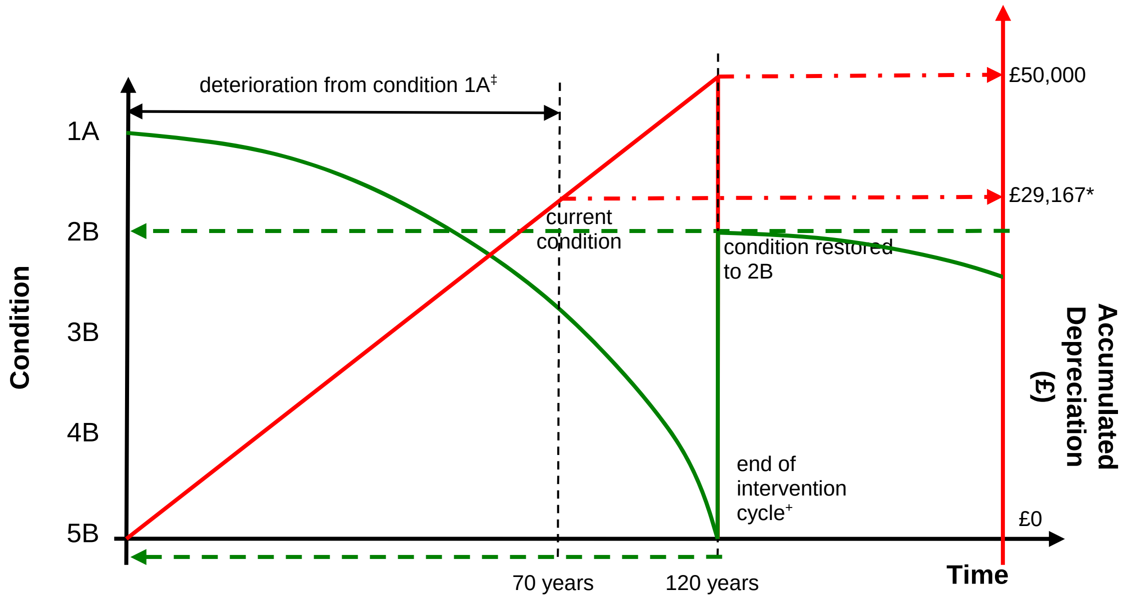


Figure 4: Annual and Accumulated Depreciation of a Component

4.2 Calculating Accumulated Depreciation at element level

4.2.1 In the majority of cases, the current condition and performance of a structure or component is somewhere between 'as new' (i.e. construct or install) and 'end of intervention cycle' (i.e. replace or maintain), with limited, if any, information on the timing and cost of past activities. The calculation of initial accumulated depreciation is based on predictions of future treatment needs, their timing and cost, and the current condition of the component. This is illustrated in the following element level example.

Example 8: Consider a single bridge element with the following details:
(i) element type = primary deck element (precast reinforced concrete);
(ii) predicted time from construction to first maintenance activity = 120 years;
(iii) current condition = 2B; and
(iv) predicted cost of concrete repairs at first intervention = £50,000 (including traffic management, access, etc.).,,,
The current condition information is used to identify an assumed age for the element, as shown below. The assumed age is then used as the basis for the accumulated depreciation calculation, i.e. 70 years of an expected 120 years' intervention cycle have been used and therefore the accumulated depreciation is £29,167.



* where £50,000 x 70 years / 120 years = £29,167

+ accumulated depreciation at end of intervention cycle (condition 5B) = cost of repairs = £50,000

‡ It is assumed that there have been no previous treatments or that the last treatment was component replacement. That is, the current condition has been reached following deterioration from condition 1A and in the same exposure environment that the component is currently experiencing.

4.2.2 A component's annual depreciation between treatments is computed by dividing capital intervention cost over the number of years between treatments as shown in Equation 13. The years of intervention are governed by the element's deterioration profile, the adopted maintenance strategy and budgetary constraints. Depending on the length of the analysis period, which is normally limited to 30 years, and the element's starting condition, the time of the next intervention could fall either within or beyond the analysis period.

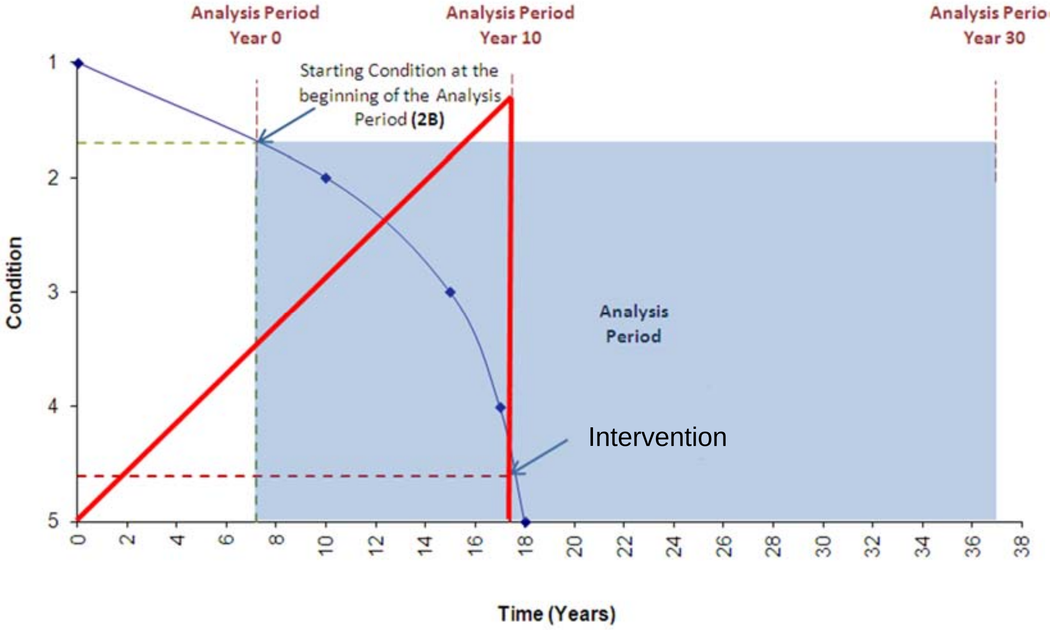
Intervention within the Analysis Period

4.2.3 Example 9 illustrates how accumulated depreciation can be calculated for a component when its next maintenance intervention falls within the analysis period.

Example 9: Consider a single bridge element with the following details:
(i) element type = expansion joint (buried joint);
(ii) exposure environment = moderate;
(iii) analysis period = 30 years;
(iv) starting condition = 2B; and
(v) replacement cost = £30,000 (including traffic management, access, etc).
For the purposes of this example, the buried joint would be treated once it reaches condition 4D, i.e. this is the pre-defined condition trigger. Sufficient funds are available and the predicted time of intervention corresponds to Year 17 in the intervention cycle as shown below. The annual depreciation for the buried joint between Year 0 and Year 10 of the analysis period is calculated as:

$$\text{Annual Depreciation} = \frac{\text{Cost of Next Intervention}}{\text{Time Between Interventions}} = \frac{£30{,}000}{17} = £1{,}765 \text{ per year}$$

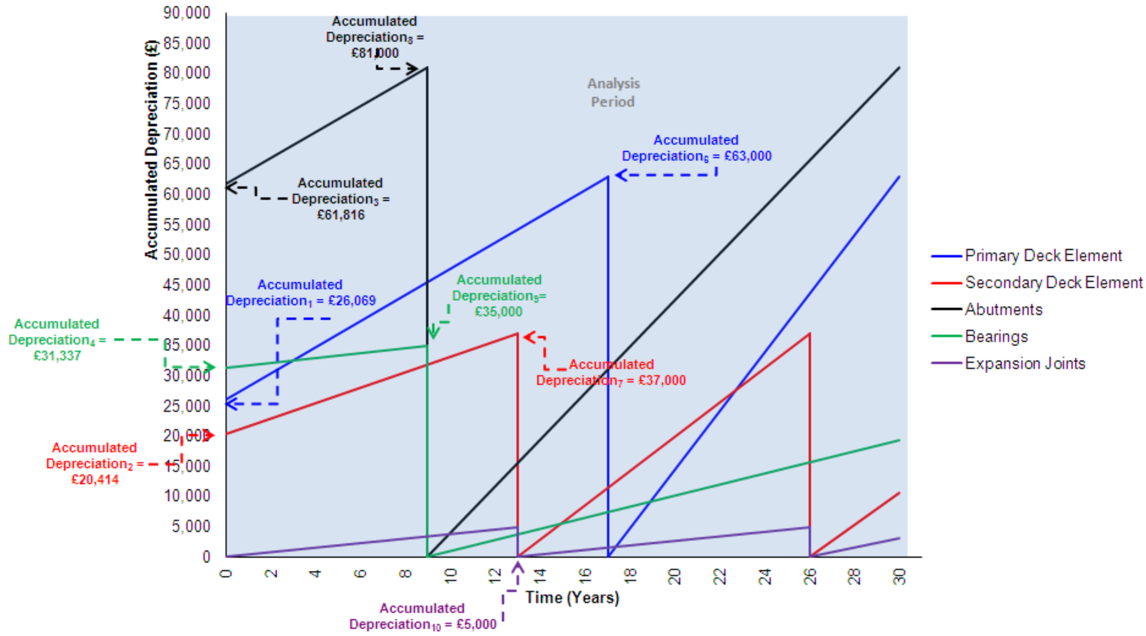
Therefore, accumulated depreciation in Year 0 of the analysis period (i.e. year 7 in the intervention cycle) is calculated as:
Accumulated Depreciation_0 = annual depreciation x years of the intervention cycle consumed
Accumulated Depreciation_0 = £1,765 x 7
Accumulated Depreciation_0 = £12,355



4.3 Calculating Depreciated Replacement Cost at Structure Level

4.3.1 A structure comprises several elements. It is anticipated that each of those elements would have different accumulated depreciation profiles depending on material type, exposure environment and applied maintenance strategies.

Example 12: Consider five elements on a bridge, e.g. primary deck element, secondary deck element, abutments, bearings and expansion joints. The diagram below illustrates accumulated depreciation profile for each of those components.



<u>Structure DRC – Year 0</u>:
The structure DRC at Year 0 is equal to the structure's GRC of £1,000,000 minus the sum of the accumulated depreciation for the primary deck element, secondary deck element, abutments, bearings and expansion joints at Year 0. The accumulated depreciation for each component is derived from the capital value of the first projected intervention in the analysis period (Section 4.2.1). This takes place in:
- year 9 for the abutments and bearings
- year 13 for the secondary deck element and expansion joints
- year 17 for the primary deck element

Structure $DRC_{(Year\ 0)}$ = £1,000,000 – £26,069 – £20,414 – £61,816 – £31,337 – £0
Structure $DRC_{(Year\ 0)}$ = £860,364

<u>Structure DRC – Year 17</u>:
The structure DRC at Year 17 is based on GRC minus the sum of the accumulated depreciation for the primary deck element, secondary deck element, abutments, bearings and expansion joints at Year 17.

<u>Primary Deck Element at Year 17</u>:
Accumulated depreciation = £63,000

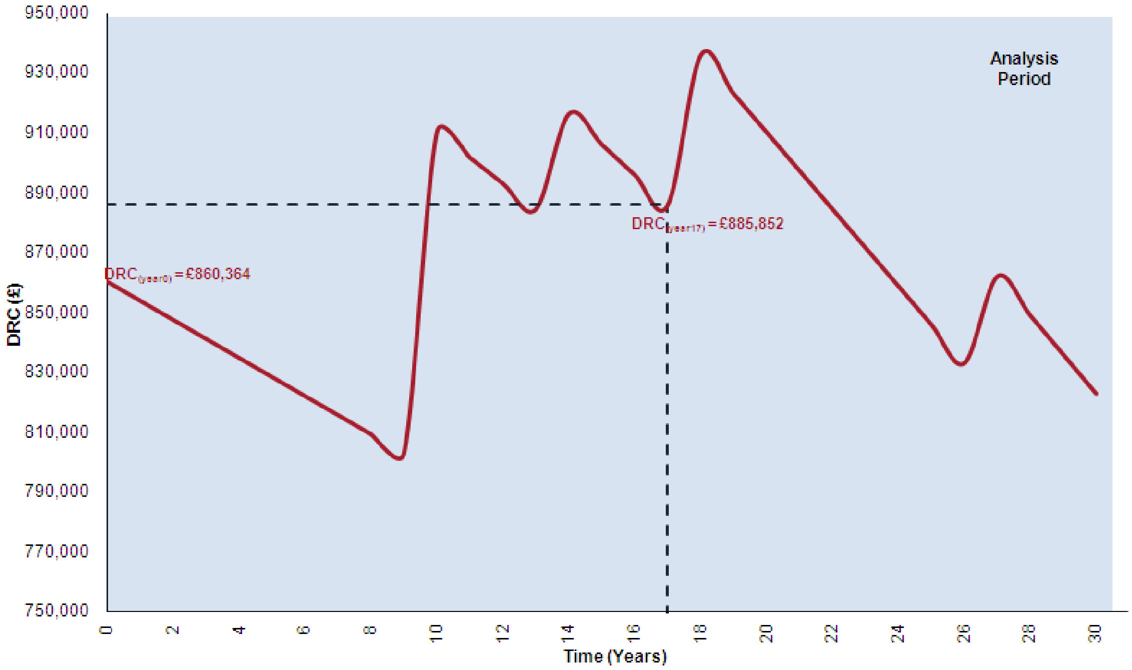
<u>Secondary Deck Element at Year 17</u>:
Maintenance cost = £37,000 (work to take place in year 26)
Accumulated depreciation = £37,000 x (17 – 13) / (26 – 13) = £11,385

Abutments at Year 17:
Maintenance cost = £81,000 (work to take place in year 30)
Accumulated depreciation = £81,000 x (17 – 9) / (30 – 9) = £30,857

Bearings at Year 17:
Maintenance cost = £35,000 (work to take place in year 47 – for simplicity the diagram above has been truncated at Year 30)
Accumulated depreciation = £35,000 x (17 – 9) / (47 – 9) = £7,368

Expansion Joints at Year 17:
Maintenance cost = £5,000 (work to take place in year 26)
Accumulated depreciation = £5,000 x (17 – 13) / (26 – 13) = £1,538

Structure DRC$_{(Year\ 17)}$ = £1,000,000 – £63,000 – £11,385 – £30,857 – £7,368 – £1,538
Structure DRC$_{(Year\ 17)}$ = £885,852



5. References

1. Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting, CIPFA, 2013.
2. Code of Practice on Transport Infrastructure Assets: Guidance Notes, CIPFA, 2015.
3. HM Treasury (2003), The Green Book: Appraisal and Evaluation in Central Government, London: The Stationery Office. Also available at http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/green_book.htm (accessed on 5 April 2011).
4. Bourke, K., Ramdas, V, Singh, S., Green, A., Crudgington, A. and Mootanah, D. (2005), Achieving Whole Life Value in Infrastructure and Buildings, London: British Research Establishment.
5. Highway Infrastructure Asset Management Guidance, UKRLG & HMEP, 2013.
6. Management of Highway Structures: A Code of Practice, TSO, 2005.
7. Highways - Maintaining a Vital Asset, What Should Councillors Know About Asset Management?, UKRLG & HMEP, 2013.
8. International Infrastructure Management Manual (International Edition), National Asset Management Support Group (NAMS limited), 2011.
9. ISO 55001:2014 Asset Management, BSI, 2014.
10. Inspection Manual for Highway Structures, Volume 1: Reference Manual, TSO, 2007.
11. LoBEG Good Practice Guide – Creating Consistent Element Inventories for Highway Structures, Version 1, July 2010.
12. Structures Asset Management Planning Toolkit, Part C: Supporting Information, Version 2.01, 2015.
13. CIPFA's Practitioners' Guide to Capital Finance in Local Government, CIPFA, 2008.
14. Bridge Condition Indicators: Volume 3 – Guidance Note on Evaluation of Bridge Condition Indicators, County Surveyors' Society, 2002.
15. Addendum to Bridge Condition Indicators: Volume 3 – Guidance Note on Evaluation of Bridge Condition Indicators, County Surveyors' Society, 2004.
16. Guidance Document for Performance Measurement of Highway Structures, Part B1: Condition Performance Indicator, Highways Agency & CSS Bridges Group, 2007.
17. Trunk Road Maintenance Manual: Volume 1 – Highways Maintenance Code, Highways Agency, 2006.

Appendix A : Finite and Indefinite Life Components

Bridges

CSS Element Type	Types/Comments	Finite or Indefinite Life?
01 - Primary deck element	These elements come in a wide range of different material types (e.g. reinforced concrete, steel, cast iron, masonry (blockwork, brickwork, prestressed concrete, FRPs, stainless steel etc.)	**Indefinite Life** - all of these element types are treated as Indefinite Life because they are normally maintained in perpetuity, i.e. maintenance activities to fix defects and or restore functionality (although in some instances the most effective management strategy is full element replacement)
02 - Transverse Beams		
03 - Secondary deck element		
04 - Half joints/Hinge Joints		
05 - Tie beam/rod		
06 - Parapet beam or cantilever		
07 - Deck bracing		
08 - Foundations		
09 - Abutments (incl. arch springing)		
10 - Spandrel wall/head wall		
11 - Pier/column		
12 - Cross-head/capping beam		
13 - Bearings	Elastomeric/rubber	**Finite Life** – bearings are treated as fixed life elements as they normally have a short life (in comparison to the whole bridge) and are replaced in totality at the end of their service life.
	Plane Sliding	
	Pot	
	Rocker	
	Roller	
	Spherical	
	Steel plate	
14 - Bearing plinth/shelf	Plinth may be cast into the shelf (whereby they are the same material) or connected to the shelf (e.g. metal plate/pad bolted or fixed to shelf); see below this table).	**Finite or Indefinite Life** – suggest it is dealt with on a case by case basis and defined accordingly. The maintenance strategy will depend on the arrangement.
15 - Superstructure drainage	Cast into superstructure (deck)	**Indefinite Life** – linked to the life of the deck
	Not cast into superstructure (deck); may be attached externally or attached internally, e.g. inside box beam.	**Finite Life** – based on life of drainage elements
16 - Substructure drainage	Cast into substructure	**Indefinite Life** – linked to the life of the substructure, e.g. abutments
	Not cast into substructure, may be attached externally or attached internally, e.g. inside hollow pier.	**Finite Life** – based on life of drainage elements

CSS Element Type	Types/Comments	Finite or Indefinite Life?
17 - Waterproofing	Boarded Systems	**Finite Life** – life may be determined by carriageway life, poor laying, expected service life, deck repairs, traffic volume, deck liveliness etc.
	Mastic Asphalt	
	Sheet Systems	
	Spray Systems	
18 – Movement/Expansion joints	Buried Joint	**Finite Life** –expansion joints are treated as fixed life elements as they normally have a short life (in comparison to the whole bridge) and are replaced in totality at the end of their service life. However, there are a number of instances (e.g. Elastomeric in Metal Runners) where component parts are replaced at regular intervals to extend/achieve the expected service life.
	Asphaltic Plug Joint	
	Nosing Joint	
	Polysulphide seals	
	Elastomeric/Reinforced Elastomeric Joint	
	Single Element Elastomeric In Metal Runners	
	Multi Element Elastomeric In Metal Runners	
	Cantilever Comb And Tooth Joint	
	Roller Shutter	
	Sliding Plate	
19 - Finishes: deck elements	Corrosion (paint) protection system **Note**: Excludes CP and silane, these are a treatment to existing elements.	**Finite Life** - considered to be a separate element. The service life will differ depending on the maintenance regime applied and the aesthetics/ambience required.
	Cladding	**Finite or Indefinite Life** – will depend on circumstances and factors e.g. type of cladding, integrity of fixings, or condition or underlying element.
	Tiling	**Finite Life** – assumed that these would be renewed every 20 to 30 years.
20 - Finishes: substructure elements	Corrosion (paint) protection system	As per element 19
	Tiling	As per element 19
	Cladding	As per element 19
21 - Finishes: parapets/safety fences	Corrosion (paint) protection system	As per element 19
	Tiling	As per element 19
	Cladding	As per element 19.
22 - Access/walkways/gantries	-	**Indefinite Life** - normally specialist features on larger/special structure and should be maintained in perpetuity.

CSS Element Type	Types/Comments	Finite or Indefinite Life?
23 - Handrail/parapets/safety fences	Concrete	**Indefinite of Fixed Life** - depends on maintenance regime and defect types, may be appropriate to define steel, aluminium and timber as fixed life.
	Steel	
	Aluminium	
	Masonry	
	Timber	
24 - Carriageway surfacing	-	**EXCLUDED or Fixed Life** – if surfacing and waterproofing (element 17) are a combined, otherwise excluded as it is assumed to be covered by pavements.
25 - Footway/verge/footbridge surfacing	-	As per element 24
26 - Invert/river bed	May be natural material or man made	**Indefinite Life**
27 - Aprons	Man made, e.g. concrete	**Indefinite Life**
28 - Fenders /cutwaters /collision protection	Man made, e.g. reinforced concrete, metal, timber	**Indefinite Life**
29 - River training works	Man made, e.g. reinforced concrete, metal, timber	**Indefinite Life**
30 - Revetment/batter paving	Man made, e.g. concrete paving, rip-rap	**Indefinite Life**
31 - Wing walls	As per elements 1 to 12	**Indefinite Life**
32 - Retaining walls	As per elements 1 to 12	**Indefinite Life**
33 - Embankments	Natural or man made	**Indefinite Life**
34 - Machinery	Will be structure specific	**EXCLUDED –** assumed to be outside the scope of the structures financial planning
35 - Approach rails/barriers/walls	-	As per element 23
36 - Signs	-	**Finite life**
37 - Lighting	-	**EXCLUDED –** assumed to be outside the scope of the structures financial planning
38 - Services	-	**EXCLUDED –** assumed to be outside the scope of the structures financial planning

Retaining Walls

CSS Element Type	Types/Comments	Finite or Indefinite Life?
1. Foundations	These elements come in a wide range of different material types (e.g. reinforced concrete, steel, cast iron, masonry (blockwork, brickwork, prestressed concrete, FRPs, stainless steel etc.)	**Indefinite Life** – as per element 1 to 12 for bridges.
2. Primary Element		
3. Secondary Element		
4. Parapet beam/plinth		
5. Drainage	Integral with structure	**Indefinite Life**
6. Movement/Expansion Joints	-	**Finite Life**
7. Finishes: Wall	Corrosion (paint) protection system	As per element 19 for bridges
	Tiling	As per element 19 for bridges
	Cladding	As per element 19 for bridges
8. Finishes: Handrail/Parapet	Corrosion (paint) protection system	As per element 19 for bridges
	Tiling	As per element 19 for bridges
	Cladding	As per element 19 for bridges
9. Handrail/Parapets/Safety Fences		As per element 23 for bridges
10. Carriageway: Top of Wall	-	**EXCLUDE** as it is assumed to be covered by pavements
11. Carriageway: Foot of Wall	-	
12. Footway/verge: Top of Wall	-	
13. Footway/verge: Foot of Wall	-	
14. Embankment: Top of Wall	-	**Indefinite Life**
15. Embankment: Foot of Wall	-	
16. Invert/river bed	May be natural material or man made	**Indefinite Life**
17. Aprons	Man mage, e.g. concrete	**Indefinite Life**

Sign/Signal Gantries

<table>
<tr><th>CSS Element Type</th><th>element/Element Level Analysis</th><th>Structure Level Analysis</th></tr>
<tr><td>1. Foundations</td><td>Indefinite Life</td><td rowspan="13">Finite Life – the whole sign/signal gantry is assumed to have a fixed life (regardless if it is a concrete, steel, aluminium, etc.) driven by deterioration and technological advances. The service life is assumed to be:

• Mild Environment – 40yrs
• Moderate Environment – 30yrs
• Severe Environment – 20yrs

It is assumed to be more efficient and economic to replace metal gantries that to repaint them in-situ. Minor cyclic and repair works (e.g. replacing bolts, cleaning, replacing fixings, etc.) would be undertaken during the life of the gantry, but their cost would be low in relation to the overall replacement cost of the gantry, i.e. several hundred pounds compared to £20,000 plus for a replacement.</td></tr>
<tr><td>2. Truss/Beams/Cantilevers</td><td>Indefinite Life</td></tr>
<tr><td>3. Transverse Members</td><td>Indefinite Life</td></tr>
<tr><td>4. Columns/Supports/Legs</td><td>Indefinite Life</td></tr>
<tr><td>5. Finishes: truss/beam/cant.</td><td>Finite Life</td></tr>
<tr><td>6. Finishes: columns/supports</td><td>Finite Life</td></tr>
<tr><td>7. Finishes: other elements</td><td>Finite Life</td></tr>
<tr><td>8. Access walkway/deck</td><td>Indefinite Life</td></tr>
<tr><td>9. Access Ladder</td><td>Indefinite Life</td></tr>
<tr><td>10. Handrail</td><td>Indefinite Life</td></tr>
<tr><td>11. Base Connections</td><td>Indefinite Life</td></tr>
<tr><td>12. Support to longitudinal connection</td><td>Indefinite Life</td></tr>
<tr><td>13. Sign and signal supports</td><td>Finite Life</td></tr>
<tr><td>14. Signs/Signals</td><td>Finite Life</td><td>Finite Life</td></tr>
<tr><td>15. Lighting</td><td colspan="2">EXCLUDED – assumed to be outside the scope of the structures financial planning</td></tr>
<tr><td>16. Services</td><td colspan="2">EXCLUDED – assumed to be outside the scope of the structures financial planning</td></tr>
</table>

Appendix B : Condition Performance Indicator Guidance Document

Note:
The following change has been made to Table 15 of the guidance document for use in the Structures Asset Management Planning Toolkit:

Structure Type	*Acronym*	*AVF*		*Units*
		Overseeing Authority	*Local Authority*	
High Mast	AVF_{HM}	0.60	0.60	number

This change recognises that the unit for a high mast in the Structures Asset Management Planning Toolkit is the number of items rather than the height in metres as in the guidance document. It is assumed that the average height of a high mast is 20 metres.