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Practical guidance on determining asset deterioration and the use of condition grade deterioration curves: Revision 1

Report – SC060078/R1

Flood and Coastal Erosion Risk Management Research and Development Programme

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Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters and contaminated land, and improving wildlife habitats.

This report is the result of research commissioned by the Environment Agency's Evidence Directorate and funded by the joint Environment Agency/Defra Flood and Coastal Erosion Risk Management Research and Development Programme.

Published by:
Environment Agency, Horizon House, Deanery Road, Bristol, BS1 5AH
www.environment-agency.gov.uk

ISBN: 978-1-84911-304-5

Email: fcerm.evidence@environment-agency.gov.uk.

Further copies of this report are available from our publications catalogue: http://publications.environment-agency.gov.uk or our National Customer Contact Centre: T: 08708 506506
E: enquiries@environment-agency.gov.uk.

Author(s):
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Dissemination Status:
Publicly available

Keywords:
Asset, deterioration, flooding, monitoring, protocol

Research Contractor:
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Miranda Kavanagh

Director of Evidence

Executive summary

To achieve effective and optimum management of their asset stock, asset management practitioners in Flood and Coastal Risk Management (FCRM) require reliable predictive tools and methodologies to use as aids in the estimation of residual asset life under different conditions of environmental exposure and maintenance schedules.

To support this need, this practical guide presents a series of asset deterioration curves (models) applicable to different types of flood and coastal defence assets. The curves are suitable for estimation of future asset condition and expected residual asset life, taking into account characteristics related to environment, asset age, material type and construction, and past and intended (future) maintenance practices.

They are based on the condition grades defined in the *Condition Assessment Manual* (Environment Agency 2006). These deterioration curves complement other Environment Agency tools and methodologies such as assessments and assessments of current and future flood risk and benefits of interventions for appraisal and investment planning. They can also facilitate the tracking of risk over the lifetime of the asset, provided the relationship between asset condition and failure probability is understood.

The following FCRM asset types are covered: vertical walls, sheet piled structures, demountable defences, earth dykes or embankments, sloping walls with slope protection/revetment, culverts, beaches, control structures, dunes and saltmarshes, maintained channels, weirs, outfalls, flap valves, moveable gates (manual and electrical), debris screens, and flood gates and barriers.

Asset deterioration rates are captured in tabular and graphical format. A step-by-step guide on the use of the curves is provided.

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Tables and figures

1 Introduction

The Environment Agency has adopted a standardised approach to assessing and quantifying the deterioration of flood and coastal defence assets based upon the progression of assets through a number of condition grade states. Condition grades are based on definitions given in the *Condition Assessment Manual*, CAM (Environment Agency 2006). Five condition grades are used, and their general descriptions are given in Table 1.1.

Table 1.1 Condition grades

Grade	Description of grade	Extent of defects
1	Very good	Cosmetic defects that will have no effect on performance
2	Good	Minor defects that will not reduce overall performance of asset
3	Fair	Defects that could reduce performance of asset
4	Poor	Defects that would significantly reduce performance of asset
5	Very poor	Severe defects resulting in complete performance failure

Source: *Condition Assessment Manual* (Environment Agency 2006)

Deterioration rates for a broad range of flood and coastal protection assets have been formulated and developed into a series of condition grade based deterioration curves, using as a basis the experiences of a range of practitioners, asset managers and consulting engineers.

Deterioration curves allow the user to evaluate the future condition of an asset and the expected residual life depending upon environmental exposure, taking into account characteristics relating to asset age, material and construction type, and past and future maintenance practices. These deterioration curves complement other Environment Agency tools and methodologies such as whole life cost assessments and assessments of current and future flood risk and benefits of interventions for appraisal and investment planning. They can also facilitate the tracking of risk over the lifetime of the asset, provided the relationship between asset condition and failure probability is understood.

Deterioration curves presented in this guidance are based and follow on from work developed in Phase 1 of R&D Project SC060078 which produced interim guidance on determining asset deterioration and the use of condition grade deterioration.

In this updated guidance, the suite of asset types has been extended to cover significantly more assets. For the first time, it considers the effects of different maintenance activities/regimes on deterioration.

A wider range of information was also used to inform this guidance. Additional information sources included: Literature in the public domain, data from the national

FCRM asset management depository NFCDD data, extended practitioner input through workshop activities and site survey findings.

The Deterioration models and guidance produced as part of this work present the most up-to-date understanding on asset deterioration and should therefore be seen as ***replacements of the Phase 1 deterioration models and guidance***.

In general, where changes between Phase 1 and Phase 2 curves are evident, these arise from the increased scope of data available for review and validation. This has led to adjustments in the positions of some condition grade transitions. In no cases were changes associated with any change in understanding of deterioration processes and failure mechanisms, which would have required more fundamental reconstruction of the curves.

This report presents these deterioration curves and explains how to use them with an accompanying table to determine the residual life of a flood defence asset. ***It is essential to use engineering judgement and practical experience alongside this guidance to apply and adapt the deterioration curves appropriately.***

Envisaged users are asset managers from the Environment Agency or any other asset management organisation such as local authorities and, in particular, staff making decisions about long-term asset management such as part of SAMPs (System Asset Management Plans) or similar activities.

The deterioration table is presented in Section 2, and Section 3 provides a step-by-step guide to forecasting the expected deterioration time to another condition grade. Differences between Phase 1 and Phase 2 curves are described in Appendix A, and Appendix B presents notes on model construction highlighting the assumptions made in developing the deterioration curves. Conclusions, references and a glossary are also provided. Appendix C presents detailed notes and data relating to each of the specific assets in turn.

2 Introducing the deterioration models

2.1 Asset classes included in the guide

The guide covers a number of key asset classes, as listed in the following two tables, which contain equivalent information. Table 2.1 lists assets by asset class and Table 2.2 lists assets by AIMS asset classification.

Table 2.1 Asset classes covered by the guide

Asset class	Material	AIMS asset classification (asset type, sub-type element)	Environment
Vertical walls (inc. with scour protection)	Concrete	Defence/wall	Fluvial
			Coastal/estuarine
	Brick and masonry		Fluvial
			Coastal/estuarine
	Timber		Fluvial
			Coastal/estuarine
	Gabion	Defence/wall/gabions	Fluvial
			Coastal/estuarine
Sheet piled structures	Anchored steel	Defence/wall/piling	Fluvial
			Coastal/estuarine
	Cantilever steel		Fluvial
			Coastal/estuarine
Demountable defences	Metal	Defence/demountable	Fluvial
	Wood		Fluvial
Earth dykes or embankments	Varying core material, e.g. clay, shale	Defence/embankment	Fluvial
			Coastal/estuarine
	With slope/toe protection or revetment		Fluvial
			Coastal/estuarine
Sloping walls with slope protection or revetment	Turf	Defence/embankment	Fluvial
			Coastal/estuarine
	Permeable revetments[1]		Fluvial
			Coastal/estuarine
	Impermeable revetments[2]		Fluvial
			Coastal/estuarine
Culverts – pipe, box, arch	Concrete/masonry/brick	Channel/simple OR complex culvert	Fluvial
	Steel		Fluvial
	Plastic		Fluvial
	Clay		Fluvial

[1] Permeable revetments: These are flexible revetments including rip-rap, turf, natural stone and concrete blocks.
[2] Impermeable revetments: These are continuous sloping structures of concrete or stone blockwork, asphalt or mass concrete. They tend to be grouted in bitumen or concrete, making them inflexible.

Asset class	Material	AIMS asset classification (asset type, sub-type element)	Environment
Beaches with and without beach control structures (rock/timber groynes, offshore breakwaters (rock), breastwork (timber) and crib walls (timber)	Shingle/sand	Defence/beach	Coastal/estuarine
Control structures	Rock groynes	Beach structure/ groyne	Coastal
	Timber groynes		Coastal
	Offshore breakwaters (rock)	Beach structure/ breakwaters	Coastal
	Crib walls and breastwork	Not classified	Coastal
Dunes with or without holding structures		Defence/dunes	Coastal
Saltmarshes, saltings and warths with or without holding structures		Land/saltmarsh	Coastal/estuarine
Maintained channel	Earth (e.g. regraded channel)	Channel/open channel	Fluvial
	Concrete		Fluvial
Weirs		Structure/weir	Fluvial
Outfalls		Structure/outfall	Fluvial
			Coastal
Flap valves, penstocks and sluice gates (manually and electrically operated moveable gates)		Structure/control gate	Coastal/fluvial
Debris screens		Structure/screen	Fluvial
Flood gates and barriers	Metal	Structure/control gate	Coastal/fluvial
	Wood		Coastal/fluvial

Table 2.2 AIMS asset classifications covered by the guide

AIMS asset classification (asset type, sub-type element)	Asset class	Material	Environment
Defence/wall	Vertical walls (inc. with scour protection)	Concrete	Fluvial
			Coastal/estuarine
		Brick and masonry	Fluvial
			Coastal/estuarine
		Timber	Fluvial
			Coastal/estuarine
Defence/wall/gabions	Vertical walls (inc. with scour protection)	Gabion	Fluvial
			Coastal/estuarine
Defence/wall/piling	Sheet piled structures	Anchored steel	Fluvial
			Coastal/estuarine
		Cantilever steel	Fluvial
			Coastal/estuarine
Defence/demountable	Demountable defences	Metal	Fluvial
		Wood	Fluvial
Defence/embankment	Earth dykes or embankments	Varying core material, e.g. clay, shale	Fluvial
			Coastal/estuarine
		With slope/toe protection or revetment	Fluvial
			Coastal/estuarine
	Sloping walls with slope protection or revetment	Turf	Fluvial
			Coastal/estuarine
		Permeable revetments[3]	Fluvial
			Coastal/estuarine
		Impermeable revetments[4]	Fluvial
			Coastal/estuarine
Channel/simple OR complex culvert	Culverts – pipe, box, arch	Concrete/masonry/brick	Fluvial
		Steel	Fluvial
		Plastic	Fluvial
		Clay	Fluvial
Defence/beach	Beaches with and without beach control structures (rock/timber groynes), offshore breakwaters (rock), breastwork (timber) and crib walls (timber)	Shingle/sand	Coastal/estuarine
Beach structure/groyne	Control structures	Rock groynes	Coastal
		Timber groynes	Coastal
Beach structure/ breakwaters	Control structures	Offshore breakwaters (rock)	Coastal
Not classified	Control structures	Crib walls and breastwork	Coastal
Defence/dunes	Dunes with or without holding structures		Coastal

[3] Permeable revetments: These are flexible revetments including rip-rap, turf, natural stone and concrete blocks.

[4] Impermeable revetments: These are continuous sloping structures of concrete or stone blockwork, asphalt or mass concrete. They tend to be grouted in bitumen or concrete, making them inflexible.

AIMS asset classification (asset type, sub-type element)	Asset class	Material	Environment
Land/saltmarsh	Saltmarshes, saltings and warths with or without holding structures		Coastal/estuarine
Channel/open channel	Maintained channel	Earth (e.g. regraded channel)	Fluvial
		Concrete	Fluvial
Structure/weir	Weirs		Fluvial
Structure/outfall	Outfalls		Fluvial
			Coastal
Structure/control gate	Flap valves, penstocks and sluice gates (manually and electrically operated moveable gates)		Coastal/fluvial
Structure/screen	Debris screens		Fluvial
Structure/control gate	Flood gates and barriers	Metal	Coastal/fluvial
		Wood	Coastal/fluvial

These assets are further classified depending on the type of environment (fluvial or coastal/estuarine), type of material and width of the asset (narrow or wide[5]).

It is to be noted that the deterioration models in Section 4 are listed by reference to asset class/material type/environment. A cross-reference to the corresponding AIMS asset classification is provided in all cases.

2.2 Modelling of factors affecting deterioration

For each classification three categories of deterioration rate are provided. These reflect estimates of the most likely (medium estimate), fastest and slowest deterioration rates. In choosing the most appropriate rate category, account should be taken of:

- the loading and environmental conditions acting upon the asset;
- the degree of difference from the assumed ‘standard’ conditions (which the asset was designed for).

The ‘medium estimate’ in the table assumes ‘standard’ or ‘average’ conditions. If the loading on, or aggressiveness of environmental conditions around, an asset is likely to be higher or lower than typical design conditions, a faster or slower rate of deterioration should be chosen depending on the severity of this shift. Engineering knowledge and local experience should be used in making any shift from average conditions.

Foundation deterioration is not taken into account in these discussions unless mentioned explicitly.

Professional judgement is needed to classify flood defence assets as they are unique structures, often made up of more than one basic type. In such cases, to develop an overall deterioration curve, it may be necessary to consider the deterioration curves

[5] Narrow assets defined as <4 m crest width, wide assets defined as 4 m or greater crest width.

associated with these component asset types in parallel and to choose the points on the curves which provide the limiting values for the overall asset being considered.

Figures in the summary deterioration table (Table 2.3 below) indicate the years to move from new (condition grade 1 or CG 1) to the condition grade of interest. The time to move from any condition grade to a worse condition grade is the difference between the two figures.

Three maintenance regimes have been considered, namely:

Maintenance Regime 1: Low/basic – do minimum repair/maintenance

- Inspection + H&S repair (annually)

Maintenance Regime 2: Medium maintenance regime

- Inspection + H&S repair (annually)
- Maintenance activities as proposed in the Environment Agency Maintenance Standards (Environment Agency 2010 and Environment Agency 2012, Appendix B) for maintaining at target CG 3 (Note: The maintenance standards will also pick up minor reactive repairs)

Maintenance Regime 3: High maintenance regime

- Inspection + H&S repair (annually)
- Maintenance activities as proposed in the Environment Agency Maintenance Standards for maintaining at target CG 2 (Note: The maintenance standards will also pick up minor reactive repairs)

2.3 Intended use and limitations

The deterioration models are designed to be used to predict the progression of asset condition through the five condition grades for the asset class/material combinations listed above. The models account for environmental factors and for the degree of maintenance undertaken. It is to be noted that in models of this type these impact factors can only be broadly classified. Hence the model outputs are 'general' or middle-range' values for the combination of parameter values (e.g. fastest deterioration/ Maintenance Regime 2). Consequently, the models have most practical use in the following situations:

- Strategically, to estimate when an asset is likely to reach a specific condition grade such that high-level investment plans (for remedial or asset replacement work) can be prepared.
- For scheduling asset-specific inspection and monitoring. Predictions of condition grade transitions, for example, may prompt more frequent inspections to capture asset deterioration before it causes a significant impact on asset performance.

The models are not direct predictors of asset performance, although they can be used to inform understanding of how an ageing asset will perform through considering the impact of the loss in structural integrity (as measured by the change in condition grade) on how an asset responds to various loadings (whether continuous, frequent–intermittent or infrequent–extreme events).

It is important to understand that the model outputs are for guidance only. It is essential that engineering judgement and practical experience are used alongside to ensure robust decision making. The models do not make decisions but provide practitioners with the ability to assess different options.

Three general categories of practitioner will benefit from use of the models, namely:

1. Strategic planners: To undertake risk assessment for facilitation in the estimation of long-term strategic investment needs for the Environment Agency Flood and Coastal Risk Management (FCRM) assets based upon risk.
2. Regional asset managers: For tactical asset management on a regional basis for facilitation in the estimation of investment needs for asset systems and for budgeting maintenance activity within the regional budget constraints.
3. Asset owners: To undertake asset-specific assessment for predicting condition trends/profile for individual assets to assist in maintenance scheduling and capital investment planning for the asset.

These are considered individually below.

Strategic planners

The outcome from a strategic appraisal is a high-level analysis to facilitate estimation of the investment needs for the Environment Agency FCRM assets as a whole (i.e. strategic investment planning/budgeting). Application of the deterioration models to the asset stock will provide a prediction of the number/length of assets within each of the condition grades. This profile can be aligned to strategic asset management policies (e.g. target condition grades) and, thereby, investment needs to achieve the desired outcome (such as maintenance activity and asset replacement/refurbishment) can be costed.

Guidance for strategic planning use is presented in Section 3 below.

Regional asset managers

Regional asset managers can use the deterioration models for tactical asset management for facilitation in the estimation of investment needs for asset systems and for budgeting maintenance activity within the regional budget constraints.

Asset owners

The asset-specific assessment will predict condition trends/profile for an individual asset. Knowing when condition grade transitions are expected will enable the asset manager to plan maintenance and refurbishment activities and, possibly, asset replacement to maintain function.

Guidance for these various uses is presented in Section 3 below.

Table 2.3 Deterioration times (years) to specified condition grades from new for different asset types and exposures

Asset class	Environment	Material	AIMS asset classific-ation	Narrow/ wide*	Maintenance regime	Expected deterioration times (years) to specified CG from new																
						Medium deterioration						Fastest deterioration						Slowest deterioration				
						1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Vertical wall	Fluvial	Concrete	Defence/ wall	N/A	1	0	15	35	50	60		0	5	20	30	40		0	20	50	70	80
					2	0	20	45	70	90		0	10	30	50	60		0	25	60	100	120
					3	0	25	55	90	120		0	15	40	70	80		0	30	70	130	160
		Brick/ masonry		N/A	1	0	15	35	50	60		0	5	20	30	40		0	20	50	70	80
					2	0	20	45	70	90		0	10	30	50	60		0	25	60	100	120
					3	0	25	55	90	120		0	15	40	70	80		0	30	70	130	160
		Timber		N/A	1	0	5	10	12	15		0	3	5	7	10		0	7	15	18	21
					2	0	10	20	25	30		0	5	10	12	15		0	15	30	35	40
					3	0	15	30	35	42		0	7	15	17	20		0	23	45	52	60
		Gabion	Defence/ wall/ gabions	N/A	1	0	5	10	22	26		0	4	8	15	18		0	5	10	25	30
					N/A																	
					N/A																	
	Coastal/ estuarine	Concrete	Defence/ wall	N/A	1	0	10	30	40	50		0	5	15	25	30		0	15	45	60	80
					2	0	15	40	55	70		0	10	20	30	40		0	20	60	80	100
					3	0	20	50	70	90		0	15	25	35	50		0	25	75	100	120
		Brick/ masonry		N/A	1	0	10	30	40	50		0	5	15	25	30		0	15	45	60	80
					2	0	15	40	55	70		0	10	20	30	40		0	20	60	80	100
					3	0	20	50	70	90		0	15	25	35	50		0	25	75	100	120
		Timber		N/A	1	0	4	8	10	14		0	2	4	6	8		0	5	13	16	20
					2	0	8	18	23	28		0	4	8	10	13		0	14	28	33	38
					3	0	13	28	33	38		0	5	13	15	18		0	21	42	48	55
		Gabion	Defence/	N/A	1	0	3	8	15	20		0	1	5	10	13		0	3	8	20	25

Asset class	Environment	Material	AIMS asset classific-ation	Narrow/ wide*	Maintenance regime	Expected deterioration times (years) to specified CG from new																
						Medium deterioration						Fastest deterioration						Slowest deterioration				
						1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
			wall/ gabions		N/A																	
					N/A																	
Sheet piles	Fluvial	Cantilevered steel	Defence/ wall/piling	N/A	1	0	15	20	40	50		0	10	15	20	25		0	20	30	60	70
					2	0	20	30	50	60		0	15	20	30	35		0	25	40	70	80
					3	0	25	40	60	70		0	20	30	40	45		0	30	50	80	90
		Anchored steel		N/A	1	0	15	20	40	50		0	10	15	20	25		0	20	30	60	70
					2	0	20	30	50	60		0	15	20	30	35		0	25	40	70	80
					3	0	25	40	60	70		0	20	30	40	45		0	30	50	80	90
	Coastal/ estuarine	Cantilevered steel		N/A	1	0	10	15	30	40		0	5	10	15	20		0	15	30	50	60
					2	0	15	25	50	60		0	10	15	25	30		0	20	40	60	70
					3	0	20	35	60	70		0	15	20	35	40		0	25	50	70	80
		Anchored steel		N/A	1	0	10	15	30	40		0	5	10	15	20		0	15	30	50	60
					2	0	15	25	50	60		0	10	15	25	30		0	20	40	60	70
					3	0	20	35	60	70		0	15	20	35	40		0	25	50	70	80
Demount-able defences	Fluvial	Metal	Defence/ demount-able	N/A	1	0	1	3	4	5		0	1	2	3	4		0	2	4	5	7
					2	0	5	10	45	55		0	2	5	35	45		0	10	20	60	70
					3	0	8	15	55	65		0	5	10	45	55		0	15	25	70	80
		Wood		N/A	1	0	1	3	4	5		0	1	2	3	4		0	2	4	5	7
					2	0	3	5	23	28		0	1	3	18	23		0	5	10	30	35
					3	0	4	8	28	33		0	3	5	23	28		0	8	13	35	40
Earth dykes or embank-ments	Fluvial	Varying core material	Defence/ embank-ment	Narrow	1	0	3	6	25	40		0	1	3	5	7		0	5	10	40	60
					2	0	15	30	60	80		0	2	5	7	10		0	20	40	70	110
					3	0	16	33	70	90		0	3	6	8	11		0	22	44	90	130
				Wide	1	0	3	6	25	40		0	2	6	10	14		0	5	10	40	60
					2	0	15	30	60	80		0	4	10	14	20		0	20	40	70	110
					3	0	16	33	70	90		0	5	10	14	20		0	22	44	90	130

Asset class	Environment	Material	AIMS asset classific-ation	Narrow/ wide*	Maintenance regime	Expected deterioration times (years) to specified CG from new																	
						Medium deterioration						Fastest deterioration						Slowest deterioration					
						1	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**
	Coastal/ estuarine			Narrow	1	0	3	6	22	30		0	1	2	4	5		0	5	10	40	60
					2	0	14	28	40	50		0	2	4	6	8		0	20	40	60	80
					3	0	15	30	45	60		0	3	5	8	10		0	22	45	80	110
				Wide	1	0	4	6	22	30		0	2	5	9	12		0	5	10	40	60
					2	0	14	30	50	60		0	4	9	12	18		0	20	40	70	90
					3	0	20	35	55	70		0	5	10	14	20		0	22	44	85	120
	Fluvial	With slope/toe protection		Narrow	1	0	15	25	35	40		0	3	8	10	12		0	20	40	60	80
					2	0	20	30	70	90		0	3	8	10	15		0	25	50	80	130
					3	0	25	45	80	100		0	15	20	30	40		0	30	60	90	140
				Wide	1	0	15	25	35	40		0	8	15	20	25		0	20	40	60	80
					2	0	20	30	70	90		0	12	20	30	40		0	25	50	100	130
					3	0	25	45	80	110		0	15	30	40	50		0	30	60	110	150
	Coastal/ estuarine			Narrow	1	0	9	19	31	40		0	3	7	10	12		0	10	20	40	60
					2	0	15	30	50	60		0	3	8	10	15		0	20	50	75	100
					3	0	20	40	60	80		0	10	20	25	30		0	30	60	100	130
				Wide	1	0	9	19	31	40		0	8	15	20	25		0	20	40	60	80
					2	0	15	30	50	60		0	12	20	30	40		0	25	50	90	120
					3	0	20	40	60	80		0	15	30	40	50		0	30	60	100	140
Sloping walls with slope protection or revetment	Fluvial	Turf	Defence/ embank-ment	Narrow	1	0	3	6	25	40		0	1	3	5	7		0	5	10	40	60
					2	0	15	30	60	80		0	2	5	7	10		0	20	40	70	110
					3	0	16	33	70	90		0	3	6	8	11		0	22	44	90	130
				Wide	1	0	3	6	25	40		0	2	6	10	14		0	5	10	40	60
					2	0	15	30	60	80		0	4	10	14	20		0	20	40	70	110
					3	0	16	33	70	90		0	5	10	14	20		0	22	44	90	130
	Coastal/ estuarine			Narrow	1	0	3	6	22	30		0	1	2	4	5		0	5	10	40	60
					2	0	14	28	40	50		0	2	4	6	8		0	20	40	60	80

Asset class	Environment	Material	AIMS asset classific-ation	Narrow/ wide*	Maintenance regime	Expected deterioration times (years) to specified CG from new																
						Medium deterioration						Fastest deterioration						Slowest deterioration				
						1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
					3	0	15	30	45	60		0	3	5	8	10		0	22	45	80	110
				Wide	1	0	4	6	22	30		0	2	5	9	12		0	5	10	40	60
					2	0	14	30	50	60		0	4	9	12	18		0	20	40	70	90
					3	0	20	35	55	70		0	5	10	14	20		0	22	44	85	120
	Fluvial	Permeable[6]		Narrow	1	0	15	25	35	40		0	3	8	10	12		0	20	40	60	80
					2	0	20	30	70	90		0	3	8	10	15		0	25	50	80	130
					3	0	25	45	80	100		0	15	20	30	40		0	30	60	90	140
				Wide	1	0	15	25	35	40		0	8	15	20	25		0	20	40	60	80
					2	0	20	30	60	90		0	12	20	30	40		0	25	50	100	130
					3	0	25	45	80	110		0	15	30	40	50		0	30	60	110	150
	Coastal/ estuarine			Narrow	1	0	9	19	31	40		0	3	7	10	12		0	10	20	40	60
					2	0	15	30	50	60		0	3	8	10	15		0	20	50	75	100
					3	0	20	40	60	80		0	10	20	25	30		0	30	60	100	130
				Wide	1	0	9	19	31	40		0	8	15	20	25		0	20	40	60	80
					2	0	15	30	50	60		0	12	20	30	40		0	25	50	90	120
					3	0	20	40	60	80		0	15	30	40	50		0	30	60	100	140
	Fluvial	Impermeable[7]		Narrow	1	0	15	25	35	40		0	3	8	10	12		0	20	40	60	80
					2	0	20	30	70	90		0	3	8	10	15		0	25	50	80	130
					3	0	25	45	80	100		0	15	20	30	40		0	30	60	90	140
				Wide	1	0	15	25	35	40		0	8	15	20	25		0	20	40	60	80
					2	0	20	30	60	90		0	12	20	30	40		0	25	50	100	130
					3	0	25	45	80	110		0	15	30	40	50		0	30	60	110	150

[6] Permeable revetments: These are flexible revetments including rip rap, turf, natural stone and concrete blocks.

[7] Impermeable revetments: These are continuous sloping structures of concrete or stone blockwork, asphalt or mass concrete. They tend to be grouted in bitumen or concrete, making them inflexible.

Asset class	Environment	Material	AIMS asset classific-ation	Narrow/ wide*	Maintenance regime	Expected deterioration times (years) to specified CG from new																
						Medium deterioration						Fastest deterioration						Slowest deterioration				
						1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
	Coastal/ estuarine			Narrow	1	0	9	19	31	40		0	3	7	10	12		0	10	20	40	60
					2	0	15	30	50	60		0	3	8	10	15		0	20	50	75	100
					3	0	20	40	60	80		0	10	20	25	30		0	30	60	100	130
				Wide	1	0	9	19	31	40		0	8	15	20	25		0	20	40	60	80
					2	0	15	30	50	60		0	12	20	30	40		0	25	50	90	120
					3	0	20	40	60	80		0	15	30	40	50		0	30	60	100	140
Pipe culverts	Fluvial	Concrete	Channel/ simple OR complex culvert	N/A	1	0	10	30	45	55		0	5	10	20	30		0	20	50	65	80
					2	0	30	55	80	90		0	20	40	60	70		0	40	70	100	115
					3	0	50	80	115	125		0	35	70	100	110		0	60	90	135	150
		Masonry/ brick		N/A	1	0	10	30	45	55		0	5	10	20	30		0	20	50	65	80
					2	0	20	40	70	80		0	10	20	35	45		0	30	60	90	110
					3	0	30	50	95	115		0	15	30	50	65		0	40	70	115	135
		Steel (corrugated galvanised)		N/A	1	0	10	30	45	55		0	5	10	20	25		0	20	50	65	75
					2	0	20	40	60	75		0	10	20	30	40		0	30	60	85	100
					3	0	30	50	75	95		0	15	30	40	50		0	40	70	105	130
		Plastic		N/A	1	0	10	30	45	55		0	5	10	20	25		0	20	50	65	75
					2	0	30	55	70	80		0	20	40	50	60		0	40	70	90	110
					3	0	50	80	95	105		0	35	70	80	90		0	60	90	115	135
		Clay		N/A	1	0	10	30	45	55		0	5	10	20	25		0	20	50	65	75
					2	0	30	55	80	90		0	20	40	60	70		0	40	70	100	115
					3	0	50	80	115	130		0	35	70	100	115		0	60	90	135	155
Beaches with and without beach control structures	Coastal	Shingle/sand	Defence/ beach		1	0	9	13	25	35		0	4	7	9	13		0	15	38	75	100
					2	0	16	30	50	75		0	7	10	13	20		0	27	50	150	200
					3	0	20	55	90	120		0	12	20	25	40		0	27	75	200	250

Asset class	Environment	Material	AIMS asset classific-ation	Narrow/ wide*	Maintenance regime	Expected deterioration times (years) to specified CG from new																
						Medium deterioration						Fastest deterioration						Slowest deterioration				
						1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Control structures	Coastal	Rock groynes	Beach structure/ groyne		1	0	19	57	114	124		0	10	30	59	67		0	44	131	262	273
					2	0	19	114	190	200		0	10	59	99	108		0	44	262	437	450
					3	0	57	190	266	285		0	30	99	139	150		0	131	437	612	635
		Timber groynes			1	0	6	13	17	20		0	2	5	8	10		0	10	20	25	30
					2	0	10	25	30	34		0	5	10	13	15		0	15	40	45	50
					3	0	14	37	43	48		0	8	15	18	20		0	20	60	65	70
		Offshore breakwaters (rock)	Beach structure/ break-water		1	0	19	57	114	124		0	10	30	59	67		0	44	131	262	273
					2	0	19	114	190	200		0	10	59	99	108		0	44	262	437	450
					3	0	57	190	266	285		0	30	99	139	150		0	131	437	612	635
		Breastwork (timber)			1	0	11	18	22	25		0	7	10	13	15		0	15	25	30	35
					2	0	15	30	35	40		0	10	15	18	20		0	20	45	50	60
					3	0	19	42	48	55		0	13	20	23	25		0	25	65	70	80
		Crib walls (timber)			1	0	11	18	22	25		0	7	10	13	15		0	15	25	30	35
					2	0	15	30	35	40		0	10	15	18	20		0	20	45	50	60
					3	0	19	42	48	55		0	13	20	23	25		0	25	65	70	80
Dunes with or without holding structures	Coastal	All	Defence/ dunes		1	0	10	15	30	40		0	5	8	10	15		0	20	40	110	150
					2	0	15	35	60	80		0	7	10	13	20		0	27	60	150	200
					3	0	20	60	100	130		0	12	20	25	40		0	30	80	190	250
Saltmarsh-es, saltings and warths with or without holding structures	Coastal	All	Land/salt-marsh		1	0	12	25	40	45		0	8	14	20	25		0	20	40	110	150
					2	0	18	40	75	90		0	10	16	25	30		0	27	60	150	200
					3	0	22	80	130	150		0	14	25	30	50		0	30	80	190	250
Maintained channels	Fluvial	Earth (e.g. regraded	Channel/ open		1	0	1	2	5	8		0	1	2	3	6		0	1	2	6	10
					2	0	2	150	250	350		0	1	140	150	200		0	3	180	300	400

Asset class	Environment	Material	AIMS asset classific-ation	Narrow/ wide*	Maintenance regime	Expected deterioration times (years) to specified CG from new																	
						Medium deterioration						Fastest deterioration						Slowest deterioration					
						1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
		channels)	channel		3	0	150	200	300	400		0	120	150	200	300		0	170	220	350	450	
Maintained channels	Fluvial	Concrete/ brick		N/A	1	0	15	35	50	60		0	5	20	30	40		0	20	50	70	80	
					2	0	20	45	70	90		0	10	30	50	60		0	25	60	100	120	
					3	0	25	55	90	120		0	15	40	70	80		0	30	70	130	160	
Weirs	Fluvial	All	Structure/ weir	N/A	1	0	15	20	40	60		0	10	15	30	40		0	20	30	50	70	
					2	0	30	50	70	90		0	20	30	50	60		0	40	70	90	110	
					3	0	45	80	100	120		0	30	45	70	80		0	60	110	130	150	
Outfalls	Fluvial	All	Structure/ outfall	N/A	1	0	15	35	50	60		0	5	20	30	40		0	20	50	70	80	
					2	0	20	45	70	90		0	10	30	50	60		0	25	60	100	120	
					3	0	25	55	90	120		0	15	40	70	80		0	30	70	130	160	
	Coastal/ estuarine	All		N/A	1	0	10	15	30	40		0	5	10	15	20		0	15	30	50	60	
					2	0	15	25	50	60		0	10	15	25	30		0	20	40	60	70	
					3	0	20	35	60	70		0	15	20	35	40		0	25	50	70	80	
Flap valves	Fluvial	Cast iron and coplastic	Structure/ control gate	N/A	1	0	8	13	17	20		0	5	9	12	15		0	10	17	21	25	
					2	0	10	17	21	25		0	8	13	17	20		0	12	20	25	30	
					3	0	12	21	25	30		0	11	17	22	25		0	14	23	29	35	
	Coastal/ estuarine	Cast iron and coplastic		N/A	1	0	5	9	12	15		0	3	6	8	10		0	8	13	17	20	
					2	0	8	13	17	20		0	5	9	12	15		0	10	17	21	25	
					3	0	11	17	22	26		0	7	12	16	20		0	12	21	25	30	
Moveable gates (manually operated)	Fluvial	all	Structure/ control gate	N/A	1	0	12	25	32	38		0	5	12	16	20		0	15	32	41	50	
					2	0	18	34	42	50		0	10	22	30	35		0	20	40	50	60	
					3	0	24	43	52	62		0	15	32	44	50		0	25	48	59	70	
	Coastal/ estuarine	all		N/A	1	0	10	14	16	18		0	4	7	9	10		0	13	22	26	30	
					2	0	15	23	27	30		0	7	11	13	15		0	18	29	35	40	
					3	0	20	32	38	42		0	10	15	17	20		0	23	36	44	50	
Moveable	Fluvial	All	Structure/	N/A	1	0	12	20	24	28		0	5	10	13	15		0	15	27	33	38	

Asset class	Environment	Material	AIMS asset classific-ation	Narrow/ wide*	Maintenance regime	Expected deterioration times (years) to specified CG from new														
						Medium deterioration					Fastest deterioration					Slowest deterioration				
						1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
gates (electrically operated)			control gate		2	0	18	29	35	40	0	10	17	21	25	0	20	33	39	45
					3	0	24	35	42	49	0	15	24	29	35	0	25	39	45	52
	Coastal/ estuarine	All		N/A	1	0	10	14	16	18	0	4	7	9	10	0	13	16	18	20
					2	0	15	20	23	25	0	7	11	13	15	0	18	24	27	30
					3	0	20	26	30	33	0	10	15	17	20	0	23	32	36	40
Debris screens	Fluvial	All	Structure/ screen	N/A	1	0	5	14	21	25	0	2	10	17	20	0	7	20	25	30
					2	0	7	20	32	40	0	5	15	25	30	0	10	25	40	50
					3	0	9	26	43	55	0	8	20	33	40	0	13	30	55	70
Flood gates and barriers	Fluvial	Metal	Structure/ control gate	N/A	1	0	12	25	32	38	0	5	12	16	20	0	15	32	41	50
					2	0	18	34	42	50	0	10	22	30	35	0	20	40	50	60
					3	0	24	43	52	62	0	15	32	44	50	0	25	48	59	70
	Coastal/ estuarine			N/A	1	0	10	14	16	18	0	4	7	9	10	0	13	22	26	30
					2	0	15	23	27	30	0	7	11	13	15	0	18	29	35	40
					3	0	20	32	38	42	0	10	15	17	20	0	23	36	44	50
	Fluvial	Wood		N/A	1	0	6	13	16	19	0	3	6	8	10	0	8	16	21	25
					2	0	9	17	21	25	0	5	11	15	18	0	10	20	25	30
					3	0	12	22	26	31	0	8	16	22	25	0	13	24	30	35
	Coastal/ estuarine			N/A	1	0	5	7	8	9	0	2	4	5	6	0	7	11	13	15
					2	0	8	12	14	15	0	4	6	7	8	0	8	15	18	20
					3	0	10	16	19	21	0	5	8	9	10	0	12	18	22	25

*Narrow assets defined as <4 m crest width, wide assets defined as 4 m or greater crest width.

3 Step-by-step guide

3.1 Steps to follow

Steps 1 to 5 below describe how the appropriate deterioration curve is selected and a method to estimate current condition grade and remaining useful life.

Step 1: Identify the type of asset

Consult the asset list as indicated above (Tables 2.1/2.2): vertical walls, embankments, culverts, etc. If the asset is of composite construction, identify all significant asset types present. Complete the selection of the type of asset by identifying:

- The type of material that the asset is made of (as appropriate to the asset type, e.g. for vertical walls: concrete, brick and masonry, timber or gabion).
- If the asset is an embankment or sloping wall: define it as narrow or wide (wide where the width of the asset crest width is 4 m or greater).

Step 2: Identify the factors influencing the asset life

- The environment which influences the asset: fluvial or coastal. Note: Assets located in estuarine environment are classed with coastal assets and covered by 'coastal' models. To classify correctly it is important to consider presence of wave loading, salt environment, daily water level variation and similar. If in doubt, it is advised that the one that matches best is selected, but sensitivity testing for other possible selections should be undertaken.
- Maintenance Regime 1, 2 or 3 (as defined in Section 2 above).

Step 3: Identify the appropriate deterioration curves

Select the relevant deterioration curves or figures in the deterioration table for that asset. Where the asset is made up of more than one basic type, it may be necessary to consider deterioration curves from the component structure types in parallel and to choose the points on the curves which provide the limiting values for the overall asset being considered. Note: This is considered a conservative approach. For better definition it is recommended to apply judgement and local knowledge about which components are critical for asset performance and give more prominence in the analysis to the deterioration of these components.

Step 4: Determine the deterioration curve

Using engineering judgement and local experience, determine the deterioration curve/profile by selecting or interpolating between fastest, medium and slowest deterioration curves/profiles, taking account of the loading and environmental conditions acting upon the asset compared with the assumed 'standard' or design conditions.

Step 5: Forecast the current condition grade and expected deterioration time to next condition grade

This relates to two scenarios:

a. Where the condition grade and the proportion of the time interval between the two boundary condition grades are known – this can place the asset at a precise location on the horizontal axis.

b. Where the specific condition grade is known but no additional information is available to position the asset more precisely than being within the grade. The guidance differs depending upon use (as defined in Section 2 above):

   - strategic planning
   - regional asset management
   - asset-specific assessment.

In undertaking the analysis, the practitioner will need to position the various existing assets onto the deterioration model. It may, for instance, be recorded that an asset is in CG 2. Since the models predict that an asset will spend a defined time within the CG 2 category, it is necessary to assess where the CG 2 asset should be placed on the curve, i.e. what proportion of the interval between CG 2 and CG 3 has already elapsed. If this information is not known for a particular asset and there is nothing in the known history of the asset to suggest otherwise, it is recommended to consider the use scenario, as explained below.

The three use scenarios need to be considered individually:

Guide for strategic planning use: It is recommended that for strategic risk-based assessment, the best-estimate placement is at the mid-point of the condition grade transition interval. This recognises that assets may be better or worse than indicated by this location, but that on balance the mid-point represents the overall average. Sometimes it is deemed necessary for the strategic estimate to be more cautious, e.g. in the case of critical assets, especially when there are high levels of uncertainty in the asset knowledge. Here the asset could be assumed to be close to transition to a worse condition grade. Within 1 to 3 years of the transition is suggested (for consistency, this value should be the same for all assets). This provides a conservative estimate for a cautious strategic assessment and avoids underestimation of the level of strategic risk for critical assets.

An example of how this can be applied is included in Example 2 in Section 3.3.2.

Guide for regional asset management use: It is recommended that for regional tactical asset management, the asset components are assumed to be approximately at the mid-point of the condition grade transition interval. Locating the assets onto a median value position on the curve gives an 'average' condition for its category, and recognises that for some asset components proportionally less of the interval has elapsed and for others proportionally more of the interval has elapsed. Overall analysis will create balance in the calculations. Where possible, and certainly for particularly critical assets, it is recommended that monitoring and visual assessment of the asset is undertaken to better define the deterioration state reached and to permit more accurate placement of the asset on the deterioration curve.

Guide for asset owner use: It is recommended that for an initial asset-specific assessment, the asset is assumed to be approximately at the mid-point of the condition grade transition interval. This will enable maintenance planning and capital investment needs for the asset to be identified to give an outline asset plan. Locating the asset onto a median value position on the curve gives it an 'average' condition for its category, but recognises there is uncertainty in this placement. To reduce this uncertainty, it is recommended that monitoring and visual assessment of the asset is undertaken to better define the deterioration state reached and to permit more accurate placement of the asset on the deterioration curve.

A summary of the placement recommendations is included in Table 3.1.

Note: These recommendations are for application to assets for which the specific condition grade is known but no additional information is available to position the asset more precisely than being within the grade.

Table 3.1 Placement of assets on the deterioration curve

Use	Non-critical assets*	Critical assets*
Strategic planning	At mid-point of interval between estimated transition points into and out of the asset's condition grade	Where deemed necessary. within 1 to 3 years of the estimated transition point to the next worse condition grade
Regional tactical asset management	At mid-point of interval between estimated transition points into and out of the asset's condition grade	Where deemed necessary, arrange monitoring and inspection to capture asset-specific condition data
Asset owner's asset-specific assessment	At mid-point of interval between estimated transition points into and out of the asset's condition grade, but use next programmed inspection to capture asset condition data to reduce uncertainty	Where deemed necessary, arrange monitoring and inspection in risk based manner to capture condition data

* As assessed by practitioners.

All uses: From the placement of the asset (either (a) or (b) above), identify the expected deterioration time(s) to the next condition grade(s) using the selected or interpolated deterioration curve.

3.2 Additional considerations

Note: The commentary below relates to the steps to follow section (Section 3.1).

When assessing specific deterioration rates, it is necessary to take various factors into account. These include:

- the type and design of the structure;
- construction materials used;
- potential weak points;
- forces and influences acting upon the structure.

Some asset-specific factors may impact on the deterioration curve selection. Some of these are listed in Table 3.2.

Table 3.2 Asset-specific factors affecting deterioration curve selection

Asset	Factor
Embankments and sloping seawalls	Likely rate of reduction in beach/berm level
	Likely rate of reduction in crest level
	Likely rate of reduction in foreshore level, gradual loss of slope material
	Degree of presence of vermin likely to generate holes
	Degree of cracking (may only be apparent during dry weather)
	Likelihood of soft/saturated areas of the defence or ground nearby during high water levels
	Risk of vandalism or damage
	Level of use by vehicles/pedestrians/animals, creating tyre ruts, vegetation and bank damage, worn surface and access points
	Anticipated loss/increase in extent and quality of vegetation, infestation by invasive plants
	Likely movement of sections of embankment
Slope erosion protection	Likely rate of reduction in level in front of defence
	Likelihood of saturated slope or ground at crest of defence
	Potential for future damage to revetment
	Potential for movement of individual parts of revetment
	Potential for movement of structure/slips within cliff
	Potential for local holes and tears within revetment
	Potential for bulging at the toe
Vertical wall structures	Likely rate of reduction in beach level
	Potential for corrosion of reinforcing steel in concrete
	Likelihood of distortion of steel piles/gaps in clutches
	Potential for loss or loosening of tie-rod fixings
	Potential for cracking
	Potential for surface damage to structure
	Potential for movement of retained ground/defence
	Likely rate of reduction in foreshore level, damage to slope
	Likely rate of loss of joint material, erosion around joints, voiding behind structure
	Rate of growth of vegetation
	Potential for seepage through wall (from retained section at low water for retaining walls and from landward face or toe during high water levels for walls with lower land immediately behind)
	Likelihood of cracking of concrete with an irregular pattern, disintegration of concrete surface (spalling), corrosion of steel
Beaches and dunes	Likely rate of reduction in beach level, loss of sediment/beach material
	Likely rate of reduction in dune crest height, loss of sand volume (increased aeolian transport)
	Likely rate of change in profile of sections of dunes or beaches
	Likely rate of toe retreat
	Potential for reduced vegetation cover (dunes)

3.3 Examples of application

This section presents two examples of application of the step-by-step guide to composite assets. This ‘composite asset’ procedure is suitable for situations where the current condition grades of the components are close (e.g. within one grade). If more definition is needed (e.g. to account for current variability in the condition of the components or to account for the criticality of the individual components and impact of their deterioration on the asset performance) the components can be considered separately. This alternative approach is demonstrated for Example 2 in Section 3.3.3.

Note: Although the asset examples are real assets, some assumptions have been made in order to demonstrate application of the models.

3.3.1 Example 1

Asset/site description

The details for this example asset have been extracted from the Thames Estuary 2100 project (Topic 4.7 – Develop Recommendations for Maintenance versus Replacement).

This asset is located on the Eastern Esplanade on the south side of Canvey Island between Marine Road and Gazelle Drive adjacent to the St Anne’s pumping station.

The current defence comprises a 2.45-m high reinforced concrete wall with wave return constructed as a cap around the top of a 10-m long steel sheet pile. The average crest height of the wall is 6.85 m AOD. A public access area/walkway is located on the landward side of the wall, on the crest of a sand fill embankment approximately 1.3 m below the top of the wall. At the toe of this embankment is the busy Eastern Esplanade road. On the riverward side of the flood wall the embankment slope is protected by a bitumen-grouted stone revetment, which is subject to wave action and tidal influence. It is understood that the construction date of these defences was roughly 1984.

The defence at this location has a condition grade of 2.

There are flood gates and public access steps provided at regular intervals along the length of the flood wall.

Purpose of assessment

The purpose of the deterioration assessment is an asset owner’s asset-specific inspection (for reference see Sections 2 and 3 and Table 3.1).

It is assumed for the estimation that this analysis is being undertaken in the year 2010.

Step 1: Identify the type of asset

This is a composite structure with three different types of asset:

- Vertical wall concrete
- Sheet pile structure (assumed anchored steel)
- Sloping wall impermeable revetment (width of crest is < 4 m (assumed), therefore asset is classed as narrow)

Step 2: Identify the factors influencing the asset life

The asset is at a coastal location exposed to wave action, saline environment and abrasion.

Maintenance regimes applicable are (assumed):

- Maintenance regime 2 for concrete wall and revetment
- Maintenance regime 3 for sheet piles

Step 3: Identify the appropriate deterioration curves

Three deterioration rates (in years) are extracted from Table 2.2 for the options:

- Vertical wall/coastal/concrete/N/A (narrow/wide)/Maintenance Regime 2
- Sheet piles/coastal/anchored steel/N/A (narrow/wide)/Maintenance Regime 3
- Sloping walls/coastal/impermeable/narrow/Maintenance Regime 2

	Medium estimate						Fastest estimate						Slowest estimate				
Grade	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Vertical concrete wall	***0***	***15***	40	55	70		***0***	10	20	30	40		***0***	***20***	60	80	100
Sheet piles	***0***	20	35	60	70		***0***	15	20	35	40		***0***	25	***50***	***70***	***80***
Sloping wall impermeable	***0***	***15***	***30***	***50***	***60***		***0***	***3***	***8***	***10***	***15***		***0***	***20***	***50***	75	100

The deterioration curve for the composite structure is obtained from the limiting values (shown in bold italic) of the three curves above.

	Medium estimate						Fastest estimate						Slowest estimate				
Grade	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Composite	***0***	***15***	***30***	***50***	***60***		***0***	***3***	***8***	***10***	***15***		***0***	***20***	***50***	***70***	***80***

Step 4: Determine the deterioration curve

The medium deterioration rate estimate is chosen as it is assumed that the asset is under standard conditions.

	Medium estimate				
Grade	1	2	3	4	5
Composite	***0***	***15***	***30***	***50***	***60***

Step 5: Forecast the current condition grade and expected deterioration time to next condition grade

The deterioration assessment is for an asset-specific inspection.

The specific condition grade is known (CG 2) but no additional information is available to position the composite asset more precisely than being within the grade. The guidance Table 3.1 above indicates that the asset should be placed at the mid-point of the CG 2 to CG 3 interval (i.e. at 22.5 years). The time for the asset to deteriorate from its current average condition grade (CG 2) to CG 3 is 7.5 years (30 – 22.5) and to CG 5 is 37.5 (7.5 + 20 + 10 from table immediately above).

Summary

Time to grade transition CG 2 to 3 (years)	Time to grade transition CG 4 to 5 (years)
7.5	37.5

3.3.2 Example 2 – considering the composite assets together

Asset/site description

This asset is a critical asset located at Overstrand in North Norfolk The current defence comprises a 2.74-m high reinforced concrete wall with a 1.43-m wide reinforced concrete apron and 4.3-m long piles as scour protection. The average crest height of the wall is 4.50 m AOD. Behind the 5.00-m wide promenade at the rear of the wall, the contorted glacial drift cliffs rise to a height of 23.6 m AOD.

The concrete wall has a condition grade of 2, tending to 3, and the steel piles and the beach have a condition grade of 3.

Purpose of assessment

The purpose of the deterioration assessment is for strategic planning (for reference see Sections 2 and 3 and Table 3.1). It is assumed for this estimation that the asset age is unknown.

Two scenarios are explained:

1. Where the asset is considered non-critical.
2. Where the asset is considered critical.

Step 1: Identify the type of asset

This is a composite structure with three different types of asset:

- Vertical wall concrete
- Sheet pile structure (assumed anchored steel)
- Beach

Step 2: Identify the factors influencing the asset life

The asset is at a coastal location. Conditions include:

- Aggressive wave action and abrasion
- Potential structural instability resulting from the lowering of beach levels

- No maintenance of the concrete wall (Maintenance regime 1) (assumed)
- No maintenance of the sheet piles (Maintenance regime 1) (assumed)
- Maintenance regime 2 for beach (assumed)

Step 3: Identify the appropriate deterioration curves

Three deterioration rates are extracted from Table 2.2 for the options:

- Vertical wall/coastal/concrete/N/A (narrow/wide)/Maintenance regime 1
- Sheet piles/coastal/anchored steel/N/A (narrow/wide)/Maintenance regime 1
- Beach/coastal/shingle, sand/Maintenance Regime 2

	Medium estimate						Fastest estimate						Slowest estimate				
Grade	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Vertical concrete wall	***0***	***10***	30	40	50		***0***	***5***	15	25	30		***0***	***15***	45	60	80
Sheet piles	***0***	***10***	***15***	***30***	***40***		***0***	***5***	***10***	15	***20***		***0***	***15***	***30***	***50***	***60***
Beach	***0***	16	30	50	75		***0***	7	***10***	***13***	***20***		0	27	50	150	200

The deterioration curve for the composite structure is obtained from the limiting values of the two curves above.

	Medium estimate						Fastest estimate						Slowest estimate				
Grade	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Composite	***0***	***10***	***15***	***30***	***40***		***0***	***5***	***10***	***13***	***20***		***0***	***15***	***30***	***50***	***60***

Step 4: Determine the deterioration curve

The medium curve is selected as it is assumed that the asset is under standard loading conditions.

	Medium estimate				
Grade	1	2	3	4	5
Composite	***0***	***10***	***15***	***30***	***40***

Step 5: Forecast the current condition grade and expected deterioration time to next condition grade

The deterioration assessment is for strategic planning for a critical asset. The specific condition grade is known (assumed to be average CG 3 for the composite structure) but no additional information is available to position the composite asset more precisely than being within the grade.

Scenario 1: Asset is considered non-critical

The guidance Table 3.1 above indicates that the asset is placed at the mid-point of the condition grade interval 3 to 4. The time for the composite asset to deteriorate from its current average condition grade (CG 3) to CG 4 is 7.5 years ((30 – 15)/2 years) and to CG 5 is17.5 years to CG 5 (7.5 + (40 – 30)) from table immediately above).

Scenario 2: Asset is considered critical (with uncertainty in data)

The guidance Table 3.1 above indicates that the asset is placed within 1 to 3 years of the transition point to next (worse) condition grade. The time for the composite asset to deteriorate from its current average condition grade (CG 3) to CG 4, which is considered the minimum condition grade acceptable for the structure, is 1 year (through the placement procedure (table above)) and 11 years to CG 5 (1 + (40 – 30)) from table immediately above).

Summary

Scenario	Time to grade transition CG 3 to 4 (years)	Time to grade transition CG 4 to 5 (years)
Scenario 1 (non-critical asset)	7.5	17.5
Scenario 2 (critical asset)	1	11

3.3.3 Example 2 – considering the composite assets separately

The alternative to the 'composite asset' procedure described in Section 3.3.2 is to consider the components separately. This would be undertaken to obtain better definition where asset components have different levels of criticality in terms of asset performance or, alternatively, where the current condition grades of the various asset components differ to a considerable degree.

Picking up on step 4 (Determining the deterioration curve), the medium curves for each of the three components are selected (it is assumed that the asset is under standard loading conditions).

	Medium estimate				
Grade	1	2	3	4	5
Vertical concrete wall	0	10	30	40	50
Sheet piles	0	10	15	30	40
Beach	0	16	30	50	75

The following is evident (assuming that the asset is critical):

- The vertical wall (currently CG 2) will be CG 3 in 1 year, CG 4 in 11 years and CG 5 in 21 years.

- The sheet piles (currently CG 3) will be CG 4 in 1 year and CG 5 in 11 years.
- The beach (currently CG 3) will be CG 4 in 1 year and CG 5 in 26 years.

This information will enable informed decisions on asset inspection and monitoring.

4 Individual deterioration models

The Individual deterioration models are presented in Appendix C.

5 Conclusions

This practical guide presents a series of asset deterioration curves applicable to different types of flood and coastal defence assets, with the aim of providing a robust and reliable means of estimating future asset condition and expected residual life. The curves take into account characteristics related to environment, asset age, material type and construction, and past and intended (future) maintenance practices. They are based on the condition grades defined in the *Condition Assessment Manual* (Environment Agency 2006). These deterioration curves complement other Environment Agency tools and methodologies such as whole life cost assessments and assessments of current and future flood risk and benefits of interventions for appraisal and investment planning. They can also facilitate the tracking of risk over the lifetime of the asset, provided the relationship between asset condition and failure probability is understood.

The following FCRM asset types are covered: vertical walls, sheet piled structures, demountable defences, earth dykes or embankments, sloping walls with slope protection/revetment, culverts, beaches, control structures, dunes and saltmarshes, maintained channels, weirs, outfalls, flap valves, moveable gates (manual and electrical), debris screens, and flood gates and barriers.

Asset deterioration rates are captured in tabular and graphical format. A step-by-step guide on the use of the curves is provided.

References

Environment Agency, 2006. *Condition Assessment Manual. Managing Flood Risk*. Document reference 116_03_SD01.

Environment Agency, 2009b. *Guidance on Determining Asset Deterioration and the Use of Condition Grade Deterioration Curves*. Environment Agency R&D Project SC060078 (Science Report: Phase 1 Report, Appendix 2).

Environment Agency, 2010. *Delivering Consistent Standards for Sustainable Asset Management, FCRM Asset Management Maintenance Standards, Version 2*. March 2010.

Environment Agency, 2012. *Technical Report – FCRM Assets: Deterioration Modelling and WLC Analysis, Appendix B: Maintenance Standards*. SC060078/R.

Glossary

Condition grade	Standards adopted by the Environment Agency to indicate the condition (and hence likely performance) of flood defence assets: 1 being a very good condition and 5 a very poor one.
Deterioration	Process involving a decline in the state of structural properties of the asset.
Deterioration curve (or model)	Expresses the deterioration with time of an asset, in terms of the anticipated time intervals to change from one condition grade to another.
Deterioration rate estimates	**Medium:** considered a typical rate providing a mid-range value representing an average situation, with assets being neither exposed nor sheltered. **Slowest:** arising from a sheltered location and/or high quality materials and construction, well-designed asset. **Fastest:** arising from an exposed location and/or poor quality materials/construction/design.
Environmental conditions	Physicochemical and biological properties of the environment that influence the asset and, in the context of this report, affect its rate of deterioration.
Failure mode	Description of one of a number of ways in which a defence may fail to meet a particular performance indicator.
H&S	Health & Safety.
Load	Factors such as high river flows, water levels and wave heights, to which the flooding and erosion system is subjected.
Maintenance regime	Programme of works undertaken to maintain the performance of an asset to a certain level.
Residual life	The remaining time that a defence is able to achieve a minimum acceptable value of defined performance in terms of its serviceability function or structural strength.
Standard conditions	Conditions for which the asset was designed.

Appendix A: Comparison with previous deterioration models (Phase 1 vs. Phase 2)

The second phase of the project has provided an opportunity to review and revise the Phase 1 deterioration curves (models). This has resulted in an enlarged suite of models covering significantly more assets and a broader range of maintenance activities/regimes.

For those assets covered by Phase 1 models, the assessment of a wide range of source material including the Phase 1 study findings, literature in the public domain, NFCDD data extracts, workshop activities and site survey findings means that the Phase 2 models can be considered updates of their corresponding Phase 1 models and should therefore be considered as replacements for Phase 1 models.

Table A.1 lists general comments regarding changes between Phase 1 and Phase 2 models. More specific information is given in Section 4 for each individual asset (as appropriate).

In general, where changes between Phase 1 and Phase 2 curves are evident, these arise from the increased scope of data available for review and validation. This has led to the adjustments in the positions of some condition grade transitions. In no cases were changes associated with any change in understanding of deterioration processes and failure mechanisms, which would have required more fundamental reconstruction of the curves.

Table A.1 Comparison of Phase 1 and Phase 2 models

Asset class	Material	Environment	Comparison
Vertical wall	Concrete	Fluvial	More rapid decline in Phase 2 compared to Phase 1 for 'No maintenance' scenario. Between 20 and 33% reduction in overall asset life (i.e. to CG 5) predicted. 'With maintenance' scenario broadly similar.
Vertical wall	Brick	Fluvial	More rapid decline in Phase 2 compared to Phase 1 for 'No maintenance' scenario. Between 20 and 33% reduction in overall asset life (i.e. to CG 5) predicted. 'With maintenance' scenario broadly similar.
Vertical wall	Gabion	Fluvial	Phase 2 same as Phase 1.
Vertical wall	Concrete	Coastal	With exception of fastest rate, 'No maintenance' scenario predicts more rapid decline in Phase 2 compared to Phase 1 (between 20 and 50% reduction in overall asset life (i.e. to CG 5)). For 'With maintenance' scenario, grade transitions and overall asset life for Phase 2 compared to Phase 1 are not consistently adjusted.
Vertical wall	Brick	Coastal	The Phase 1 report indicated that it was not effective to carry out maintenance for this asset type. Phase 2 has introduced some maintenance which is considered to prolong asset condition and life. For 'No maintenance' scenario – more rapid decline in Phase 2, with between 33 and 50% reduction in overall asset life (i.e. to CG 5).
Vertical wall	Steel piles	Fluvial	The review process for Phase 2 suggested that the Phase 1 curves may be too optimistic. Phase 2 predictions for the 'No maintenance' scenario give between 55 and 67% lower overall asset life (i.e. to CG 5) , with a corresponding reduction in age to grade transitions. Phase 1 curves for sheet steel structures assumed no differences between 'With maintenance' and 'No maintenance' scenarios. This was reviewed and considered to be incorrect. The Phase 2 set of curves predicts longer lives as a consequence of increased maintenance compared with Phase 2 'No maintenance' scenario (40 to 80% improvement). However, these life values (i.e. to CG 5) are not as long as Phase 1 predictions.
Vertical wall	Steel piles	Coastal	For 'No maintenance' scenario, Phase 2 curves predicted slightly shorter asset lives (i.e. to CG 5) (by 15 to 33%). For 'With maintenance' scenario, the Phase 2 and Phase 1 curves are broadly similar.
Sloping walls	Turf	Fluvial	'No maintenance' scenario: same results for Phase 1 and 2. 'With maintenance' scenario: grades 1, 2 and 3, Phase 2 as for Phase 1, but Phase 2 has much shorter overall lives (i.e. to CG 5) (by between 20 and 40%), except for fastest rate where they are similar. (Applicable to both narrow and wide assets.)

Asset class	Material	Environment	Comparison
Sloping walls	Impermeable and permeable	Coastal	These two categories have the same deterioration curves in Phase 2, similarly Phase 1. Phase 2 'No maintenance' scenario: more rapid decline for fastest (narrow) and slowest (narrow and wide), by between 50 and 60%, compared with Phase 1 equivalents. 'With maintenance' scenario: Phase 2 curves predict longer lives (i.e. to CG 5) (by between 40 and 60% for medium and fastest deterioration) compared with Phase 1. For slowest deterioration with maintenance, the Phase 1 curve predicts approximately 10% longer life.
Sloping walls	Phase 1: Rip-rap, rigid and flexible compared to permeable Phase 2	Fluvial	Phase 1 curves for these categories: • Wide: generally similar although rip-rap maintenance has longer life to CG 4 and CG 5 (slowest and medium deterioration rates) • Narrow: No maintenance/no rear protection – all same. Rigid + rear protection is better than rip-rap/flexible • Narrow with maintenance: rip-rap better, with longer life (i.e. to CG 5) (both with and without rear protection), for slowest and medium (but not fastest rate, where it is same). (Exception: rip-rap with rear protection worse at early condition grades (1, 2 and 3). Phase 2 curves similar overall to Phase 1 curves.
Sloping walls	Impermeable and permeable	Fluvial	These two categories have the same deterioration curves in Phase 2. The deterioration curves are on a par with rip-rap, rigid and flexible Phase 1 (see also entry above).
Culverts		Fluvial	Phase 1 deterioration curves covered a variety of materials. The fastest, medium and slowest deterioration rates included the effect of material. Phase 2 deterioration curves have been prepared for individual materials, making the curves more flexible.
Shingle beach			'No maintenance' scenario: Phase 2 deterioration curves indicate longer lives for slowest and medium deterioration rate scenarios (between 25 and 50% longer life (i.e. to CG 5)). 'With maintenance' scenario: Phase 2 curves predict between two and three times asset life compared with Phase 1 curves.
Dunes			'No maintenance' scenario: Phase 2 deterioration curves indicate longer lives (i.e. to CG 5) for slowest and medium deterioration rate scenarios (33 and 150% respectively). 'With maintenance' scenario: Phase 2 curves predict between two and three times asset life compared with Phase 1 curves.

Appendix B: Notes on model construction

The steps in model construction were as follows:

1. Establish the design life of an asset in the category.

2. Identify the deterioration processes for the asset group.

3. Identify relative rates of deterioration and pre-eminent deterioration processes for a range of scenarios (e.g. environmental/exposure conditions) and maintenance practices (Regimes 1, 2 or 3). This step assesses the effect of the various maintenance activities (type and frequency) on the rate of deterioration and to what degree the deterioration processes can be prevented or slowed.

4. Consider how factors influencing deterioration (as in 3 above) would impact on asset life (cf. design life) and establish the anchors for end of asset life (transition to CG 5).

5. Consider how deterioration progresses for each asset type under each maintenance regime scenario – for example this could be initially slow through CG 1, 2 and 3 and then more rapidly to CG 4 and then CG 5. This will give the general shape of the deterioration curve.

6. To assist in the model construction and validation, apply the evidence from various sources including (as available):

    - Previous models, e.g. Phase 1 Report – deterioration curves with commentary and interviews with asset managers.

    - NFCDD data extracts. Note: It was not possible to align the assets represented by the extracted data to the environmental conditions or maintenance regime pertaining. Any general agreement between deterioration curve and condition grade/age can be considered as evidence of validation.

    - Site survey data (including historical records for sites studied showing condition grade trends over time).

    - Results of workshop activities using asset managers' and practitioners' expert judgement.

Appendix C: Deterioration Models

C.1 Vertical walls (inc. with scour protection)

Figure C1 shows a basic line sketch of this type of asset: vertical brick, masonry or concrete wall.

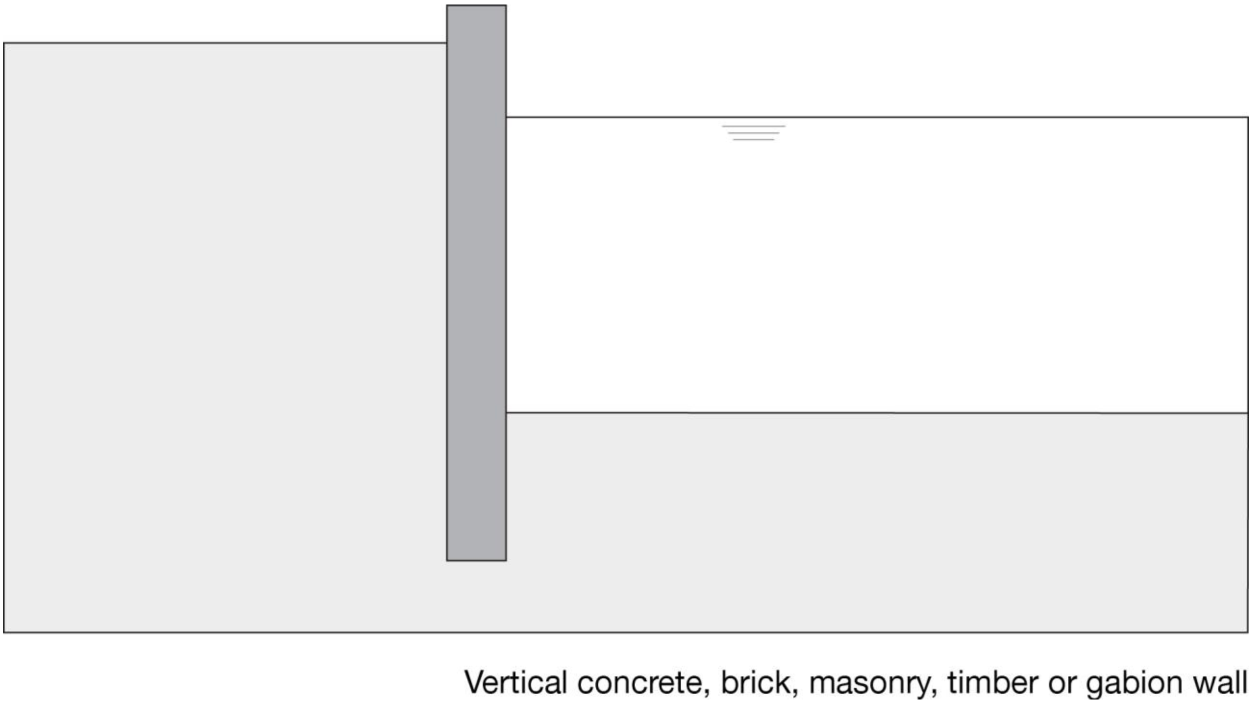


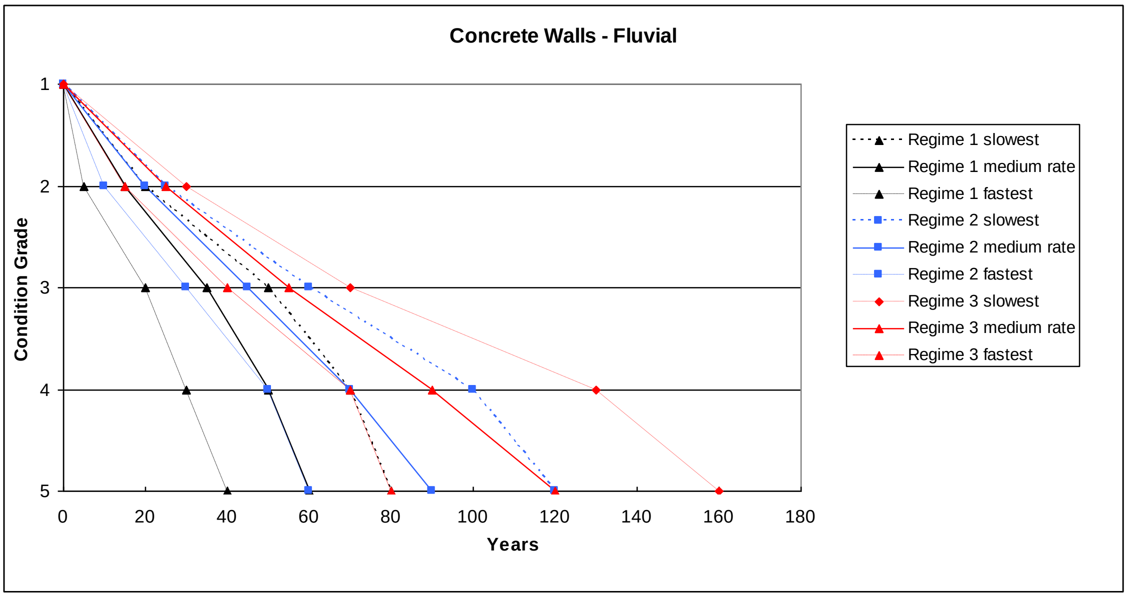
Figure C1 Vertical wall

a. Concrete vertical wall (fluvial and coastal/estuarine)

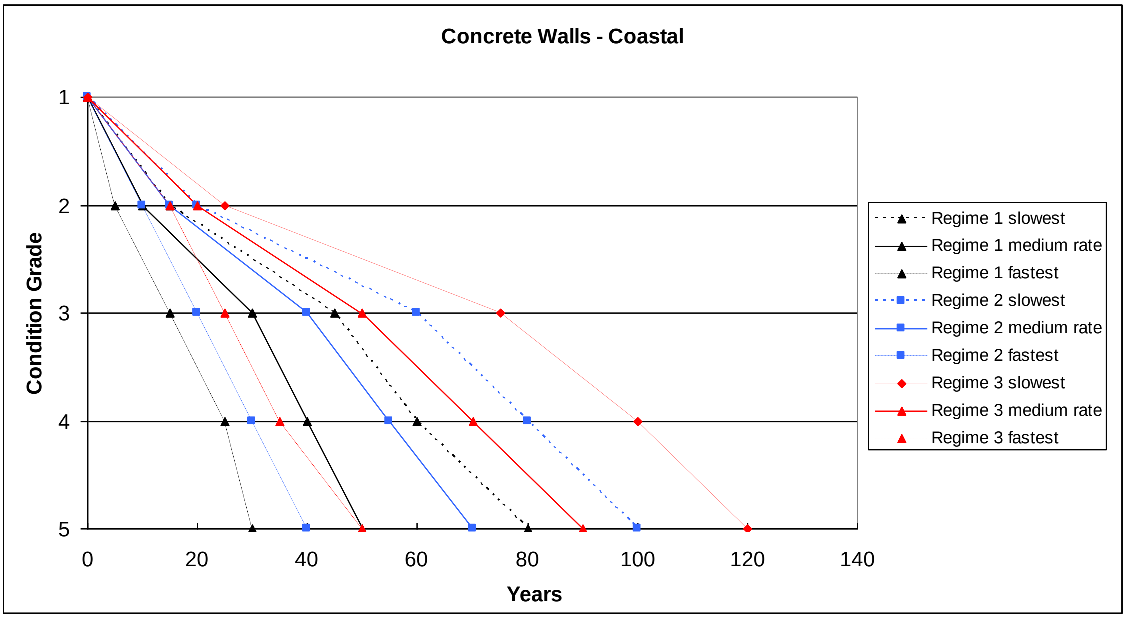
AIMS asset classification: Defence/wall

Models

Vertical Wall Concrete – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	70	80
2 – Medium	0	25	60	100	120
3 – High	0	30	70	130	160
Medium rate					
1 – Low/basic	0	15	35	50	60
2 – Medium	0	20	45	70	90
3 – High	0	25	55	90	120
Fastest rate					
1 – Low/basic	0	5	20	30	40
2 – Medium	0	10	30	50	60
3 – High	0	15	40	70	80



Vertical Wall Concrete – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	45	60	80
2 – Medium	0	20	60	80	100
3 – High	0	25	75	100	120
Medium rate					
1 – Low/basic	0	10	30	40	50
2 – Medium	0	15	40	55	70
3 – High	0	20	50	70	90
Fastest rate					
1 – Low/basic	0	5	15	25	30
2 – Medium	0	10	20	30	40
3 – High	0	15	25	35	50



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include those that compromise the integrity of the asset overall, for example:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Failure or damage to scour protection
4. Washout of fill
5. Settlement

and those that affect the integrity of the materials:

6. Exposure/corrosion of reinforcement
7. Honeycombing, flaking or spalling of concrete
8. Abrasion damage
9. Sealant or joint fill material loss
10. Cracks or fissuring
11. Corrosion of concrete units

Scour protection and backfill replacement can be used to manage deterioration caused by processes 1 to 4 above. The material-based deterioration processes can be managed through concrete repair, joint repair and sealant replacement, with the exception of corrosion of concrete units where component replacement would be needed (considered asset refurbishment and not maintenance).

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Toe scour
- Damage to scour protection
- Movement of structure
- Material degradation

Effect of environmental exposure/material quality

As a general rule, coastal rates are higher than fluvial to account for wave action and sediment abrasion. A coastal environment is also likely to result in more rapid deterioration of the concrete (and reinforcement if exposed) due to corrosion and may result in an increased probability of toe scour leading to undermining.

Fluvial slowest rate: The wall is in a protected location set back from the water's edge or it is a wall raising (wall extended in height, on an existing structure), and the material quality is appropriate for the environment/location. Surrounding strata and foundations are assumed to be stable. Construction is of a good quality, the asset is well designed.

Coastal slowest rate: The seawall is in a protected location at the back of the foreshore or it is at the top of a protected slope. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed with appropriate cover. There is little or no erosion risk in front of the wall. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time, and foundation material may suffer from erosion. The wall may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Beach levels may vary (dependent upon seasonal and storm conditions). The bed material may be a very coarse material and cause abrasion problems to the concrete, which in reinforced concrete may expose reinforcement leading to chloride ingress and corrosion of the bars. The water is either saline or brackish. The wall may suffer from poor quality materials and/or construction and/or design. The deterioration rate would increase from that in a fluvial environment.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks carried out are visual inspections of the wall. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by loss of surrounding support strata. Generally, the deterioration mechanisms would be through joint failures and lack of repairs. Abrasion of concrete, chloride ingress, reinforcement corrosion and toe erosion may occur, especially in exposed, coastal/estuarine environments.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including vegetation clearance, minor concrete/joint repair and scour protection/backfill replacement offsets concrete deterioration. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works), although some abrasion of concrete, chloride ingress, reinforcement corrosion and toe erosion may occur in exposed, coastal/estuarine environments.

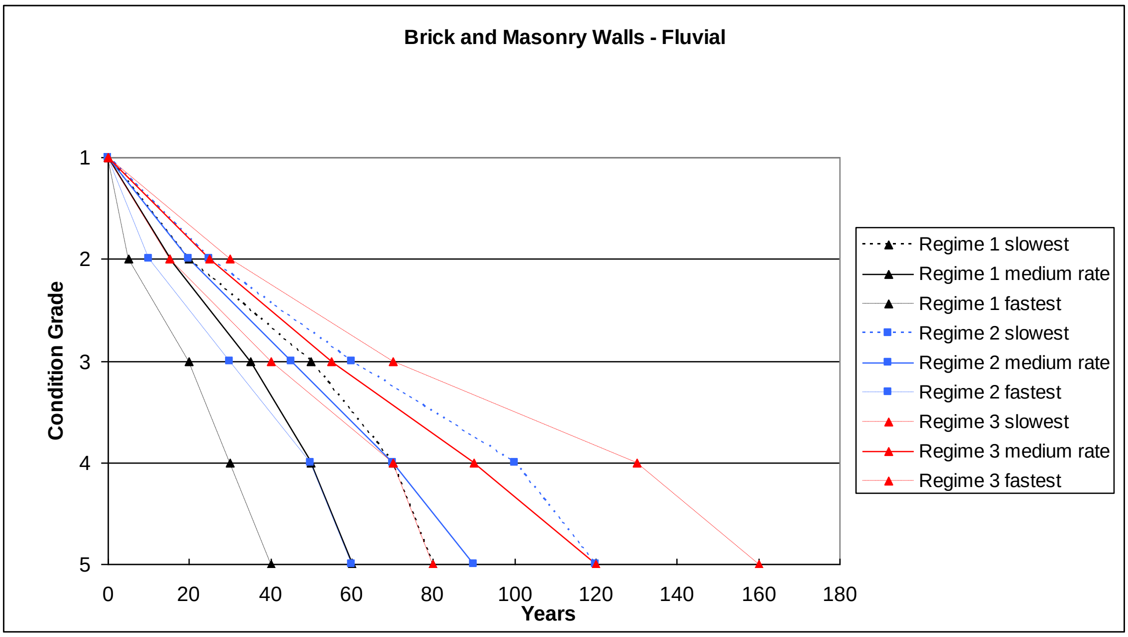
Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor concrete/joint repair and scour protection/backfill replacement offsets concrete deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

b. Brick and masonry (fluvial and coastal/estuarine)

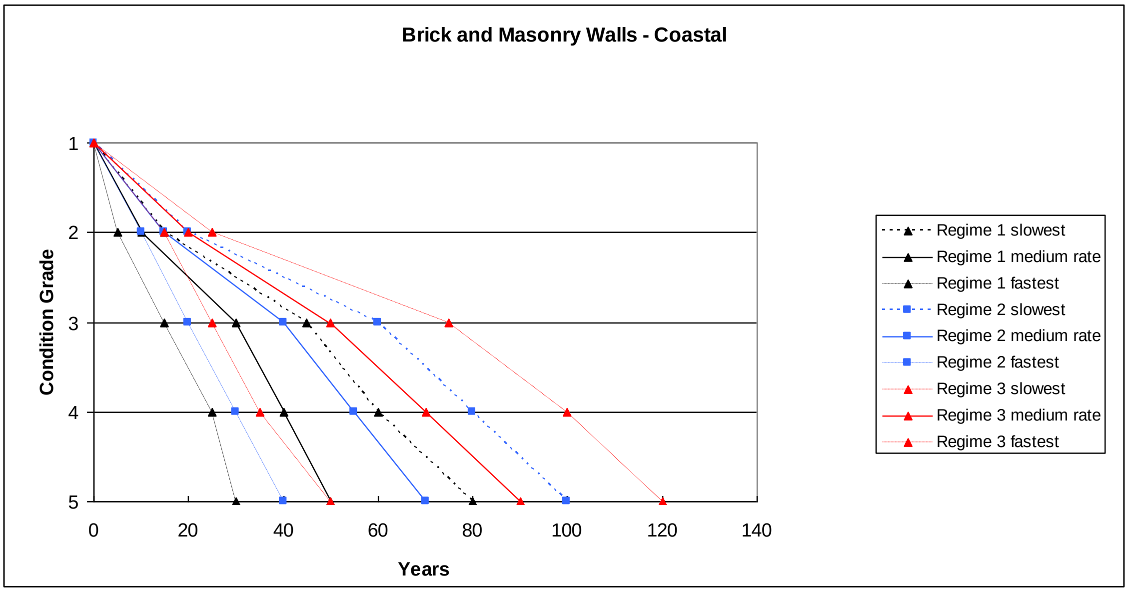
AIMS asset classification: Defence/wall

Models

Vertical Wall Brick and Masonry – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	70	80
2 – Medium	0	25	60	100	120
3 – High	0	30	70	130	160
Medium rate					
1 – Low/basic	0	15	35	50	60
2 – Medium	0	20	45	70	90
3 – High	0	25	55	90	120
Fastest rate					
1 – Low/basic	0	5	20	30	40
2 – Medium	0	10	30	50	60
3 – High	0	15	40	70	80



Vertical Wall Brick and Masonry – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	45	60	80
2 – Medium	0	20	60	80	100
3 – High	0	25	75	100	120
Medium rate					
1 – Low/basic	0	10	30	40	50
2 – Medium	0	15	40	55	70
3 – High	0	20	50	70	90
Fastest rate					
1 – Low/basic	0	5	15	25	30
2 – Medium	0	10	20	30	40
3 – High	0	15	25	35	50



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include those that compromise the integrity of the asset overall, for example:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Failure or damage to scour protection
4. Washout of fill
5. Settlement

and those that affect the integrity of the materials:

6. Abrasion damage
7. Damage to brickwork
8. Mortar/joint fill material loss
9. Cracks or fissuring

Scour protection and backfill replacement can be used to manage deterioration caused by processes 1 to 4 above. The material-based deterioration processes can be managed through brick repair/replacement, re-pointing and mortar/joint repair.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Toe scour
- Damage to scour protection
- Movement of structure
- Material degradation (mortar loss and damage to bricks)

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the brickwork due to wave action and increased abrasion and may result in an increased probability of toe scour leading to undermining. Deterioration rates are considered similar to concrete.

Fluvial slowest rate: The wall is in a protected location set back from the water's edge or it is a wall raising (wall extended in height, on an existing structure), and the material quality is appropriate for the environment/location. Foundations are assumed to be stable, construction is of a good quality and the asset is well designed.

Coastal slowest rate: The seawall is in a protected location at the back of the foreshore or it is at the top of a protected slope. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed with appropriate cover. There is little or no erosion risk in front of the wall. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time, and foundation material may suffer from erosion. The wall may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Beach levels may vary (dependent upon seasonal and storm conditions). The bed material may be a very coarse material and cause abrasion problems to the concrete, which in reinforced concrete may expose reinforcement leading to chloride ingress and corrosion of the bars. The water is either saline or brackish. The wall may suffer from poor quality materials and/or construction and/or design. The deterioration rate would increase from that in a fluvial environment.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks carried out are visual inspections of the wall. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by loss of surrounding support strata. The deterioration mechanisms would be through water ingress, mortar cracking/loss, loss of bricks and lack of repairs. Undermining of the toe may occur (exposed locations).

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including visual inspections of the wall from land, vegetation clearance, minor brickwork and joint repair, re-pointing, sealant replacement/repair, and scour protection/backfill replacement offsets material deterioration. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works), although some mortar cracking/loss, cracking of brick/blockwork and loss of brick/blocks and undermining of the toe may occur in exposed locations.

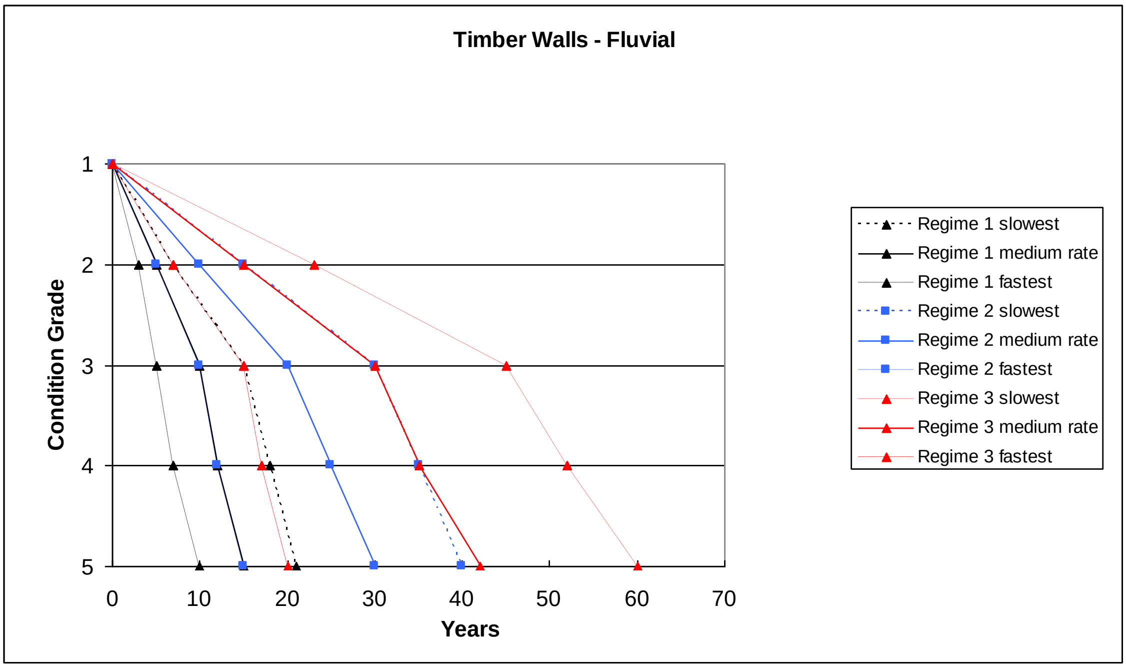
Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including visual inspections of the wall from land, vegetation clearance, minor brickwork and joint repair, re-pointing, sealant replacement/repair, and scour protection/backfill replacement offsets material deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

c. Timber (fluvial and coastal/estuarine)

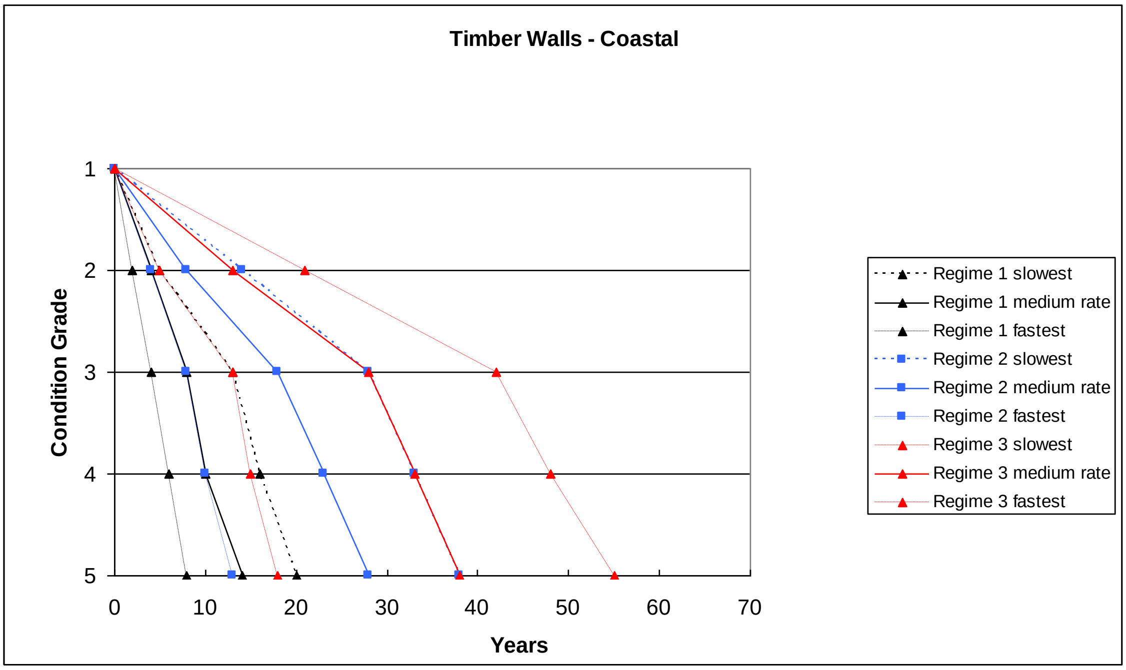
AIMS asset classification: Defence/wall

Models

Vertical Wall Timber – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	7	15	18	21
2 – Medium	0	15	30	35	40
3 – High	0	23	45	52	60
Medium rate					
1 – Low/basic	0	5	10	12	15
2 – Medium	0	10	20	25	30
3 – High	0	15	30	35	42
Fastest rate					
1 – Low/basic	0	3	5	7	10
2 – Medium	0	5	10	12	15
3 – High	0	7	15	17	20



Vertical Wall Timber – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	13	16	20
2 – Medium	0	14	28	33	38
3 – High	0	21	42	48	55
Medium rate					
1 – Low/basic	0	4	8	10	14
2 – Medium	0	8	18	23	28
3 – High	0	13	28	33	38
Fastest rate					
1 – Low/basic	0	2	4	6	8
2 – Medium	0	4	8	10	13
3 – High	0	5	13	15	18



Model assumptions

Design life

The design life of such an asset is approximately 25 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include those that compromise the integrity of the asset overall, for example:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Failure or damage to scour protection
4. Washout of fill
5. Settlement

and those that affect the integrity of the materials:

6. Abrasion damage
7. Chemical damage to timber components
8. Insect damage, rot or decay of timber components
9. Corrosion of fixings

Scour protection and backfill replacement can be used to manage deterioration caused by processes 1 to 4 above. The material-based deterioration processes can be managed through minor timber/joint/fixings repair, timber plank replacement and timber treatment.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Toe scour
- Damage to scour protection
- Movement of structure
- Material degradation (disintegration of components)

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the timber wall due to wave action and increased abrasion and may result in an increased probability of toe scour leading to undermining. The marine environment will have a detrimental effect on metal fixings leading to more rapid corrosion and functional loss.

Fluvial slowest rate: The wall is in a protected location set back from the water's edge or it is a crest wall. The material quality is appropriate for the environment/location. Foundations are assumed to be stable, construction is of a good quality and the asset is well designed. More applicable to hardwood structures.

Coastal slowest rate: The seawall is in a protected location at the back of the foreshore or it is at the top of a protected slope. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, the asset is well designed. There is little or no erosion risk in front of the wall. More applicable to hardwood structures.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time, and foundation material may suffer from erosion. The wall may suffer from poor quality materials/construction/design. More applicable to softwood structures.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Beach levels may vary (dependent upon seasonal and storm conditions). The bed material may be a very coarse material and cause abrasion problems to the timber and fixings, and there is a risk of marine borers. The water is either saline or brackish. The wall may suffer from poor quality materials and/or construction and/or design. The deterioration rate would increase from that in a fluvial environment. More applicable to softwood structures.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks carried out are visual inspections of the wall. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation, through rotting of individual timbers, fungal decay, infestations of marine borers and corrosion and failure of fixings, compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including visual inspections of the wall from land, vegetation clearance, minor timber, joint and fixings repair/treatment, sealant replacement/repair, and scour protection/backfill replacement offsets material deterioration. Actions include review of

H&S provisions and their repair/replacement (signs, hand railings, etc). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). Some material deterioration (e.g. rotting of individual timbers, fungal decay, infestations of marine borers, corrosion and failure of fixings) can be expected, especially in exposed coastal environments.

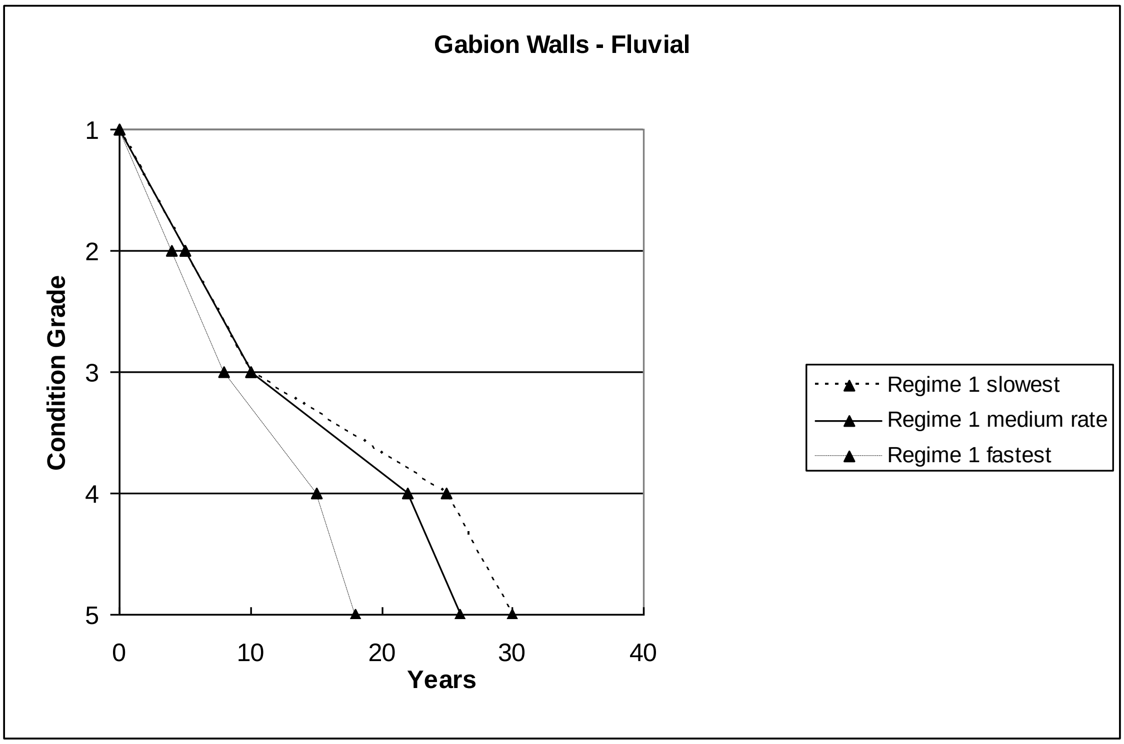
Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including visual inspections of the wall from land, vegetation clearance, minor timber, joint and fixings repair/treatment, sealant replacement/repair, and scour protection/backfill replacement offsets material deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

d. Gabion (fluvial and coastal/estuarine)

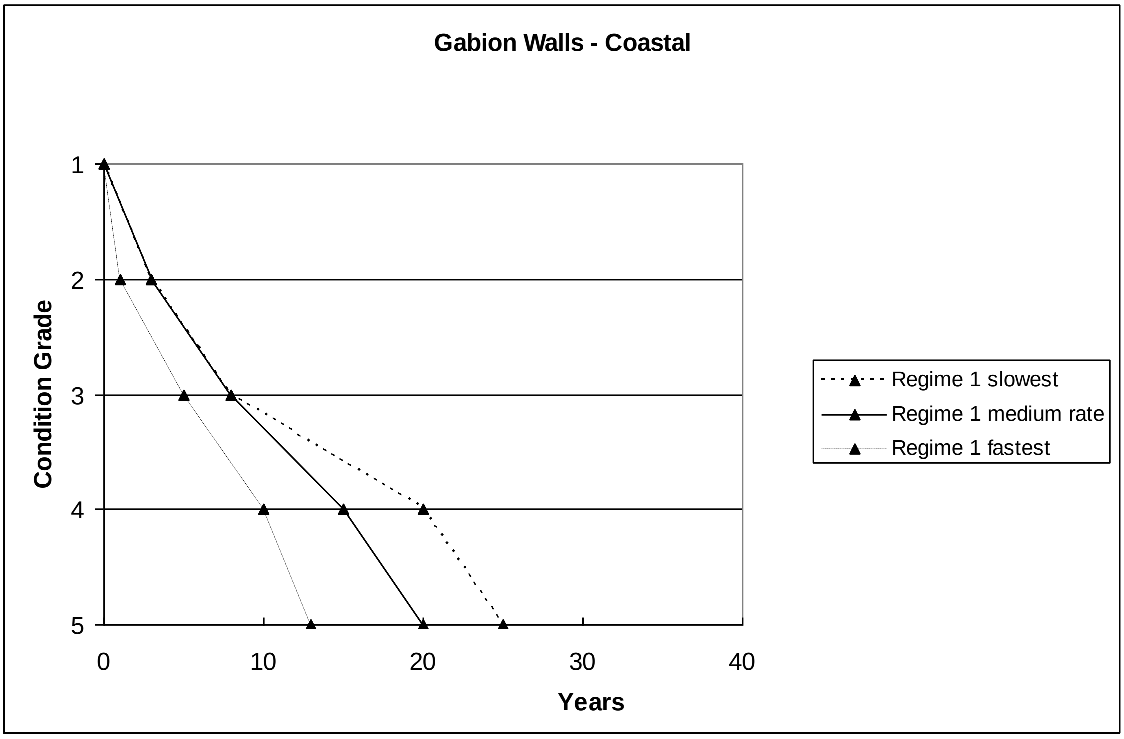
AIMS asset classification: Defence/wall/gabions

Models

Vertical Wall Gabion – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	25	30
2 – Medium	Only one maintenance regime for gabions. All other work is refurbishment				
3 – High	Only one maintenance regime for gabions. All other work is refurbishment				
Medium rate					
1 – Low/basic	0	5	10	22	26
2 – Medium	Only one maintenance regime for gabions. All other work is refurbishment				
3 – High	Only one maintenance regime for gabions. All other work is refurbishment				
Fastest rate					
1 – Low/basic	0	4	8	15	18
2 – Medium	Only one maintenance regime for gabions. All other work is refurbishment				
3 – High	Only one maintenance regime for gabions. All other work is refurbishment				



Vertical Wall Gabion – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	3	8	20	25
2 – Medium	Only one maintenance regime for gabions. All other work is refurbishment				
3 – High	Only one maintenance regime for gabions. All other work is refurbishment				
Medium rate					
1 – Low/basic	0	3	8	15	20
2 – Medium	Only one maintenance regime for gabions. All other work is refurbishment				
3 – High	Only one maintenance regime for gabions. All other work is refurbishment				
Fastest rate					
1 – Low/basic	0	1	5	10	13
2 – Medium	Only one maintenance regime for gabions. All other work is refurbishment				
3 – High	Only one maintenance regime for gabions. All other work is refurbishment				



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include those that compromise the integrity of the asset overall, for example:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Failure or damage to scour protection
4. Settlement

and those that affect the integrity of the materials:

5. Abrasion damage
6. Deformation of gabions
7. Corrosion and breakage of wires in gabions
8. Missing bricks/blocks or loss of fill material in gabions

Scour protection can be used to manage deterioration caused by processes 1 to 3 above. The material-based deterioration processes can be managed through repair/rewiring of gabion cages and replacing connecting wires and by refilling gabion cages. These activities are, however, classed as refurbishment and not maintenance.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Toe scour
- Washout of fill
- Movement of structure
- Disintegration of basket/rock packing

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the gabion wall due to wave action and increased abrasion (e.g. of plastic coatings by sand transport) and may result in an increased probability of toe scour leading to undermining. The acidity and salinity of water will influence rate of deterioration of metal components leading to more rapid corrosion and functional loss.

Fluvial slowest rate: The gabions are in a protected location set back from the water's edge. The material quality is appropriate for the environment/location. Foundations are assumed to be stable, and construction is of a good quality.

Coastal slowest rate: The gabions are in a protected location at the back of the foreshore. Parts of them are submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the wall.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time. The asset may also suffer from poor quality or inappropriate materials.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Beach levels may vary (dependent upon seasonal and storm conditions). The bed material may be a very coarse material and cause abrasion problems to the timber and fixings, and there is a risk of marine borers. The water is either saline or brackish. The wall may suffer from poor quality materials and/or construction and/or design. The deterioration rate would increase from that in a fluvial environment.

Effect of maintenance regime

It is difficult to carry out any effective maintenance, and therefore it is unlikely that there would be any differentiation between Regimes 1, 2 and 3.

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks likely to be carried out on gabions are visual inspections of the wall. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by loss of surrounding support strata.

Maintenance Regime 2: Not applicable to gabion walls.

Maintenance Regime 3: Not applicable to gabion walls.

C.2 Sheet piled structures

a. Anchored steel (fluvial and coastal/estuarine)

AIMS asset classification: Defence/wall/piling

Figure C2 shows a basic line sketch of this type of asset: sheet piled structure – anchored steel.

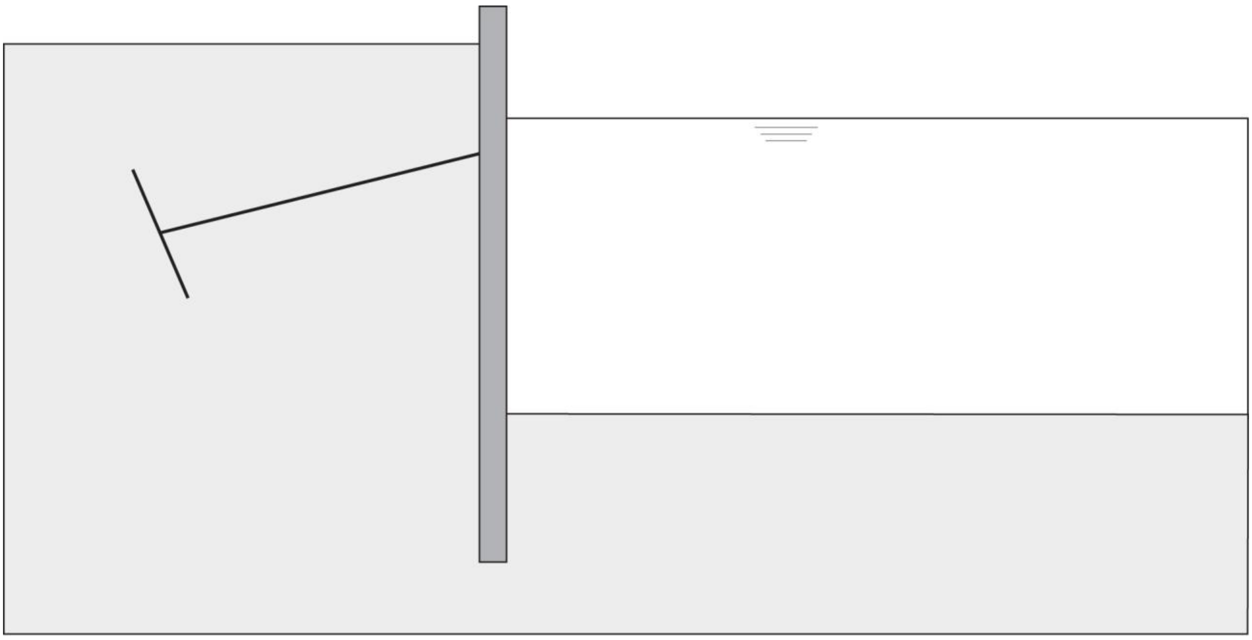
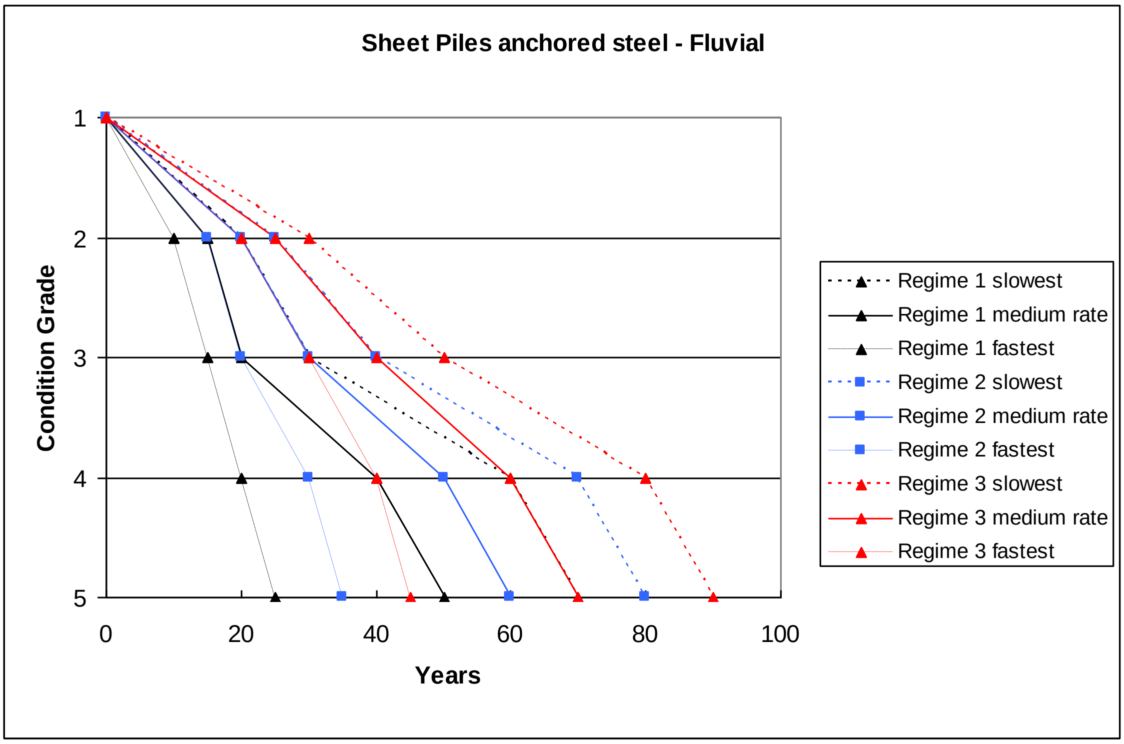


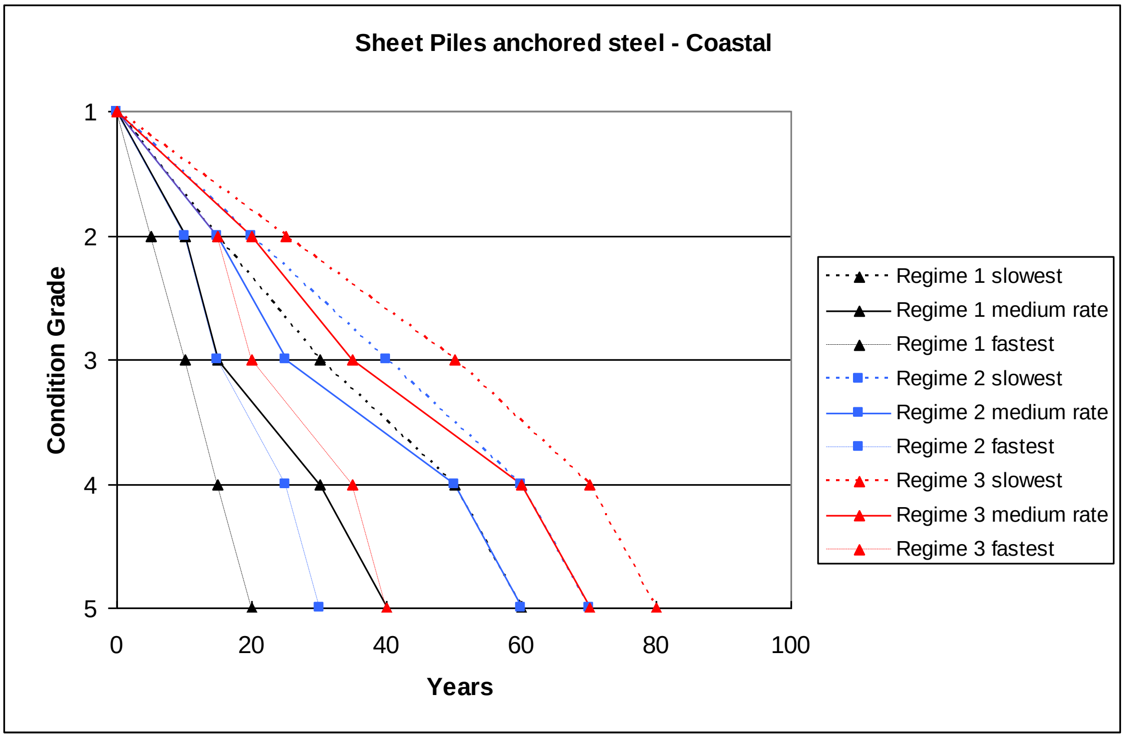
Figure C2 Sheet piled structure – anchored steel

Models

Sheet piled structures anchored steel – fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	30	60	70
2 – Medium	0	25	40	70	80
3 – High	0	30	50	80	90
Medium rate					
1 – Low/basic	0	15	20	40	50
2 – Medium	0	20	30	50	60
3 – High	0	25	40	60	70
Fastest rate					
1 – Low/basic	0	10	15	20	25
2 – Medium	0	15	20	30	35
3 – High	0	20	30	40	45



Sheet piled structures anchored steel – coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	30	50	60
2 – Medium	0	20	40	60	70
3 – High	0	25	50	70	80
Medium rate					
1 – Low/basic	0	10	15	30	40
2 – Medium	0	15	25	50	60
3 – High	0	20	35	60	70
Fastest rate					
1 – Low/basic	0	5	10	15	20
2 – Medium	0	10	15	25	30
3 – High	0	15	20	35	40



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include those that compromise the integrity of the asset overall, for example:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Settlement

and those that affect the integrity of the materials:

4. Corrosion of sheet piles or reinforcement including ALWC (Accelerated Low Water Corrosion)
5. Chemical damage to timber components
6. Insect damage, rot or decay of timber components
7. Damage to structural components (e.g. tie-rod or anchorage system)
8. Abrasion damage
9. Fatigue of steel

Scour protection and backfill replacement can be used to manage deterioration caused by processes 1 and 2 above. The material-based deterioration processes 4 to 8 can be managed through corrosion protection works, timber treatment and minor repair works. Fatigue of steel would require refurbishment rather than maintenance.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Toe scour
- Movement of structure
- Material degradation (disintegration of components)

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the steel wall due to wave action and increased abrasion and may result in an increased probability of toe scour leading to undermining. The saline marine environment will have a detrimental effect on the steel components, leading to more rapid corrosion and functional loss. Similarly timber components are also expected to degrade more rapidly in a marine environment.

Fluvial slowest rate: The wall is in a protected location set back from the water's edge or it is a crest wall. The material quality is appropriate for the environment/location, and is protected by an appropriate coating system. Construction is of a good quality, and the asset is well designed.

Coastal slowest rate: The wall is in a protected location at the back of the foreshore or it is a crest wall. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. The wall is protected by an appropriate coating system, construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the wall. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time. Also it may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. The bed material may cause abrasion problems just above the bed level. Part of the wall is submerged at all states of the tide. If the splash zone coincides with the point of maximum bending moment in the pile, then corrosion will reduce structural capacity of the section, leading to early failure of the pile. The water is either saline or brackish. Also it may suffer from poor quality materials/construction/design. The deterioration rate would increase from that in a fluvial environment.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks carried out are visual inspections of the wall from land. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including visual inspections of the wall from land, vegetation clearance, minor repair, corrosion protection/prevention (e.g. painting) and timber treatment (to timber components) and scour protection/backfill replacement offsets material deterioration. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including visual inspections of the wall from land, vegetation clearance, minor repair, corrosion protection/prevention (e.g. painting) and timber treatment (to timber components) and scour protection/backfill replacement offsets material deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

b. Cantilevered steel (fluvial and coastal/estuarine)

AIMS asset classification: Defence/wall/piling

Figure C3 shows a basic line sketch of this type of asset: sheet piled structure – cantilevered steel.

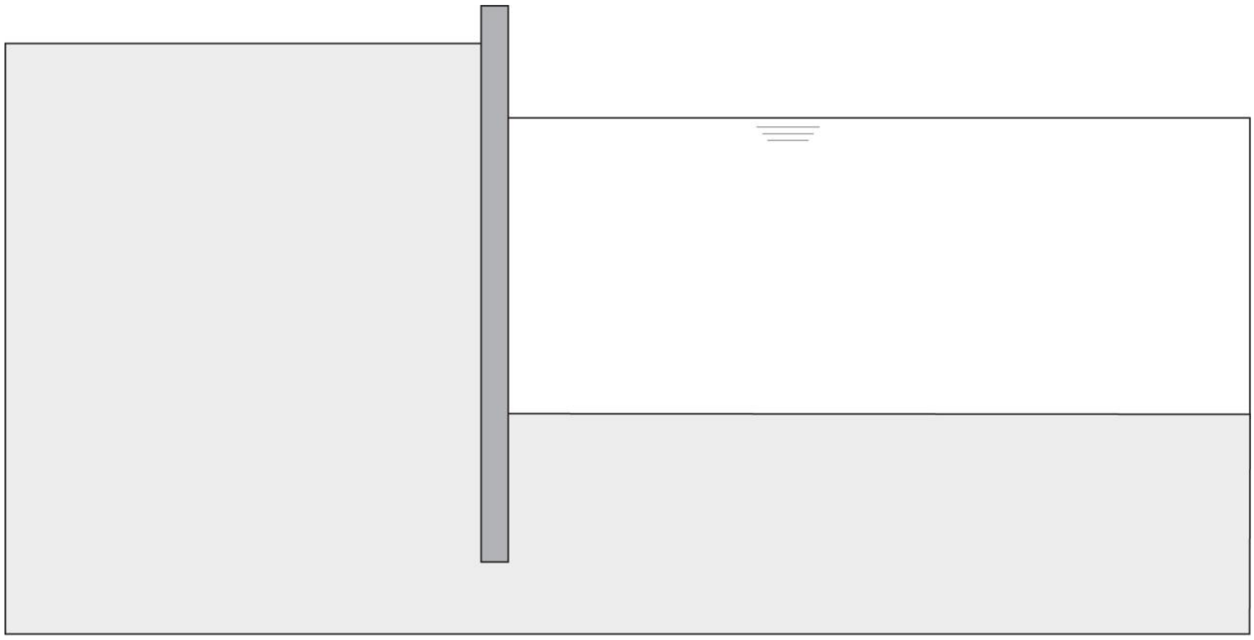
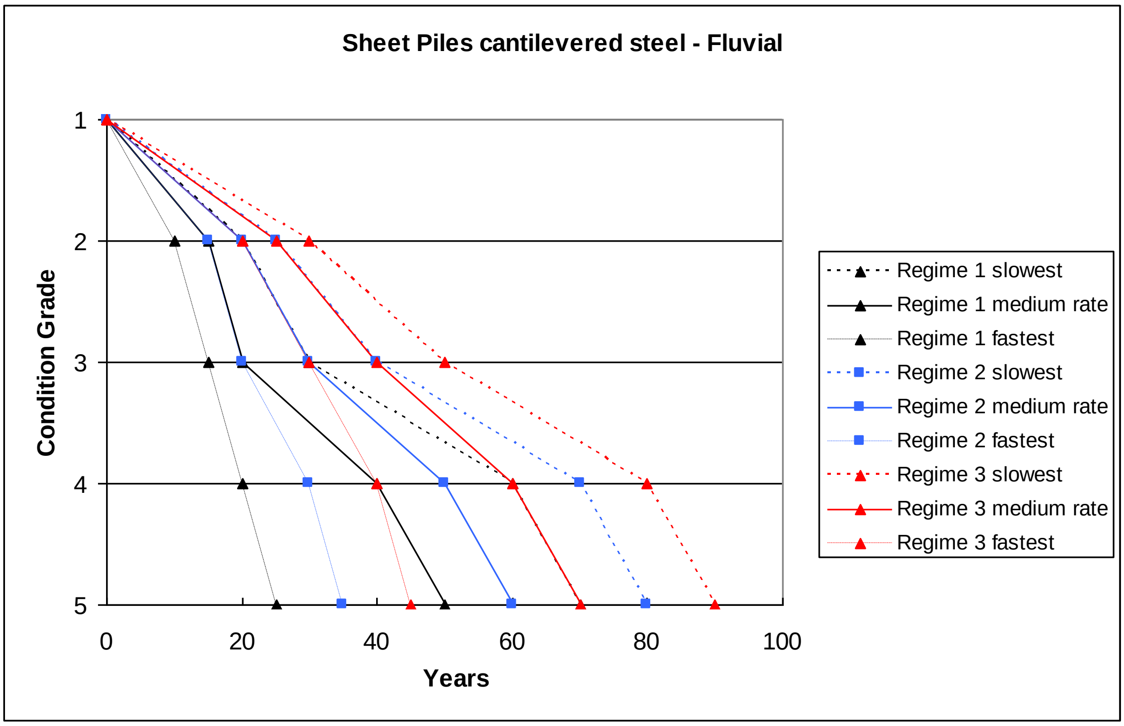


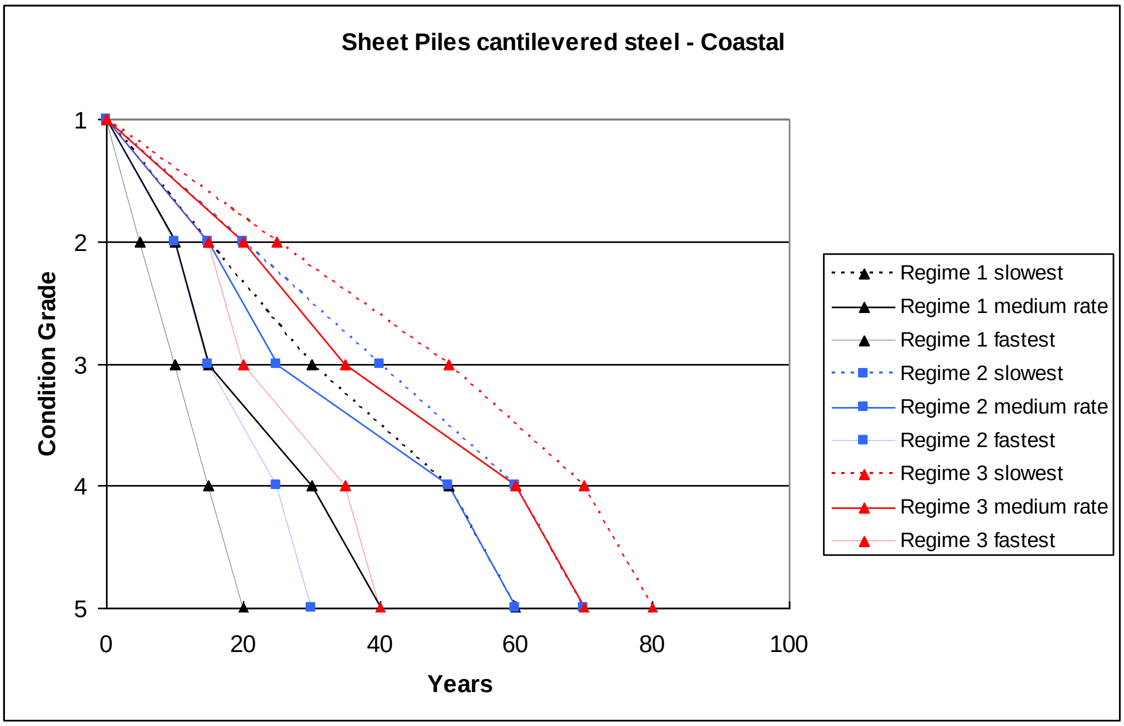
Figure C3 Sheet piled structure – cantilevered steel

Models

Sheet Piled Structures Cantilevered Steel – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	30	60	70
2 – Medium	0	25	40	70	80
3 – High	0	30	50	80	90
Medium rate					
1 – Low/basic	0	15	20	40	50
2 – Medium	0	20	30	50	60
3 – High	0	25	40	60	70
Fastest rate					
1 – Low/basic	0	10	15	20	25
2 – Medium	0	15	20	30	35
3 – High	0	20	30	40	45



Sheet Piled Structures Cantilevered Steel – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	30	50	60
2 – Medium	0	20	40	60	70
3 – High	0	25	50	70	80
Medium rate					
1 – Low/basic	0	10	15	30	40
2 – Medium	0	15	25	50	60
3 – High	0	20	35	60	70
Fastest rate					
1 – Low/basic	0	5	10	15	20
2 – Medium	0	10	15	25	30
3 – High	0	15	20	35	40



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include those that compromise the integrity of the asset overall, for example:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Settlement

and those that affect the integrity of the materials:

4. Corrosion of sheet piles or reinforcement including ALWC (Accelerated Low Water Corrosion)
5. Chemical damage to timber components
6. Insect damage, rot or decay of timber components
7. Damage to structural components
8. Abrasion damage
9. Fatigue of steel

Scour protection and backfill replacement can be used to manage deterioration caused by processes 1 and 2 above. The material-based deterioration processes 4 to 8 can be managed through corrosion protection works, timber treatment and minor repair works. Fatigue of steel would require refurbishment rather than maintenance.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Toe scour
- Movement of structure
- Material degradation (disintegration of components)

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the steel wall due to wave action and increased abrasion and may result in an increased probability of toe scour leading to undermining. The saline marine environment will have a detrimental effect on the steel components, leading to more rapid corrosion and functional loss. Similarly timber components are also expected to degrade more rapidly in a marine environment.

Fluvial slowest rate: The wall is in a protected location set back from the water's edge or it is a crest wall. The material quality is appropriate for the environment/location, and is protected by an appropriate coating system. Construction is of a good quality, and the asset is well designed.

Coastal slowest rate: The wall is in a protected location at the back of the foreshore or it is a crest wall. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. The wall is protected by an appropriate coating system, construction is of a good quality and the asset is well designed. There is little or no erosion risk in front of the wall. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time. Also it may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. The bed material may cause abrasion problems just above the bed level. Part of the wall is submerged at all states of the tide. If the splash zone coincides with the point of maximum bending moment in the pile, then corrosion will reduce structural capacity of the section, leading to early failure of the pile. The water is either saline or brackish. Also it may suffer from poor quality materials/construction/design. The deterioration rate would increase from that in a fluvial environment.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks carried out are visual inspections of the wall from land. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including visual inspections of the wall from land, vegetation clearance, minor repair, corrosion protection/prevention (e.g. painting) and timber treatment (to timber components) and scour protection/backfill replacement offsets material deterioration. Actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including visual inspections of the wall from land, vegetation clearance, minor repair, corrosion protection/prevention (e.g. painting) and timber treatment (to timber components) and scour protection/backfill replacement offsets material deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.3 Demountable defences

Figure C4 shows a basic line sketch of this type of asset: demountable defence – metal or wood.

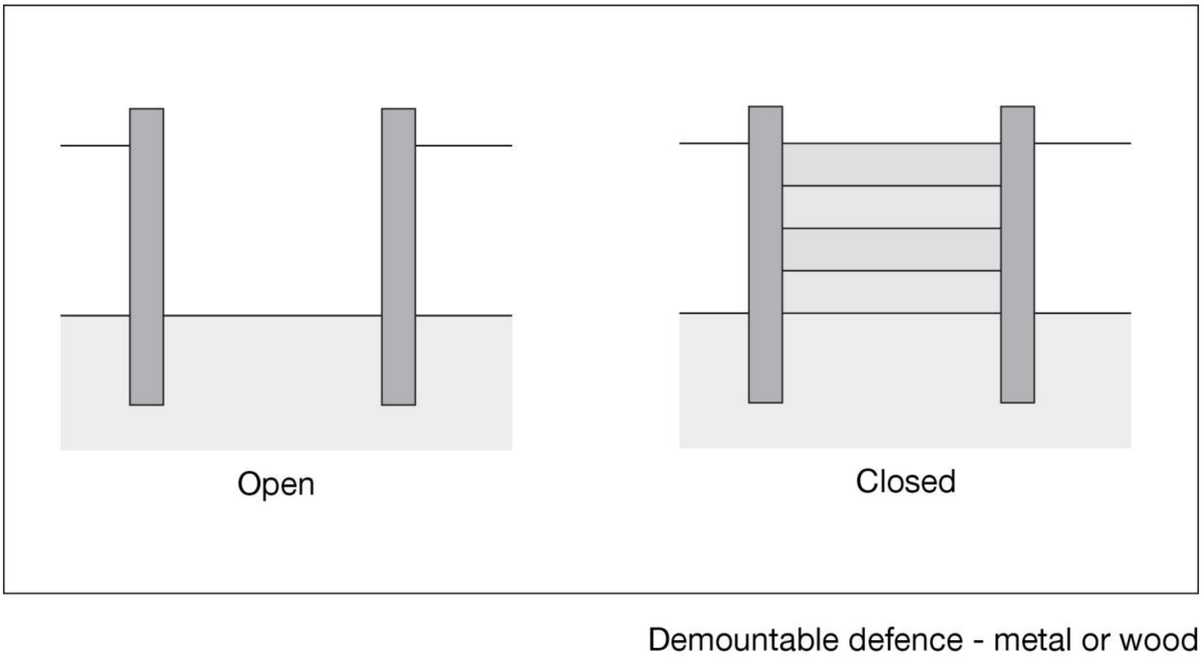


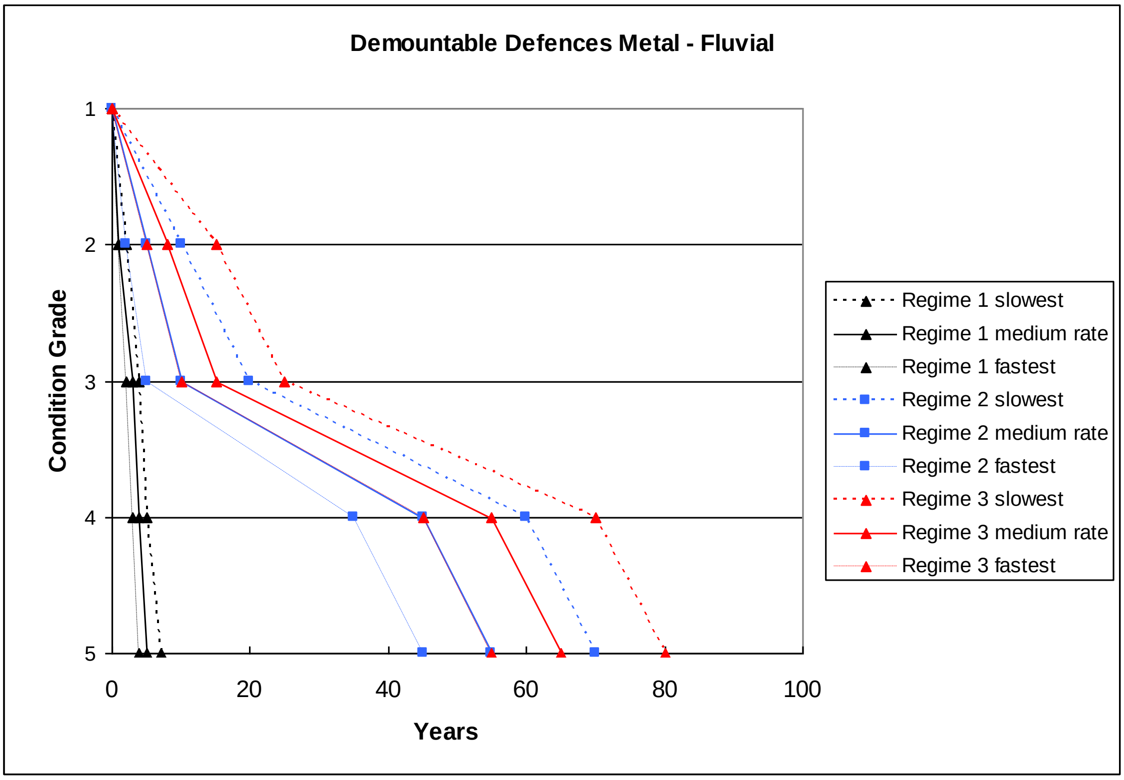
Figure C4 Demountable defence – metal or wood

a. Metal (fluvial)

AIMS asset classification: Defence/demountable

Models

Demountable Defences Metal – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	2	4	5	7
2 – Medium	0	10	20	60	70
3 – High	0	15	25	70	80
Medium rate					
1 – Low/basic	0	1	3	4	5
2 – Medium	0	5	10	45	55
3 – High	0	8	15	55	65
Fastest rate					
1 – Low/basic	0	1	2	3	4
2 – Medium	0	2	5	35	45
3 – High	0	5	10	45	55



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

These types of defences can take many forms: be free standing, framed, flexible or rigid. The defence will require a permanent foundation with cast-in fixing points, and a mechanism to tie into the permanent defence (end connection).

The deterioration processes affecting these assets include:

1. Support walls damaged or collapsed
2. Obstruction preventing deployment/erection
3. Anchorage points damaged or missing
4. Gaps present between elements
5. Corrosion/decay of elements
6. Seals missing or perished
7. Handling points damaged/missing

Repair of structures, replacement of parts and corrosion prevention treatment are possible during maintenance works. Closure of small gaps (process 4 above) may be possible on site. Major replacement of defence components is considered refurbishment.

The following deterioration processes dominate the rate of deterioration:

- Material degradation (disintegration of components)
- Third party interference/obstructions

Effect of environmental exposure/material quality

Deterioration rates: Slowest, medium and fastest relate to impact of influencing factors such as quality of materials/construction and general specification and to influence of environmental factors such as wave action/water turbulence and force and sediment abrasion.

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. This curve relates predominantly to the likelihood of extreme and rapid material degradation.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including minor repair and corrosion prevention offsets material deterioration. Maintenance includes: for fixing points and sealing plate (ground) – checking cover plates, cleaning and lubricating fixing points and sealing plate; for stanchions – cleaning after use and checking for wear and damage; for dam beams – cleaning after use, checking for wear, damage or loss; for dam beam seals (EDPM, neoprene, etc) – checking for wear, damage and loss, replacement of seals; for end connections – cleaning and checking for wear, damage, etc.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance as above but with increased frequency and more stringent criteria for repair.

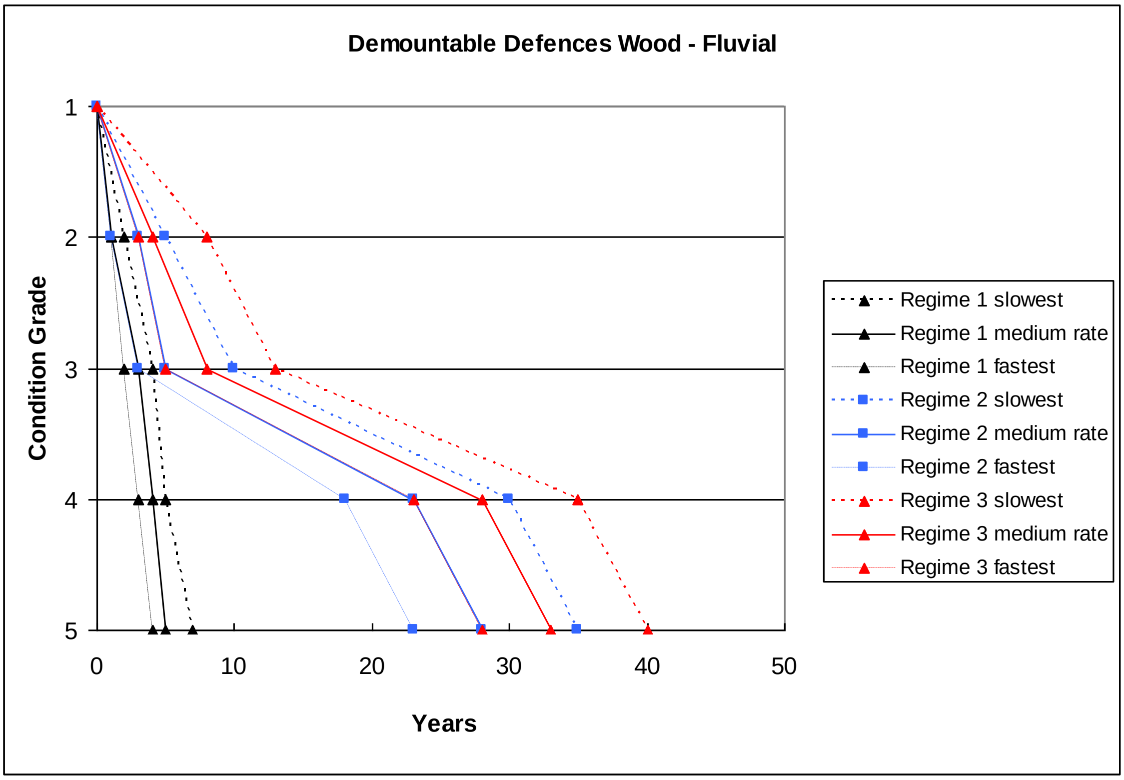
General note: It is evident that maintenance can prolong the life of these assets considerably. With well-maintained assets (Regimes 2 and 3), the deterioration rate only accelerates when the asset is in CG 4 (evidenced by the shorter time intervals in this grade, compared to CG 3). This is attributed to the fact that the asset is less able to withstand the regularly occurring loadings, in view of the presence of progressively more cracks, interstices, discontinuities and crevices, which will then have proportionally bigger effects.

b. Wood (fluvial)

AIMS asset classification: Defence/demountable

Models

Demountable Defences Wood – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	2	4	5	7
2 – Medium	0	5	10	30	35
3 – High	0	8	13	35	40
Medium rate					
1 – Low/basic	0	1	3	4	5
2 – Medium	0	3	5	23	28
3 – High	0	4	8	28	33
Fastest rate					
1 – Low/basic	0	1	2	3	4
2 – Medium	0	1	3	18	23
3 – High	0	3	5	23	28



Model assumptions

General

Values based upon demountable defences – metal – as follows:

- Maintenance Regime 1 as for metal defences.
- Maintenance Regimes 2 and 3 assumed to be half time (rounded up) of metal defences.

Timber is considered to be less durable than steel.

Design life

The design life of such an asset is approximately 25 to 40 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

These types of defences can take many forms: be free standing, framed, flexible or rigid. The defence will require a permanent foundation with cast-in fixing points, and a mechanism to tie into the permanent defence (end connection).

The deterioration processes affecting these assets include:

1. Support walls damaged or collapsed
2. Obstruction preventing deployment/erection
3. Anchorage points damaged or missing
4. Gaps present between elements
5. Corrosion/decay of elements
6. Seals missing or perished
7. Handling points damaged/missing

Repair of structures, replacement of parts and timber treatment is possible during maintenance works. Closure of small gaps (process 4 above) may be possible on site. Major replacement of defence components is considered refurbishment.

The following deterioration processes dominate the rate of deterioration:

- Material degradation (disintegration of components)
- Third party interference/obstructions

Effect of environmental exposure/material quality

Deterioration rates: Slowest, medium and fastest relate to impact of influencing factors such as quality of materials/construction and general specification and to impact of environmental factors such as wave action/water turbulence and force and sediment abrasion.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid material degradation.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including minor repair and timber treatment offsets material deterioration. Maintenance includes: for fixing points and sealing plate (ground) – checking cover plates, cleaning and lubricating fixing points and sealing plate; for stanchions – cleaning after use and checking for wear and damage; for dam beams – cleaning after use, checking for wear, damage or loss; for dam beam seals (EDPM, neoprene, etc) – checking for wear, damage and loss, replacement of seals; for end connections – cleaning and checking for wear, damage, etc.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance as above but with increased frequency and more stringent criteria for repair.

General note: It is evident that maintenance can prolong the life of these assets considerably. With well-maintained assets (Regimes 2 and 3), the deterioration rate only accelerates when the asset is in CG 4 (evidenced by the shorter time intervals in this grade, compared to CG 3). This is attributed to the fact that the asset is less able to withstand the regularly occurring loadings, in view of the presence of progressively more cracks, interstices, discontinuities and crevices, which will then have proportionally bigger effects.

C.4 Earth dykes or embankments

a. Varying core material, e.g. clay, shale (fluvial and coastal/estuarine)

AIMS asset classification: Defence/embankment

Figure C5 shows a basic line sketch of this type of asset: earth dykes or embankments – varying core material.

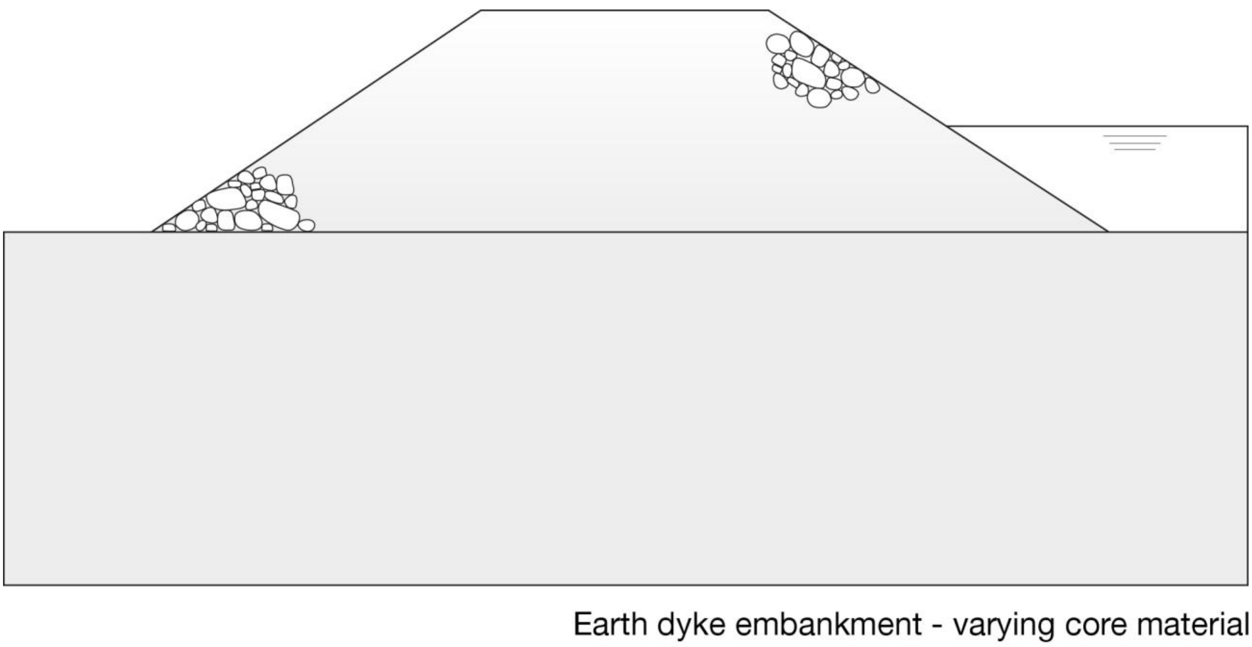
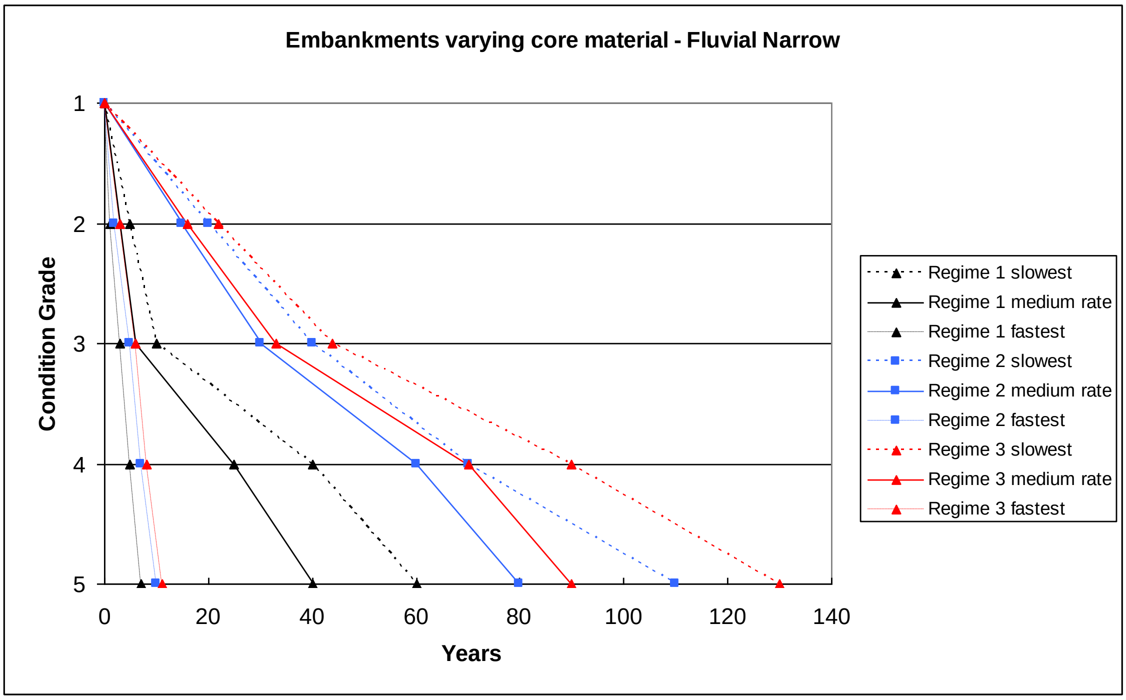


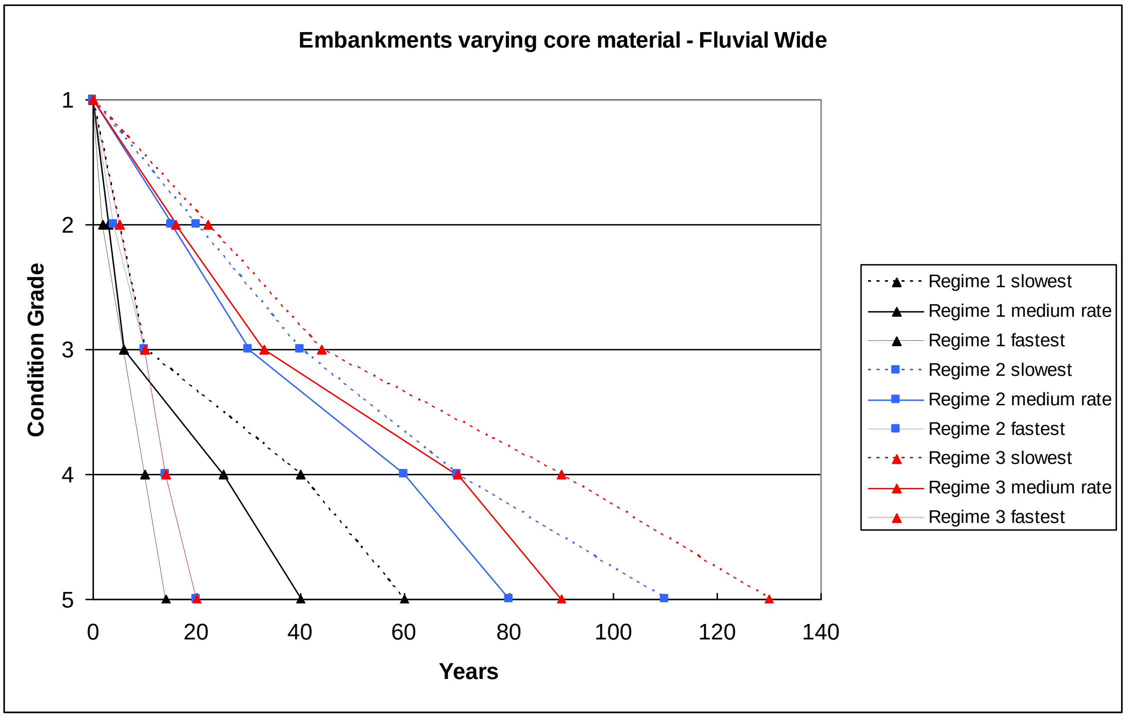
Figure C5 Earth dykes and embankments – varying core material

Models

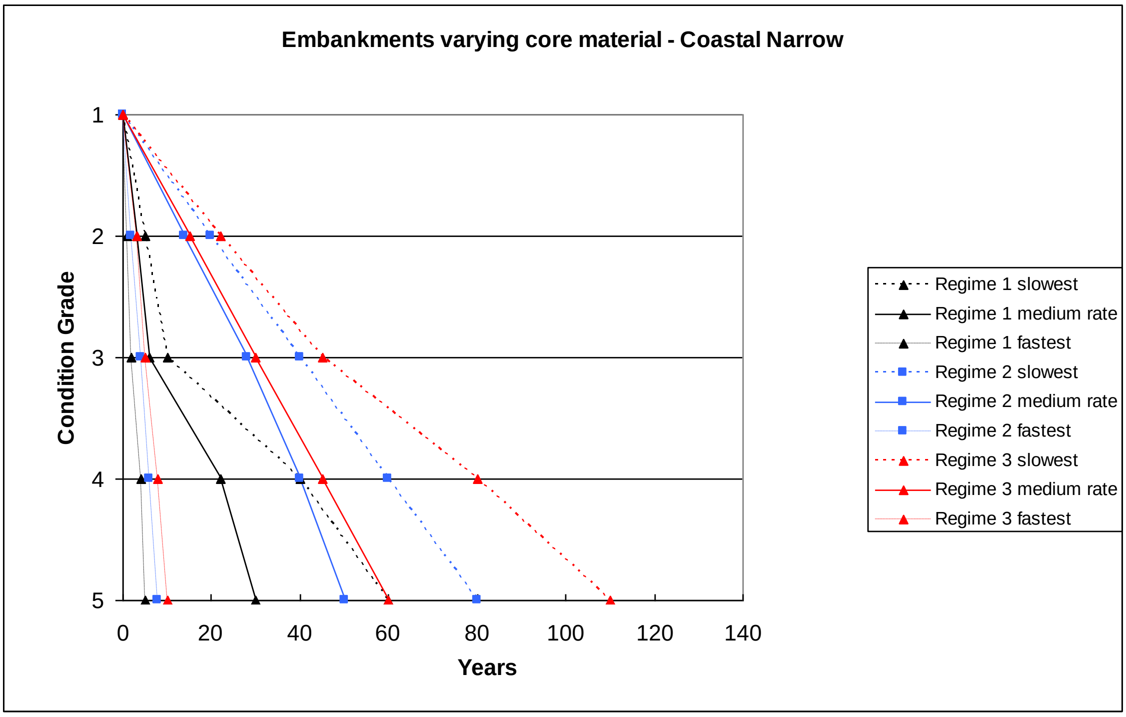
Earth Dykes and Embankments varying core material – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	40	60
2 – Medium	0	20	40	70	110
3 – High	0	22	44	90	130
Medium rate					
1 – Low/basic	0	3	6	25	40
2 – Medium	0	15	30	60	80
3 – High	0	16	33	70	90
Fastest rate					
1 – Low/basic	0	1	3	5	7
2 – Medium	0	2	5	7	10
3 – High	0	3	6	8	11



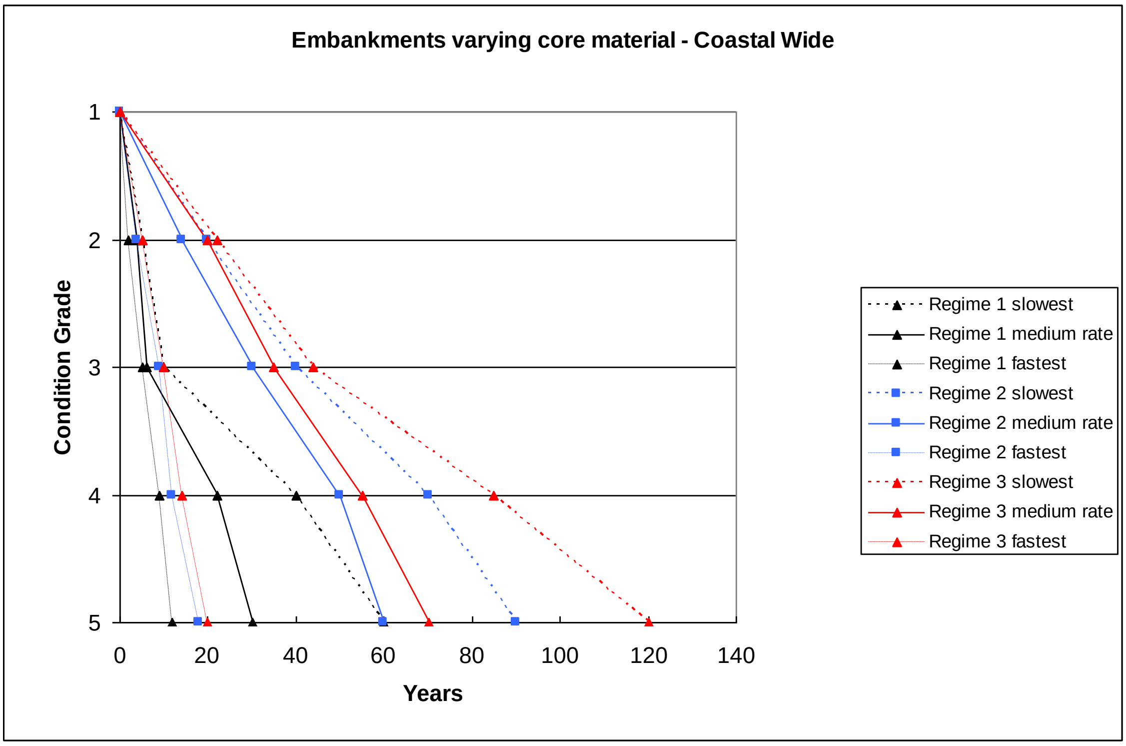
Earth Dykes and Embankments varying core material – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	40	60
2 – Medium	0	20	40	70	110
3 – High	0	22	44	90	130
Medium rate					
1 – Low/basic	0	3	6	25	40
2 – Medium	0	15	30	60	80
3 – High	0	16	33	70	90
Fastest rate					
1 – Low/basic	0	2	6	10	14
2 – Medium	0	4	10	14	20
3 – High	0	5	10	14	20



Earth Dykes and Embankments varying core material – Coastal/estuarine Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	40	60
2 – Medium	0	20	40	60	80
3 – High	0	22	45	80	110
Medium rate					
1 – Low/basic	0	3	6	22	30
2 – Medium	0	14	28	40	50
3 – High	0	15	30	45	60
Fastest rate					
1 – Low/basic	0	1	2	4	5
2 – Medium	0	2	4	6	8
3 – High	0	3	5	8	10



Earth Dykes and Embankments varying core material – Coastal/estuarine Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	40	60
2 – Medium	0	20	40	70	90
3 – High	0	22	44	85	120
Medium rate					
1 – Low/basic	0	4	6	22	30
2 – Medium	0	14	30	50	60
3 – High	0	20	35	55	70
Fastest rate					
1 – Low/basic	0	2	5	9	12
2 – Medium	0	4	9	12	18
3 – High	0	5	10	14	20



Model assumptions

Design life

The design life of such an asset is approximately 50 to 100 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Settlement
4. Lateral movement or sliding
5. Shallow failures within slope
6. Vegetation damage or loss (grass cover)
7. Erosion/scour of embankment
8. Loss of fines due to seepage/infiltration
9. Cracking or fissuring
10. Crest or slope damage from animals, vehicles or people

Maintenance will control only processes 8 to 10, for example with vermin and vegetation control and minor repair to embankment (for surface cracking, rutting, erosion).

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Backfill washout
- Animal burrows
- Movement of structure
- Structural damage to slopes/crest

Piping and overtopping are typical failure modes.

Effect of asset width

For fluvial environments, narrow and wide assets are covered by the same deterioration curves for slowest and medium deterioration. Their differences in this environment and condition are not considered to have a significant overall effect. For fastest deterioration, the wide asset is considered less vulnerable to geotechnical problems – the main factor in fastest deterioration conditions – and deteriorates at a slower rate.

For coastal embankments, wide assets are predicted to deteriorate more slowly than the narrow counterparts, being better able to withstand the more aggressive environment. Wide assets are less susceptible to washout of backfill when overtopping occurs because of their size.

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the embankment due to wave action and increased abrasion and may result in an increased probability of damage to slopes and crests and toe erosion.

Fluvial slowest rate: The embankment is in a protected location set back from the water's edge, the material quality is appropriate for the environment/location, construction is of a good quality and the asset is well designed. In this scenario, the rate of asset degradation will be driven by the rate of deterioration of natural vegetation (the scenario assumes no vermin or rutting and no geotechnical problems).

Coastal slowest rate: The embankment is in a protected location at the back of the foreshore. Part of the asset is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the embankment. The deterioration rate would increase from that in a fluvial environment and be governed by the same factors (deterioration of natural vegetation).

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time. Also it may suffer from poor quality materials/soils/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Part of the embankment is submerged at all states of the tide. The water is either saline or brackish. Also it may suffer from poor quality materials/soils/construction/design. The deterioration rate would increase from that in a fluvial environment due to the impact of waves. The rate of deterioration in this scenario is likely to be driven by deterioration relating to overtopping leading to breach or a slip failure in the embankment.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through erosion/backfill washout compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including vermin and vegetation control and minor repair to embankment (for surface cracking, rutting, erosion) offsets asset degradation. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including vermin and vegetation control and minor repair to embankment (for surface cracking, rutting, erosion) offsets asset degradation (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Works

Normal maintenance: grass cutting, vermin control and repairs to rutting. Topping up and settlement work is considered refurbishment.

b. With slope/toe protection or revetment (fluvial and coastal/estuarine)

AIMS asset classification: Defence/embankment

Figure C6 shows a basic line sketch of this type of asset: earth dykes or embankments – with slope/toe protection or revetment.

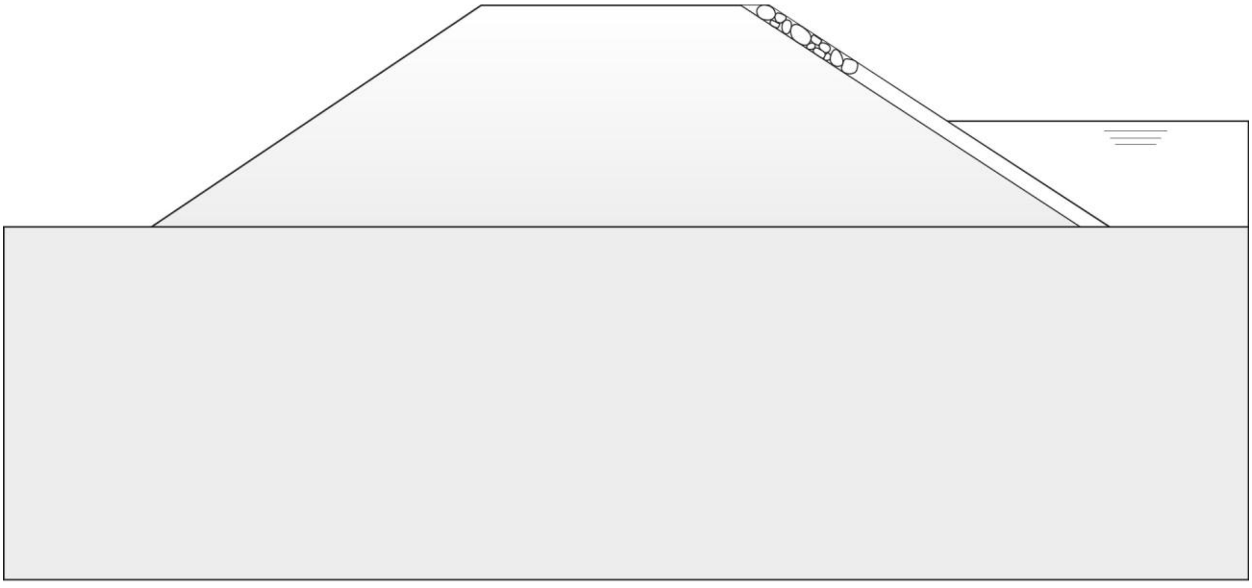
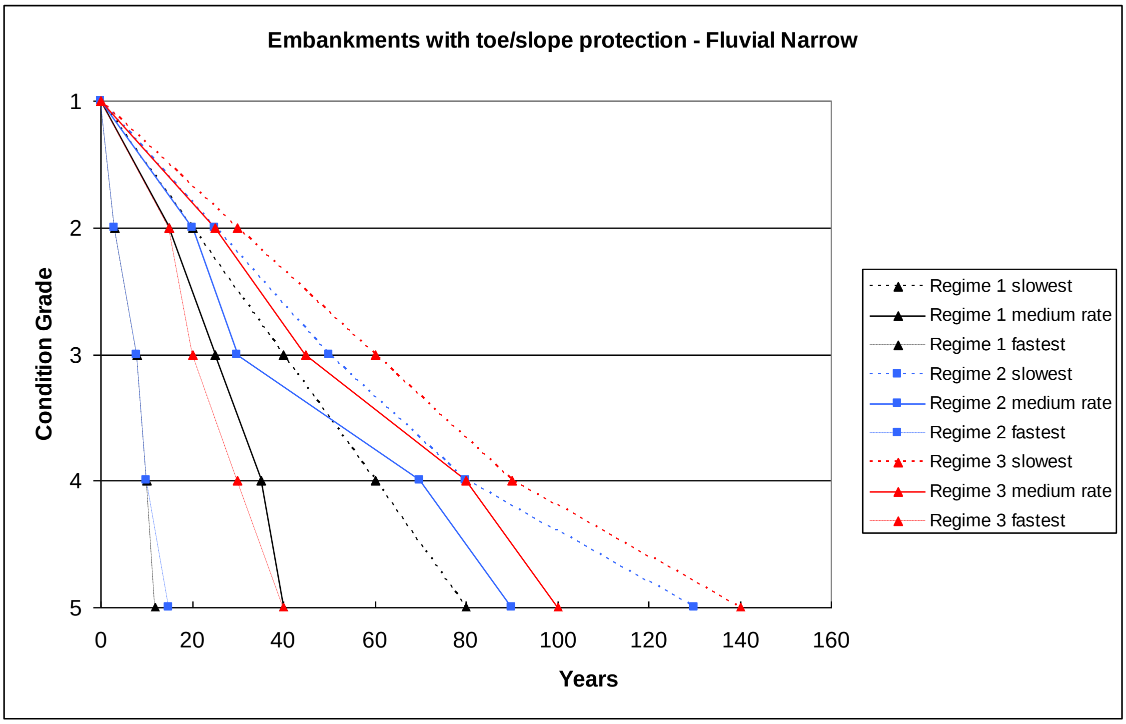


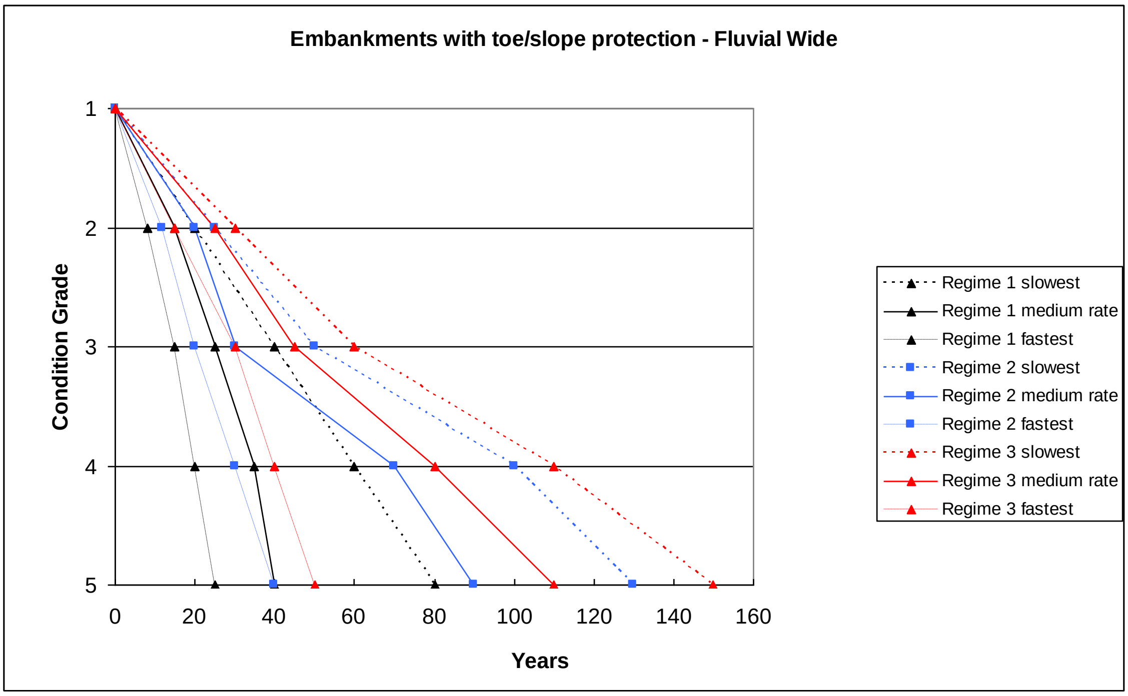
Figure C6 Earth dykes and embankments – with slope/toe protection or revetment

Models

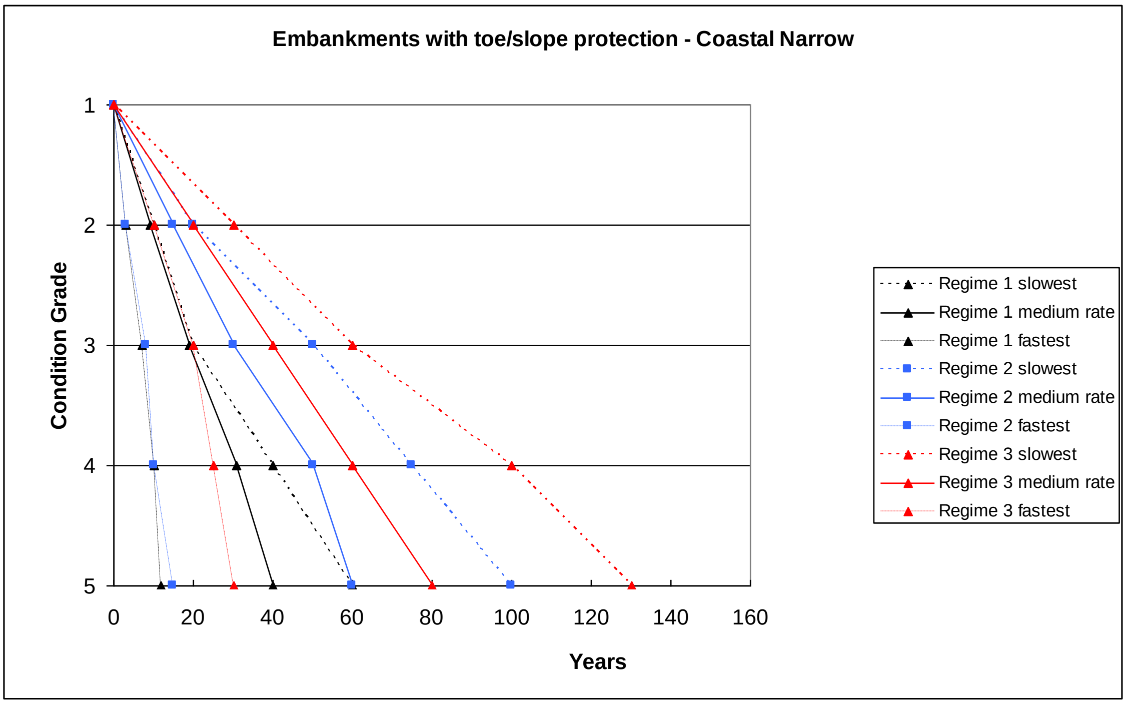
Earth Dykes and Embankments with toe/slope protection – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	80	130
3 – High	0	30	60	90	140
Medium rate					
1 – Low/basic	0	15	25	35	40
2 – Medium	0	20	30	70	90
3 – High	0	25	45	80	100
Fastest rate					
1 – Low/basic	0	3	8	10	12
2 – Medium	0	3	8	10	15
3 – High	0	15	20	30	40



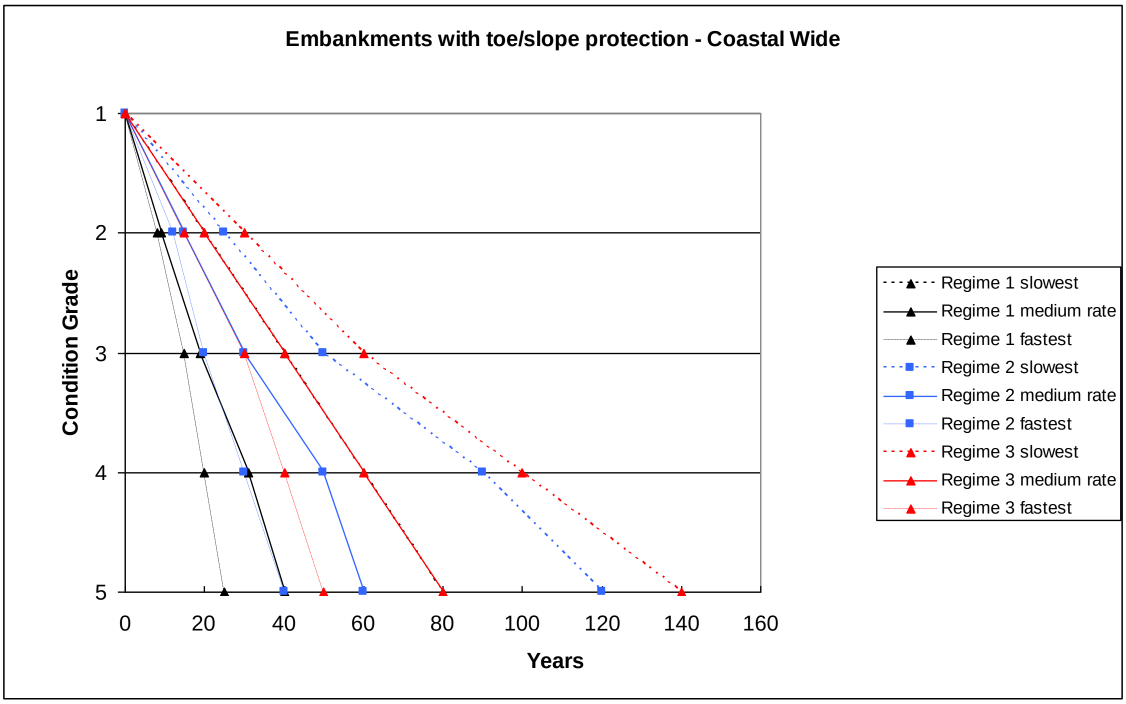
Earth Dykes and Embankments with toe/slope protection – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	100	130
3 – High	0	30	60	110	150
Medium rate					
1 – Low/basic	0	15	25	35	40
2 – Medium	0	20	30	70	90
3 – High	0	25	45	80	110
Fastest rate					
1 – Low/basic	0	8	15	20	25
2 – Medium	0	12	20	30	40
3 – High	0	15	30	40	50



Earth Dykes and Embankments with toe/slope protection – Coastal/estuarine Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	10	20	40	60
2 – Medium	0	20	50	75	100
3 – High	0	30	60	100	130
Medium rate					
1 – Low/basic	0	9	19	31	40
2 – Medium	0	15	30	50	60
3 – High	0	20	40	60	80
Fastest rate					
1 – Low/basic	0	3	7	10	12
2 – Medium	0	3	8	10	15
3 – High	0	10	20	25	30



Earth Dykes and Embankments with toe/slope protection – Coastal/estuarine Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	90	120
3 – High	0	30	60	100	140
Medium rate					
1 – Low/basic	0	9	19	31	40
2 – Medium	0	15	30	50	60
3 – High	0	20	40	60	80
Fastest rate					
1 – Low/basic	0	8	15	20	25
2 – Medium	0	12	20	30	40
3 – High	0	15	30	40	50



Model assumptions

Design life

The design life of such an asset is approximately 50 to 100 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Settlement
4. Lateral movement or sliding
5. Shallow failures within slope
6. Vegetation damage or loss (grass cover)
7. Erosion/scour of embankment
8. Loss of fines due to seepage/infiltration
9. Cracking or fissuring
10. Crest or slope damage from animals, vehicles or people
11. Damage to slope/toe protection

Maintenance will control only processes 8 to 10, for example with vermin and vegetation control and minor repair to embankment (for surface cracking, rutting, erosion) and repair to slope/toe protection.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Damage to slope protection/revetment
- Backfill washout
- Animal burrows
- Movement of structure
- Structural damage to slopes/crest

Revetment failure washout of fill and piping are typical failure modes.

Effect of asset width

For fluvial environments, narrow and wide assets are covered by the similar deterioration curves for slowest and medium deterioration, with a slight beneficial effect for wide assets at later grade transitions (to CG 4 and CG 5) with maintenance. For fastest deterioration, the wide asset is considered less vulnerable to geotechnical problems – the main factor in fastest deterioration conditions – and deteriorates at a slower rate.

For coastal embankments, wide and narrow assets deteriorating at a medium rate are considered to follow the same curve with the slope protection having the predominant effect. For slowest and fastest deterioration rates the wide assets deteriorate less quickly because with fastest rates wide assets are less vulnerable to geotechnical problems (as for fluvial) and with slowest deterioration rates the impact of slope protection is less critical.

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the embankment due to wave action and increased abrasion and may result in an increased probability of damage to slopes and crests.

Fluvial slowest rate: The embankment is in a protected location set back from the water's edge, the material quality is appropriate for the environment/location, construction is of a good quality and the asset is well designed.

Coastal slowest rate: The embankment is in a protected location at the back of the foreshore. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the embankment. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time. Also it may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Part of the embankment is submerged at all states of the tide. The water is either saline or brackish. Also it may suffer from poor quality materials/construction/design. The deterioration rate would increase from that in a fluvial environment.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through damage to slope protection/revetment followed by slope erosion/backfill washout compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including vermin and vegetation control and minor repair to embankment (for surface cracking, rutting, erosion) and repair to slope/toe protection offsets asset degradation. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including vermin and vegetation control and minor repair to embankment (for surface cracking, rutting, erosion) and repair to slope/toe protection offsets asset degradation (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.5 Sloping walls with slope protection or revetment

a. Turf (fluvial and coastal/estuarine)

AIMS asset classification: Defence/embankment

Figure C7 shows a basic line sketch of this type of asset: sloping walls with slope protection or revetment – turf.

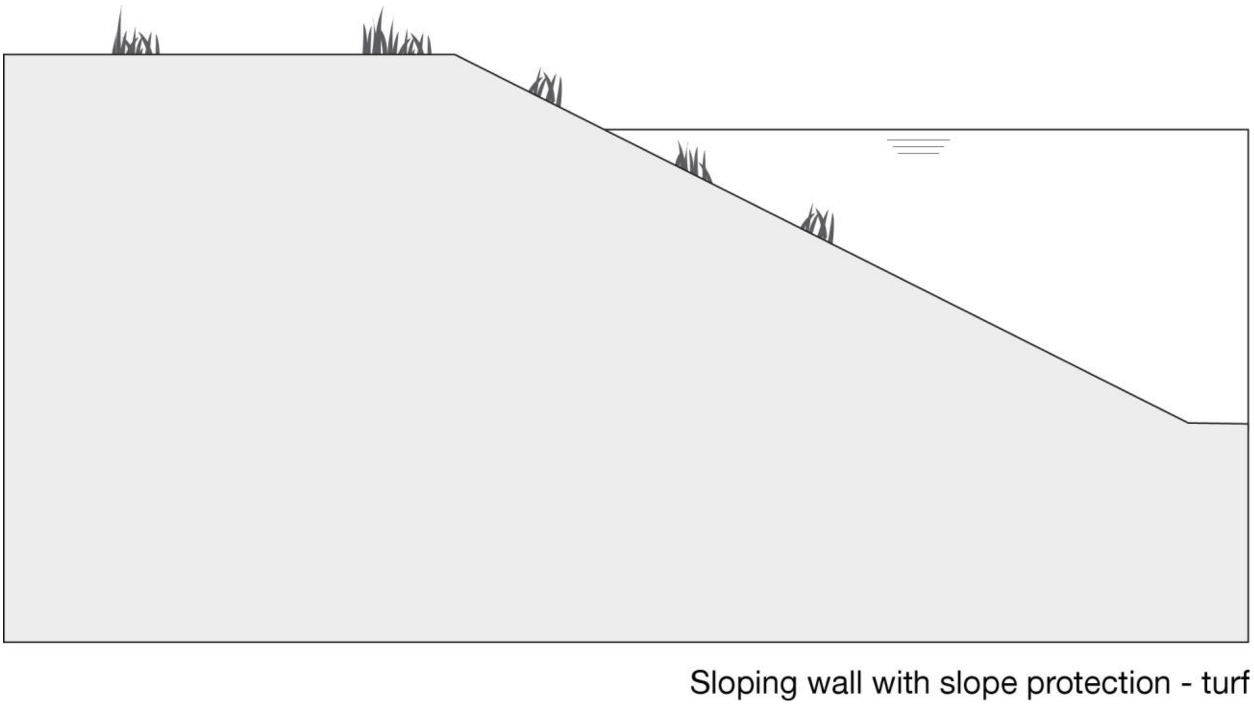
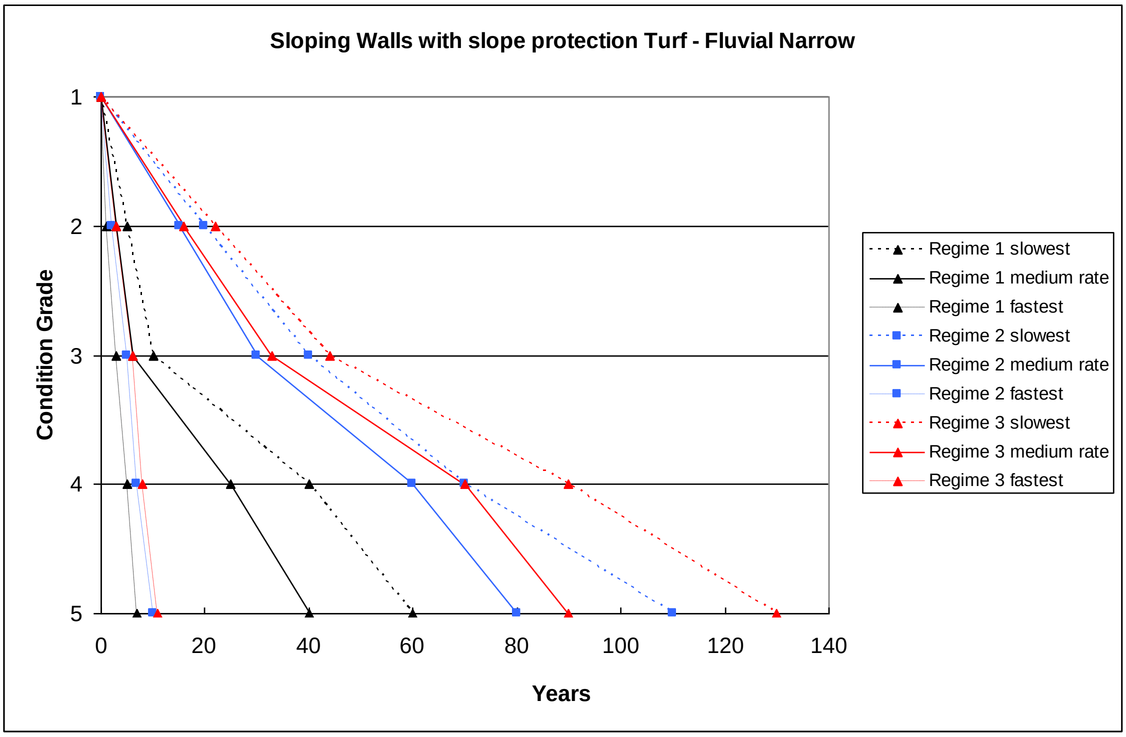


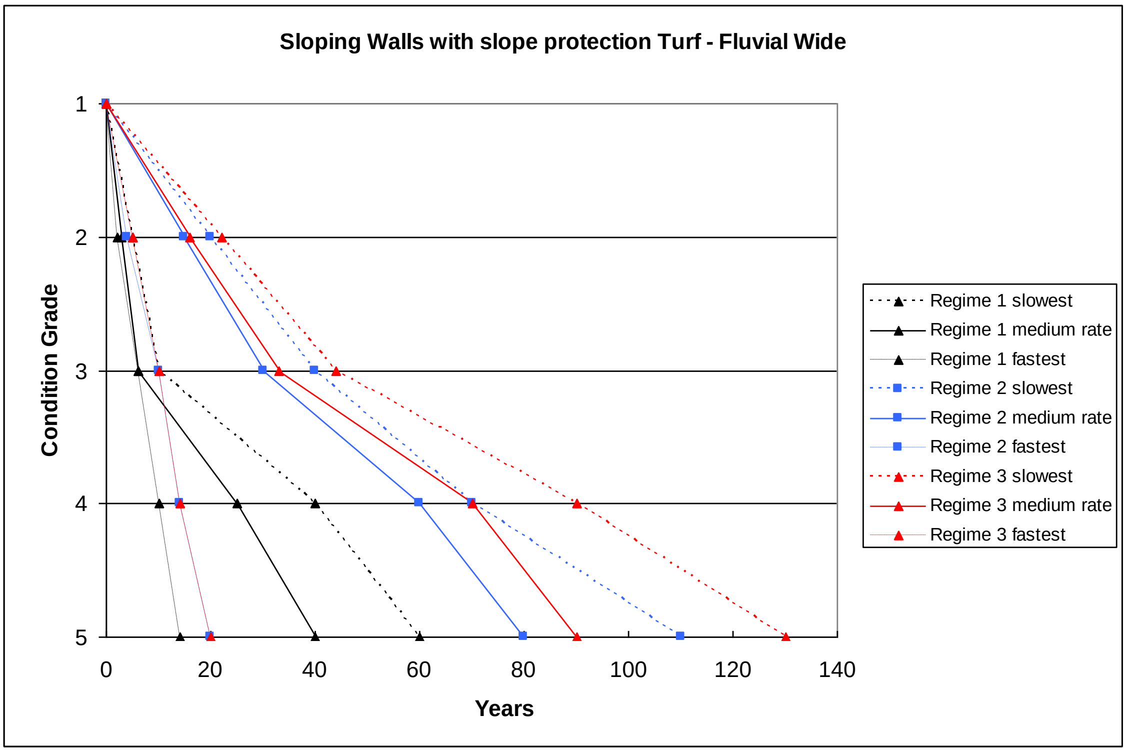
Figure C7 Sloping wall with slope protection or revetment – turf

Models

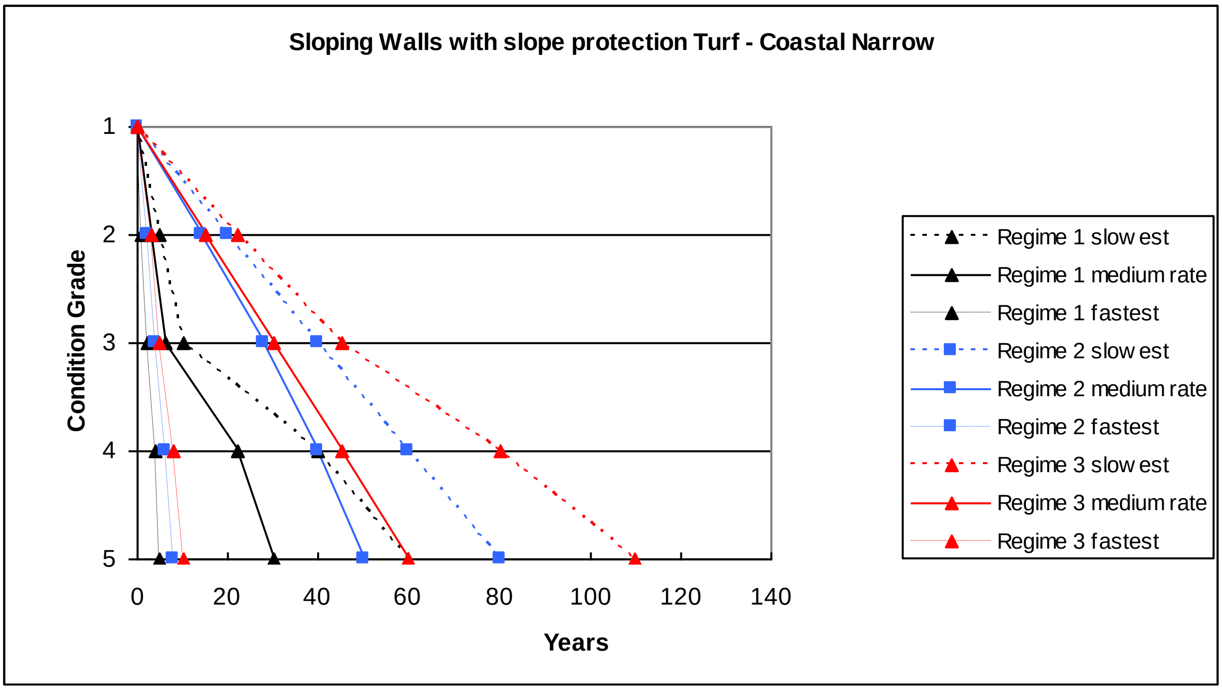
Sloping walls with slope protection or revetment Turf – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	40	60
2 – Medium	0	20	40	70	110
3 – High	0	22	44	90	130
Medium rate					
1 – Low/basic	0	3	6	25	40
2 – Medium	0	15	30	60	80
3 – High	0	16	33	70	90
Fastest rate					
1 – Low/basic	0	1	3	5	7
2 – Medium	0	2	5	7	10
3 – High	0	3	6	8	11



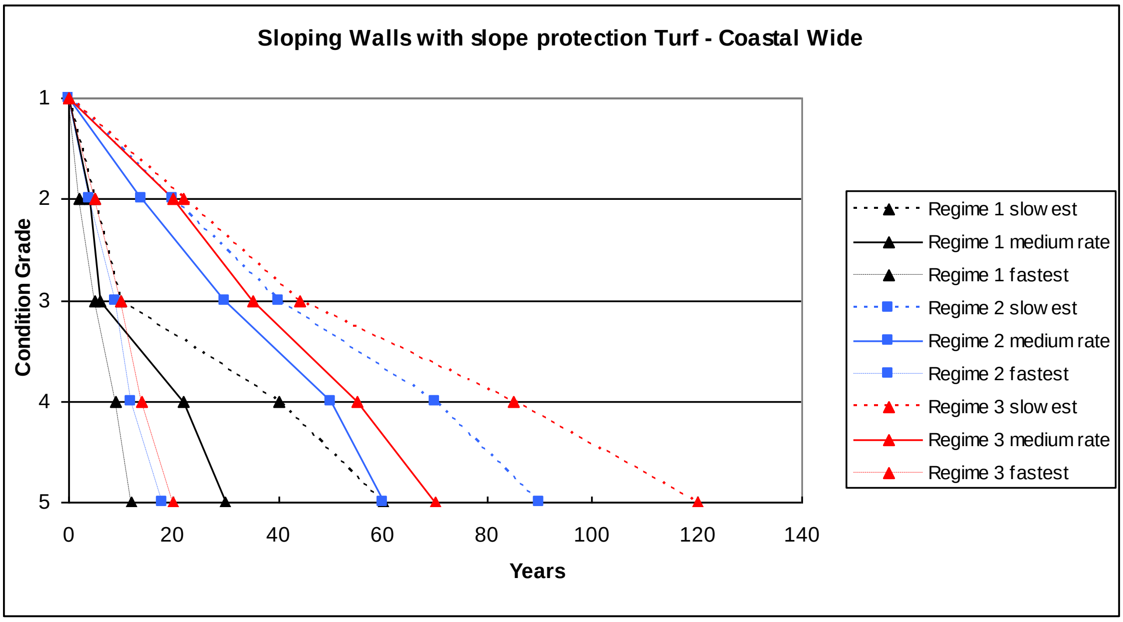
Sloping walls with slope protection or revetment Turf – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	40	60
2 – Medium	0	20	40	70	110
3 – High	0	22	44	90	130
Medium rate					
1 – Low/basic	0	3	6	25	40
2 – Medium	0	15	30	60	80
3 – High	0	16	33	70	90
Fastest rate					
1 – Low/basic	0	2	6	10	14
2 – Medium	0	4	10	14	20
3 – High	0	5	10	14	20



Sloping walls with slope protection or revetment Turf – Coastal/estuarine Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	40	60
2 – Medium	0	20	40	60	80
3 – High	0	22	45	80	110
Medium rate					
1 – Low/basic	0	3	6	22	30
2 – Medium	0	14	28	40	50
3 – High	0	15	30	45	60
Fastest rate					
1 – Low/basic	0	1	2	4	5
2 – Medium	0	2	4	6	8
3 – High	0	3	5	8	10



Sloping walls with slope protection or revetment Turf – Coastal/estuarine Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	40	60
2 – Medium	0	20	40	70	90
3 – High	0	22	44	85	120
Medium rate					
1 – Low/basic	0	4	6	22	30
2 – Medium	0	14	30	50	60
3 – High	0	20	35	55	70
Fastest rate					
1 – Low/basic	0	2	5	9	12
2 – Medium	0	4	9	12	18
3 – High	0	5	10	14	20



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Lateral movement or sliding
4. Erosion/scour of embankment
5. Settlement
6. Shallow failures within slope
7. Vegetation damage or loss (grass cover)
8. Loss of fines due to seepage/infiltration
9. Cracking or fissuring
10. Crest or slope damage from animals, vehicles or people

Scour protection and backfill replacement can be used to manage deterioration caused by processes 1 to 4 above. Maintenance will also control processes 8 to 10 through action to reduce cracking, rutting and erosion, and with vermin and vegetation control. Items 5 to 7 cannot be controlled through maintenance practices, requiring refurbishment instead.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Washout of fill
- Structural damage to slope
- Movement of structure
- Damage to revetments/slope protection

Turf protection failure, washout of fill and piping are typical failure modes.

Effect of asset width

For fluvial environments, narrow and wide assets are covered by the same deterioration curves for slowest and medium deterioration. Their differences in this environment and condition are not considered to have a significant overall effect. For fastest deterioration, the wide asset is considered less vulnerable to geotechnical problems – the main factor in fastest deterioration conditions – and deteriorates at a slower rate.

For coastal embankments, wide assets are predicted to deteriorate more slowly than the narrow counterparts, being better able to withstand the more aggressive environment. Wide assets are less susceptible to washout of backfill when overtopping occurs because of their size.

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the wall due to wave action and increased abrasion and may result in an increased probability of damage to slopes and crests and toe erosion.

Fluvial slowest rate: The wall is in a protected location set back from the water's edge, the material quality is appropriate for the environment/location, construction is of a good quality and the asset is well designed.

Coastal slowest rate: The wall is in a protected location at the back of the foreshore. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the wall. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time. Also it may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Part of the wall is submerged at all states of the tide. The water is either saline or brackish. Also it may suffer from poor quality materials/construction/design. The deterioration rate would increase from that in a fluvial environment.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through erosion of slope protection/backfill washout compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including vegetation and vermin control and repairs to rutting, erosion, etc, and scour protection/backfill replacement offsets asset degradation. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including vegetation and vermin control and repairs to rutting, erosion, etc, scour protection/backfill replacement offsets material deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Works

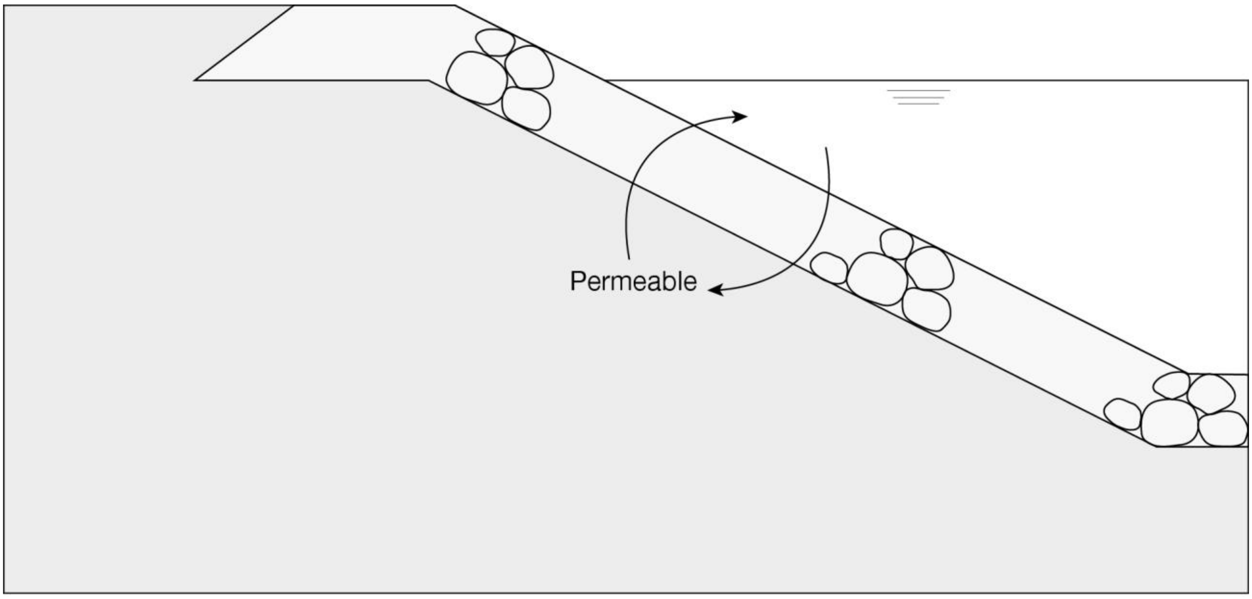
Normal maintenance: grass cutting, vermin control and repairs to rutting. Topping up and settlement work is considered refurbishment.

b. Permeable revetments (fluvial and coastal/estuarine)

AIMS asset classification: Defence/embankment

Examples: rip-rap/rock armour, free, interlocking or cable-tied concrete blockwork, concrete mattress, armour flex, etc

Figure C8 shows a basic line sketch of this type of asset: sloping walls with slope protection or revetment – permeable revetments.

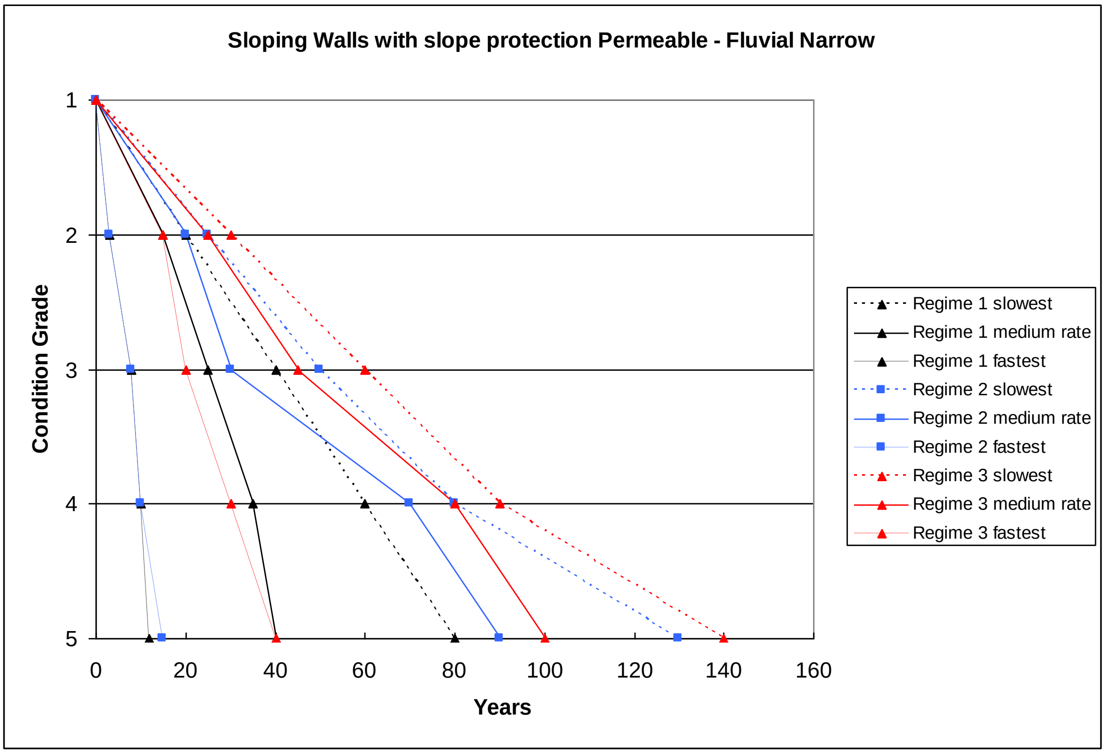


Sloping wall with slope protection - permeable revetment

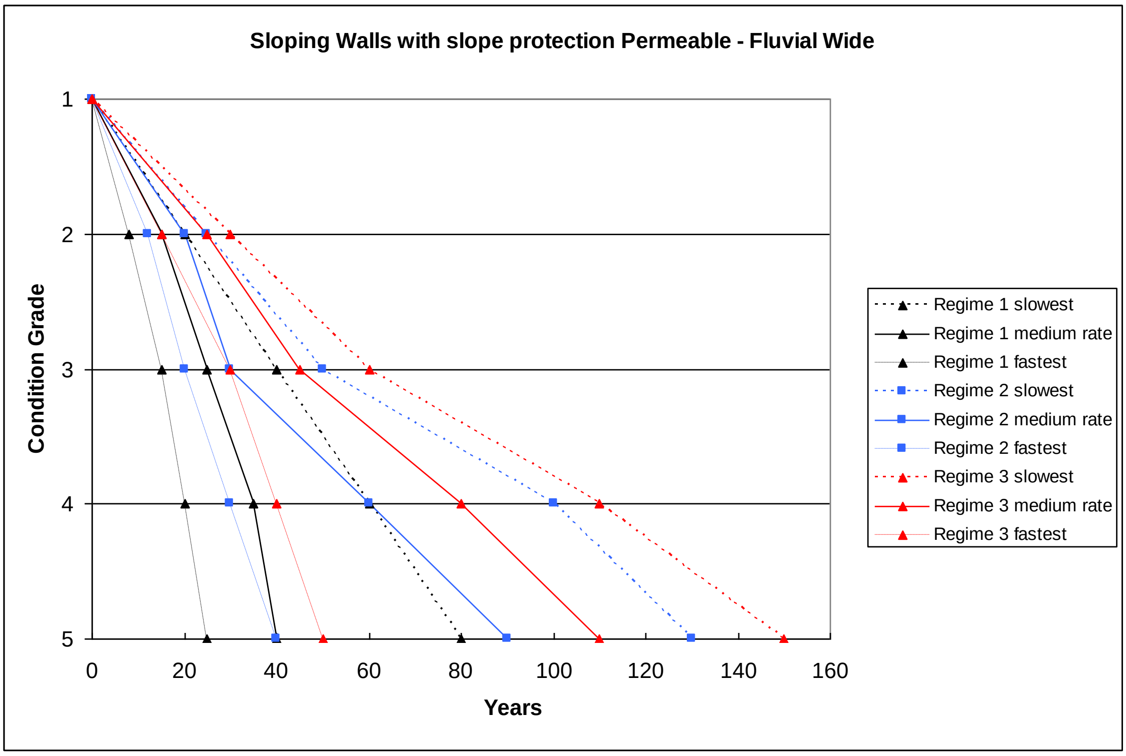
Figure C8 Sloping wall with slope protection or revetment – permeable revetments

Models

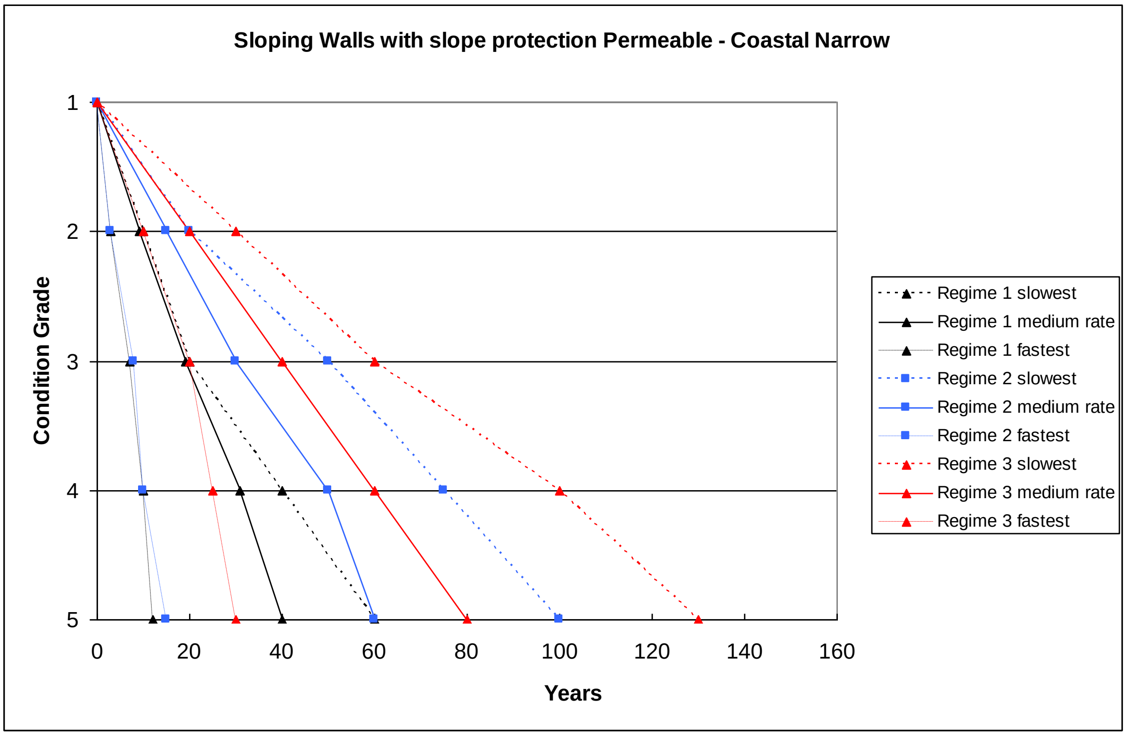
Sloping walls with slope protection or revetment Permeable revetments – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	80	130
3 – High	0	30	60	90	140
Medium rate					
1 – Low/basic	0	15	25	35	40
2 – Medium	0	20	30	70	90
3 – High	0	25	45	80	100
Fastest rate					
1 – Low/basic	0	3	8	10	12
2 – Medium	0	3	8	10	15
3 – High	0	15	20	30	40



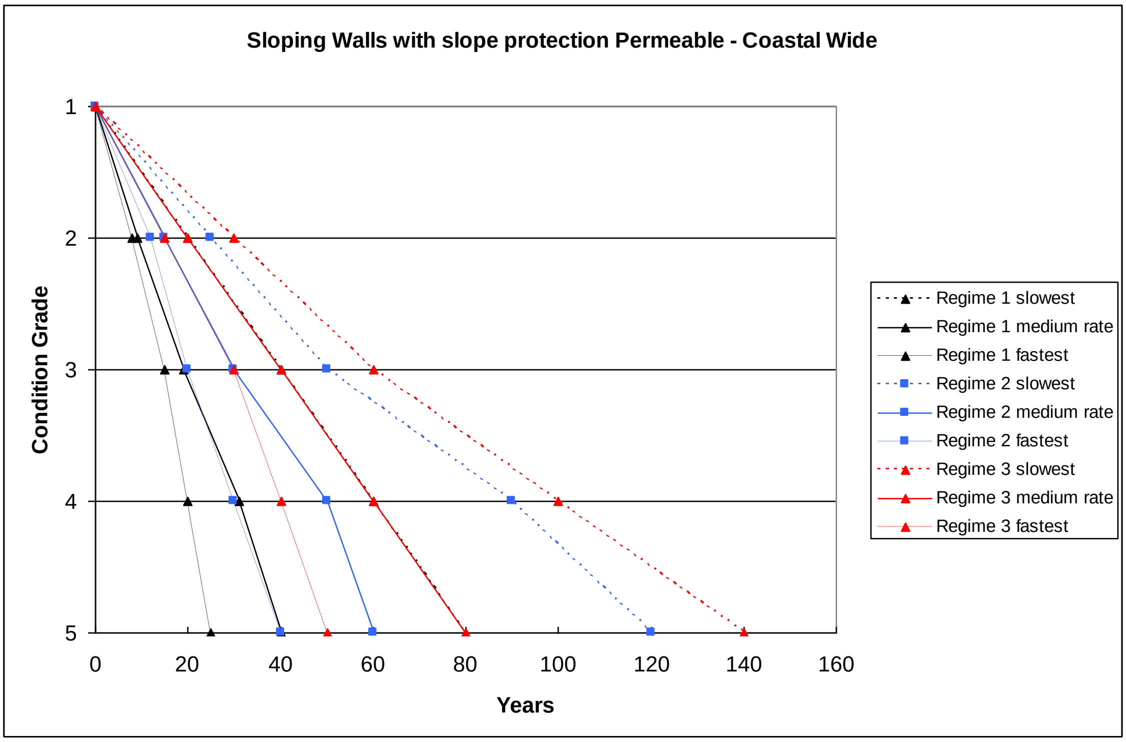
Sloping walls with slope protection or revetment Permeable revetments – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	100	130
3 – High	0	30	60	110	150
Medium rate					
1 – Low/basic	0	15	25	35	40
2 – Medium	0	20	30	60	90
3 – High	0	25	45	80	110
Fastest rate					
1 – Low/basic	0	8	15	20	25
2 – Medium	0	12	20	30	40
3 – High	0	15	30	40	50



Sloping walls with slope protection or revetment Permeable revetments – Coastal/estuarine Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	10	20	40	60
2 – Medium	0	20	50	75	100
3 – High	0	30	60	100	130
Medium rate					
1 – Low/basic	0	9	19	31	40
2 – Medium	0	15	30	50	60
3 – High	0	20	40	60	80
Fastest rate					
1 – Low/basic	0	3	7	10	12
2 – Medium	0	3	8	10	15
3 – High	0	10	20	25	30



Sloping walls with slope protection or revetment Permeable revetments – Coastal/estuarine Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	90	120
3 – High	0	30	60	100	140
Medium rate					
1 – Low/basic	0	9	19	31	40
2 – Medium	0	15	30	50	60
3 – High	0	20	40	60	80
Fastest rate					
1 – Low/basic	0	8	15	20	25
2 – Medium	0	12	20	30	40
3 – High	0	15	30	40	50



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Lateral movement or sliding
4. Erosion/scour of embankment
5. Settlement
6. Shallow failures within slope
7. Vegetation damage or loss (grass cover)
8. Loss of fines due to seepage/infiltration
9. Cracking or fissuring
10. Crest or slope damage from animals, vehicles or people
11. Damage to revetment/scour protection

Scour protection can be used to manage deterioration caused by processes 1 to 4 above. Maintenance will also control processes 8 to 10 through action to reduce cracking, rutting and erosion, with vermin and vegetation control and replacement of missing/damaged elements. Items 5 to 7 cannot be controlled through maintenance practices, requiring refurbishment instead.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Washout of fill
- Structural damage to slope
- Movement of structure
- Damage to revetments/slope protection

Revetment failure, washout of fill and piping are typical failure modes.

Effect of asset width

For fluvial environments, narrow and wide assets are covered by similar deterioration curves for slowest and medium deterioration, with a slight beneficial effect for wide assets at later grade transitions (to CG 4 and CG 5) with maintenance. For fastest deterioration, the wide asset is considered less vulnerable to geotechnical problems – the main factor in fastest deterioration conditions – and deteriorates at a slower rate.

For coastal embankments, wide and narrow assets deteriorating at a medium rate are considered to follow the same curve with the slope protection having the predominant effect. For slowest and fastest deterioration rates the wide assets deteriorate less quickly because with fastest rates wide assets are less vulnerable to geotechnical problems (as for fluvial) and with slowest deterioration rates the impact of slope protection is less critical.

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the wall due to wave action and increased abrasion and may result in an increased probability of damage to slopes and crests and toe erosion.

Fluvial slowest rate: The wall is in a protected location set back from the water's edge, the material quality is appropriate for the environment/location, construction is of a good quality and the asset is well designed.

Coastal slowest rate: The wall is in a protected location at the back of the foreshore. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the wall. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time. Also it may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Part of the wall is submerged at all states of the tide. The water is either saline or brackish. Also it may suffer from poor quality materials/construction/design. The deterioration rate would increase from that in a fluvial environment.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through damage to slope protection/revetment followed by slope erosion/backfill washout compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including vegetation and vermin control and repairs to cracking, rutting, erosion and repairs to components, seal/joint repairs, etc, scour protection/backfill replacement offsets asset degradation. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including vegetation and vermin control and repairs to cracking, rutting, erosion and repairs to components, seal/joint repairs, etc, scour protection/backfill replacement offsets material deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

c. Impermeable revetments (fluvial and coastal/estuarine)

AIMS asset classification: Defence/embankment

Examples: grouted stone, asphalt, asphaltic concrete, stone asphalt, etc

Figure C9 shows a basic line sketch of this type of asset: sloping walls with slope protection or revetment – impermeable revetments.

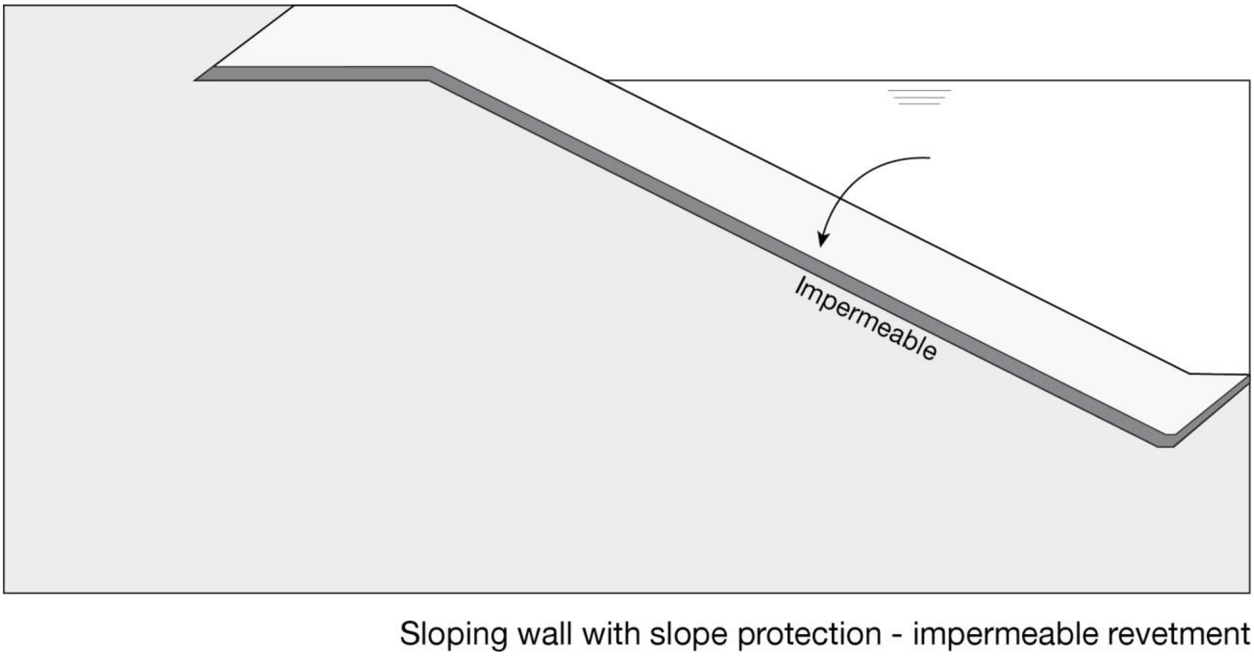
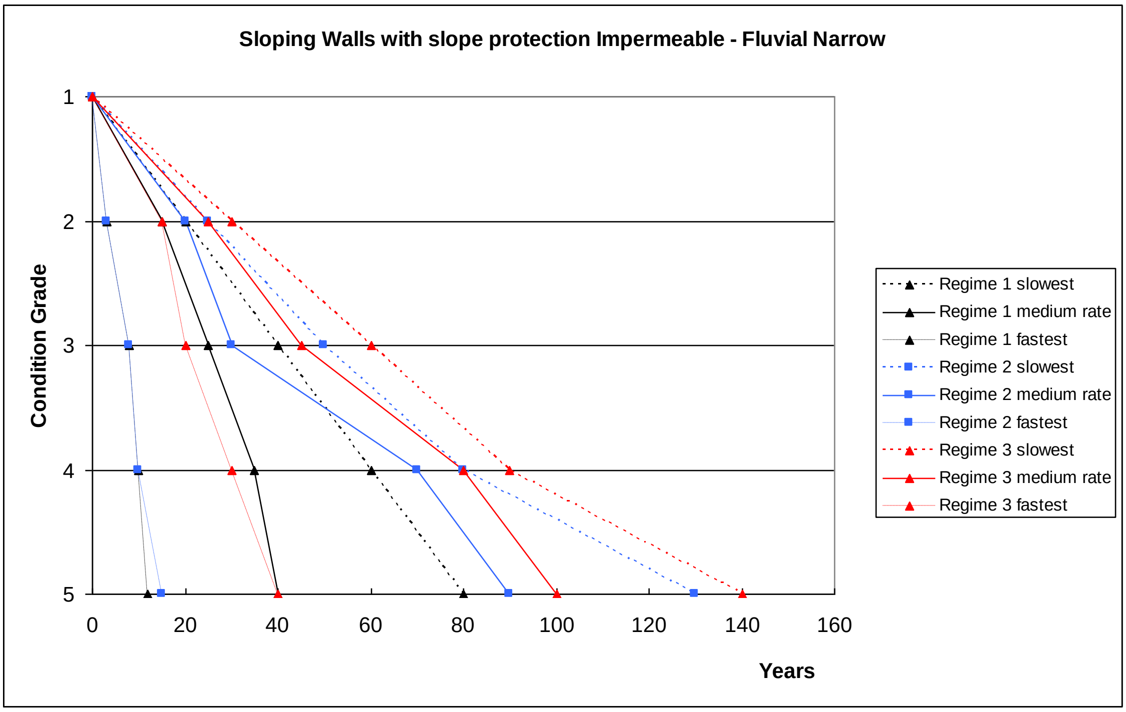


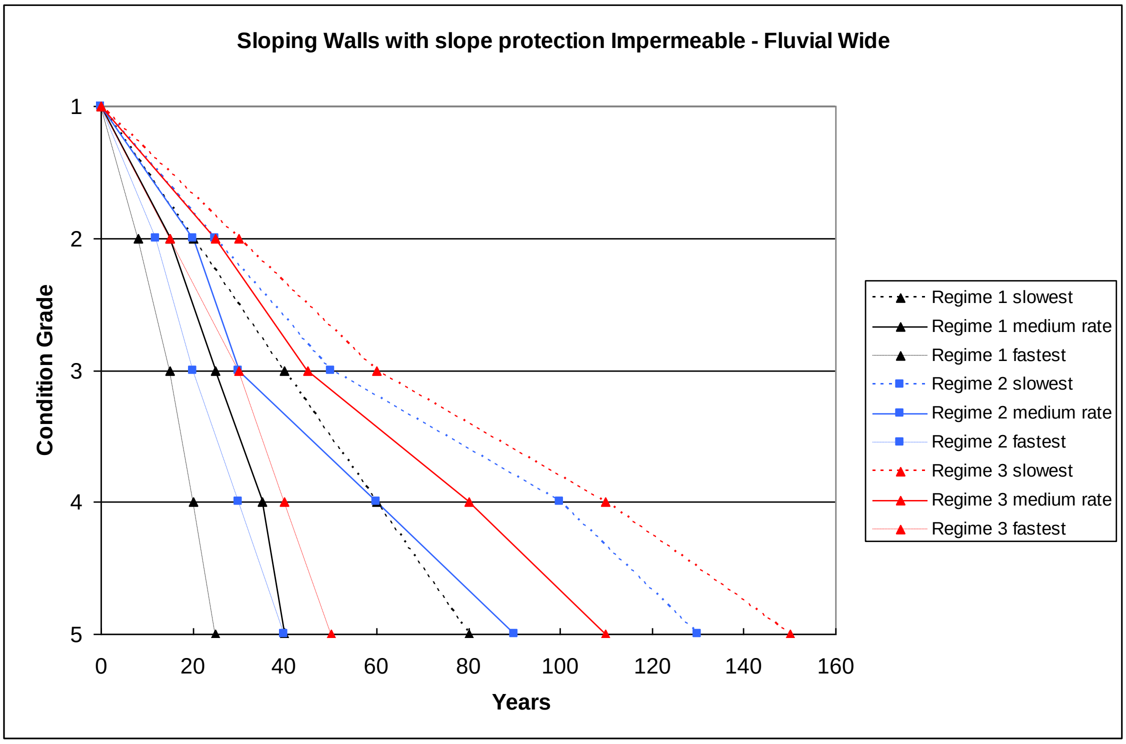
Figure C9 Sloping wall with slope protection or revetment – impermeable revetments

Models

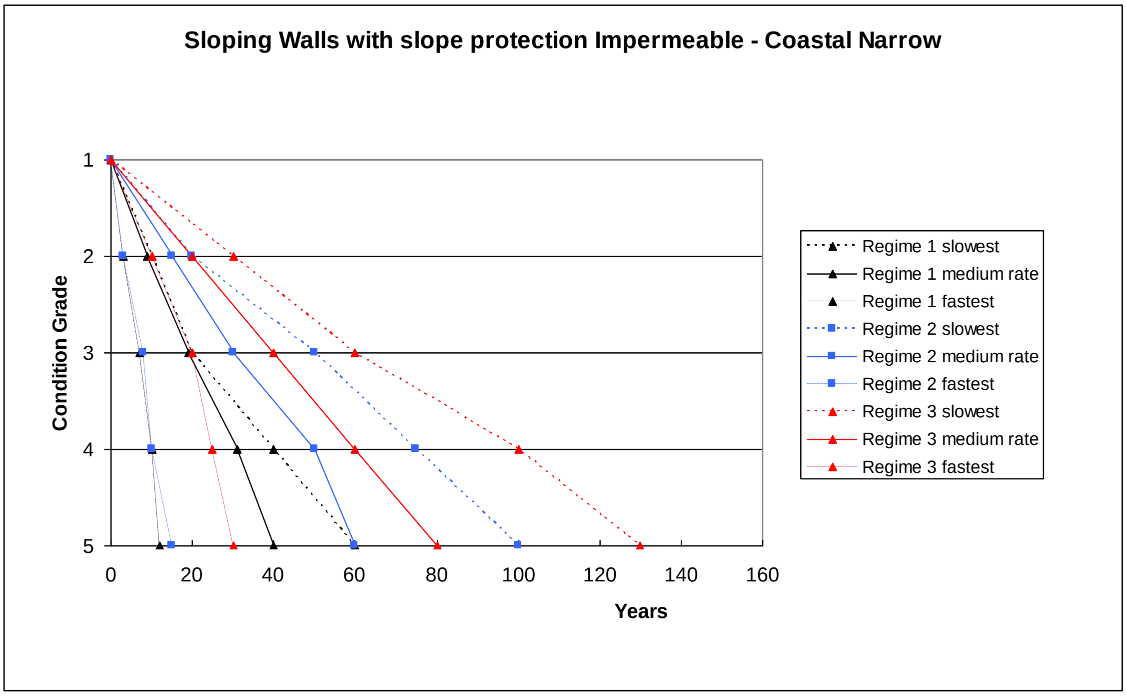
Sloping walls with slope protection or revetment Impermeable revetments – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	80	130
3 – High	0	30	60	90	140
Medium rate					
1 – Low/basic	0	15	25	35	40
2 – Medium	0	20	30	70	90
3 – High	0	25	45	80	100
Fastest rate					
1 – Low/basic	0	3	8	10	12
2 – Medium	0	3	8	10	15
3 – High	0	15	20	30	40



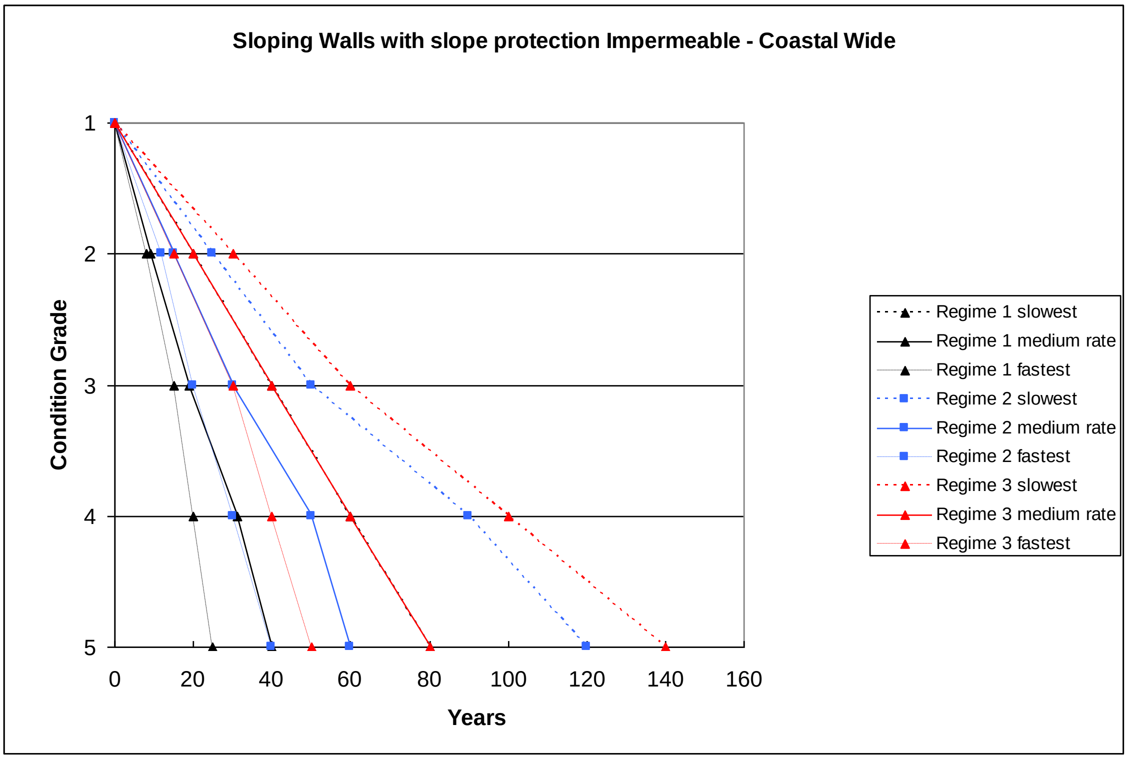
Sloping walls with slope protection or revetment Impermeable revetments – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	100	130
3 – High	0	30	60	110	150
Medium rate					
1 – Low/basic	0	15	25	35	40
2 – Medium	0	20	30	60	90
3 – High	0	25	45	80	110
Fastest rate					
1 – Low/basic	0	8	15	20	25
2 – Medium	0	12	20	30	40
3 – High	0	15	30	40	50



Sloping walls with slope protection or revetment Impermeable revetments – Coastal/estuarine Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	10	20	40	60
2 – Medium	0	20	50	75	100
3 – High	0	30	60	100	130
Medium rate					
1 – Low/basic	0	9	19	31	40
2 – Medium	0	15	30	50	60
3 – High	0	20	40	60	80
Fastest rate					
1 – Low/basic	0	3	7	10	12
2 – Medium	0	3	8	10	15
3 – High	0	10	20	25	30



Sloping walls with slope protection or revetment Impermeable revetments – Coastal/estuarine Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	60	80
2 – Medium	0	25	50	90	120
3 – High	0	30	60	100	140
Medium rate					
1 – Low/basic	0	9	19	31	40
2 – Medium	0	15	30	50	60
3 – High	0	20	40	60	80
Fastest rate					
1 – Low/basic	0	8	15	20	25
2 – Medium	0	12	20	30	40
3 – High	0	15	30	40	50



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Movement in or loss of surrounding supporting strata
2. Undermining
3. Lateral movement or sliding
4. Erosion/scour of embankment
5. Settlement
6. Shallow failures within slope
7. Vegetation damage or loss (grass cover)
8. Loss of fines due to seepage/infiltration
9. Cracking or fissuring
10. Crest or slope damage from animals, vehicles or people
11. Damage to revetment/scour protection

Scour protection can be used to manage deterioration caused by processes 1 to 4 above. Maintenance will also control processes 8 to 10 through action to reduce cracking, rutting and erosion with vermin and vegetation control and replacement of missing/damaged elements. Items 5 to 7 cannot be controlled through maintenance practices, requiring refurbishment instead.

Vandalism can also cause the asset to deteriorate either through direct damage or by making the asset vulnerable to other deterioration mechanisms. Whether this can be successfully managed and prevented depends upon the asset location and access. Some of the standard maintenance activities would counter some effects of vandalism.

The following deterioration processes dominate the rate of deterioration:

- Washout of fill
- Structural damage to slope
- Movement of structure
- Damage to revetments/slope protection

Revetment failure, washout of fill and piping are typical failure modes.

Effect of asset width

For fluvial environments, narrow and wide assets are covered by similar deterioration curves for slowest and medium deterioration, with a slight beneficial effect for wide assets at later grade transitions (to CG 4 and CG 5) with maintenance. For fastest deterioration, the wide asset is considered less vulnerable to geotechnical problems – the main factor in fastest deterioration conditions – and deteriorates at a slower rate.

For coastal embankments, wide and narrow assets deteriorating at a medium rate are considered to follow the same curve with the slope protection having the predominant effect. For slowest and fastest deterioration rates the wide assets deteriorate less quickly because with fastest rates wide assets are less vulnerable to geotechnical problems (as for fluvial) and with slowest deterioration rates the impact of slope protection is less critical.

Effect of environmental exposure/material quality

As a general rule, a coastal environment is likely to result in more rapid deterioration of the wall due to wave action and increased abrasion and may result in an increased probability of damage to slopes and crests and toe erosion.

Fluvial slowest rate: The wall is in a protected location set back from the water's edge, the material quality is appropriate for the environment/location, construction is of a good quality and the asset is well designed.

Coastal slowest rate: The wall is in a protected location at the back of the foreshore. Part of the wall is submerged at high tides. The water is either saline or brackish. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the wall. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location which could form the river bank, and is partly immersed all the time. Also it may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. Part of the wall is submerged at all states of the tide. The water is either saline or brackish. Also it may suffer from poor quality materials/construction/design. The deterioration rate would increase from that in a fluvial environment.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through damage to slope protection/revetment followed by slope erosion/backfill washout compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including vegetation and vermin control and repairs to cracking, rutting, erosion and repairs to components, seal/joint repairs, etc, scour protection/backfill replacement offsets asset degradation. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including vegetation and vermin control and repairs to cracking, rutting, erosion and repairs to components, seal/joint repairs, etc, scour protection/backfill replacement offsets material deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.6 Culverts – pipe, box, arch (all fluvial)

Figure C10 shows a basic line sketch of this type of asset: culverts – pipe, box, arch.

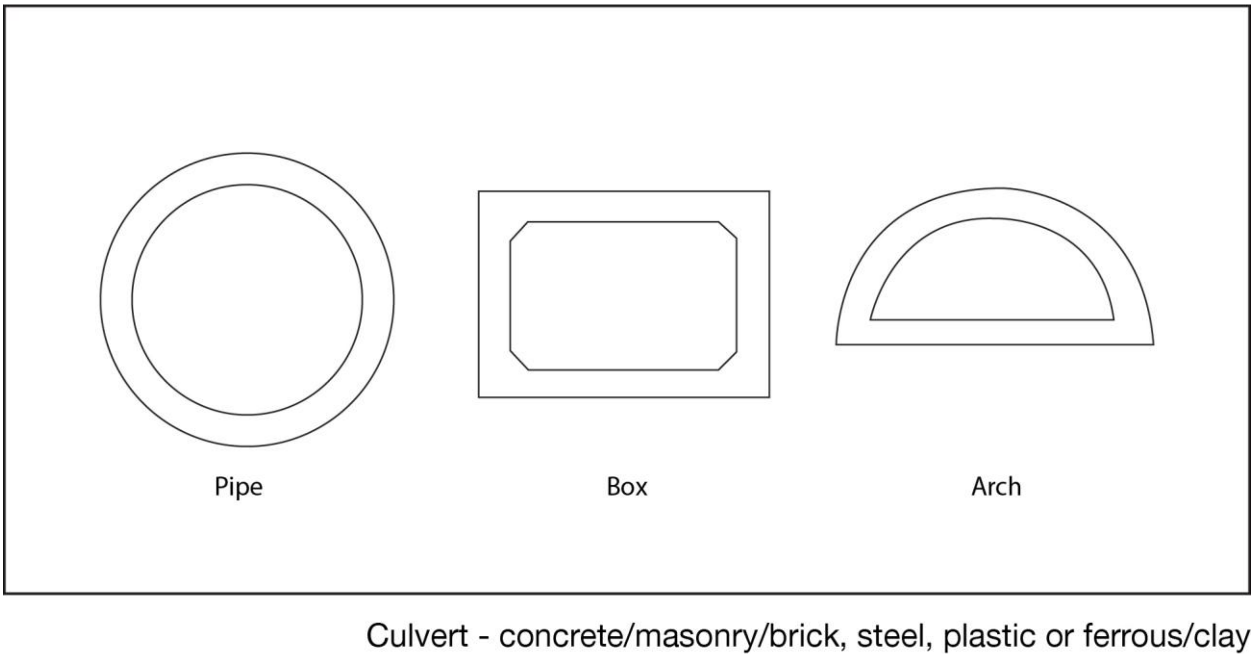


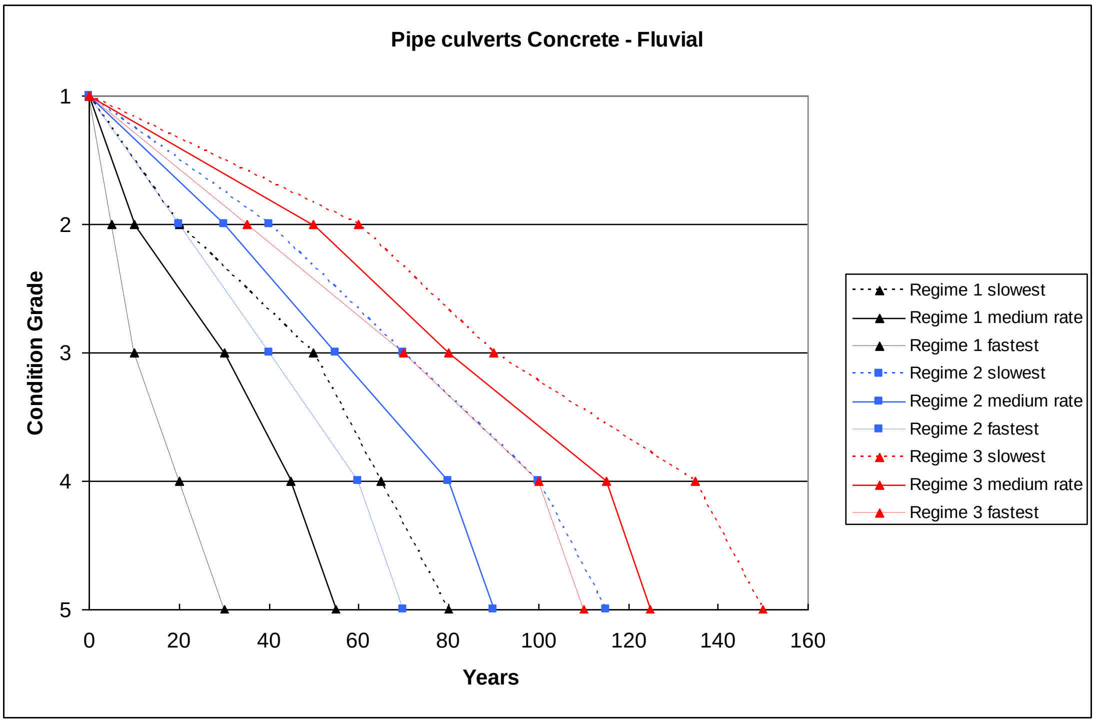
Figure C10 Culverts – pipe, box, arch

a. Concrete

AIMS asset classification: Channel/simple OR complex culvert

Models

Culverts Concrete – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	65	80
2 – Medium	0	40	70	100	115
3 – High	0	60	90	135	150
Medium rate					
1 – Low/basic	0	10	30	45	55
2 – Medium	0	30	55	80	90
3 – High	0	50	80	115	125
Fastest rate					
1 – Low/basic	0	5	10	20	30
2 – Medium	0	20	40	60	70
3 – High	0	35	70	100	110



Model assumptions

Note: Deterioration curves for culverts were provided in Phase 1. These were not identified with specific material types except for a reference made to the curves being based upon concrete and brick/masonry walls (fluvial) except for fastest estimates, which are considered quicker in culverts (cf. fluvial brick and masonry and concrete walls), because of variability of materials and difficulties in inspections. The Phase 1 curves form the basis of the curves presented here with account taken of specific materials. It was noted in Phase 1 that some structures (material not specified) are almost 200 years old and reported as in acceptable condition. (It is considered that the design was more conservative in those days; a modern culvert of similar materials may not last so long.)

Design life

The design life of such an asset is approximately 100 to 120 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. Note: There is a body of evidence gathering which suggests that pipes may last longer (based on literature from the Concrete Pipeline Systems Association). The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality and design/installation is poor.

Deterioration

Culvert deterioration mechanisms are hydraulic wear (on invert and/or along the wet/dry line), seepage through boltholes/joints from backfill and structural instability of the invert from ageing or through excessive material degradation.

The deterioration processes affecting these assets include:

1. Deformation to culvert
2. Settlement to invert or soffit
3. Cracking, fissuring, or spalling of concrete or other components
4. Corrosion of elements
5. Missing blocks
6. Sealant or joint fill material loss
7. Vegetation growth inside culvert/root penetration

With the exception of settlement, these processes can be controlled by maintenance, including minor repair and blockwork repair, sealant replacement, joint repair, debris/vegetation clearance and removal of silt. Downstream scour protection may also be needed.

Replacement of protective coatings, backfill replacement, lining the culvert with additional plates and paving replacement are classed as refurbishment (and not maintenance).

The following deterioration processes dominate the rate of deterioration:

- Blockage
- Structural failure

Effect of environmental exposure/material quality

Slowest rate: The culvert is in continuous use, with a continued flow of deep water. It is self-cleansing or there is little or no sediment within the channel.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The culvert is at the extreme ends of use (either high or no flow) and the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks likely to be carried out on the culvert are inspection/review of H&S provisions and their repair/replacement (signs, hand railings, etc); there is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by blockage and obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including inspections, CCTV surveys, minor repair, silt and obstruction removal, vegetation clearance, joint repairs (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Note: In some larger diameter pipes man-access can be gained for survey and repair.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including inspections, CCTV surveys, minor repair, silt and obstruction removal, vegetation clearance, joint repairs (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

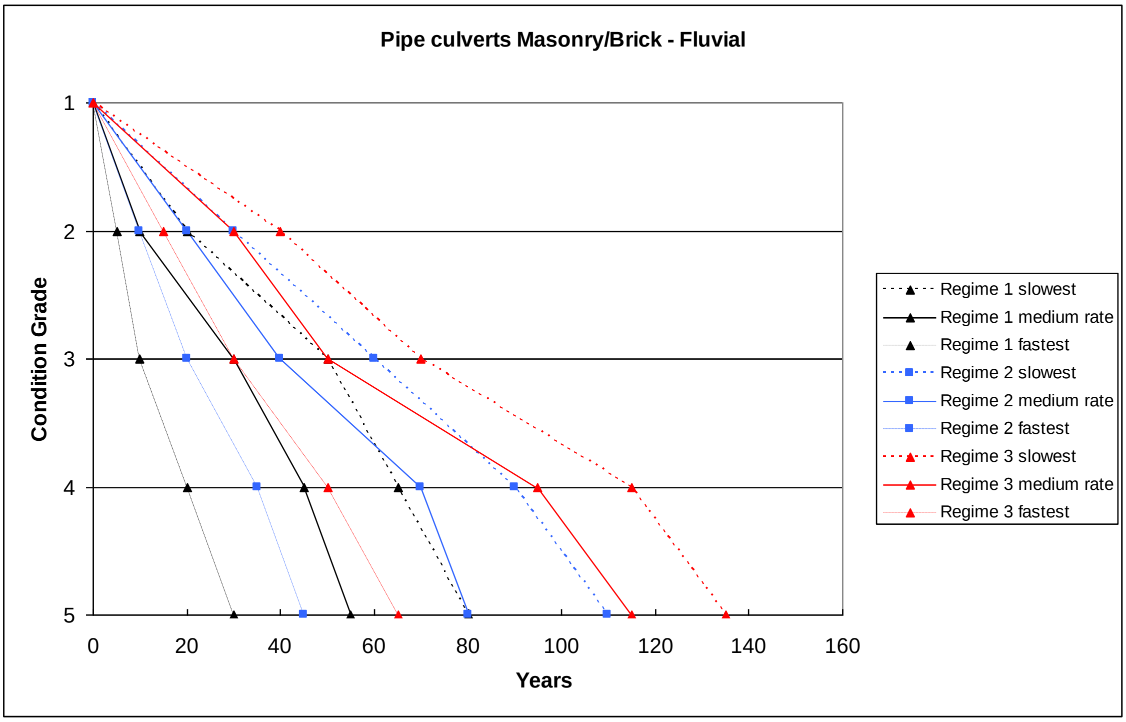
Note: In some larger diameter pipes man-access can be gained for survey and repair.

b. Masonry/brick

AIMS asset classification: Channel/simple OR complex culvert

Models

Culverts Brick/Masonry – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	65	80
2 – Medium	0	30	60	90	110
3 – High	0	40	70	115	135
Medium rate					
1 – Low/basic	0	10	30	45	55
2 – Medium	0	20	40	70	80
3 – High	0	30	50	95	115
Fastest rate					
1 – Low/basic	0	5	10	20	30
2 – Medium	0	10	20	35	45
3 – High	0	15	30	50	65



Model assumptions

Note: Deterioration curves for culverts were provided in Phase 1. These were not identified with specific material types except for a reference made to the curves being based upon concrete and brick/masonry walls (fluvial) except for fastest estimates which are considered quicker in culverts (cf. fluvial brick and masonry and concrete walls) because of variability of materials and difficulties in inspections. The Phase 1 curves form the basis of the curves presented here with account taken of specific materials. It was noted in Phase 1 that some structures (material not specified) are almost 200 years old and reported as in acceptable condition. (It is considered that the design was more conservative in those days; a modern culvert of similar materials may not last so long.)

These asset types are typically quite old as newer assets are constructed using other materials which in general make culverts easier to construct, give more flexibility to size (length and diameter), allow for reduced maintenance, are made from lighter materials and are more economical.

Design life

The design life of such an asset is approximately 100 to 120 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality and design/installation is poor.

Deterioration

Culvert deterioration mechanisms are: hydraulic wear (on invert and/or along the wet/dry line), seepage through boltholes/joints from backfill, and structural instability of the invert from ageing or through excessive material degradation.

The deterioration processes affecting these assets include:

1. Deformation to culvert
2. Settlement to invert or soffit
3. Cracking, fissuring, or spalling of bricks/concrete or other components
4. Corrosion of elements
5. Missing bricks/blocks
6. Sealant or joint fill material loss
7. Vegetation growth inside culvert/root penetration

With the exception of settlement, these processes can be controlled by maintenance including: minor repair, re-pointing and brickwork repair, sealant replacement, joint repair, debris/vegetation clearance and removal of silt. Downstream scour protection may also be needed.

Replacement of protective coatings, backfill replacement, lining the culvert with additional plates and paving replacement are classed as refurbishment (and not maintenance)

The following deterioration processes dominate the rate of deterioration:

- Blockage
- Structural failure

Effect of environmental exposure/material quality

Slowest rate: The culvert is in continuous use, with a continued flow of deep water. It is self-cleansing or there is little or no sediment within the channel.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The culvert is at the extreme ends of use (either high or no flow) and the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. The only maintenance tasks likely to be carried out on the culvert are inspection/review of H&S provisions and their repair/replacement (signs, hand railings, etc); there is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by blockage and obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including minor repair, re-pointing and brickwork repair, sealant replacement, joint repair, brick replacement (in those large enough to safely access), debris/vegetation clearance and removal of silt (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Note: In some larger diameter pipes man-access can be gained for survey and repair.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, re-pointing and brickwork repair, sealant replacement, joint repair, brick replacement (in those large enough to safely access), debris/vegetation clearance and removal of silt (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

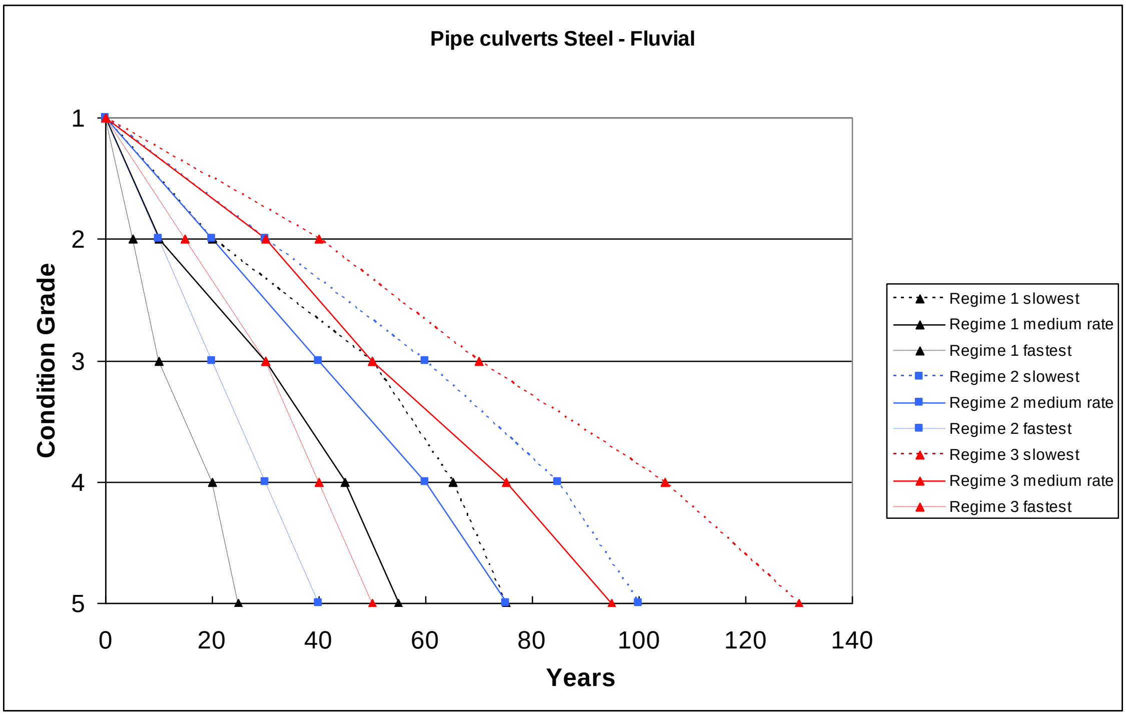
Note: In some larger diameter pipes man-access can be gained for survey and repair.

c. Steel (corrugated galvanised)

AIMS asset classification: Channel/simple OR complex culvert

Models

Culverts Steel – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	65	75
2 – Medium	0	30	60	85	100
3 – High	0	40	70	105	130
Medium rate					
1 – Low/basic	0	10	30	45	55
2 – Medium	0	20	40	60	75
3 – High	0	30	50	75	95
Fastest rate					
1 – Low/basic	0	5	10	20	25
2 – Medium	0	10	20	30	40
3 – High	0	15	30	40	50



Model assumptions

General

Asset: Steel culverts can be formed by either curved corrugated sheets riveted together in the factory or from helically wound pipe incorporating a lock seam. Culverts are typically available in 6 m lengths and with a maximum diameter of 6 m, thus reducing the number of joints in a culvert. Joins are usually made with coupling bands. The steel is normally treated with a protective coating, typically galvanising.

Material: Assumed to be galvanised corrugated steel pipes, as used by both the Environment Agency and Highways Agency, with a diameter up to 3 m. Pipes will have a typical design life of 100 years.

The basic maintenance curves are considered to be as for concrete. With maintenance, grade transitions and end of asset life occur slightly earlier for steel culverts compared to concrete and brick and masonry assets.

Design life

The design life of such an asset is based on material degradation, for galvanised corrugated steel pipe this is typically between 100 and 120 years, but to achieve this would require a systematic management of the asset and assumes that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality and design/installation is poor.

Deterioration

Culvert deterioration mechanisms are hydraulic wear (on invert and/or along the wet/dry line) removing protective coatings and exposing the steel substrate, seepage through boltholes/joints from backfill, and structural instability of the invert from ageing or through excessive material degradation (linked to invert corrosion), etc.

The deterioration processes affecting these assets include:

1. Deformation to culvert
2. Settlement to invert or soffit
3. Cracking or fissuring of structure/components
4. Corrosion of elements
5. Missing blocks
6. Sealant or joint fill material loss
7. Vegetation growth inside culvert/root penetration

With the exception of settlement, these processes can be controlled by maintenance, including minor repair and corrosion prevention, sealant replacement, joint repair, debris/vegetation clearance and removal of silt. Downstream scour protection may also be needed.

Replacement of protective coatings, backfill replacement, lining the culvert with additional plates and paving replacement are classed as refurbishment (and not maintenance).

The following deterioration processes dominate the rate of deterioration:

- Blockage
- Structural failure

Effect of environmental exposure/material quality

Slowest rate: The culvert is in continuous use, with a continued flow of deep water. It is self-cleansing or there is little or no sediment within the channel.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The culvert is at the extreme ends of use (either high or no flow), and the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks carried out are inspections of H&S provisions and their repair/replacement (signs, hand railings, etc); there is no maintenance of the culvert. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by blockage and obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including inspections, CCTV surveys minor repair and corrosion prevention, sealant replacement, joint repair, debris/vegetation clearance and removal of silt (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Note: In some larger diameter pipes man-access can be gained for survey and repair.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including inspections, CCTV surveys minor repair and corrosion prevention, sealant replacement, joint repair, debris/vegetation clearance and removal of silt (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

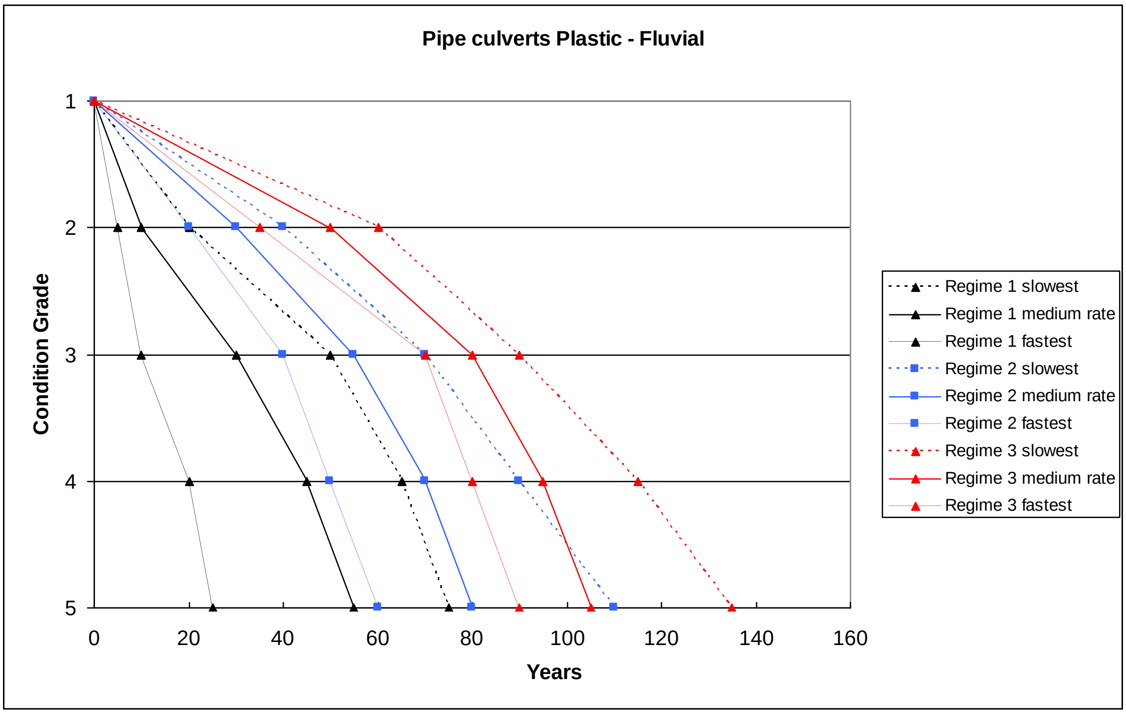
Note: In some larger diameter pipes man-access can be gained for survey and repair.

d. Plastic

AIMS asset classification: Channel/simple OR complex culvert

Models

Culverts Plastic – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	65	75
2 – Medium	0	40	70	90	110
3 – High	0	60	90	115	135
Medium rate					
1 – Low/basic	0	10	30	45	55
2 – Medium	0	30	55	70	80
3 – High	0	50	80	95	105
Fastest rate					
1 – Low/basic	0	5	10	20	25
2 – Medium	0	20	40	50	60
3 – High	0	35	70	80	90



Model assumptions

General

Asset: A culvert is typically defined as being >900 mm in diameter (<900 mm is a pipe and is not considered here). Section lengths are typically 6 m long, thus reducing the number of joints in a culvert. Joints are normally fusion welded.

Material: Deterioration is based on material degradation of the pipe (the typical design life of plastic pipe is 100 years – based on Polypipe Ridgestorm XL).

Design life

The design life of such an asset is based on material degradation. For plastic pipes this is typically 100 years before they need to be recycled and replaced (based on Polypipe Ridgestorm XL). The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied, quality of materials, and construction techniques used and stability of the foundations. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality and design/installation is poor.

Deterioration

Culvert deterioration mechanisms are hydraulic wear (on invert and/or along the wet/dry line), seepage through boltholes/joints from backfill, and structural instability of the invert from ageing or through excessive material de-gradation.

The deterioration processes affecting these assets include:

1. Deformation to culvert
2. Settlement to invert or soffit
3. Cracking or fissuring of structure/components
4. Degradation of elements
5. Missing blocks
6. Sealant or joint fill material loss
7. Vegetation growth inside culvert/root penetration

With the exception of settlement, these processes can be controlled by maintenance including minor repair, sealant replacement, debris/vegetation clearance and removal of silt. Downstream scour protection may also be needed.

Backfill replacement, lining the culvert with additional plates and paving replacement are classed as refurbishment (and not maintenance)

The following deterioration processes dominate the rate of deterioration:

- Blockage
- Structural failure

Effect of environmental exposure/material quality

Slowest rate: The culvert is in continuous use, with a continued flow of deep water. It is self-cleansing or there is little or no sediment within the channel.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The culvert is at the extreme ends of use (either high or no flow) and the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by blockage and obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including CCTV surveys, minor repair, joint repairs, silt and obstruction removal and vegetation clearance (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Note: In larger diameter pipes man-access can be gained to undertake joint repairs; however, as the numbers of joints are minimised and they are typically fusion welded the need to repair should be minimised.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including CCTV surveys, minor repair, joint repairs, silt and obstruction removal and vegetation clearance (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

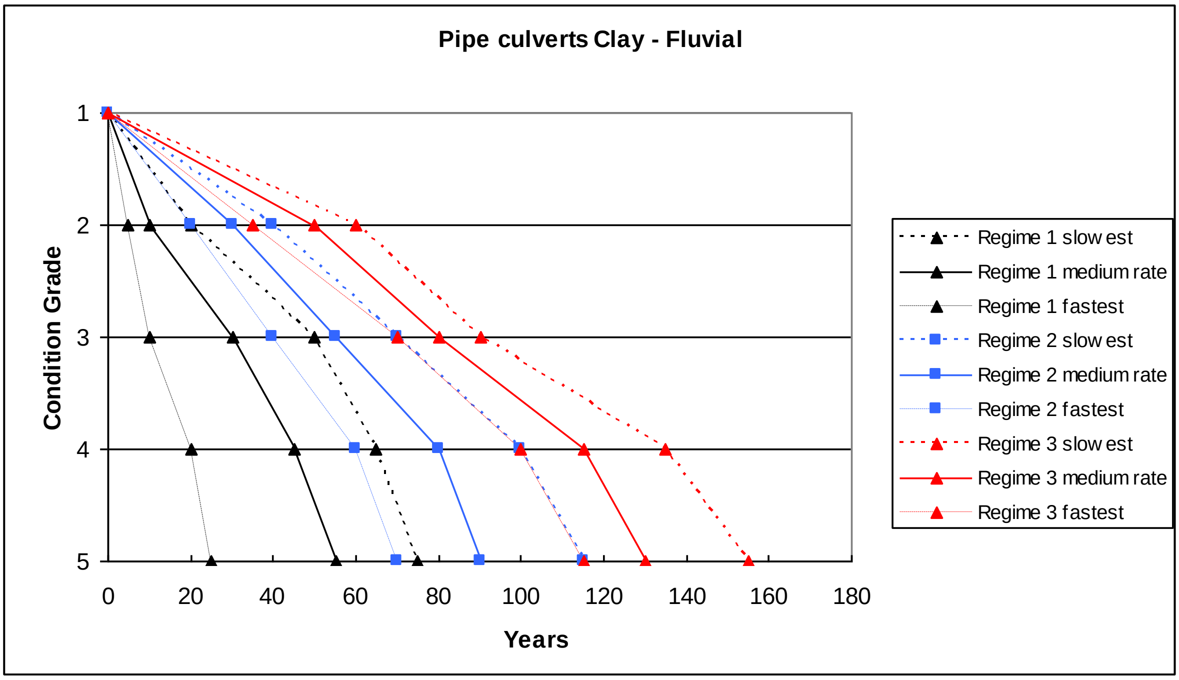
Note: In larger diameter pipes man-access can be gained to undertake joint repairs; however, as the numbers of joints are minimised and they are typically fusion welded the need to repair should be minimised.

e. Clay

AIMS asset classification: Channel/simple OR complex culvert

Models

Culverts Clay – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	65	75
2 – Medium	0	40	70	100	115
3 – High	0	60	90	135	155
Medium rate					
1 – Low/basic	0	10	30	45	55
2 – Medium	0	30	55	80	90
3 – High	0	50	80	115	130
Fastest rate					
1 – Low/basic	0	5	10	20	25
2 – Medium	0	20	40	60	70
3 – High	0	35	70	100	115



Model assumptions

General

Material: Clay piped culverts are very old and not generally used for culverts these days. Assumed similar to smaller diameter concrete pipes.

Design life

The design life of such an asset is approximately 100 to120 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. Note: There is a body of evidence gathering which suggests that pipes may last longer (based on literature from the Concrete Pipeline Systems Association). The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality and design/installation is poor.

Deterioration

Culvert deterioration mechanisms are hydraulic wear (on invert and/or along the wet/dry line), seepage through boltholes/joints from backfill, and structural instability of the invert from ageing or through excessive material degradation.

The deterioration processes affecting these assets include:

1. Deformation to culvert
2. Settlement to invert or soffit
3. Cracking or fissuring of structure/components
4. Degradation of elements
5. Missing blocks
6. Sealant or joint fill material loss
7. Vegetation growth inside culvert/root penetration

With the exception of settlement, these processes can be controlled by maintenance including minor repair, sealant replacement, joint repair, debris/vegetation clearance and removal of silt. Downstream scour protection may also be needed.

Replacement of protective coatings, backfill replacement, lining the culvert with additional plates and paving replacement are classed as refurbishment (and not maintenance).

The following deterioration processes dominate the rate of deterioration:

- Blockage
- Structural failure

Effect of environmental exposure/material quality

Slowest rate: The culvert is in continuous use, with a continued flow of deep water. It is self-cleansing or there is little or no sediment within the channel.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The culvert is at the extreme ends of use (either high or no flow) and the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. The only maintenance tasks likely to be carried out on the culvert are inspection/review of H&S provisions and their repair/replacement (signs, hand railings, etc); there is no maintenance of the asset. This curve relates predominantly to the likelihood of extreme and rapid material degradation compounded by blockage and obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including inspections, CCTV surveys, minor repair, silt and obstruction removal, vegetation clearance, joint repairs (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Note: In some larger diameter pipes man-access can be gained for survey and repair.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including inspections, CCTV surveys, minor repair, silt and obstruction removal, vegetation clearance, joint repairs (and downstream scour protection) offsets asset deterioration and more frequent inspection captures deterioration before it becomes a problem (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Note: In some larger diameter pipes man-access can be gained for survey and repair.

C.7 Beaches

With and without beach control structures (rock/timber groynes, offshore breakwaters (rock), breastwork (timber) and crib walls (timber)

a. Shingle/sand (coastal/estuarine)

AIMS asset classification: Defence/beach

Figure C11 shows a basic line sketch of this type of asset: beach (shingle/sand).

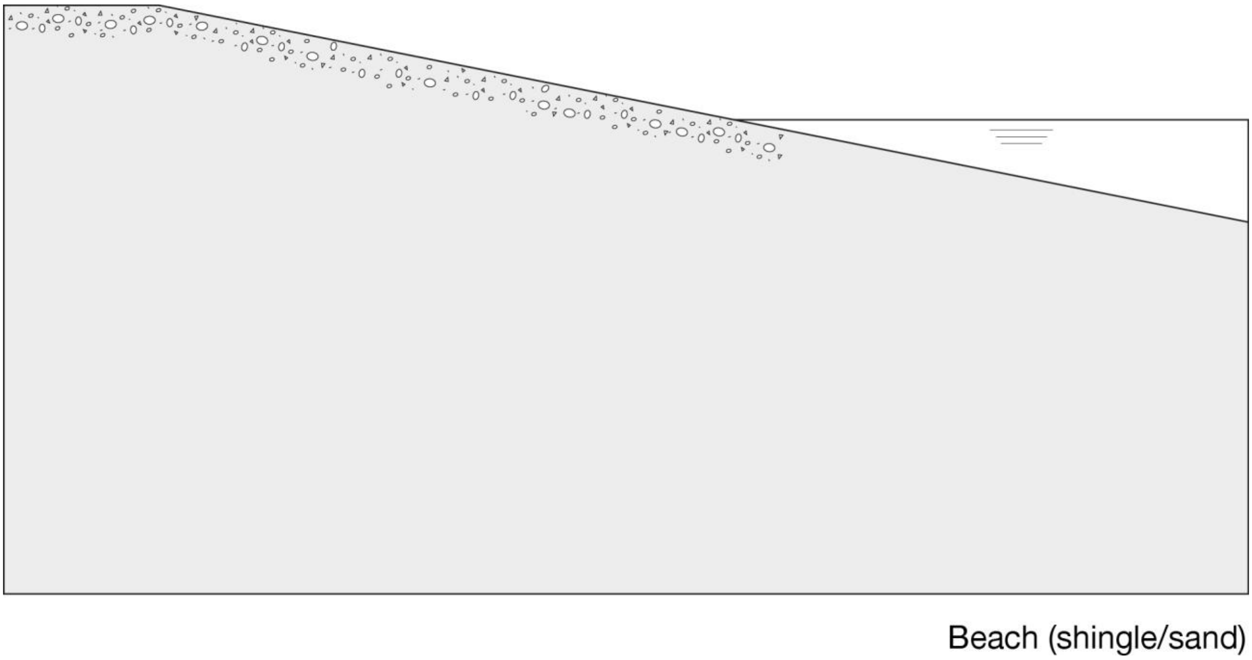
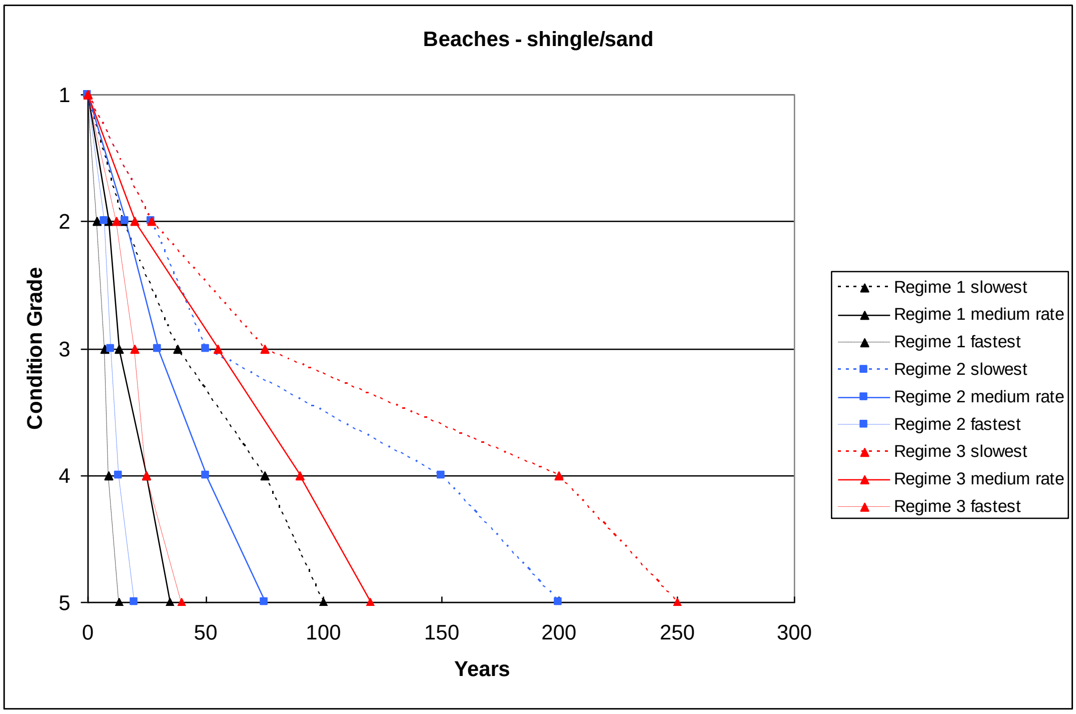


Figure C11 Beach (shingle/sand)

Models

Beaches Shingle/sand					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	38	75	100
2 – Medium	0	27	50	150	200
3 – High	0	27	75	200	250
Medium rate					
1 – Low/basic	0	9	13	25	35
2 – Medium	0	16	30	50	75
3 – High	0	20	55	90	120
Fastest rate					
1 – Low/basic	0	4	7	9	13
2 – Medium	0	7	10	13	20
3 – High	0	12	20	25	40



Model assumptions

Design life

Not applicable.

Deterioration

The deterioration processes affecting these assets are:

1. Continuous reduction in cross-sectional area or extent over the long term
2. Extensive reduction in cross-sectional area or extent due to extreme event
3. Damage to control structures
4. Gullying
5. Percolation through the beach
6. Third party damage, e.g. boat damage
7. Wind erosion

It is understood that changes to the cross-sectional area have the greatest impact on deterioration of performance. It is assumed in this analysis that the performance of the beach is related to how it may respond to storms and/or long-term changes to drift rates, i.e. is there sufficient material to be drawn down/lost alongshore and still provide the required beach cross-section.

Effect of environmental exposure/material quality

Slowest rate: The beach lies in a sheltered area where the sediment balance is stable/accreting. The existing beach is wide with a broad, high backshore. Assuming a stable/accreting beach, then there will be a slow change in condition, primarily in relation to sea-level rise and increased storminess, which may reduce the stability of the sediment balance.

Medium rate: Considered a typical rate providing a mid-range value. Assumes a stable beach with periods of erosion. Sensitivity to erosion results in storm damage being a possibility.

Fastest rate: The beach lies in an exposed area where the sediment balance is eroding. The existing beach is narrow and provides the required performance profile with little buffer for erosion loss. There may be a very rapid change in condition, primarily in relation to storm events.

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. The only maintenance tasks carried out are inspections. Without ongoing beach management, including recycling or renourishment, beaches on eroding frontages may rapidly lose material resulting in changes to the cross-sectional area of the beach, therefore reducing the performance of the asset. Where the beach is exposed and in poor condition, this can happen very rapidly during a single storm event. Where the beach is more sheltered and in better condition, it may be able to withstand greater storm events. As noted in Phase 1, for shingle beaches, initial deterioration is slow but then accelerates; later, following substantial beach loss, further deterioration slows.

On some frontages, shingle beaches lie in areas of natural accretion and require little if any maintenance over the long term.

If the beach is stable/accreting isolated locations of beach narrowing may occur, i.e. at the down-drift ends of groyne fields, etc. This would reduce the performance of the asset.

For beaches sensitive to erosion or eroding beaches, isolated locations of beach narrowing may occur, i.e. at the down-drift ends of groyne fields, etc.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance, including frequent inspections and monitoring, vegetation clearance, recycling and renourishment, offsets deterioration. Deterioration rates are dominated by the ability of the beach to withstand erosion in between recycling and renourishment events.

If the beach is stable/accreting, then ongoing recycling and renourishment can address deterioration and ensure a condition grade of 3 can be maintained over the longer term.

For beaches sensitive to erosion, ongoing recycling and renourishment can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced, i.e. post storm, before reprofiling. Therefore, there is an increased risk of beach deterioration.

For an eroding beach, ongoing recycling and renourishment can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced, i.e. post storm, before reprofiling. Therefore there is an increased risk of rapid beach deterioration.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including recycling and renourishment offsets deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are dominated by the ability of the beach to withstand erosion in between recycling and renourishment events.

If the beach is stable/accreting, then ongoing recycling and renourishment can address deterioration and ensure a condition grade of 2 can be maintained over the longer term.

For beaches sensitive to erosion, ongoing recycling and renourishment can address deterioration to a certain degree. However, as it is sensitive to erosion, there may be occasions where the asset performance is reduced, i.e. post storm, before reprofiling. Therefore there is an increased risk of beach deterioration.

For an eroding beach, ongoing recycling and renourishment can address deterioration to a certain degree. However, as it is prone to erosion, there may be occasions where the asset performance is reduced, i.e. post storm, before reprofiling. Therefore there is an increased risk of rapid beach deterioration.

C.8 Control structures (coastal)

a. Rock groynes

AIMS asset classification: Beach structure/groyne

Figure C12 shows a basic line sketch of this type of asset: control structures – rock (and timber) groynes.

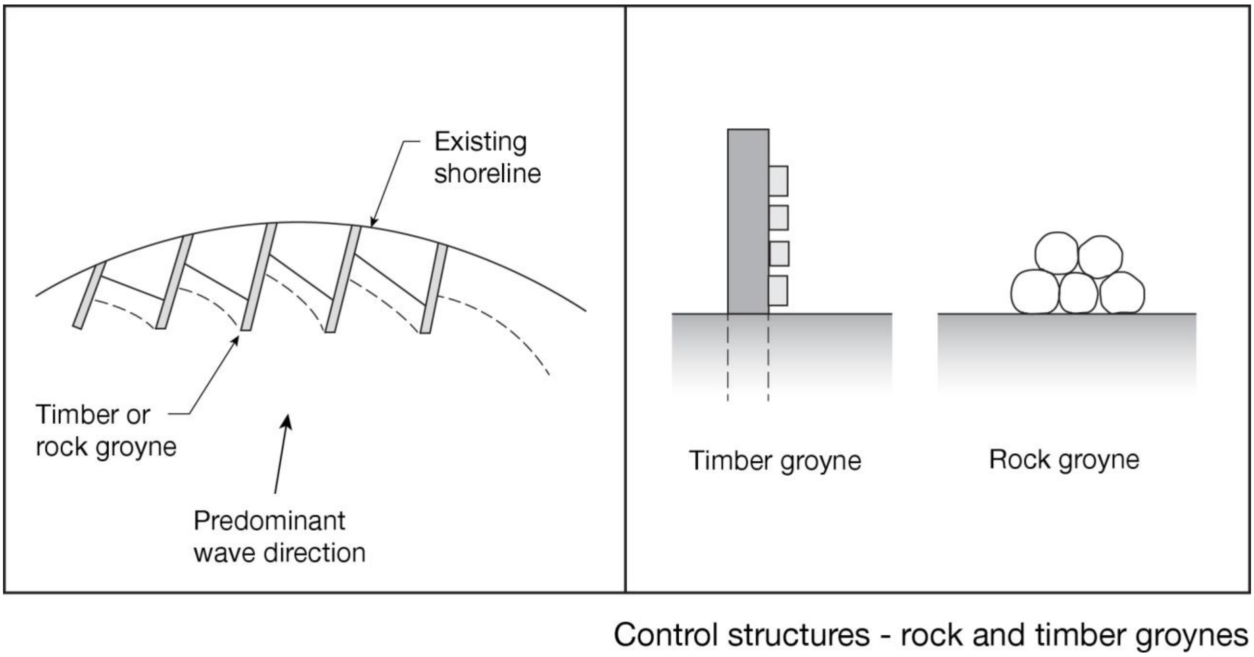
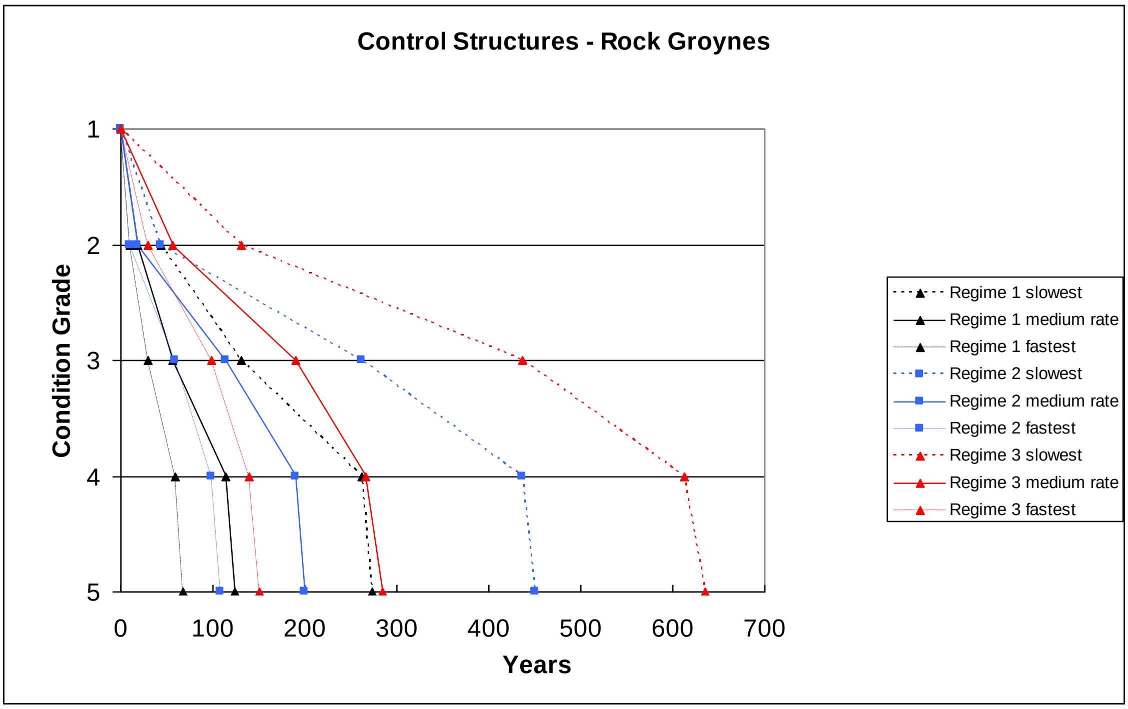


Figure C12 Control structures – rock (and timber) groynes

Models

Control Structures Rock Groynes – Coastal					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	44	131	262	273
2 – Medium	0	44	262	437	450
3 – High	0	131	437	612	635
Medium rate					
1 – Low/basic	0	19	57	114	124
2 – Medium	0	19	114	190	200
3 – High	0	57	190	266	285
Fastest rate					
1 – Low/basic	0	10	30	59	67
2 – Medium	0	10	59	99	108
3 – High	0	30	99	139	150



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets are:

1. Voids in rock packing
2. Extents of loosely packed rock
3. Loss of rock armour or infill
4. Exposure of rock toe
5. Settlement of rock
6. Damage to exposed geotextile layer

Items 1 to 4 can be managed through maintenance activities, for example by redistribution of rocks (after heaving storm), by scour protection or by replacing damaged/eroded rocks. The effects of settlement and damage to geotextile layers cannot be managed through maintenance.

The following deterioration processes dominate the rate of deterioration:

- Movement of structure
- Exposure of rock core/geotextile
- Disintegration of rock packing

Effect of environmental exposure/material quality

Slowest rate: The asset is in a relatively protected location at the back of the foreshore. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the asset.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The asset is in an exposed location. The asset may suffer from poor quality materials/construction/design.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid asset degradation (rock movement and loss of optimum packing) compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including minor repair, rock redistribution and replacement and scour protection offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, rock redistribution and replacement and scour protection offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). Asset lives can be considerably extended under this maintenance regime, particularly in the slowest deterioration rate scenario, with estimates indicating end of asset life in excess of 600 years, a consequence of the very low material erosion in protected environments and the high stability of the asset structure/foundations. In addition, even with progressive loss and degradation of the rock over CG 3 and CG 4, the rocks' presence will still act as a barrier to longshore drift in some situations and may therefore have some control performance value.

Work

Maintenance is understood to mean minor re-siting of rocks on the structure; importing of new rock would constitute refurbishment.

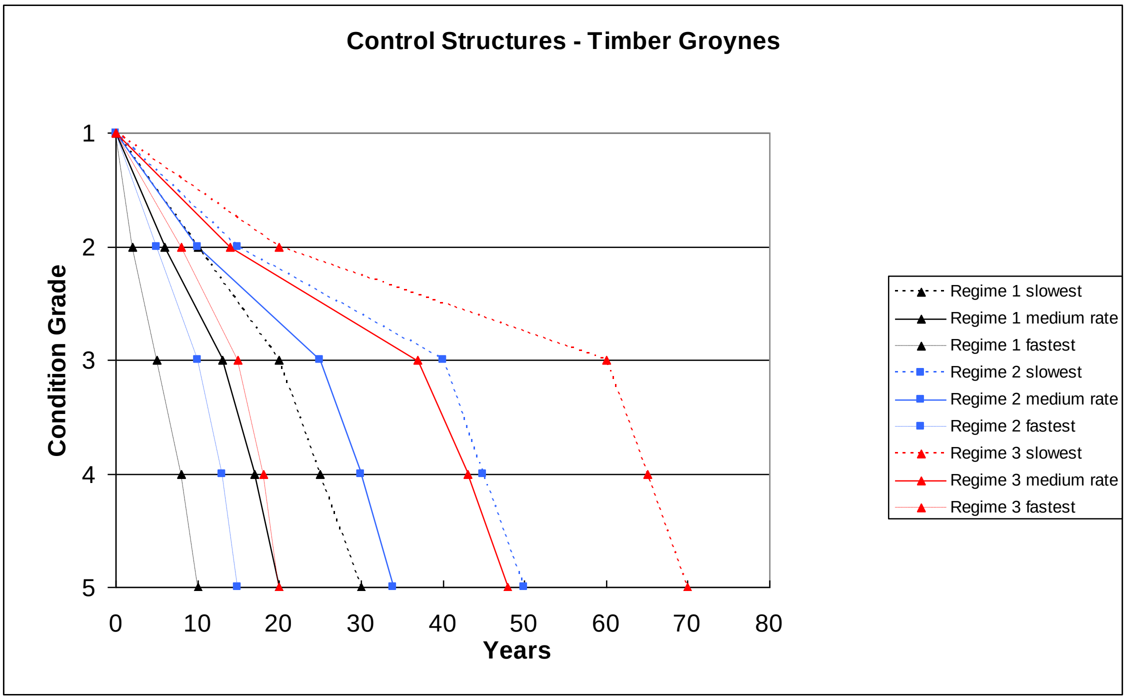
b. Timber groynes

AIMS asset classification: Beach structure/groyne

(See Figure C12 above)

Models

Control Structures Timber Groynes – Coastal					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	10	20	25	30
2 – Medium	0	15	40	45	50
3 – High	0	20	60	65	70
Medium rate					
1 – Low/basic	0	6	13	17	20
2 – Medium	0	10	25	30	34
3 – High	0	14	37	43	48
Fastest rate					
1 – Low/basic	0	2	5	8	10
2 – Medium	0	5	10	13	15
3 – High	0	8	15	18	20



Model assumptions

Design life

The design life of such an asset is approximately 25 to 40 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets are:

1. Missing or damaged planks
2. Missing or damaged ties, walings and fixings
3. Groyne no longer able to arrest drift of beach material
4. Movement, rotation, bulging or undermining

These deterioration processes can be managed through maintenance activities, for example by replacing damaged/worn planks and elements and by recycling built-up material.

The following deterioration processes dominate the rate of deterioration:

- Movement of structure
- Disintegrated or missing components

Effect of environmental exposure/material quality

Slowest rate: The asset is in a relatively protected location at the back of the foreshore. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the asset. More applicable to hardwood structures.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The asset is in an exposed location. The asset may suffer from poor quality materials/construction/design. More applicable to softwood structures

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid material/asset degradation compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including replacing damaged/worn planks and elements and by recycling built-up material offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including replacing damaged/worn planks and elements and by recycling built-up material offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

c. Offshore breakwaters (rock)

AIMS asset classification: Beach structure/breakwaters

Figure C13 shows a basic line sketch of this type of asset: control structures – offshore breakwater (rock).

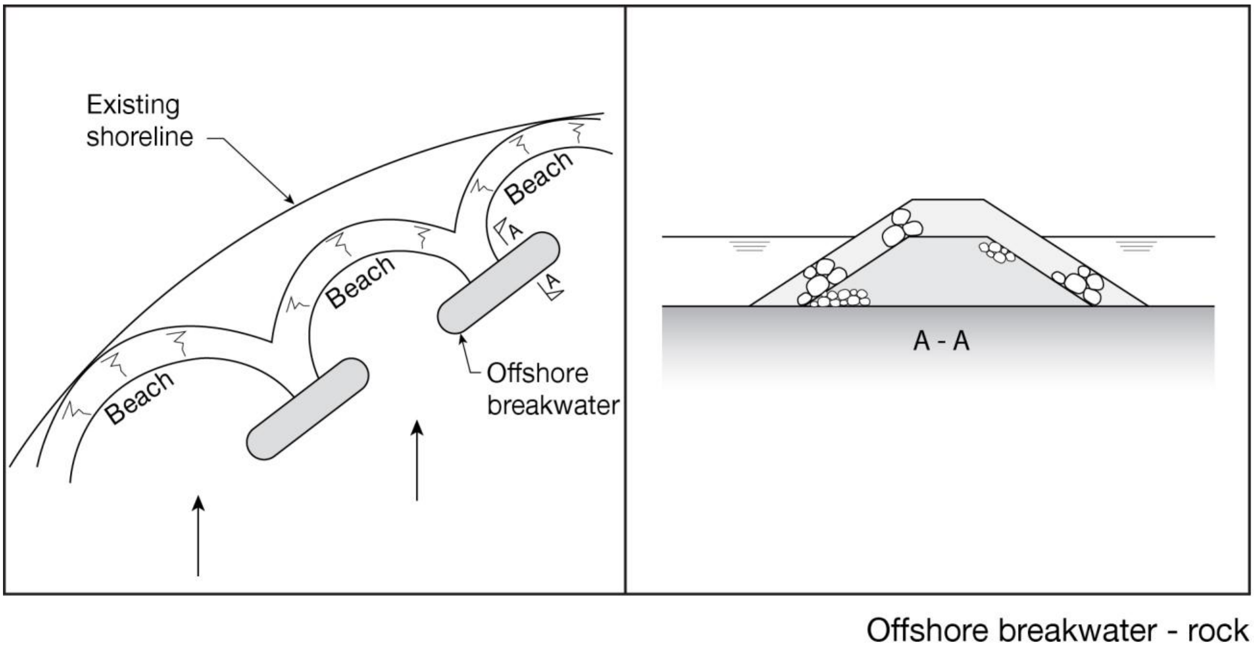
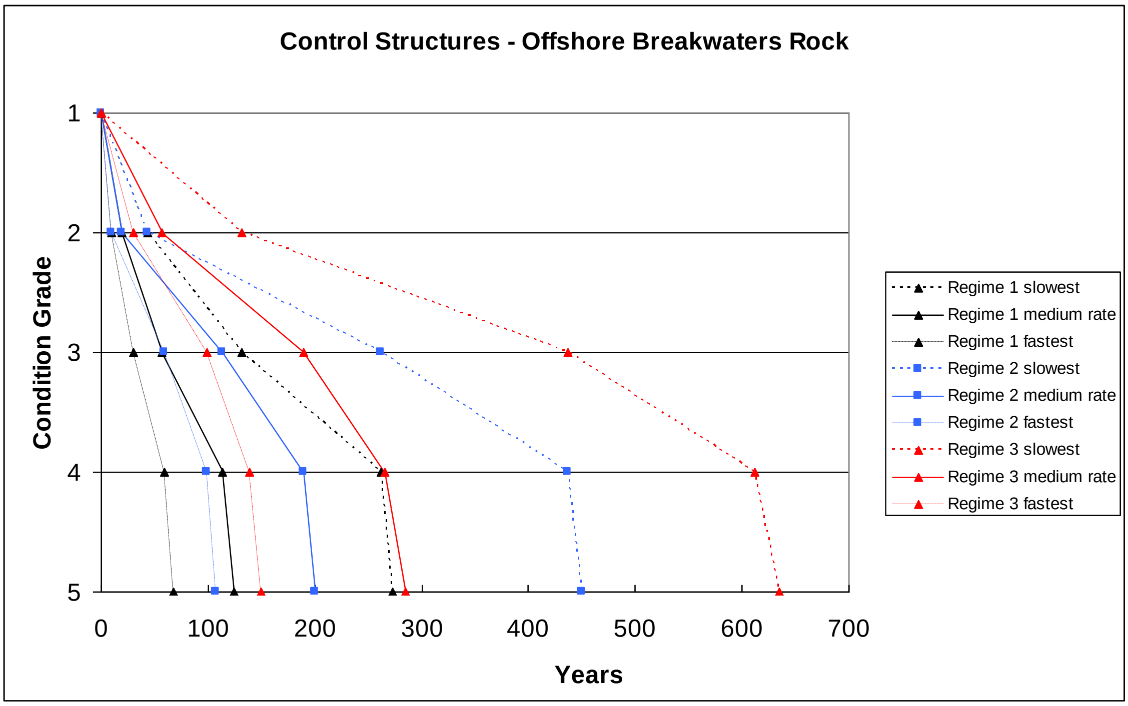


Figure C13 Control structures – offshore breakwater (rock)

Models

Control Structures Breakwaters (Rock) – Coastal					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	44	131	262	273
2 – Medium	0	44	262	437	450
3 – High	0	131	437	612	635
Medium rate					
1 – Low/basic	0	19	57	114	124
2 – Medium	0	19	114	190	200
3 – High	0	57	190	266	285
Fastest rate					
1 – Low/basic	0	10	30	59	67
2 – Medium	0	10	59	99	108
3 – High	0	30	99	139	150



Model assumptions

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets are:

1. Voids in rock packing
2. Extents of loosely packed rock
3. Exposure of rock toe
4. Loss of rock armour or infill
5. Settlement of rock
6. Damage to exposed geotextile layer

Items 1 to 4 can be managed through maintenance activities, for example by redistribution of rocks (after heaving storm), by scour protection or by replacing damaged/eroded rocks. The effects of settlement and damage to geotextile layers cannot be managed through maintenance.

The following deterioration processes dominate the rate of deterioration:

- Movement of structure
- Exposure of rock core/geotextile
- Disintegration of rock packing

Effect of environmental exposure/material quality

Slowest rate: The asset is in a relatively protected location at the back of the foreshore. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the asset.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The asset is in an exposed location. The asset may suffer from poor quality materials/construction/design.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades (particularly CG 4), this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. This curve relates predominantly to the likelihood of extreme and rapid asset degradation (rock movement and loss of optimum packing) compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including minor repair, rock redistribution and replacement, and scour protection offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, rock redistribution and replacement, and scour protection offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). In addition, even with progressive loss and degradation of the rock, the rocks’ presence will still act as a barrier to longshore drift in some situations and may therefore have some control performance value.

Work

Maintenance is understood to mean minor re-siting of rocks on the structure; importing of new rock would constitute refurbishment.

d. Crib wall – timber

Figure C14 shows a basic line sketch of this type of asset: control structures – crib wall (timber).

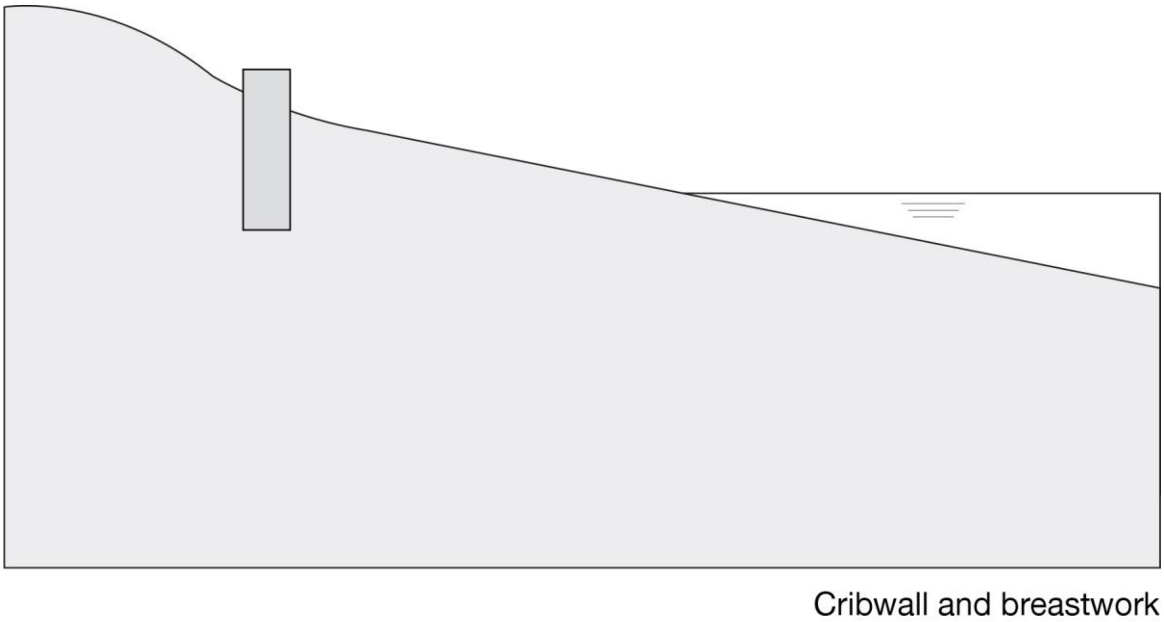
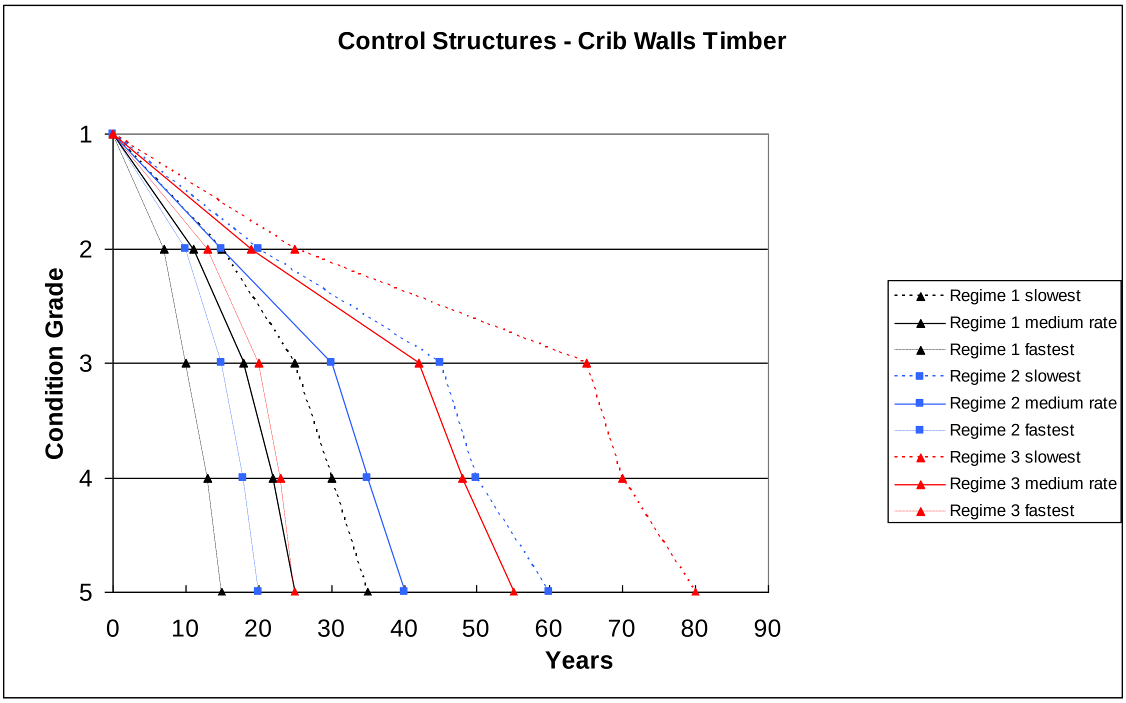


Figure C14 Control structures – crib wall (timber)

Models

Crib wall Timber – Coastal					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	25	30	35
2 – Medium	0	20	45	50	60
3 – High	0	25	65	70	80
Medium rate					
1 – Low/basic	0	11	18	22	25
2 – Medium	0	15	30	35	40
3 – High	0	19	42	48	55
Fastest rate					
1 – Low/basic	0	7	10	13	15
2 – Medium	0	10	15	18	20
3 – High	0	13	20	23	25



Model assumptions

Material: These assets are typically a hollow gravity structure for retaining fill that is infilled with granular material (stone).

Design life

The design life of such an asset is approximately 25 to 40 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

Curves have been based on those for timber groynes, although crib walls are considered to be less exposed as they are typically constructed landward of groynes at the top of a beach (so grade transitions occur slightly later in asset life). Same curves as for timber breastwork.

The deterioration processes affecting these assets are:

1. Missing or damaged planks
2. Missing or damaged ties, walings and fixings
3. Groyne no longer able to arrest drift of beach material
4. Movement, rotation, bulging or undermining

These deterioration processes can be managed through maintenance activities, for example by replacing damaged/worn planks and elements and by recycling built-up material.

The following deterioration processes dominate the rate of deterioration:

- Movement of structure
- Disintegrated or missing components

Effect of environmental exposure/material quality

Slowest rate: The asset is in a relatively protected location at the back of the foreshore. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the asset. More applicable to hardwood structures.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The asset is in an exposed location. The asset may suffer from poor quality materials/construction/design. More applicable to softwood structures.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid material/asset degradation compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including replacing damaged/worn planks and elements and by recycling built-up material offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

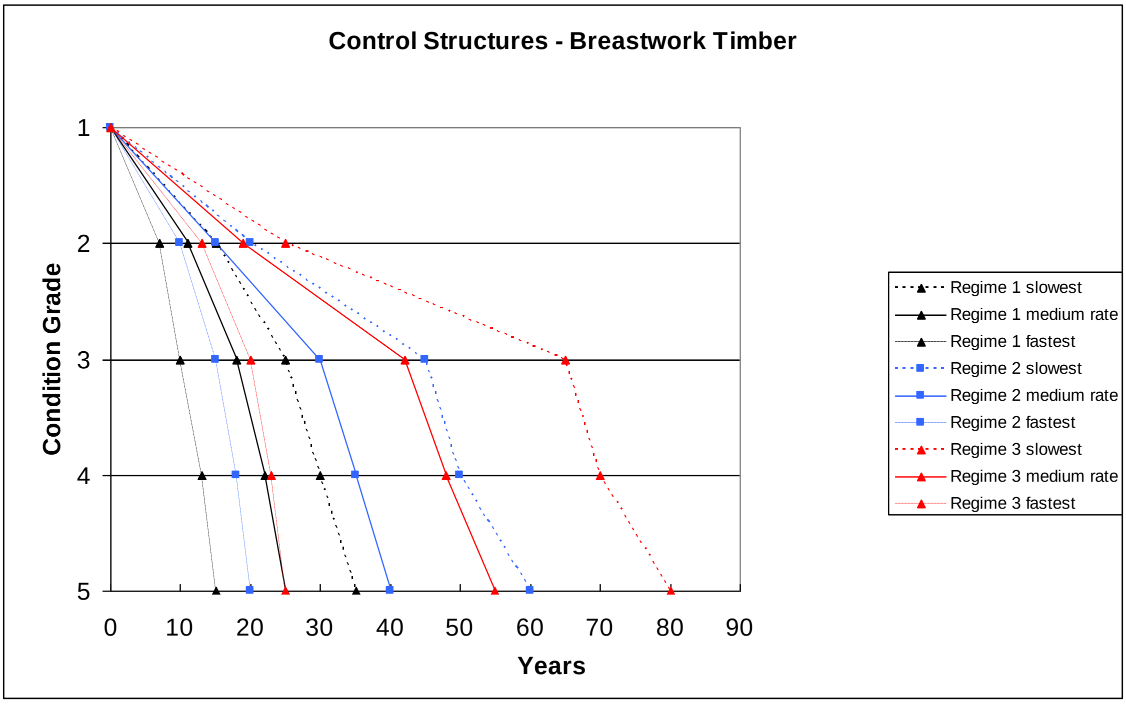
Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including replacing damaged/worn planks and elements and by recycling built-up material offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

e. Breastwork – timber

(See Figure C14 above)

Models

Breastwork Timber – Coastal					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	25	30	35
2 – Medium	0	20	45	50	60
3 – High	0	25	65	70	80
Medium rate					
1 – Low/basic	0	11	18	22	25
2 – Medium	0	15	30	35	40
3 – High	0	19	42	48	55
Fastest rate					
1 – Low/basic	0	7	10	13	15
2 – Medium	0	10	15	18	20
3 – High	0	13	20	23	25



Model assumptions

Design life

The design life of such an asset is approximately 25 to 40 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

Curves have been based on those for timber groynes, although breastwork timbers are considered to be less exposed as they are typically constructed landward of groynes at the top of a beach (so grade transitions occur slightly later in asset life). Same curves as for timber crib walls.

The deterioration processes affecting these assets include:

1. Missing or damaged planks
2. Missing or damaged ties, walings and fixings
3. Groyne no longer able to arrest drift of beach material
4. Movement, rotation, bulging or undermining

These deterioration processes can be managed through maintenance activities, for example by replacing damaged/worn planks and elements and by recycling built-up material.

The following deterioration processes dominate the rate of deterioration:

- Movement of structure
- Disintegrated or missing components

Effect of environmental exposure/material quality

Slowest rate: The asset is in a relatively protected location at the back of the foreshore. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. There is little or no erosion risk in front of the asset. More applicable to hardwood structures.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The asset is in an exposed location. The asset may suffer from poor quality materials/construction/design. More applicable to softwood structures. Note: The structure is intended to provide protection against erosion or breaching during storm events. It is unlikely to be appropriate in areas of high wave energy, or where there is no beach fronting the structure.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid material/asset degradation compounded by loss of surrounding support strata.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including replacing damaged/worn planks and elements and by recycling built-up material offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including replacing damaged/worn planks and elements and by recycling built-up material offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.9 Dunes and saltmarshes

a. Dunes – with or without holding structures (coastal)

AIMS asset classification: Defence/dunes

Figure C15 shows a basic line sketch of this type of asset: dunes.

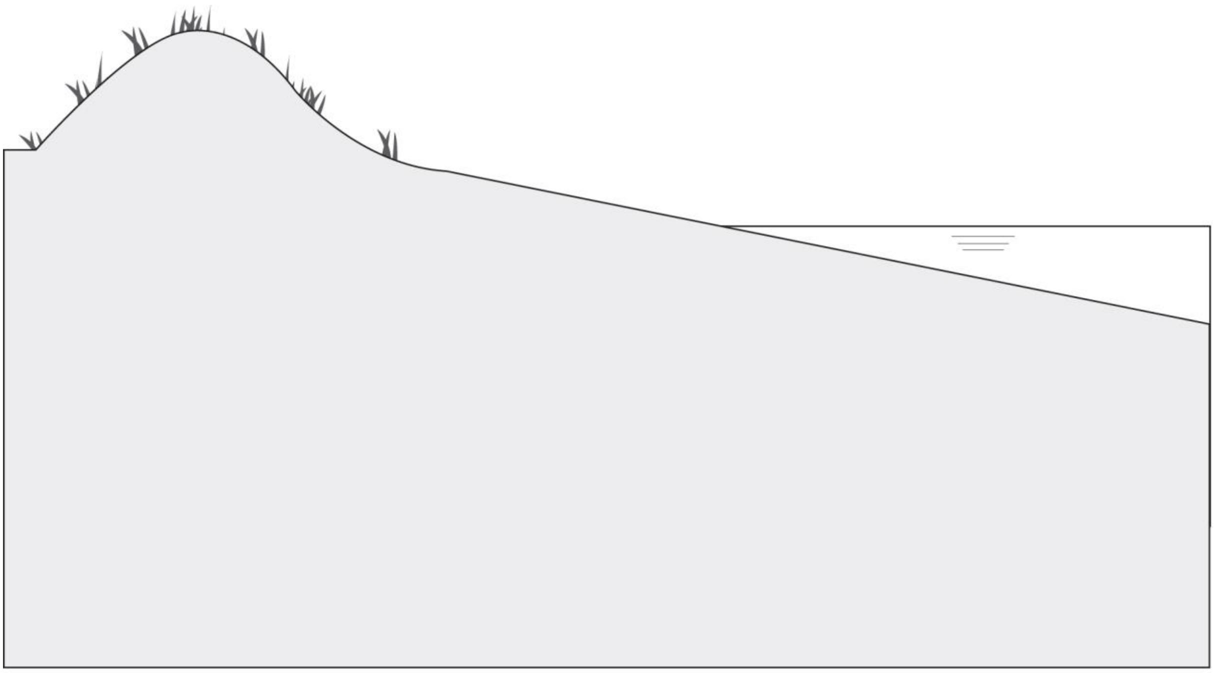
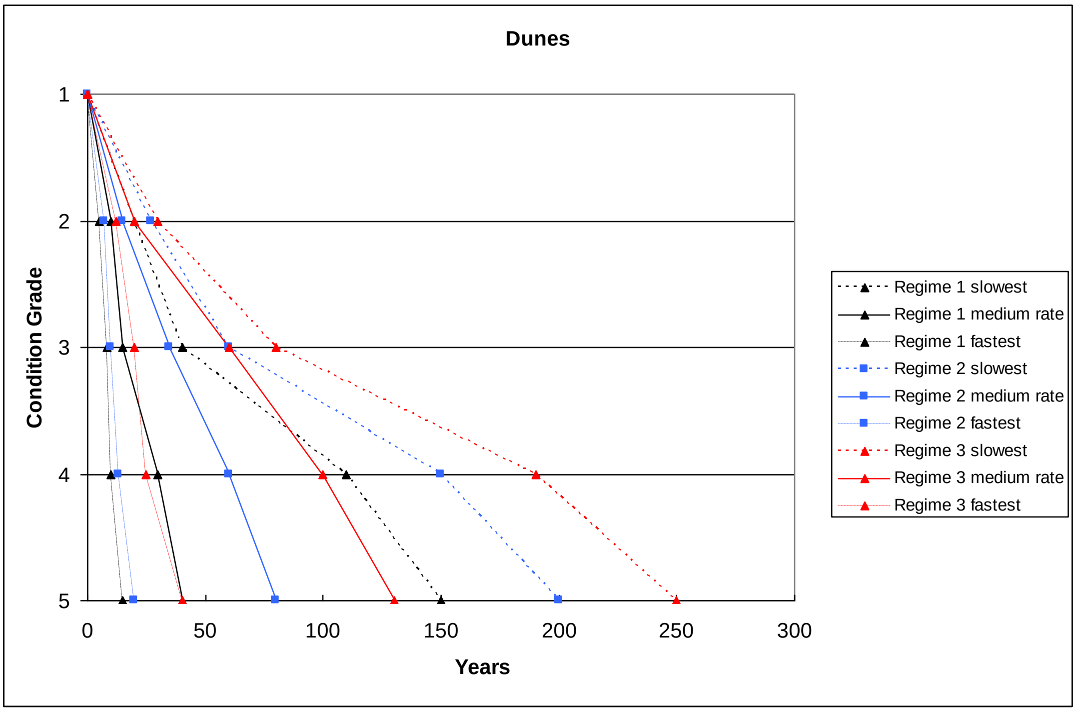


Figure C15 Dunes

Models

Dunes – Coastal					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	110	150
2 – Medium	0	27	60	150	200
3 – High	0	30	80	190	250
Medium rate					
1 – Low/basic	0	10	15	30	40
2 – Medium	0	15	35	60	80
3 – High	0	20	60	100	130
Fastest rate					
1 – Low/basic	0	5	8	10	15
2 – Medium	0	7	10	13	20
3 – High	0	12	20	25	40



Model assumptions

Design life

Not applicable.

Deterioration

The signs of deterioration for these assets are:

1. Narrow or flat dune system
2. Damage or loss of vegetation
3. Low beach fronting dunes
4. Erosion or collapse of seaward dune slope
5. Evidence of overtopping, i.e. runnels
6. Damage to control structures
7. Third party damage, e.g. boat damage
8. Presence of foreign objects

It is understood that changes to the fronting beach and cross-sectional area of the dunes have the greatest impact on deterioration of performance. Vegetation condition is also very important for the maintenance of dunes.

Effect of environmental exposure/material quality

Slowest rate: The dune lies in a sheltered area and is stable/accreting. The fronting beach is wide and protects the dune on most frequent events. Assuming a stable/accreting dune, then there will be a slow change in condition, primarily in relation to sea-level rise and increased storminess or changes to wind climate, which may reduce the stability of the sediment balance.

Medium rate: Considered a typical rate providing a mid-range value. Assuming a stable dune with periods of erosion, there may be a slow reduction in dune volume and therefore deterioration of performance.

Fastest rate: The dune is relict and no longer accreting. The dune lies in an exposed area and suffers erosion. The fronting beach is narrow and the seaward dune slope is eroding. There may be a very rapid change in condition, primarily in relation to storm events.

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. The only maintenance tasks carried out are inspections. Without ongoing dune management, including the installation of wind traps, planting of marram grass, etc, relict dunes on eroding frontages may lose material resulting in changes to the cross-sectional area of the dune and, therefore, reducing the performance of the asset. Where the dune is exposed and the fronting beach is in poor condition, this can happen very rapidly during a single storm event. Where the dune is more sheltered and the fronting beach is in better condition, the dune may be able to withstand greater storm events.

On some frontages, dunes are accreting and growing in response and therefore require little if any maintenance over the long term.

If the dune is stable/accreting, isolated locations of vegetation loss or erosion of the dune front slope may occur. This would reduce the performance of the asset.

For dunes sensitive to erosion or eroding dunes, isolated locations of vegetation loss or erosion of the dune front slope may occur, i.e. near access paths, outfalls, etc.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance includes frequent inspections and monitoring, vegetation clearance, construction of sand fences, replanting, vermin control and reducing human and/or vehicular traffic with appropriate signage and fencing. Deterioration rates are dominated by the ability of the dune and fronting beach to withstand erosion in between recycling and renourishment events.

If the dune is stable/accreting, then ongoing maintenance of control structures and replanting can address deterioration and ensure a condition grade of 3 can be maintained over the longer term.

For dunes sensitive to erosion, ongoing maintenance of control structures and replanting can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced, i.e. post storm. Therefore there is an increased risk of dune deterioration.

For an eroding dune, ongoing maintenance of control structures and replanting can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced, i.e. post storm. Therefore there is an increased risk of rapid dune deterioration.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance includes frequent inspections and monitoring, vegetation clearance, construction of sand fences, replanting, vermin control and reducing human and/or vehicular traffic with appropriate signage and fencing (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are dominated by the ability of the dune and fronting beach to withstand erosion in between recycling and renourishment events.

If the dune is stable/accreting, then ongoing maintenance of control structures and replanting can address deterioration on this dune and ensure a condition grade of 2 can be maintained over the longer term.

For dunes sensitive to erosion, ongoing maintenance of control structures and replanting can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced, i.e. post storm. Therefore, there is an increased risk of dune deterioration.

For an eroding dune, ongoing maintenance of control structures and replanting can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced, i.e. post storm. Therefore, there is an increased risk of rapid dune deterioration.

b. Saltmarshes

AIMS asset classification: Land/saltmarsh

Sub-type: Saltmarshes, saltings and warths with or without holding structures (coastal/estuarine)

Figure C16 shows a basic line sketch of this type of asset: saltmarsh.

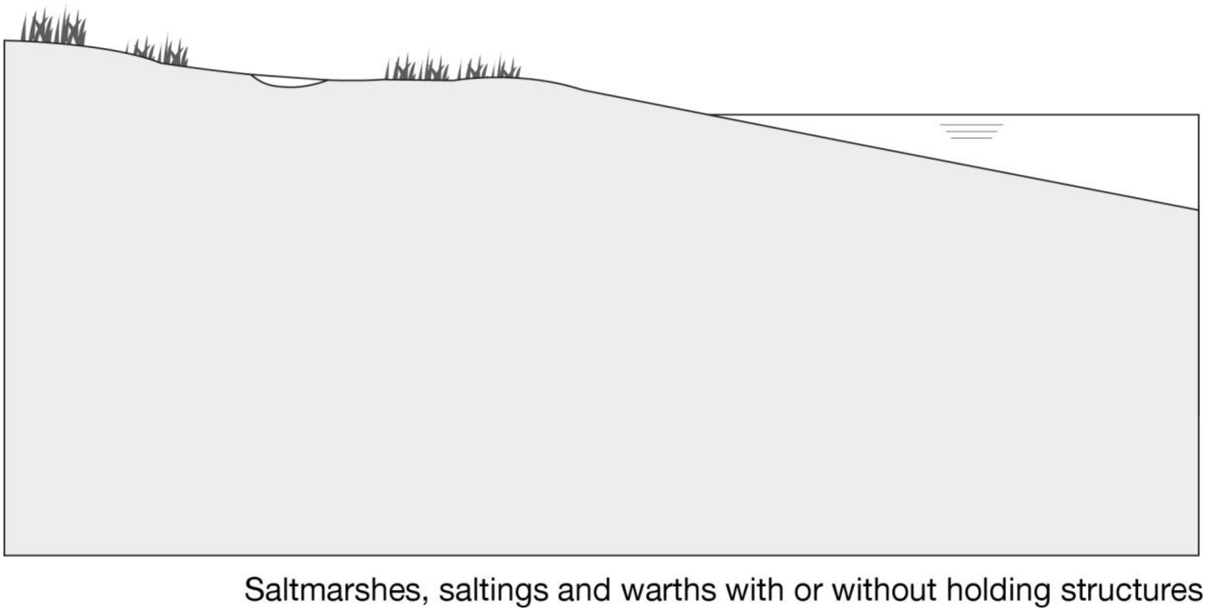
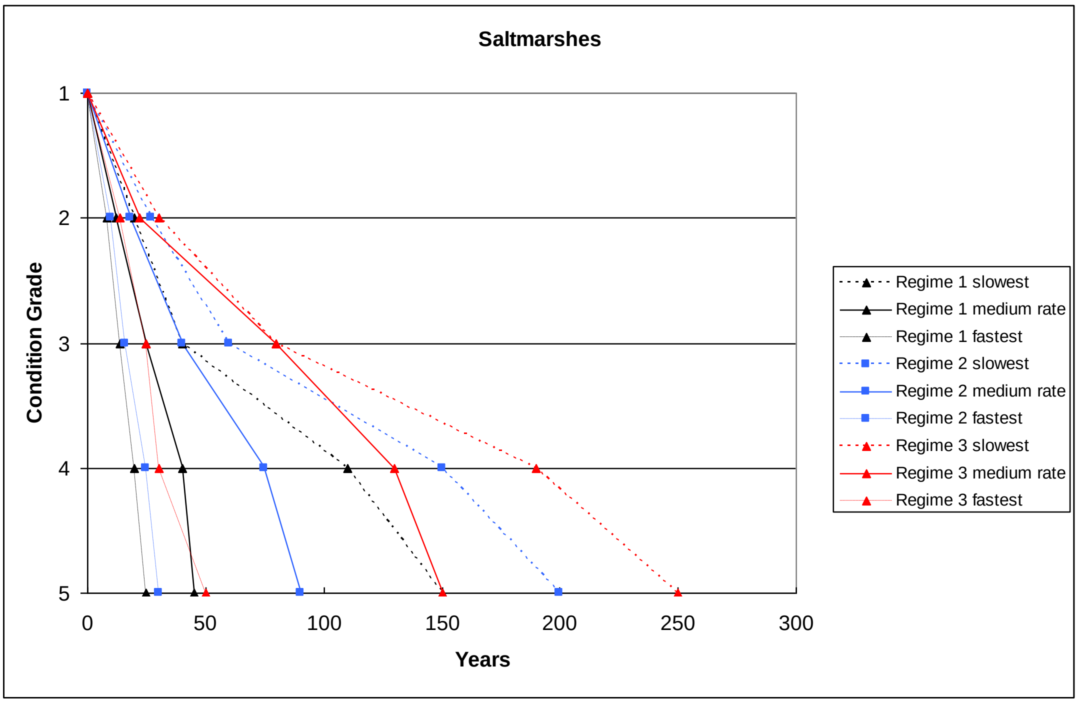


Figure C16 Saltmarsh

Models

Saltmarshes – Coastal					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	40	110	150
2 – Medium	0	27	60	150	200
3 – High	0	30	80	190	250
Medium rate					
1 – Low/basic	0	12	25	40	45
2 – Medium	0	18	40	75	90
3 – High	0	22	80	130	150
Fastest rate					
1 – Low/basic	0	8	14	20	25
2 – Medium	0	10	16	25	30
3 – High	0	14	25	30	50



Model assumptions

Design life

Not applicable.

Deterioration

The signs of deterioration for these assets are:

1. Steep and narrow slope
2. Erosion of marsh toe
3. Widening and lengthening of creek system
4. Vegetation loss or damage
5. Third party damage, e.g. grazing
6. Exposed underlying mud flat
7. Presence of foreign objects

It is understood that changes to the saltmarsh vegetation, creek system and front slope of the saltmarsh are the greatest indicators of deterioration of performance.

Effect of environmental exposure/material quality

Slowest rate: The saltmarsh lies in a sheltered area and is stable/accreting. Assuming a stable/accreting saltmarsh, then there will be a slow change in condition, primarily in relation to sea-level rise and increased storminess, which may reduce the stability of the sediment balance, or changes to vegetation (disease, etc).

Medium rate: Considered a typical rate providing a mid-range value. Assuming a stable saltmarsh with periods of erosion, there may be a slow reduction in saltmarsh extent and therefore deterioration of performance.

Fastest rate: The saltmarsh is small in extent and lies in an exposed area. Assuming an eroding saltmarsh which lies in an exposed area, there may be a very rapid change in condition, primarily in relation to ongoing erosion or poor vegetation condition.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades, this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating/eroding assets.

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. The only maintenance tasks carried out are inspections. Without ongoing saltmarsh management, including the installation of scour protection, protection of vegetation, etc, some saltmarshes on eroding frontages may lose material resulting in a reduction of the plan area of the marsh. Maintaining healthy vegetation and reducing erosion ensures performance of the marsh to reduce wave energy and provide flood protection.

On some frontages, saltmarshes are accreting and growing as a result and therefore require little if any maintenance over the long term.

Although saltmarshes may undergo rapid erosion due to increased submersion (change in tidal regime) or due to boat wake scour, etc, they are unlikely to be completely lost during single storm events. Therefore, it is felt that saltmarshes may be predicted to have a longer residual life under the range of scenarios than dunes and beaches.

If the saltmarsh is stable, isolated locations of vegetation loss or erosion of the saltmarsh may occur. This would reduce the performance of the asset.

For saltmarshes sensitive to erosion or eroding saltmarshes, isolated locations of vegetation loss or erosion of the saltmarsh front slope may occur, i.e. near access paths, outfalls, etc.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance include frequent inspections and monitoring, installation of scour protection, replanting/vegetation maintenance, and reducing human and/or vehicular traffic with appropriate signage and fencing. Deterioration rates are dominated by the ability of the saltmarsh to withstand ongoing erosion.

If the saltmarsh is stable/accreting, then ongoing maintenance of control structures and vegetation maintenance can address deterioration on this saltmarsh and ensure a condition grade of 3 can be maintained over the longer term.

For saltmarshes sensitive to erosion, ongoing maintenance of control structures and vegetation maintenance can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced. Therefore, there is an increased risk of saltmarsh deterioration.

For an eroding saltmarsh, ongoing maintenance of control structures and vegetation maintenance can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced. Therefore, there is an increased risk of rapid saltmarsh deterioration.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance includes frequent inspections and monitoring, installation of scour protection, replanting/vegetation maintenance, and reducing human and/or vehicular traffic with appropriate signage and fencing (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are dominated by the ability of the saltmarsh to withstand ongoing erosion.

If the saltmarsh is stable/accreting, then ongoing maintenance of control structures and vegetation maintenance can address deterioration on this saltmarsh and ensure a condition grade of 2 can be maintained over the longer term.

For saltmarshes sensitive to erosion, ongoing maintenance of control structures and vegetation maintenance can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced. Therefore, there is an increased risk of saltmarsh deterioration.

For an eroding saltmarsh, ongoing maintenance of control structures and vegetation maintenance can address deterioration to a certain degree. However, there may be occasions where the asset performance is reduced. Therefore, there is an increased risk of rapid saltmarsh deterioration.

C.10 Maintained channels (fluvial)

Figure C17 shows a basic line sketch of this type of asset: maintained channel.

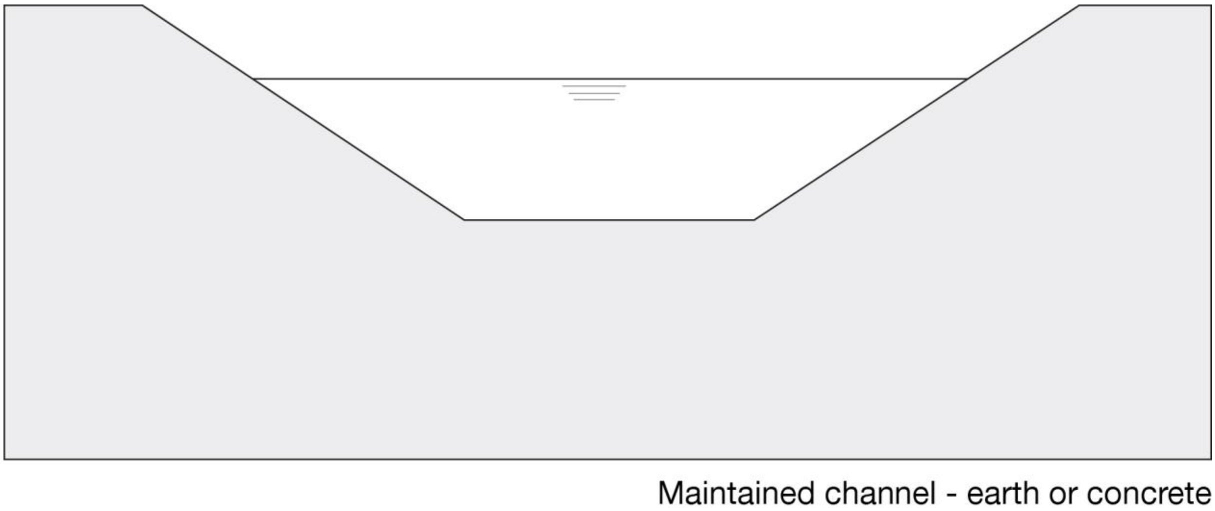


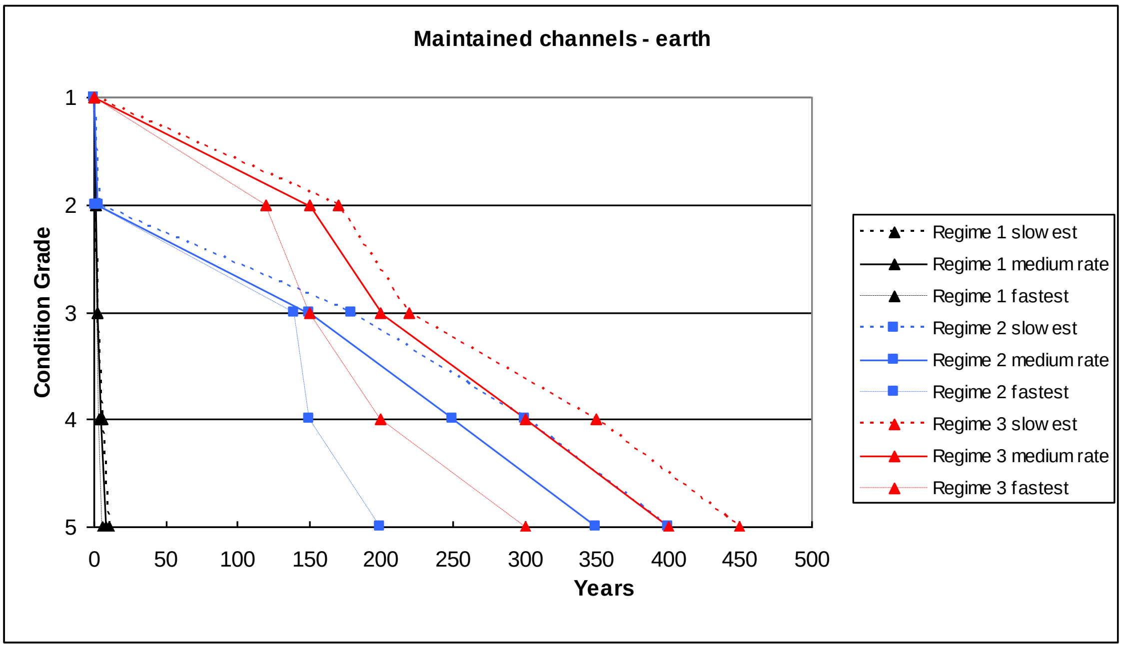
Figure C17 Maintained channel

a. Earth (e.g. regraded channel)

AIMS asset classification: Channel/open channel

Models

Maintained Channels earth – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	1	2	6	10
2 – Medium	0	3	180	300	400
3 – High	0	170	220	350	450
Medium rate					
1 – Low/basic	0	1	2	5	8
2 – Medium	0	2	150	250	350
3 – High	0	150	200	300	400
Fastest rate					
1 – Low/basic	0	1	2	3	6
2 – Medium	0	1	140	150	200
3 – High	0	120	150	200	300



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and bank collapse of the channel, progressing from CG 1 (no obstruction to conveyance and no bank movement) to CG 5 (fully obstructed flow and bank collapse).

Design life

The design life of such an asset is approximately 50 to 100 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

Note: It is very difficult to put a timescale on the deterioration of a natural channel. Deterioration is very dependent upon environment, bed and bank material, location in catchment, and shape of channel.

The deterioration processes affecting these assets include:

1. Overgrown vegetation
2. Instability in channel construction
3. Signs of sediment deposits
4. Trash deposits
5. Foreign objects present

The primary effect of these processes is to cause gradual loss of conveyance.

All these processes can be controlled by maintenance, including vegetation clearance, scour protection work, backfill replacement, vermin control and debris/obstruction removal and de-silting.

The following deterioration processes dominate the rate of deterioration:

- Leakage/interruption to flow
- Movement of banks

Effect of environmental exposure/material quality

Slowest rate: The channel is well designed to deal with both upper and lower flows in the channel, with appropriate use of materials. The channel is well constructed.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The channel is not able to deal with extreme flows (both high and low), the upstream catchment could be heavily vegetated and the channel may carry high volumes of silt in flood flows. Maintenance of the channel is poor. The channel structure may be suffering from poor quality materials/construction/design. Deterioration would be shown by movement at channel section joints, cracks/erosion, build up of sediments, vegetation growth, etc.

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through overgrown vegetation and bank collapse, compounded by blockage and obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance includes vegetation clearance, scour protection work, backfill replacement, vermin control and debris/obstruction removal and de-silting offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance includes vegetation clearance, scour protection work, backfill replacement, vermin control and debris/obstruction removal and de-silting offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

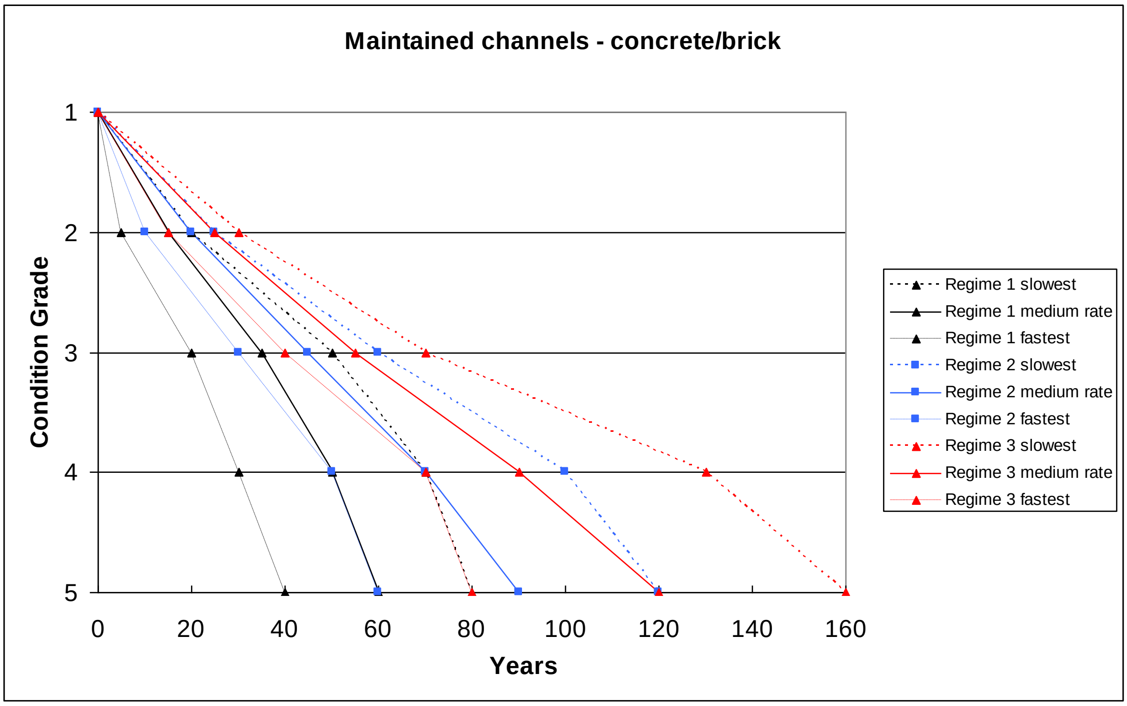
It is evident that maintenance can prolong the life of these assets considerably. Life to the CG 3 transition is extended significantly with Regimes 2 and 3. Accelerating deterioration rate (evidenced by the shorter time intervals in later grades, compared to CG 2) is largely prevented in all cases except fastest rates of deterioration, where the regularly occurring high loadings have proportionally bigger effects on the progressively eroding assets.

b. Concrete/masonry

AIMS asset classification: Channel/open channel

Models

Maintained Channels concrete/masonry – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	70	80
2 – Medium	0	25	60	100	120
3 – High	0	30	70	130	160
Medium rate					
1 – Low/basic	0	15	35	50	60
2 – Medium	0	20	45	70	90
3 – High	0	25	55	90	120
Fastest rate					
1 – Low/basic	0	5	20	30	40
2 – Medium	0	10	30	50	60
3 – High	0	15	40	70	80



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and bank collapse of the channel, progressing from CG 1 (no obstruction to conveyance and no bank movement) to CG 5 (fully obstructed flow and bank collapse).

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration mechanisms are very similar to those of concrete/brickwork vertical walls, with additional issues of maintaining conveyance of the channel. These curves are for man-made channel sections, typically found in the urban environment. The difference between concrete channels and natural (earth) channels is that deterioration of the former is influenced primarily by processes affecting the material (concrete), whereas the latter is affected by ground movement and associated bank stability. Basic maintenance applied to earth channels leaves the asset very vulnerable to bank collapse and flow obstruction with overgrown vegetation and debris collection. A concrete channel is not so vulnerable to basic maintenance; the channel is less susceptible to vegetation growth and debris collection. Hence the grade transitions occur much earlier for earth channels under no maintenance. However, with regular/frequent maintenance (Regimes 2 and 3) earth channels can be kept almost indefinitely in good/satisfactory condition, since deterioration processes can be virtually halted and conveyance functions maintained. For concrete structures, regular/frequent maintenance cannot stop material degradation and hence grade transitions occur sooner.

The deterioration processes affecting these assets include:

1. Overgrown vegetation
2. Instability in channel construction
3. Signs of sediment deposits
4. Trash deposits
5. Foreign objects present
6. Abrasion damage
7. Cracks or fissuring
8. Sealant or joint fill loss
9. Flaking/spalling of concrete

The primary effect of these processes is to cause gradual loss of conveyance and eventually structural failure.

All these processes can be controlled by maintenance, including vegetation clearance, concrete/sealant/joint repair, scour protection work, backfill replacement, vermin control and debris/obstruction removal and de-silting.

The following deterioration processes dominate the rate of deterioration:

- Leakage/interruption to flow
- Movement of banks

Effect of environmental exposure/material quality

Slowest rate: The channel is well designed to deal with both upper and lower flows in the channel, with appropriate use of materials. The channel is well constructed.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: Channel not able to deal with extreme flows (both high and low), the upstream catchment could be heavily vegetated and the channel may carry high volumes of silt in flood flows. Maintenance of the channel is poor. The channel structure may be suffering from poor quality materials/construction/design. Deterioration would be shown by movement at channel section joints, cracks/erosion, build up of sediments, vegetation growth, etc.

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. The only maintenance tasks carried out are inspections of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no planned maintenance of the channel; however, there is reactive maintenance after storms/events to remove obstructions. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through overgrown vegetation and material deterioration, compounded by blockage and obstruction, i.e. primarily loss of capacity, joint failures.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including inspections/surveys of the structure/channel, vegetation clearance, concrete/sealant/joint repair, minor repairs to the crest, wing walls and apron, scour protection work, backfill replacement, vermin control and debris/obstruction removal and de-silting offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works) with some deterioration at the joints.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including inspections/surveys of the structure/channel, vegetation clearance, concrete/sealant/joint repair, minor repairs to the crest, wing walls and apron, scour protection work, backfill replacement, vermin control and debris/obstruction removal and de-silting offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.11 Weirs (fluvial)

AIMS asset classification: Structure/weir

Figure C18 shows a basic line sketch of this type of asset: weir.

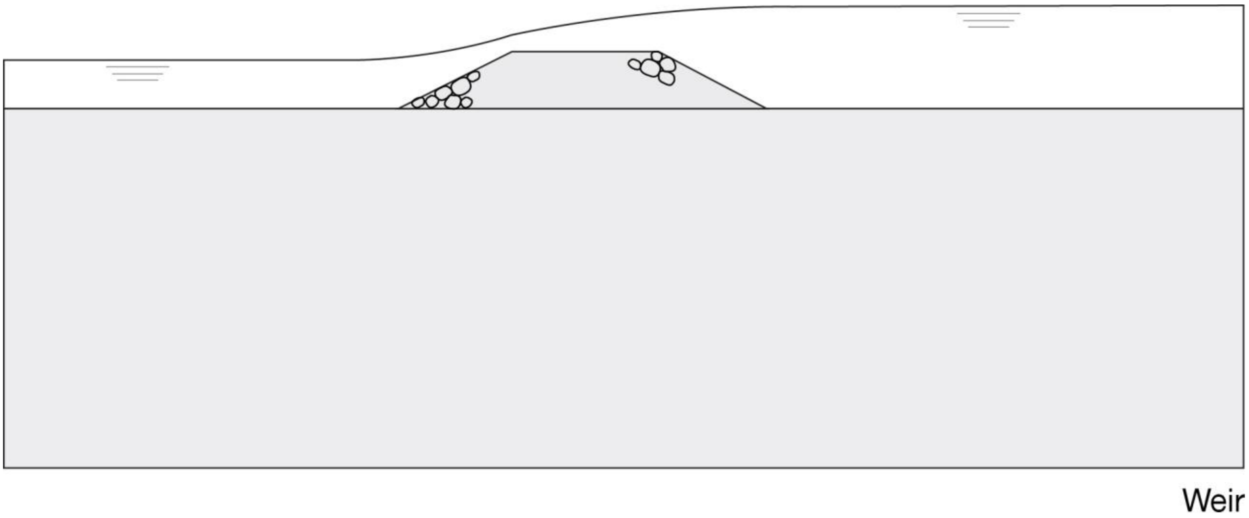
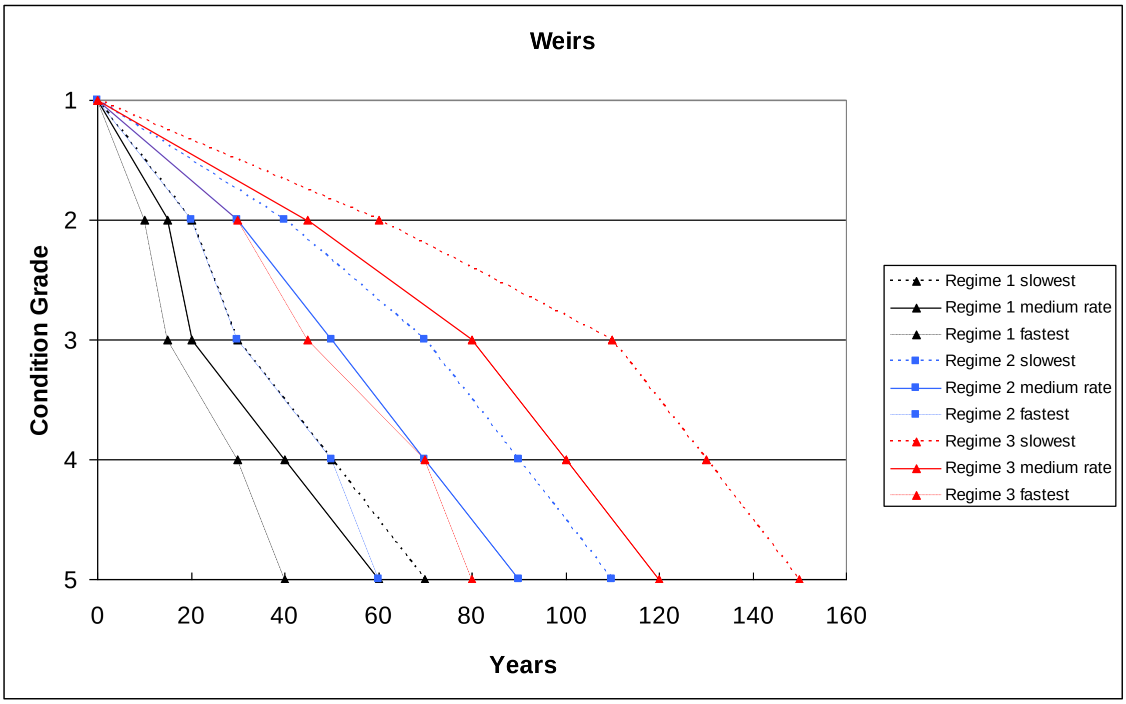


Figure C18 Weir

Models

Weirs – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	30	50	70
2 – Medium	0	40	70	90	110
3 – High	0	60	110	130	150
Medium rate					
1 – Low/basic	0	15	20	40	60
2 – Medium	0	30	50	70	90
3 – High	0	45	80	100	120
Fastest rate					
1 – Low/basic	0	10	15	30	40
2 – Medium	0	20	30	50	60
3 – High	0	30	45	70	80



Model assumptions

Note: The deterioration curves apply to fixed weirs only. They do not include moving weirs. The condition grades are indicative of both loss of conveyance and structural degradation of the weir, progressing from CG 1 (no obstruction to conveyance and no structural damage) to CG 5 (fully obstructed flow and structural failure).

Design life

The design life of such an asset is approximately 100 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Cracks, erosion or damage to crest, apron or wing walls
2. Uneven flow over crest
3. Sediment deposits on upstream face
4. Signs of erosion at structure sides/undermining
5. Loss of revetment at structure sides
6. Movement of abutments or wing walls
7. Vegetation encroachment
8. Settlement
9. Blockwork or mortar missing

All these processes except settlement can be controlled by maintenance including: debris/vegetation clearance, repair of damaged elements, scour protection work, backfill replacement, dredging upstream and blockage removal.

The following deterioration processes dominate the rate of deterioration:

- Foreign materials/blockage
- Disintegration of elements
- Movement of structure

Effect of environmental exposure/material quality

Slowest rate: The weir is located in an appropriate position within the catchment and the channel. The purpose of the weir and its environment have been considered, and an appropriate type of weir designed. The weir has been constructed using appropriate materials. Foundation is stable and there is appropriate scour protection if required.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The weir is located in an extreme environment (heavily vegetated area, channel carries high volumes of silt, or bed material is gravel and cobbles). Maintenance upstream of the weir is poor. The structure (wing walls/crest/apron) may be suffering from poor quality materials/construction/design. Deterioration would be shown by movement of elements, cracks/erosion, uneven flows, upstream build up of sediments, etc.

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. The only maintenance tasks carried out are inspections of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no maintenance of the weir, wing walls, apron or scour protection.

This curve relates predominantly to the likelihood of extreme and rapid asset degradation through overgrown vegetation and material deterioration (erosion/abrasion and loss of protection), compounded by blockage/obstruction and silting.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including inspections/surveys of the structure debris/vegetation clearance on and around the structure, repair of damaged elements, minor repairs to the crest, wing walls and apron scour protection work, backfill replacement, de-silting, dredging upstream and blockage removal offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including inspections/surveys of the structure debris/vegetation clearance on and around the structure, repair of damaged elements, minor repairs to the crest, wing walls and apron scour protection work, backfill replacement, de-silting, dredging upstream and blockage removal offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.12 Outfalls (fluvial and coastal/estuarine)

AIMS asset classification: Structure/outfall

Figure C19 shows a basic line sketch of this type of asset: outfalls.

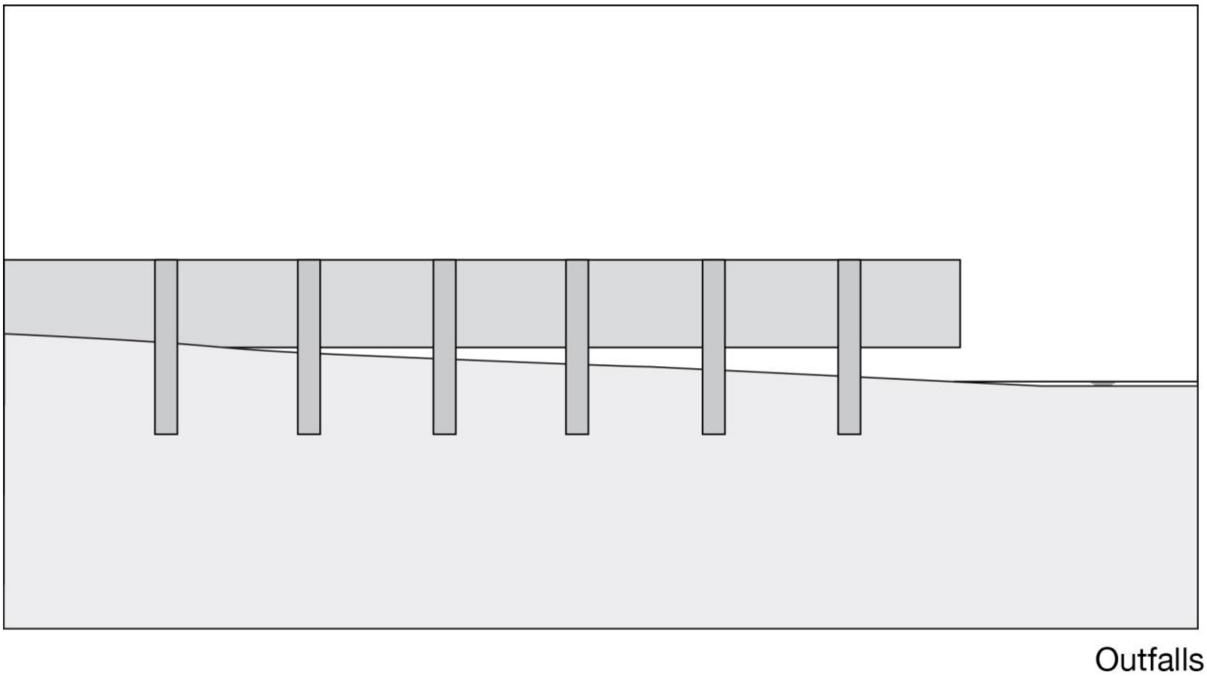
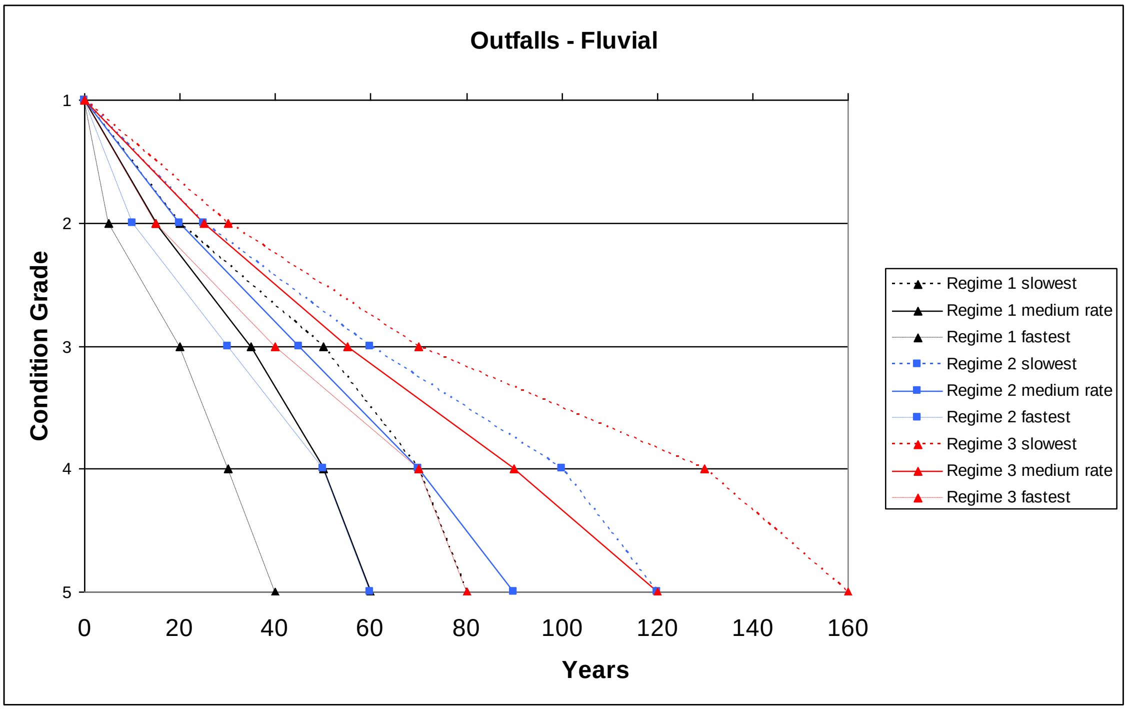


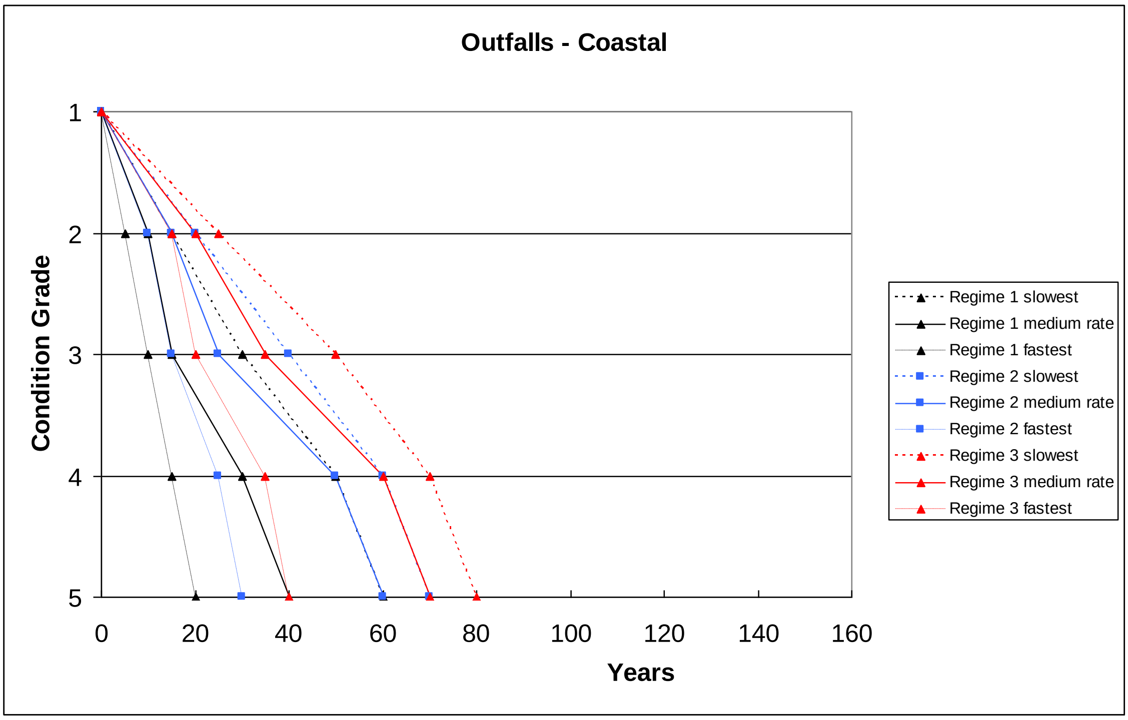
Figure C19 Outfalls

Models

Outfalls – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	20	50	70	80
2 – Medium	0	25	60	100	120
3 – High	0	30	70	130	160
Medium rate					
1 – Low/basic	0	15	35	50	60
2 – Medium	0	20	45	70	90
3 – High	0	25	55	90	120
Fastest rate					
1 – Low/basic	0	5	20	30	40
2 – Medium	0	10	30	50	60
3 – High	0	15	40	70	80



Outfalls – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	30	50	60
2 – Medium	0	20	40	60	70
3 – High	0	25	50	70	80
Medium rate					
1 – Low/basic	0	10	15	30	40
2 – Medium	0	15	25	50	60
3 – High	0	20	35	60	70
Fastest rate					
1 – Low/basic	0	5	10	15	20
2 – Medium	0	10	15	25	30
3 – High	0	15	20	35	40



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and structural degradation of the outfall, progressing from CG 1 (no obstruction to conveyance and no structural damage) to CG 5 (fully obstructed flow and structural failure/collapse).

General:

These structures are normally constructed from a mixture of elements, which may include pipe work (various materials), steel sheet piles, precast and *in situ* concrete, flap valves, debris screens, etc. The curve is based on the shortest life of the above major structural elements (i.e. steel sheet piles). Any allowances for flap valves/moveable gates (which are covered by other deterioration curves) are excluded from these curves.

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Discharge outlet buried or blocked
2. Movement or settlement
3. Scour or undermining
4. Cracks in main structural elements
5. Broken timbers
6. Leaking pipe
7. Loss of thickness of piles due to corrosion, abrasion, etc
8. Fixings failing or missing

All these processes can be controlled by maintenance, including obstruction removal, minor repair works and replacement of seals, corrosion control, scour protection work and backfill replacement.

The following deterioration processes dominate the rate of deterioration:

- Interruption to flow
- Disintegration of elements
- Movement of structure

Effect of environmental exposure/material quality

Deterioration fluvial – general: The curves assume that the structure is located within the river bank and the walls, apron, etc are, in general, constructed from concrete.

Deterioration coastal – general: The structure is assumed to run across the foreshore/beach and be curtailed within the tidal zone. Not included in this are the effects/impacts of longshore/on and offshore sediment movements. Excluded from these curves are any allowances for flap valves.

Fluvial slowest rate: The asset is in a protected location set back from the water's edge, the material quality is appropriate for the environment/location, construction is of a good quality and the asset is well designed.

Coastal slowest rate: The asset is in a protected location at the back of the foreshore. The material quality is appropriate for the coastal/estuarine environment. Construction is of a good quality, and the asset is well designed. The deterioration rate would increase from that in a fluvial environment.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is in an exposed location. Also it may suffer from poor quality materials/construction/design.

Coastal fastest rate: The asset is in an exposed coastal/estuarine location. It may suffer from poor quality materials/construction/design. The deterioration rate would increase from that in a fluvial environment.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades (particularly CG 4), this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through material deterioration (pipework, structural elements, fixings), compounded by blockage/obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including obstruction removal, minor repair works and replacement of seals, corrosion control, scour protection work and backfill replacement offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including obstruction removal, minor repair works and replacement of seals, corrosion control, scour protection work and backfill replacement offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.13 Flap valves (fluvial and coastal/estuarine)

AMS asset classification: Structure/control gate

Figure C20 shows a basic line sketch of this type of asset: flap valve.

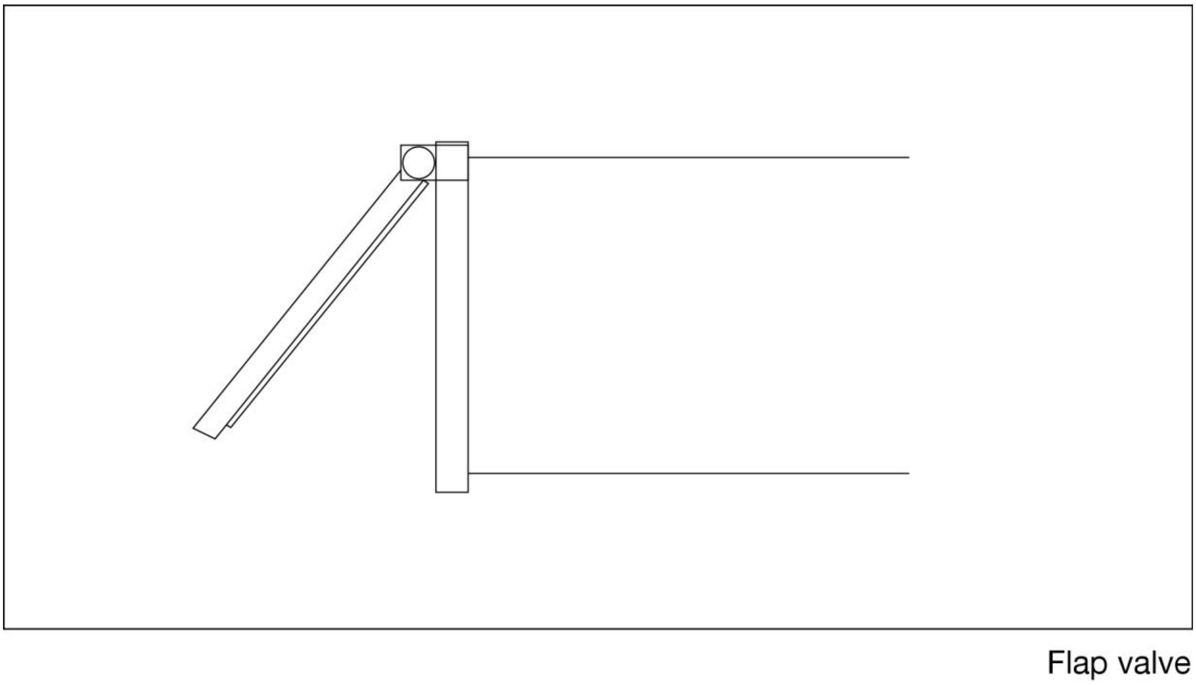
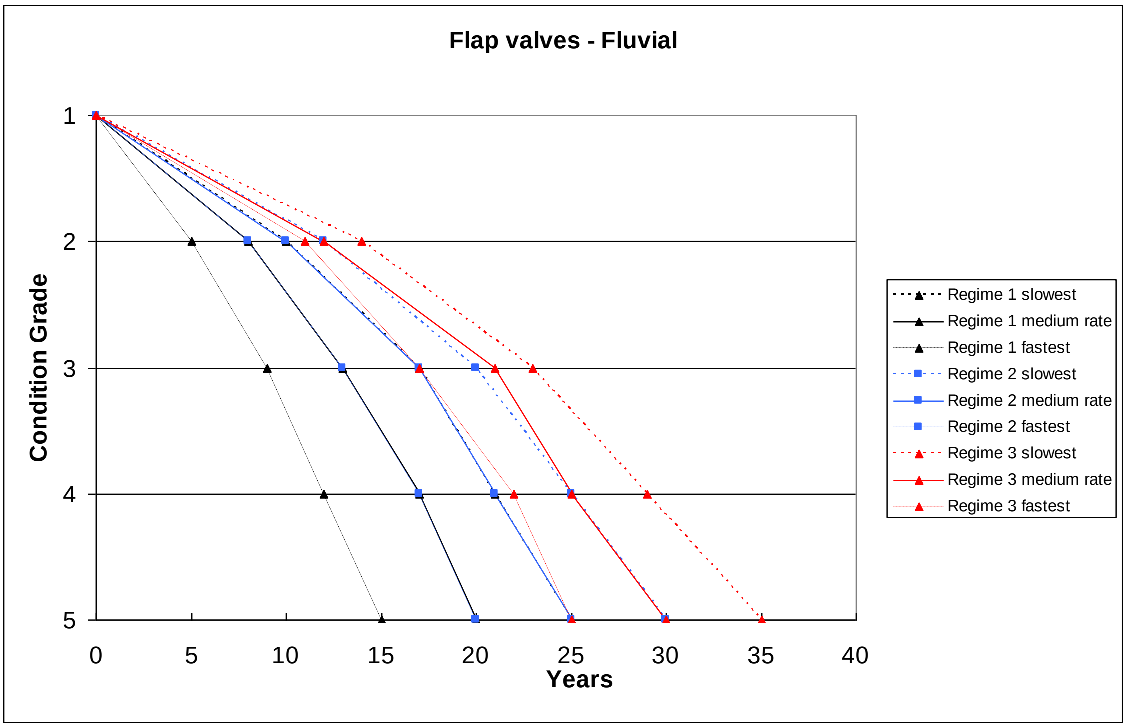


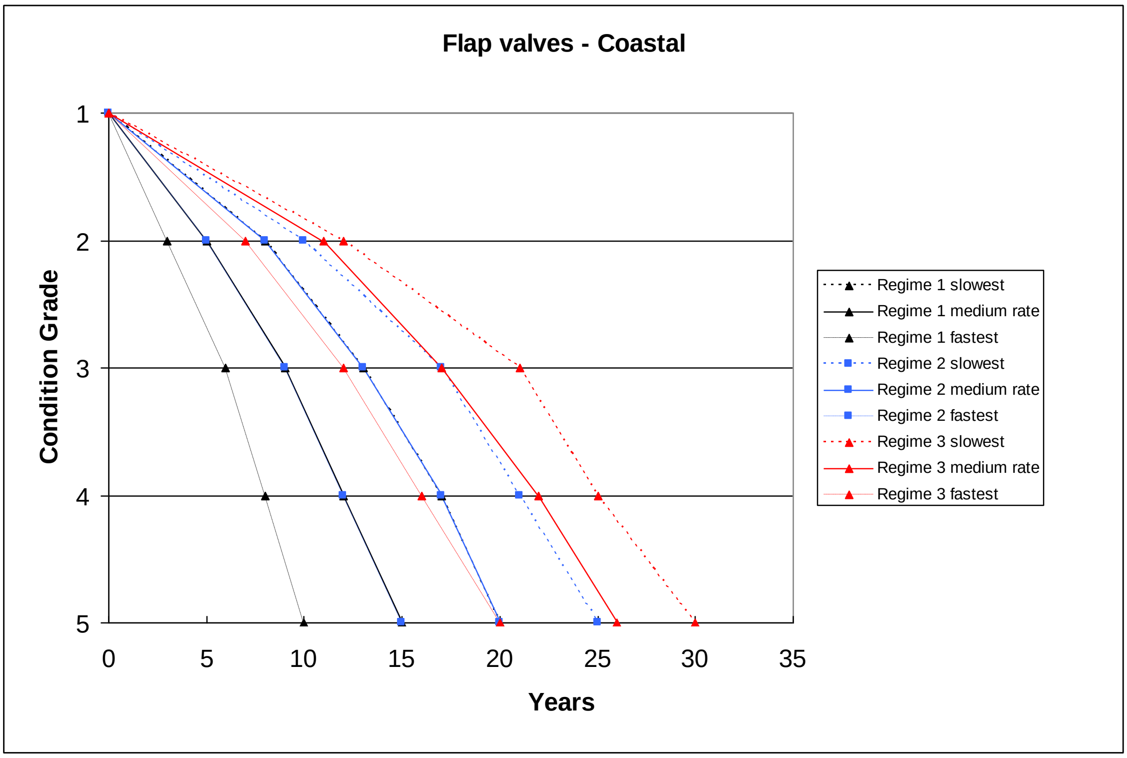
Figure C20 Flap valve

Models cast iron and coplastic

Flap Valves – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	5	10	15	20
2 – Medium	0	10	15	25	30
3 – High	0	15	20	35	40
Medium rate					
1 – Low/basic	0	8	13	17	20
2 – Medium	0	10	17	21	25
3 – High	0	12	21	25	30
Fastest rate					
1 – Low/basic	0	5	9	12	15
2 – Medium	0	8	13	17	20
3 – High	0	11	17	22	25



Flap Valves – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	8	13	17	20
2 – Medium	0	10	17	21	25
3 – High	0	12	21	25	30
Medium rate					
1 – Low/basic	0	5	9	12	15
2 – Medium	0	8	13	17	20
3 – High	0	11	17	22	26
Fastest rate					
1 – Low/basic	0	3	6	8	10
2 – Medium	0	5	9	12	15
3 – High	0	7	12	16	20



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and structural degradation of the flap valve/structure, progressing from CG 1 (no obstruction to conveyance and no structural damage) to CG 5 (fully obstructed flow and structural failure/collapse).

Design life

The design life of such an asset is approximately 25 to 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Mechanism seized, operation compromised
2. Gate timbers rotten or missing
3. Flap has lost support, been damaged, has moved, is missing or is unable to operate
4. Corrosion, leakage, siltation or blockage
5. Damaged or missing mountings or fixings
6. Hinge bolts worn, corroded or missing
7. Siltation preventing operation
8. Deterioration of headwall

All these processes can be controlled by maintenance, including cleaning, replacing damaged elements, lubrication of moving parts, corrosion control and removing obstructions to flow.

The following deterioration processes dominate the rate of deterioration:

- Obstructions
- Disintegration of elements

Effect of environmental exposure/material quality

Fluvial slowest rate: The flap valve is in a protected location, the material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is average. Deterioration mechanisms would be based on damage caused by blockages and/or material corrosion around the hinges.

Coastal slowest rate: The flap valve is in a protected location, the material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is average. Deterioration mechanisms would be based on damage caused by blockages and/or material corrosion around the hinge.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The asset is located in a harsh environment, and subject to extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration mechanisms would be through either fatigue or seizure of the hinge mechanism, flap or seating damage and/or fixing corrosion. Damage may also result from blockages.

Coastal fastest rate: The asset is located in a harsh environment, and subject to extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration would be through fatigue or seizure of the hinge mechanism, flap or seating damage and/or fixing corrosion. Damage may also result from blockages or fatigue/erosion due to wave action.

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. For the purpose of this model, only the basic H&S maintenance has been applied. No channel and flap maintenance is applied. It is assumed that H&S maintenance would be based on the surrounding structure and does not include the flap and its hinges. However, since the flap valve is likely to seize without maintenance, it is assumed that the flap would be freed and marine growth removed (if coastal) as a breakdown maintenance activity in order to keep the valve operational.

This curve relates predominantly to the likelihood of extreme and rapid asset degradation through material deterioration (gates/flaps, structural elements, hinges/fixings), compounded by blockage/obstruction and silting.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including H&S maintenance (surrounding structure), cleaning, replacing damaged elements, lubrication of moving parts, hinge and flap inspection and maintenance including greasing of hinges, channel and flap clearance, corrosion control and removing obstructions to flow offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including H&S maintenance (surrounding structure), cleaning, replacing damaged elements, lubrication of moving parts, hinge and flap inspection and maintenance including greasing of hinges, channel and flap clearance, corrosion control and removing obstructions to flow offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.14 Moveable gates (fluvial and coastal/estuarine)

Figure C21 shows a basic line sketch of this type of asset: moveable gates – penstock.

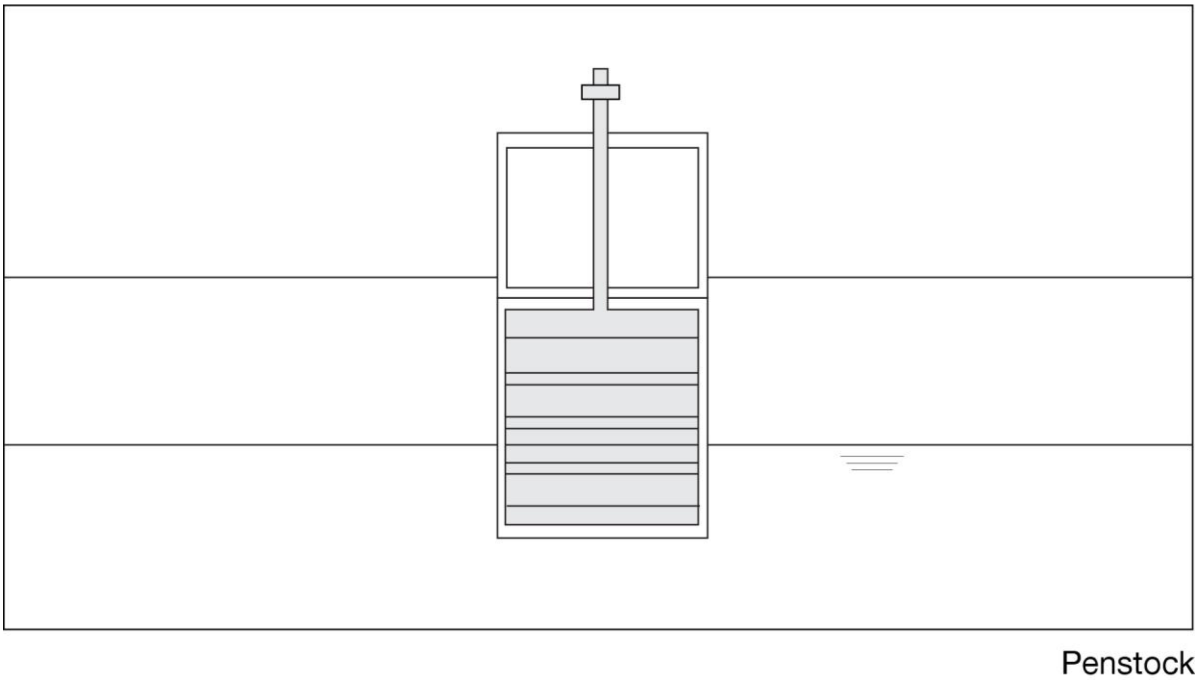


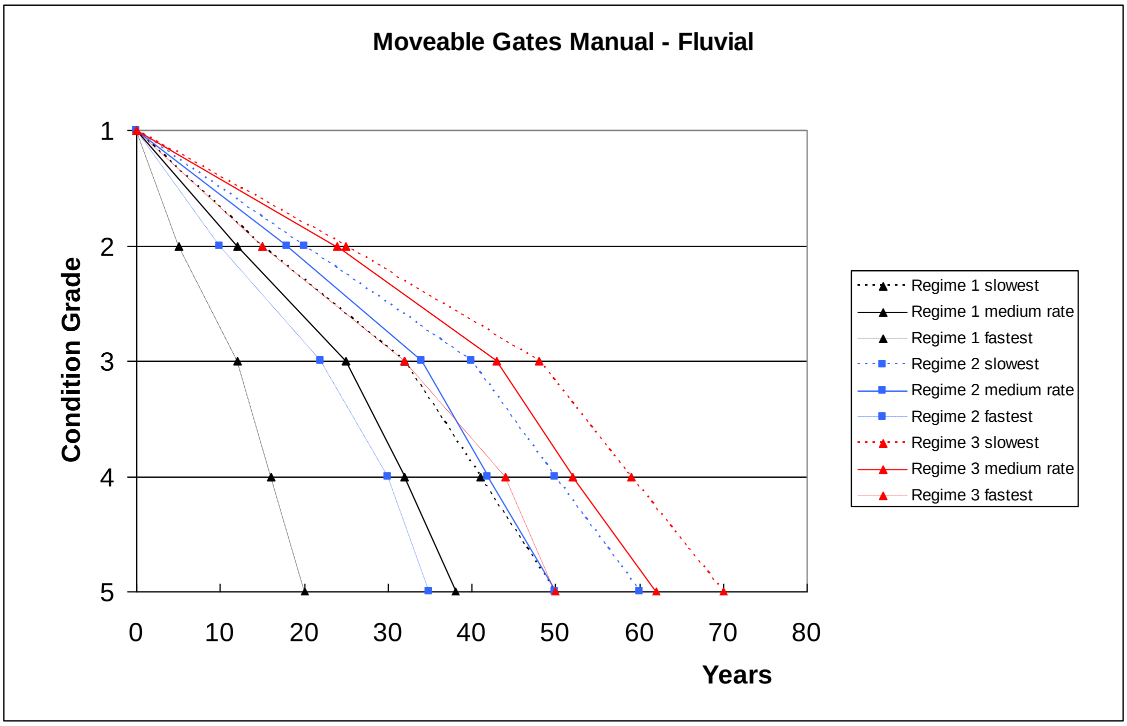
Figure C21 Moveable gate – penstock

a. Moveable gates – manual

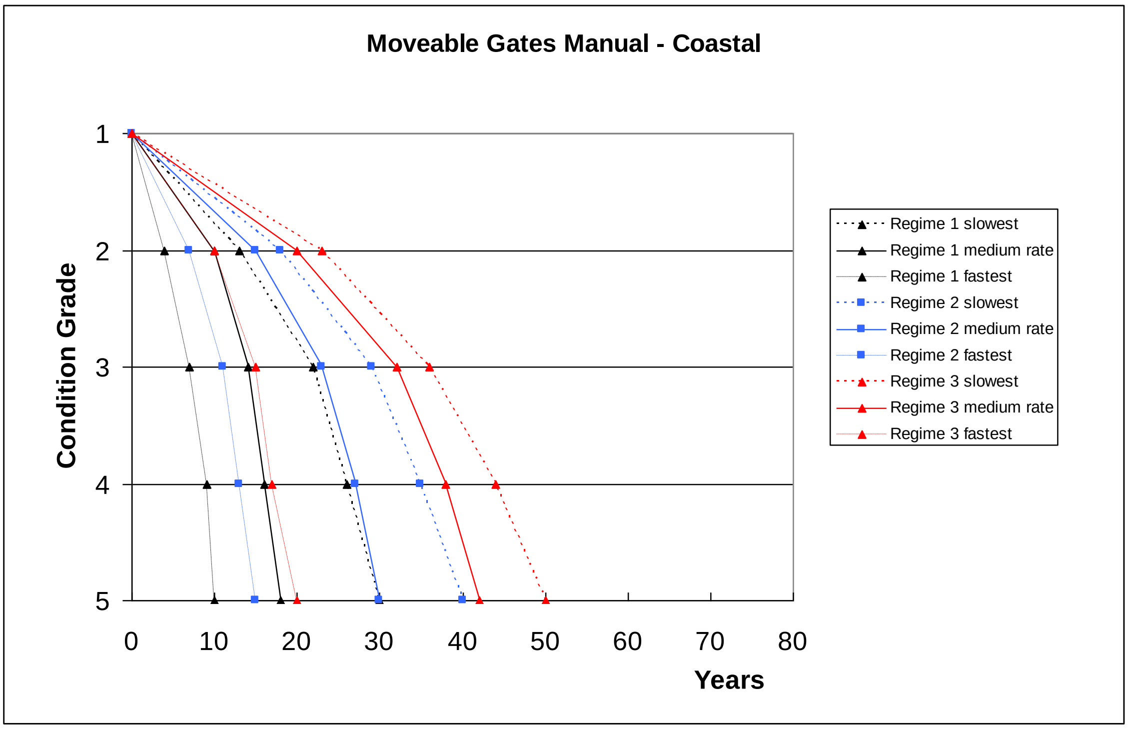
AIMS asset classification: Structure/control gate

Models:

Moveable Gates (Manual) – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	32	41	50
2 – Medium	0	20	40	50	60
3 – High	0	25	48	59	70
Medium rate					
1 – Low/basic	0	12	25	32	38
2 – Medium	0	18	34	42	50
3 – High	0	24	43	52	62
Fastest rate					
1 – Low/basic	0	5	12	16	20
2 – Medium	0	10	22	30	35
3 – High	0	15	32	44	50



Moveable Gates (Manual) – Fluvial – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	13	22	26	30
2 – Medium	0	18	29	35	40
3 – High	0	23	36	44	50
Medium rate					
1 – Low/basic	0	10	14	16	18
2 – Medium	0	15	23	27	30
3 – High	0	20	32	38	42
Fastest rate					
1 – Low/basic	0	4	7	9	10
2 – Medium	0	7	11	13	15
3 – High	0	10	15	17	20



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and structural degradation of the structure, progressing from CG 1 (no obstruction to conveyance and no structural damage) to CG 5 (fully obstructed flow and structural failure/collapse).

Design life

The design life of such an asset is approximately 25 to 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Mechanism seized, operation compromised
2. Gate timbers rotten or missing
3. Flap has lost support, been damaged, has moved, is missing or is unable to operate
4. Corrosion, leakage, siltation or blockage
5. Damaged or missing mountings or fixings
6. Hinge bolts worn, corroded or missing
7. Siltation preventing operation
8. Deterioration of headwall

All these processes can be controlled by maintenance, including cleaning, replacing damaged/inoperable elements, mechanical maintenance (lubrication of moving parts, oil level checks, oil/filter replacement, chain drive tensioning and replacing gate seals), corrosion control and removing obstructions to flow.

The following deterioration processes dominate the rate of deterioration:

- Obstructions
- Disintegration of elements

Effect of environmental exposure/material quality

Fluvial slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is frequent. Deterioration mechanisms would be based on damage caused by blockages, material fatigue (moving parts) and corrosion through loss of protection.

Coastal slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is frequent. Deterioration mechanisms would be based on damage caused by blockages, material fatigue (moving parts) and corrosion through loss of protection.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The gate is located in a harsh environment, and subject to the extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration mechanisms could be through either fatigue or seizure of the moving parts, sill damage due to debris blockages, corrosion of fixings, or loss of corrosion protection of the gates.

Coastal fastest rate: The gate is located in a harsh environment, and subject to the extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration mechanisms could be through either fatigue or seizure of the moving parts, sill damage due to debris blockages, corrosion of fixings, or loss of corrosion protection of the gates.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades (particularly CG 4), this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. For the purpose of this model, only the basic H&S maintenance has been applied. No channel or gate maintenance is applied with the exception of complying with statutory requirements such as the Lifting Operations and Lifting Equipment Regulations. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through material deterioration (gates/flaps, structural elements, hinges/fixings), compounded by blockage/obstruction and silting.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance (additional to Maintenance Regime 1) including cleaning, replacing damaged/inoperable elements, mechanical maintenance (lubrication of moving parts, oil level checks, oil/filter replacement, chain drive tensioning and replacing gate seals), corrosion control, minor repairs to the corrosion protection systems, removing obstructions to flow, debris removal and clearance, maintenance of the headworks, gates and frames offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). Note: Replacement of corrosion protection systems and major components such as gates, gearboxes, spindles or bearings requiring significant temporary works is considered a refurbishment activity and therefore not counted.

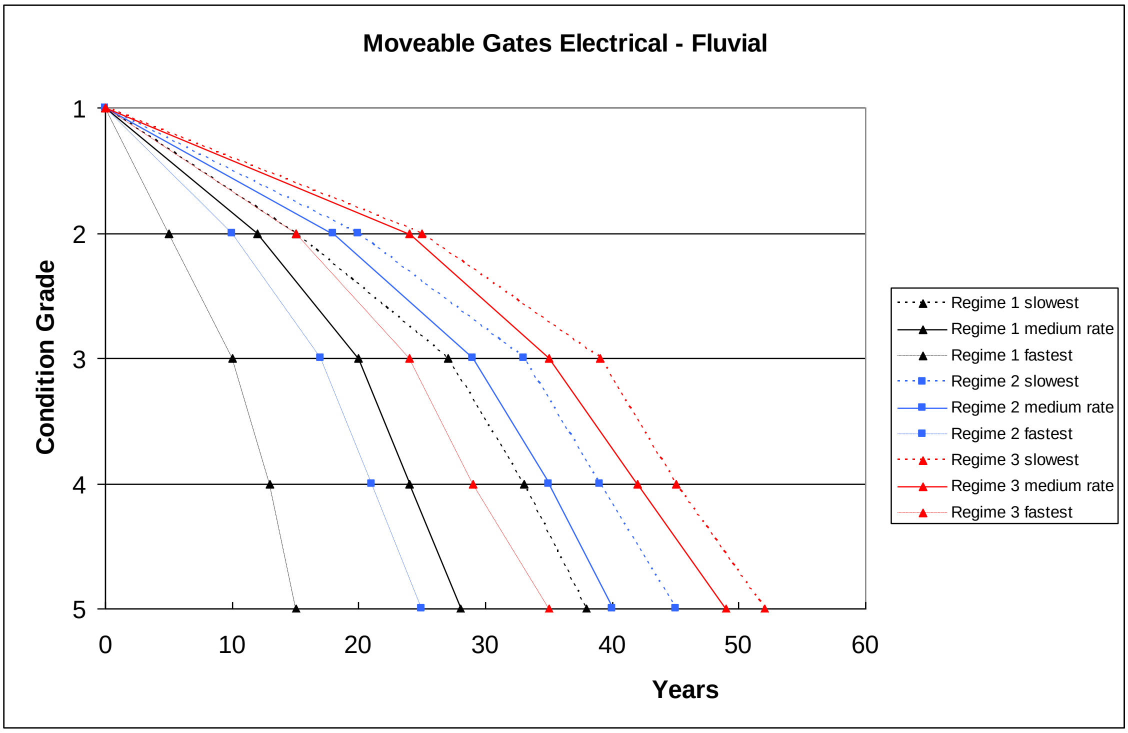
Maintenance Regime 3: High, maintain CG 2. Frequent maintenance (additional to Maintenance Regime 1) including cleaning, replacing damaged/inoperable elements, mechanical maintenance (lubrication of moving parts, oil level checks, oil/filter replacement, chain drive tensioning and replacing gate seals), corrosion control, minor repairs to the corrosion protection systems, removing obstructions to flow, debris removal and clearance, maintenance of the headworks, gates and frames offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). Note: Replacement of corrosion protection systems and major components such as gates, gearboxes, spindles or bearings requiring significant temporary works is considered a refurbishment activity and therefore not counted.

b. Moveable gates – electrical

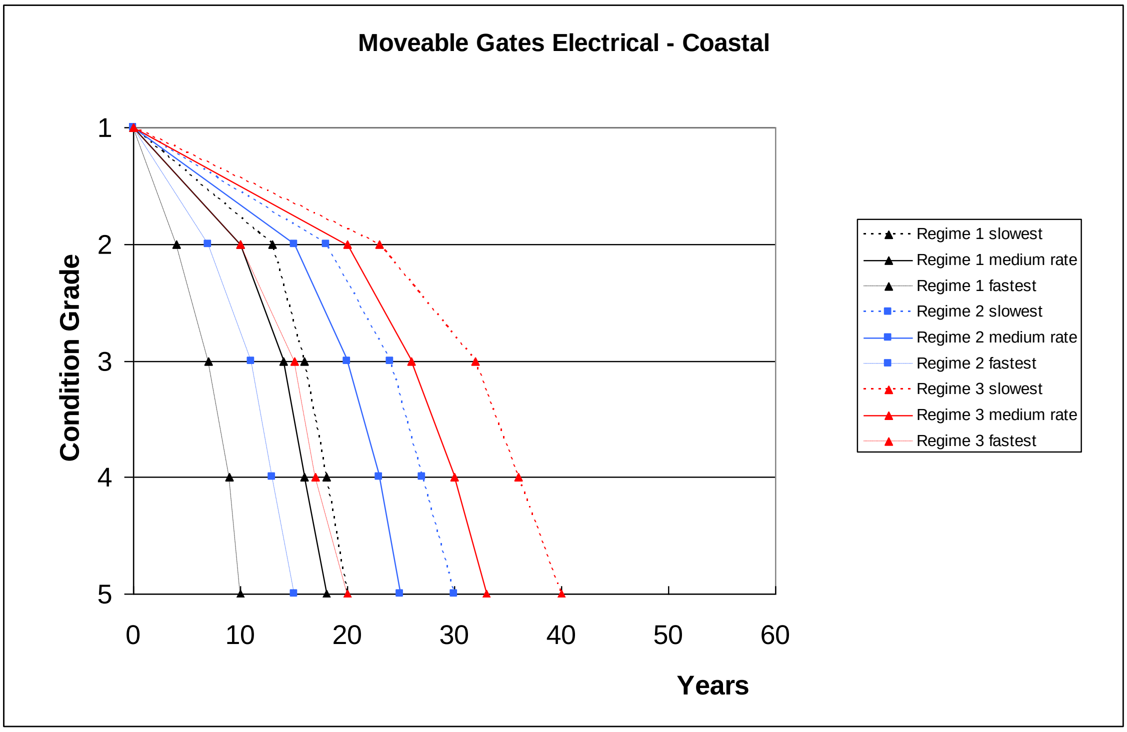
AIMS asset classification: Structure/control gate

Models:

Moveable Gates (Electrical) – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	27	33	38
2 – Medium	0	20	33	39	45
3 – High	0	25	39	45	52
Medium rate					
1 – Low/basic	0	12	20	24	28
2 – Medium	0	18	29	35	40
3 – High	0	24	38	46	52
Fastest rate					
1 – Low/basic	0	5	10	13	15
2 – Medium	0	10	17	21	25
3 – High	0	15	24	29	35



Moveable Gates (Electrical) – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	13	16	18	20
2 – Medium	0	18	24	27	30
3 – High	0	23	32	36	40
Medium rate					
1 – Low/basic	0	10	14	16	18
2 – Medium	0	15	20	23	25
3 – High	0	20	26	30	33
Fastest rate					
1 – Low/basic	0	4	7	9	10
2 – Medium	0	7	11	13	15
3 – High	0	10	15	17	20



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and structural degradation of the structure, progressing from CG 1 (no obstruction to conveyance and no structural damage) to CG 5 (fully obstructed flow and structural failure/collapse).

Design life

The design life of such an asset is approximately 25 to 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

Deterioration rate is governed principally by the electrical system, which has a shorter life than that of the mechanical elements it controls. The curves for electrically operated gates predict shorter time to grade transitions compared to manually operated gates.

The deterioration processes affecting these assets include:

1. Mechanism seized, operation compromised
2. Gate timbers rotten or missing
3. Flap has lost support, been damaged, has moved, is missing or is unable to operate
4. Corrosion, leakage, siltation or blockage
5. Damaged or missing mountings or fixings
6. Hinge bolts worn, corroded or missing
7. Siltation preventing operation
8. Deterioration of headwall
9. Electrical elements seized/operation compromised

All these processes can be controlled by maintenance, including cleaning, replacing damaged/inoperable elements (including electrical components), mechanical/electrical (lubrication of moving parts, oil level checks, oil/filter/breather replacement, chain drive tensioning and replacing gate and oil seals and replacing small motors, telemetry, PLCs (Programmable Logic Controllers), switches, bulbs, sensors and batteries), corrosion control and removing obstructions to flow.

The following deterioration processes dominate the rate of deterioration:

- Obstructions
- Disintegration of elements

Effect of environmental exposure/material quality

Fluvial slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is frequent. Deterioration is based on the electrical system, which has a shorter life than that of the mechanical elements it controls. Deterioration mechanisms could be through water ingress or vermin.

Coastal slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is frequent. Deterioration is based on the electrical system, which has a shorter life than that of the mechanical elements it controls. Deterioration mechanisms could be through water ingress, vermin.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The gate is located in a harsh environment, and subject to the extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration is based on the electrical system, which has a shorter design life and is susceptible to extremes of weather.

Coastal fastest rate: The gate is located in a harsh environment, and subject to the extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration is based on the electrical system, which has a shorter design life and is susceptible to extremes of weather.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades (particularly CG 4), this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. For the purpose of this model, only the basic H&S maintenance has been applied. No channel or gate maintenance is applied with the exception of complying with statutory requirements such as the Lifting Operations and Lifting Equipment Regulations, Pressure Systems Regulations and Wiring Regulations. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through material deterioration (gates/flaps, structural elements, hinges/fixings), compounded by blockage/obstruction and silting.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance (additional to that in Maintenance Regime 1) including cleaning, replacing damaged/inoperable elements (including electrical components), mechanical/electrical (lubrication of moving parts, oil level checks, oil/filter/breather replacement, chain drive tensioning and replacing gate and oil seals and replacing small motors (<4 kW), telemetry, PLCs, switches, bulbs, sensors and batteries), corrosion control, minor repairs to the corrosion protection systems, removing obstructions to flow and debris removal/clearance offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). Note: Replacement of corrosion protection systems and major components such as gates, gearboxes, large motors, spindles, bearings, control panels and wiring installations requiring significant temporary works or long periods of plant unavailability are considered refurbishment activities and are therefore not counted.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance (additional to that in Maintenance Regime 1) including cleaning, replacing damaged/inoperable elements (including electrical components), mechanical/electrical (lubrication of moving parts, oil level checks, oil/filter/breather replacement, chain drive tensioning and replacing gate and oil seals and replacing small motors (<4 kW), telemetry, PLCs, switches, bulbs, sensors and batteries), corrosion control, minor repairs to the corrosion protection systems, removing obstructions to flow and debris removal/clearance offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). Note: Replacement of corrosion protection systems and major components such as gates, gearboxes, large motors, spindles, bearings, control panels and wiring installations requiring significant temporary works or long periods of plant unavailability are considered refurbishment activities and are therefore not counted.

C.15 Debris screens (fluvial)

AIMS asset classification: Structure/screen

Figure C22 shows a basic line sketch of this type of asset: debris screen.

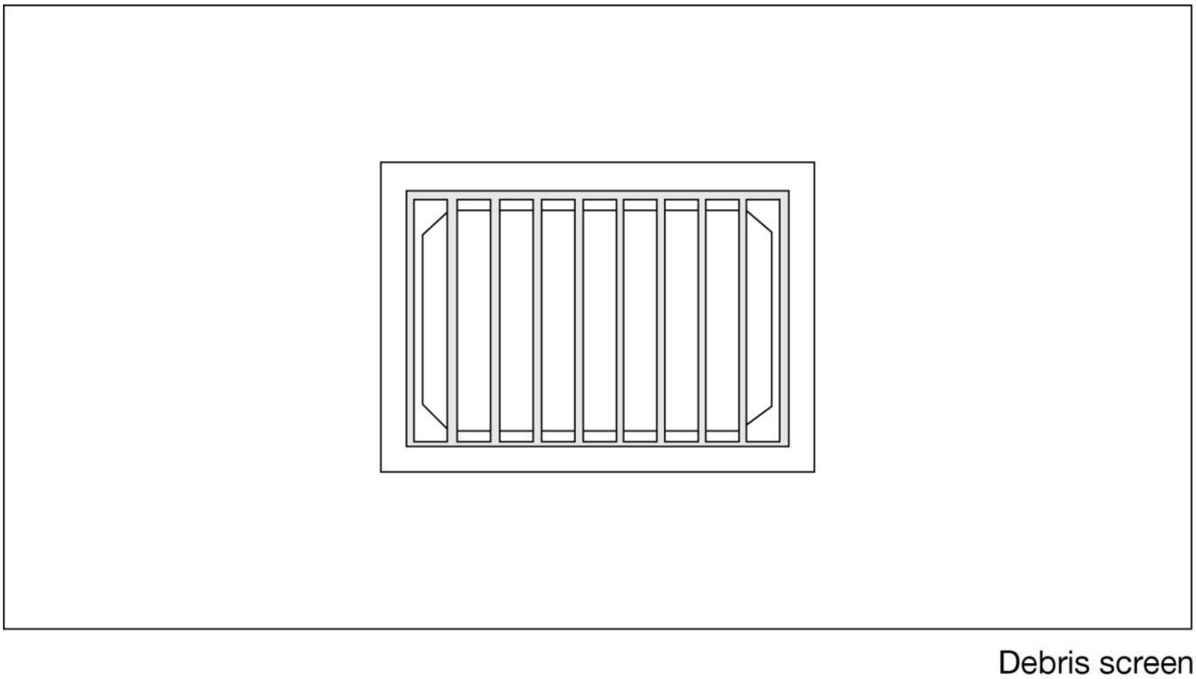
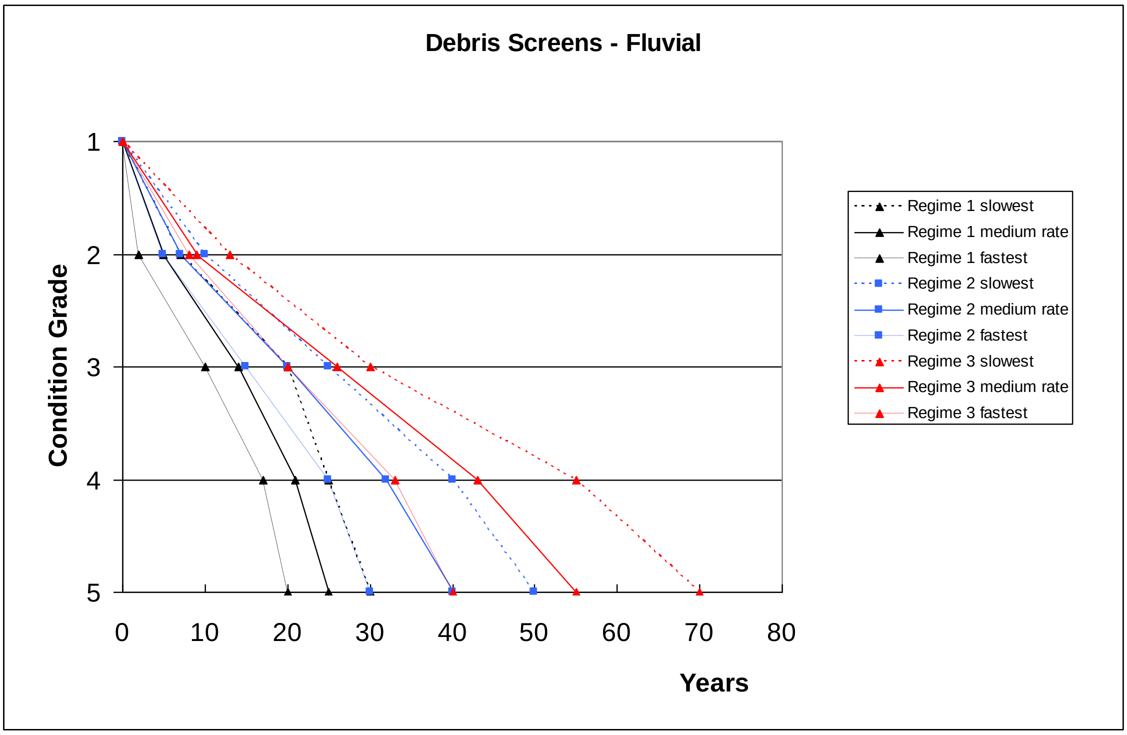


Figure C22 Debris screen

Models

Debris Screens – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	7	20	25	30
2 – Medium	0	10	25	40	50
3 – High	0	13	30	55	70
Medium rate					
1 – Low/basic	0	5	14	21	25
2 – Medium	0	7	20	32	40
3 – High	0	9	26	43	55
Fastest rate					
1 – Low/basic	0	2	10	17	20
2 – Medium	0	5	15	25	30
3 – High	0	8	20	33	40



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and structural degradation of the debris screen/structure, progressing from CG 1 (no obstruction to conveyance and no structural damage) to CG 5 (fully obstructed flow and structural failure/collapse).

Design life

The design life of such an asset is approximately 25 to 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Corrosion of bars and fixing elements
2. Defects to bars, fixing or headwalls
3. Bar spacing distorted
4. Screen missing or not fixed correctly
5. Mortar loss or surface spalling of headwall
6. Headwall missing

All these processes except headwall missing can be controlled by maintenance, including minor repair works, surface damage repair, bar replacement and fixing point repair, and headwall repair.

The following deterioration processes dominate the rate of deterioration:

- Obstructions
- Leakage/interruption to flow
- Disintegration of elements

Effect of environmental exposure/material quality

Slowest rate: The debris screen is assumed to be located on a culvert or outfall that is in continuous use. Water levels are steady with a continuous flow of water. There are only small amounts of vegetation/debris within the channel and there is little or no sediment within the channel. The screen is bolted/cast into the headwall and is galvanised with appropriate material for cast-in items and bolts.

Medium rate: Considered a typical rate providing a mid-range value.

Fastest rate: The screen is assumed to be located on a culvert or outfall at the extreme ends of use (either high or no flow) and the upstream channel is heavily vegetated and is subject to high silt volumes. The screen and/or its fixings may suffer from poor quality materials/construction/design.

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. The only maintenance tasks carried out are inspections of H&S provisions and their repair/replacement (signs, hand railings, etc). There is no maintenance of the culvert/screen. However, reactive obstruction removal is undertaken otherwise screens would block up and the asset would become inoperable. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through material deterioration (bars, hinges/fixings, headwall), compounded by blockage/obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including regular clearance of debris and vegetation from the screen and the surrounding channel, de-silting, minor repair works, surface damage repair, bar replacement, fixing point repair and headwall repair offsets asset deterioration. Deterioration of the asset is based on material degradation of the screen by hydraulic wear removing protective coatings and exposing the steel substrate, failure of fixings due to storm damage, corrosion of fixings, etc, and, additionally, by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including regular clearance of debris and vegetation from the screen and the surrounding channel, de-silting, minor repair works, surface damage repair, bar replacement, fixing point repair and headwall repair offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

C.16 Flood gates and barriers (fluvial and coastal/estuarine)

Figure C23 shows a basic line sketch of this type of asset: flood gates and barriers.

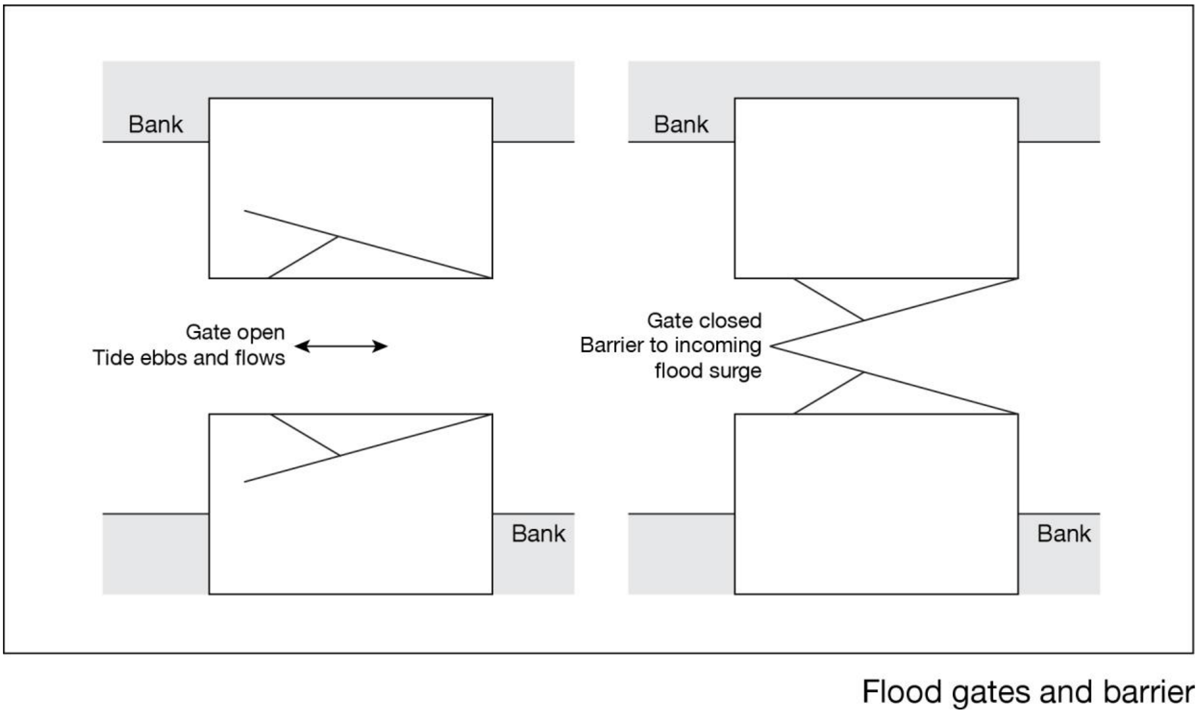


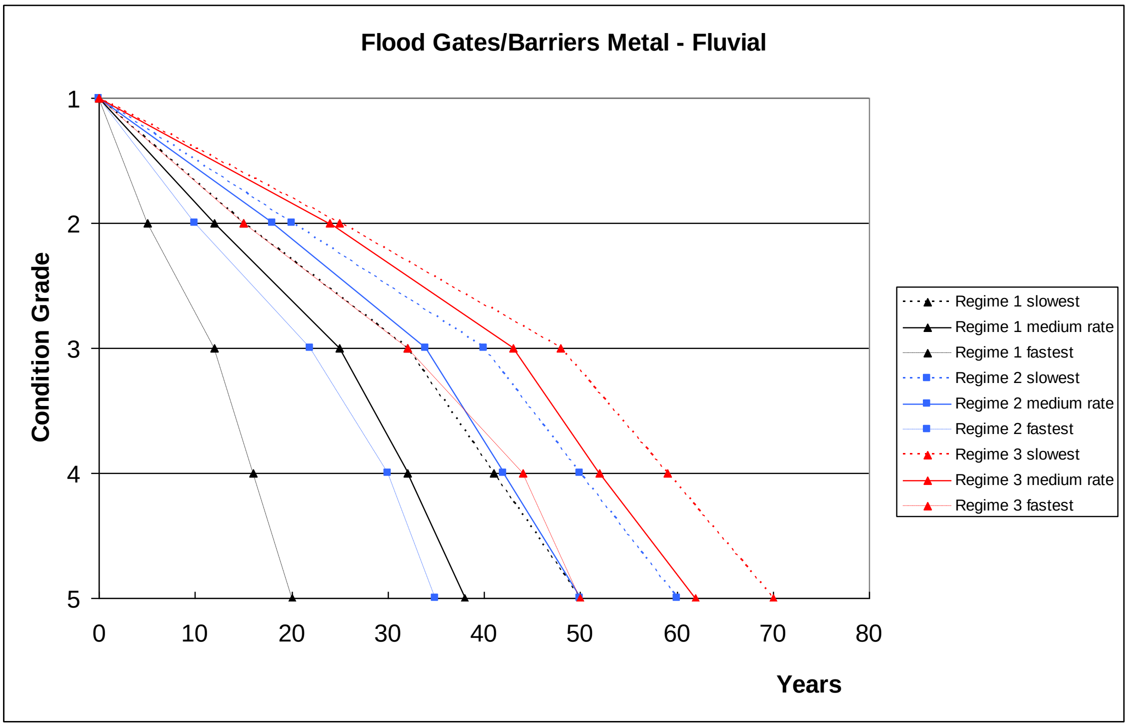
Figure C23 Flood gates and barriers

a. Metal

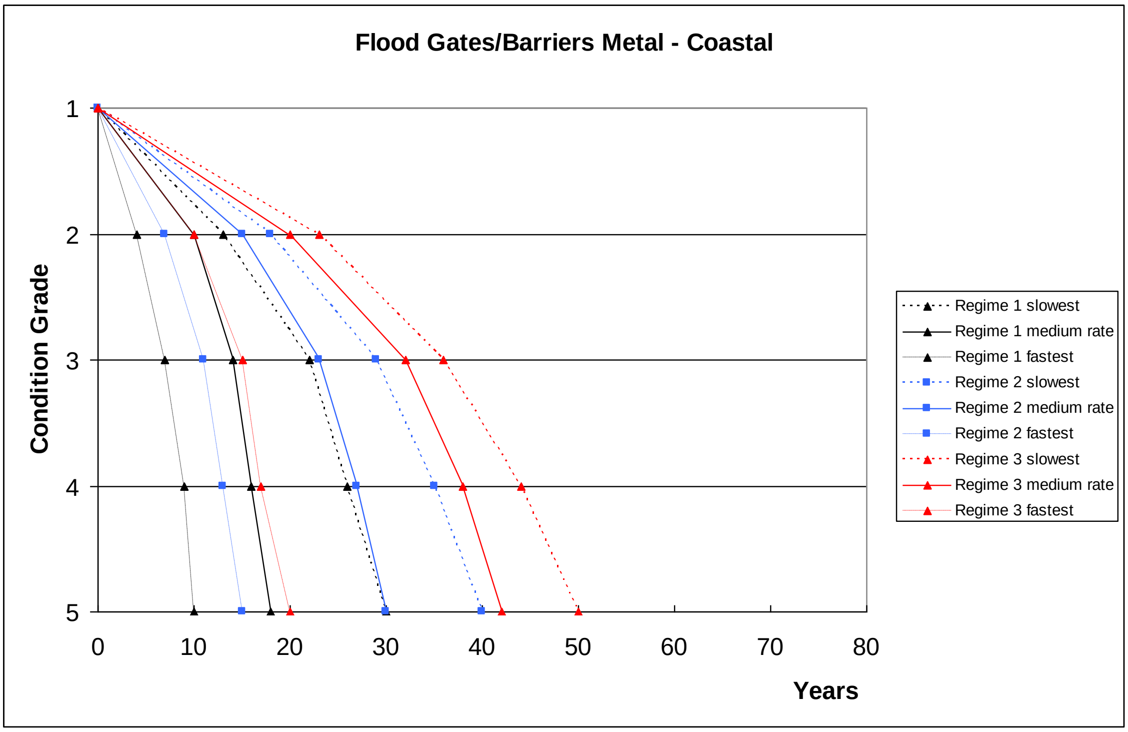
AIMS asset classification: Structure/control gate

Models

Flood Gates and Barriers Metal – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	15	32	41	50
2 – Medium	0	20	40	50	60
3 – High	0	25	48	59	70
Medium rate					
1 – Low/basic	0	12	25	32	38
2 – Medium	0	18	34	42	50
3 – High	0	24	43	52	62
Fastest rate					
1 – Low/basic	0	5	12	16	20
2 – Medium	0	10	22	30	35
3 – High	0	15	32	44	50



Flood Gates and Barriers Metal – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	13	22	26	30
2 – Medium	0	18	29	35	40
3 – High	0	23	36	44	50
Medium rate					
1 – Low/basic	0	10	14	16	18
2 – Medium	0	15	23	27	30
3 – High	0	20	32	38	42
Fastest rate					
1 – Low/basic	0	4	7	9	10
2 – Medium	0	7	11	13	15
3 – High	0	10	15	17	20



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and structural degradation of the flap valve/structure, progressing from CG 1 (no obstruction to conveyance and no structural damage) to CG 5 (fully obstructed flow and structural failure/collapse). Deterioration curves are based upon those for moveable gates (manual).

Asset: These generally appear in walls where access is required (footpaths, tracks, roads, etc). They are used to maintain the flood defence level where it is above existing ground level. They are normally hinged and therefore fixed in location, and they are stored (in open position) immediately behind the wall or in a recess. They may have seals and a ground sealing plate. Some more modern ones are removable and could therefore be classed as demountable defences.

Design life

The design life of such an asset is approximately 50 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

The deterioration processes affecting these assets include:

1. Damage to or gaps in gate or barrier
2. Gate seals damaged, failed or missing
3. Locking mechanism damaged, seized or missing
4. Hinges difficult to operate
5. Distortion of gate or frame
6. Gate missing or obstructed
7. Corrosion of metal gate
8. Cracking of concrete/brickwork

All these processes can be controlled by maintenance, including repair of damaged elements, corrosion control, replacement of components and lubrication of moving parts.

The following deterioration processes dominate the rate of deterioration:

- Obstructions/third party interference
- Disintegration of elements
- Operation error

Effect of environmental exposure/material quality

Fluvial slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is frequent. Deterioration mechanisms would be based on damage caused by blockages and/or corrosion through loss of protection.

Coastal slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is frequent. Deterioration mechanisms would be based on damage caused by blockages and/or corrosion through loss of protection.

Fluvial medium rate: Considered a typical rate providing a mid-range value.

Coastal medium rate: Considered a typical rate providing a mid-range value. The deterioration rate would increase from that in a fluvial environment.

Fluvial fastest rate: The gate is located in a harsh environment, and subject to the extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration mechanisms could be through corrosion of fixings, loss of corrosion protection of the gates.

Coastal fastest rate: The gate is located in a harsh environment, and subject to the extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration mechanisms could be through corrosion of fixings, loss of corrosion protection of the gates.

General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades (particularly CG 4), this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic ‘do minimum’. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through material deterioration (gates/frames, moving parts, fixings), compounded by blockage/obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including repair of damaged elements, corrosion control, replacement of components and lubrication of moving parts offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

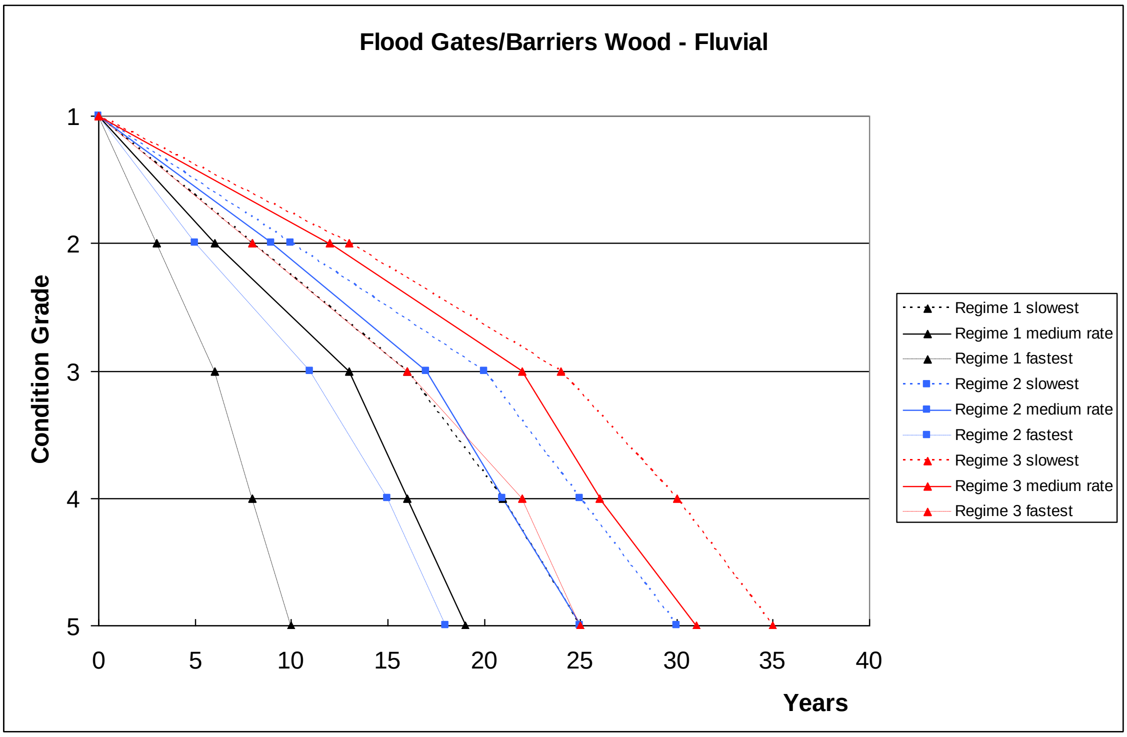
Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including repair of damaged elements, corrosion control, replacement of components and lubrication of moving parts offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works).

b. Wood

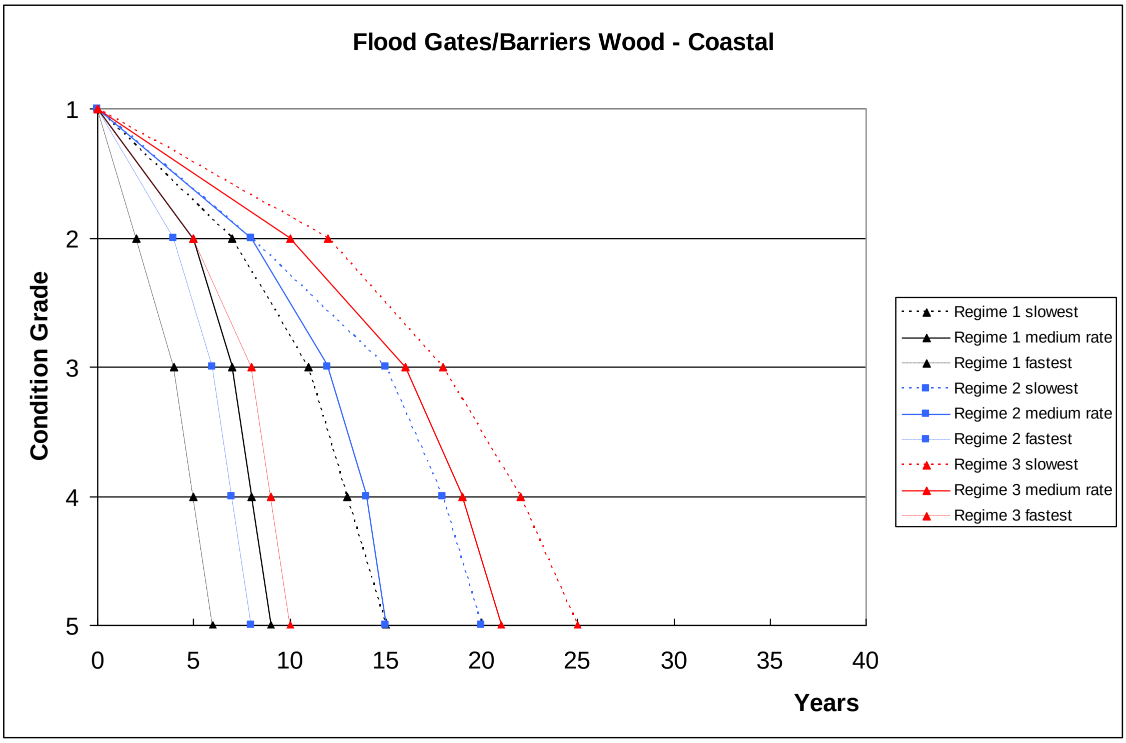
AIMS asset classification: Structure/control gate

Models

Flood Gates and Barriers Wood – Fluvial					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	8	16	21	25
2 – Medium	0	10	20	25	30
3 – High	0	13	24	30	35
Medium rate					
1 – Low/basic	0	6	13	16	19
2 – Medium	0	9	17	21	25
3 – High	0	12	22	26	31
Fastest rate					
1 – Low/basic	0	3	6	8	10
2 – Medium	0	5	11	15	18
3 – High	0	8	16	22	25



Flood Gates and Barriers Wood – Coastal/estuarine					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/basic	0	7	11	13	15
2 – Medium	0	8	15	18	20
3 – High	0	12	18	22	25
Medium rate					
1 – Low/basic	0	5	7	8	9
2 – Medium	0	8	12	14	15
3 – High	0	10	16	19	21
Fastest rate					
1 – Low/basic	0	2	4	5	6
2 – Medium	0	4	6	7	8
3 – High	0	5	8	9	10



Model assumptions

Note: The condition grades are indicative of both loss of conveyance and structural degradation of the flap valve/structure, progressing from CG 1 (no obstruction to conveyance and no structural damage) to CG 5 (fully obstructed flow and structural failure/collapse). Values are based upon those for flood gates and barriers – metal – and are assumed to be half the time (rounded up) of these metal defences.

Asset: These generally appear in walls where access is required (footpaths, tracks, roads, etc). They are used to maintain the flood defence level where it is above existing ground level. They are normally lock gates (largest), and stop logs used as a temporary defence when a gate has been removed.

Design life

The design life of such an asset is approximately 25 to 40 years based on normal engineering practice and assuming that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The life of such an asset may extend beyond the design life but this is dependent upon the environmental conditions, maintenance applied and quality of materials used. Conversely, a harsh or exposed environment can reduce the life of the asset below the design life, especially where maintenance and material quality is poor.

Deterioration

For gates in water deterioration would be related to marine borers and/or wet rot, corrosion of hinges, damage through operation, damage from collisions, sill damage, scour, etc. Deterioration for stop logs would mainly be through damage to logs during installation and removal, marine borers and wet rot (if installed for an extended time), damage to log recess (operation and accidental), cleaning out of debris and silt build up.

The deterioration processes affecting these assets include:

1. Damage to or gaps in gate or barrier
2. Gate seals damaged, failed or missing
3. Locking mechanism damaged, seized or missing
4. Hinges difficult to operate
5. Distortion of gate or frame
6. Gate missing or obstructed
7. Degradation of timber gate
8. Cracking of concrete/brickwork

All these processes can be controlled by maintenance, including repair of damaged elements, timber treatment, replacement of components and lubrication of moving parts.

The following deterioration processes dominate the rate of deterioration:

- Obstructions/third party interference
- Disintegration of elements

- Operation error

Effect of environmental exposure/material quality

Fluvial slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is frequent. Deterioration mechanisms would be based on damage caused by blockages and/or corrosion through loss of protection.

Coastal slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, the asset is well designed and the usage is frequent. Deterioration mechanisms would be based on damage caused by blockages and/or corrosion through loss of protection.

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General note: Where the model indicates an acceleration in deterioration rate, as evidenced by shorter time intervals in successive grades (particularly CG 4), this is attributed to the fact that regularly occurring loadings have proportionally bigger effects on the progressively deteriorating assets (which will contain progressively more cracks, interstices, discontinuities and crevices).

Effect of maintenance regime

Maintenance Regime 1: Low/basic 'do minimum'. This curve relates predominantly to the likelihood of extreme and rapid asset degradation through material deterioration (gates/frames, moving parts, fixings), compounded by blockage/obstruction.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including repair of damaged elements, timber treatment, replacement of components and lubrication of moving parts offsets asset deterioration. Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). Able to maintain at CG 3 (or better) for 21 years (fluvial) and 14 years (coastal) on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including repair of damaged elements, timber treatment, replacement of components and lubrication of moving parts offsets asset deterioration (i.e. as for Maintenance Regime 2 above but with increased frequency and more stringent criteria for repair). Deterioration rates are predominantly defined by likelihood of movement in surrounding strata (or other deterioration processes not affected by maintenance works). Able to maintain at CG 2 (or better) 22 years (fluvial) and 16 years (coastal) on this basis (at medium deterioration rate).

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