defra
Department for Environment Food and Rural Affairs

Environment Agency

delivering benefits through evidence

Technical report – FCRM assets: deterioration modelling and WLC analysis

Appendix A: Deterioration models

Report – SC060078/R3

Flood and Coastal Erosion Risk Management Research and Development Programme

Appendix A – Deterioration models – asset by asset

Contents

A. 1 Introduction

A.1.1 Using the deterioration models

The types of assets analysed in this guide are:

- Vertical walls (including with scour protection)
- Sheet piled structure
- Demountable defences
- Earth dykes or embankments
- Sloping walls with slope protection or revetment
- Culverts
- Beaches
- Control structures
- Dunes and shingle beaches
- Natural maintained channels
- Weirs
- Outfalls
- Flap valves
- Moveable gates (manual)
- Moveable gates (electrical)
- Debris screens
- Flood gates and barriers

These assets are further classified depending on the type of environment (fluvial or coastal/estuarine), type of material, width of the asset (narrow or wide[1]) and the maintenance regime.

For each classification three categories of deterioration rates are provided reflecting 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 tables 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

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

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 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 A.1) indicate the years to move from Condition Grade 1 to the condition grade (CG) of interest. The time to move from any condition grade to a worse condition grade is the difference between both figures.

Three maintenance regimes have been considered:

- Low/basic
- Medium
- High

Table A.1 Deterioration times (years) to different condition grades for different asset types and exposures

Asset class	Environment	Material	AIMS asset classification	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/ wall/ gabions	N/A	1	0	3	8	15	20		0	1	5	10	13		0	3	8	20	25
					N/A																	
					N/A																	

Asset class	Environment	Material	AIMS asset classification	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
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/ embankment	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 classification	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	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/ embankment	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
					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

Asset class	Environment	Material	AIMS asset classification	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
					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[2]		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[3]		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

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

[3] 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 classification	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	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
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	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 classification	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
structures																						
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/ breakwater		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/ saltmarsh		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	Fluvial	Earth (e.g.	Channel/		1	0	1	2	5	8		0	1	2	3	6		0	1	2	6	10

Asset class	Environment	Material	AIMS asset classification	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		regraded channels)	open channel		2	0	2	150	250	350		0	1	140	150	200		0	3	180	300	400
					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

Asset class	Environment	Material	AIMS asset classification	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**
Moveable gates (electrically operated)	Fluvial	All	Structure/ control gate	N/A	1	0	12	20	24	28		0	5	10	13	15		0	15	27	33	38
					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																						

A.1.2 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 (including ranging environmental conditions and access difficulties) 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 Grade 5).

5. Consider how deterioration progresses for each asset type under each maintenance regime scenario – for example this could be initially slow through Grades 1, 2 and 3 and then more rapidly to CG4 and then CG5. This will give the general shape of the deterioration curve.

Notes: Steps 1 to 5 were undertaken by Halcrow experts, as appropriate to the asset group, using their project and general expertise, literature in the public domain and the findings of Phase 1 of this study (in particular the deterioration curves and commentaries)

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

   - Phase 1 Report – deterioration curves with commentary and interviews with asset managers.

   - NFCDD data extracts (Condition Grade 4 and separately all condition grades by asset age). Note: It was not possible to align the assets represented by the extracted data to the environmental conditions or maintenance regime pertaining. A general agreement between deterioration curve and condition grade/age was sought as evidence of validation.

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

   - Results of Workshop activities (18 April 2011).

A.1.3 Step-by-step guide

Step 1: Identify the type of asset:

Reference asset list as indicated above (Section A.1.1): 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 if it is 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.
- Maintenance Regime 1, 2 or 3 (as defined in the Technical Report).

Step 3: 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 4: Forecast the current condition grade and expected deterioration time

From the asset age, identify the likely current condition grade of the asset and forecast the expected deterioration time(s) to the next condition grade(s) using the selected or interpolated deterioration curve. It is assumed that it takes the full period to get to the next condition grade; hence, there are no intermediate states between condition grades. For example, to move from CG 2 to CG 5 it takes the difference between both figures. Note: If the asset age is not known, the Environment Agency's *Condition Assessment Manual* can be used to assist in assigning the current condition grade from asset-specific site observations.

A.1.4 Comparison of Phase 1 and Phase 2 deterioration models

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, NDFCC data extracts, workshop activities and site survey findings (see Section A.1.2 above), the Phase 2 models are considered updates of their corresponding Phase 1 models and should therefore be considered as replacements for Phase 1 models.

Table A.2 lists general comments regarding changes between Phase 1 and Phase 2 models. More specific information is given in Section A.2 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.2 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 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 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). 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	Phase 1 reported it was not effective to carry out maintenance. 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.
Vertical wall	Steel piles	Fluvial	The review process for Phase 2 suggested that the Phase 1 curves may be too optimistic. Predictions for the ‘No maintenance’ scenario gave between 55 and 67% reduction in overall asset life, 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 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 (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 Phase1, but Phase 2 has much shorter overall lives (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 (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 Grades 4 and 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 (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 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 comprised 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) ‘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 for slowest and most likely scenarios (33 and 150% respectively) ‘With maintenance’ scenario: Phase 2 curves predict between two and three times asset life compared with Phase 1 curves.

A. 2 Individual deterioration models

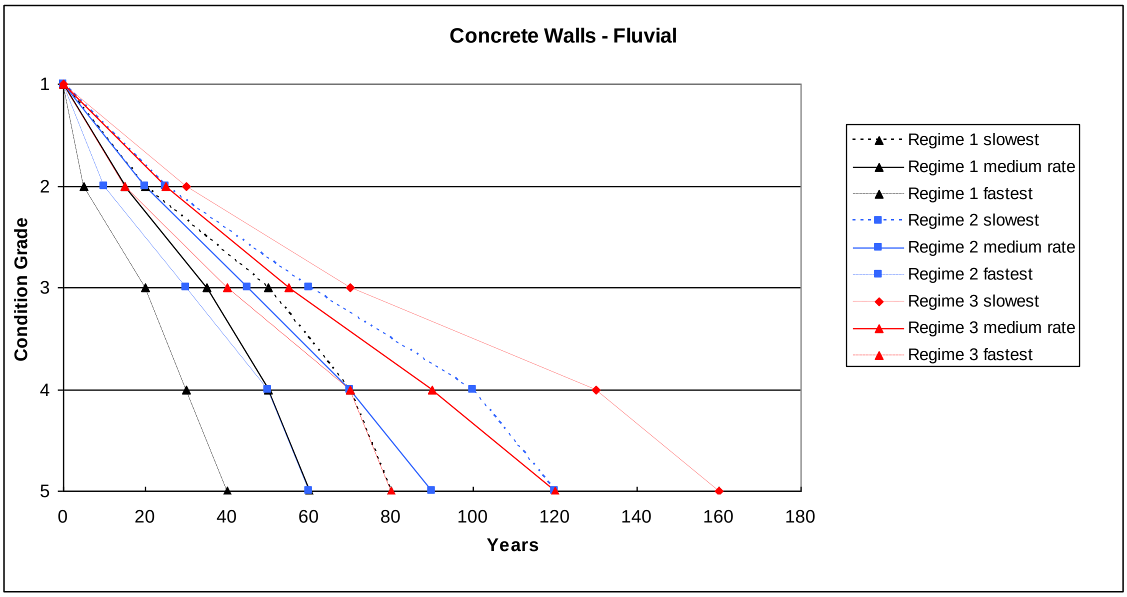
A.2.1 Vertical walls (inc. with scour protection)

A.2.1.1 Concrete (fluvial and coastal/estuarine)

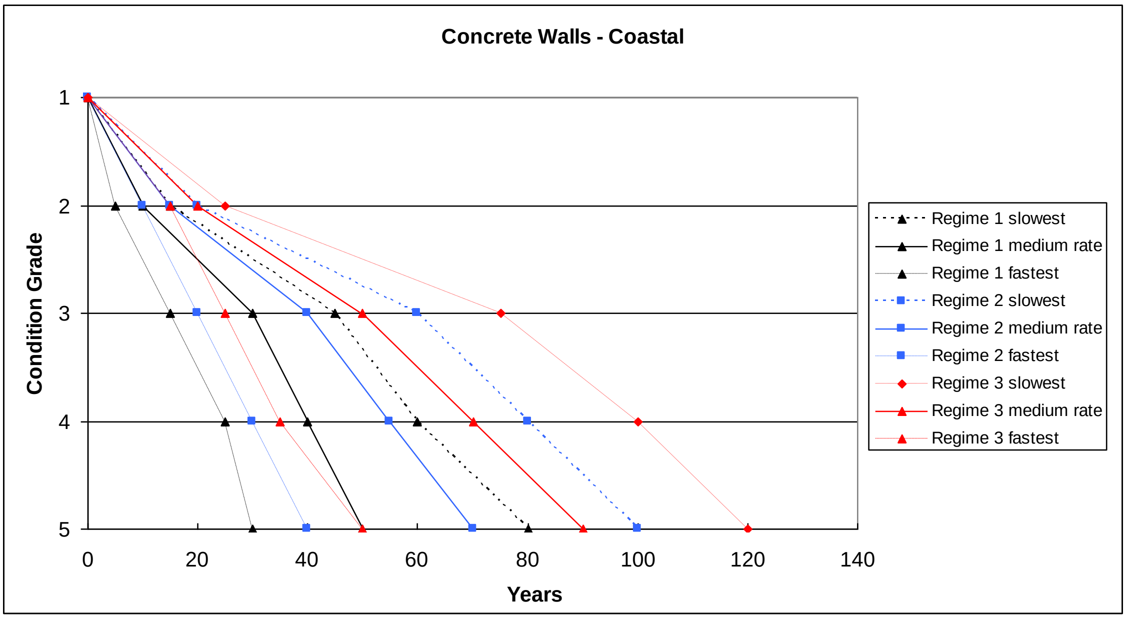
AIMS asset classification: Defence/wall

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



Assumptions:

Deterioration: The deterioration processes affecting these assets include:

Those that compromise the integrity of the asset overall, e.g.:

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 condition: Coastal is 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.

Maintenance Regime 1: Low/Basic ‘do minimum’. 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 minor concrete/joint repair and scour protection/backfill replacement offsets concrete 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 70 years (fluvial) and 55 years (coastal) on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 55 years (fluvial) and 50 years (coastal) on this basis (at medium deterioration rate).

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, 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.

Notes on model construction – vertical walls concrete

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	General agreement but some adjustment of age at grade transitions for 'No maintenance' Regime 1 to give shorter overall timescales to CG 5 (i.e. more rapid decline for Phase 2 curves compared to Phase 1 with overall reduction of 15 to 30 years in asset life dependent upon deterioration rate/exposure)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	The data extracts broadly supported the deterioration curves developed for this asset. CG 3, 4 and 5 were in general agreement. There were some low age assets graded 3 and 4 (5 years and 25 years) which was not consistent with the curve. Similarly there were some older assets recording low CGs (i.e. CG 1 at 48 years and CG 2 at 88 years)
Site survey	Y (1 asset)	Grade for asset consistent with deterioration curve
Workshop	Y	Findings are in broad agreement with deterioration curves

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	General agreement but some adjustment of age at later grade transitions for slowest deterioration rate to give an overall shorter life (no maintenance and maintenance scenarios). Some similar adjustment to shorter lives for medium rate scenario Note: Phase 1 curve, slowest deterioration for coastal vertical concrete walls indicate no benefit of maintenance (in terms of age at grade transitions). This is not consistent with the corresponding curves for fluvial assets and also the commentary in the Phase 1 guidance document. Phase 2 curves have corrected this anomaly
Phase 1 interview	Y	Interviews recorded asset life as 100+ years consistent with the deterioration curve (slowest deterioration rate with maintenance)
NFCDD database	Y	The data extracts broadly supported the deterioration curves developed for this asset. Low age assets were recorded with poor condition grades, i.e. CG 4 at 5 years and CG 3 at 1 year

Evidence	Available Y/N?	Comments
Site survey	Y (1 asset)	Grade for asset consistent with deterioration curve
Workshop	N	Not applicable

Additional comments: vertical walls concrete

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. The maintenance is basic as stated above. The deterioration mechanisms would be through joint failures and lack of repairs. The asset is assumed to reach CG 5 in year 80 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include repair of concrete, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case appropriate maintenance is undertaken. The deterioration mechanisms would be at the joints. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 120 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Rate	Maintenance Regime	Assumptions
Medium	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is the basic as stated above. The deterioration mechanisms would be through joint failures and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 60 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include repair of concrete, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case appropriate maintenance is undertaken as per the above. The deterioration mechanisms would be at the joints. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 90 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Fastest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset is reduced below the 'design life' due to; environmental conditions, and lack of maintenance, and or materials/design used. In this case the maintenance is only very basic as stated above. The deterioration mechanisms would be through joint failures, and a lack of repairs. The asset is assumed to prematurely reach CG 5 in year 40.

Rate	Maintenance Regime	Assumptions
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include repair of concrete, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and or materials/design used. In this case maintenance is undertaken. The deterioration mechanisms would be at the joints. The asset is assumed to reach CG 5 in year 60.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the environment is coastal/estuarine, and the maintenance is basic as stated above. The deterioration mechanisms would be through joint failures and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 80 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include repair of concrete, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the environment is benign, and appropriate maintenance is undertaken. The deterioration mechanisms would be at the joints. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 100 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Rate	Maintenance Regime	Assumptions
Medium	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the environment is neither exposed nor sheltered, but, maintenance is the basic as stated above. The deterioration mechanisms would be through joint failures and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 60 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include repair of concrete, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the environment is neither exposed nor sheltered, but, appropriate maintenance is undertaken. The deterioration mechanisms would be at the joints. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 70 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

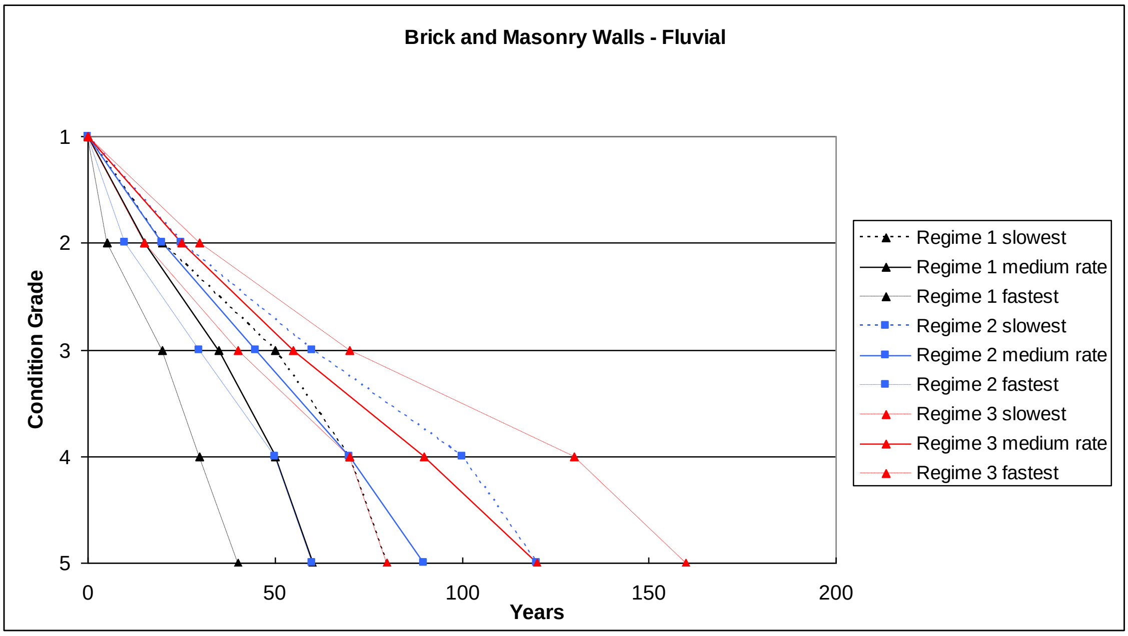
Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks carried out are visual inspections of the wall, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc), there is no maintenance of the asset. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset is reduced below the 'design life' due to; environmental conditions, and lack of maintenance, and or quality of materials/construction/design used. In this case the environment is an exposed and harsh environment. The maintenance is basic as stated above. The deterioration mechanisms would be through; abrasion of concrete, chloride ingress, reinforcement corrosion, joint failures, toe erosion and the lack of repair. The asset is assumed to reach CG 5 in year 30.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include repair of concrete, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice.The life of such an asset is reduced below the 'design life' due to; environmental conditions, and or quality of materials/construction/design used. In this case the environment is an exposed and harsh environment. The deterioration mechanisms would be through; abrasion of concrete, chloride ingress, reinforcement corrosion, joint failures, toe erosion and the lack of repair. The asset is assumed to reach CG 5 in year 40.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.1.2 Brick and masonry (fluvial and coastal/estuarine)

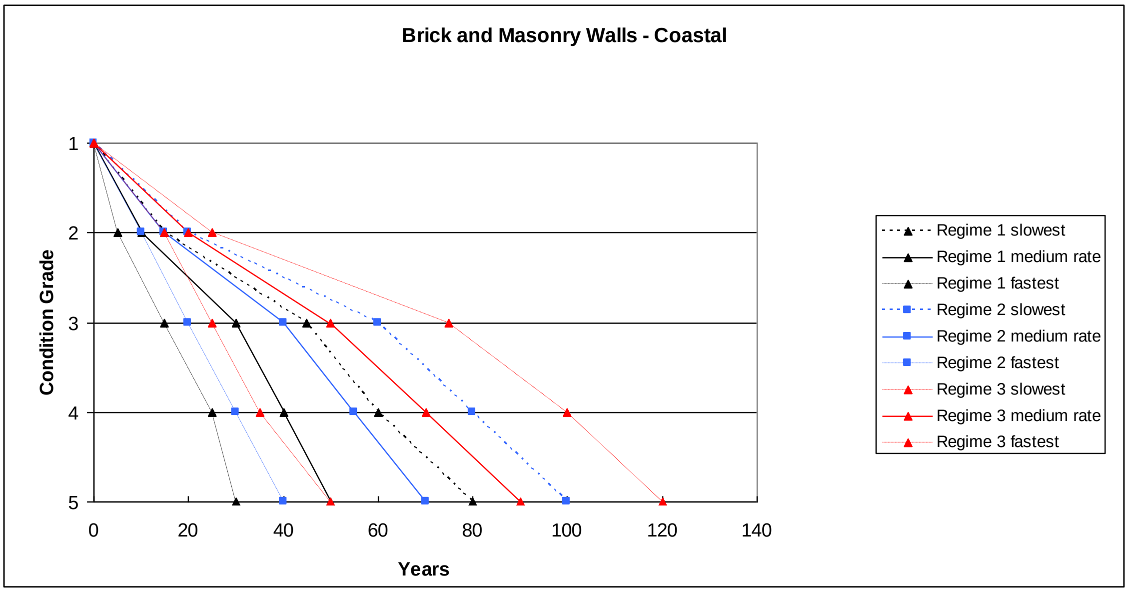
AIMS asset classification: Defence/wall

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



Assumptions:

Deterioration: The deterioration processes affecting these assets include:

Those that compromise the integrity of the asset overall, e.g.:

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 condition: 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.

Maintenance Regime 1: Low/Basic ‘do minimum’. 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 minor brickwork and joint repair and scour protection/backfill replacement offsets material 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 70 years (fluvial) and 55 years (coastal) on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor brickwork and joint 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). Able to maintain at CG 2 (or better) for 55 years (fluvial) and 50 years (coastal) on this basis (at medium deterioration rate).

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.

Notes on model construction – vertical walls brick and masonry

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Good agreement with deterioration curves including maintenance. Some adjustment to shorter times for transitions for No maintenance curves giving a shorter predicted asset life (to Grade 5) with overall reduction of 15 to 30 years in asset life dependent upon deterioration rate/exposure
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	The data extracts broadly supported the deterioration curves developed for this asset. A 100-year-old CG 2 asset and one of 26 years at CG 4 were inconsistent with the curve
Site survey	Y (14 assets)	Grades for assets consistent with deterioration curve
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	For 'No maintenance' Phase 2 scenario there was some adjustment of age at grade transitions for all deterioration rates to give overall shorter lives (by between 30 and 70 years overall. Note: The Phase 1 commentary indicated that the Phase 1 curves related generally to tougher brick/masonry materials (in view of coastal location). Phase 2 curves have assumed materials are more representative of an 'average' grade/quality. Phase 1 curves did not include maintenance (not considered effective). Some maintenance activities have been devised for Phase 2
Phase 1 interview	Y	Interviews recorded asset life as 120+ years consistent with the deterioration curve (slowest deterioration rate with maintenance)
NFCDD database	Y	The data extracts broadly supported the deterioration curves developed for this asset, although there was a low age asset CG 4 (8 years). In contrast one asset 150 years old was recorded as CG 4
Site survey	Y (15 assets)	Historical records for study sites indicated long age assets at CG 3 (78 years) and CG 4 (160 years). Other records were consistent with the deterioration curves

Evidence	Available Y/N?	Comments
Workshop	Y	Findings are in broad agreement with deterioration curves

Additional comments: vertical walls brick and masonry

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through water ingress, mortar cracking/loss, loss of bricks and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 80 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include joint repair, re-pointing, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case appropriate maintenance is undertaken. The deterioration mechanisms would be through mortar cracking/loss, cracking of brick/blockwork and loss of brick/blocks. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 120 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Rate	Maintenance Regime	Assumptions
Medium	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through water ingress, cracking/loss of mortar, cracking/loss of brick/blockwork. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 60 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include joint repair, re-pointing, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms would be through water ingress, cracking/loss of mortar, cracking/loss of brick/blockwork. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 90 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Rate	Maintenance Regime	Assumptions
Fastest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset is reduced below the 'design life' due to; environmental conditions, and lack of maintenance, and or materials/design used. In this case the maintenance is only very basic as stated above. The deterioration mechanisms would be through water ingress, cracking/loss of mortar, cracking/loss of brick/blockwork, undermining of the toe, and a lack of repairs. The asset is assumed to prematurely reach CG 5 in year 40.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include joint repair, re-pointing, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' due to; location, environmental conditions, and maintenance, and or materials/design used. In this case the maintenance is undertaken as stated above. The deterioration mechanisms would be through water ingress, cracking/loss of mortar, cracking/loss of brick/blockwork, undermining of the toe. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to prematurely reach CG 5 in year 60.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through joint failures and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 80.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include joint repair, re-pointing, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case appropriate maintenance is undertaken. The deterioration mechanisms would be through abrasion, mortar cracking/loss, cracking of brick/blockwork and loss of brick/blocks. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 100.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Rate	Maintenance Regime	Assumptions
Medium	1	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. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through abrasion, water ingress, mortar cracking/loss, loss of brick/blockwork. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 60.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include joint repair, re-pointing, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms would be through abrasion, water ingress, mortar cracking/loss, loss of brick/blockwork. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 70.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

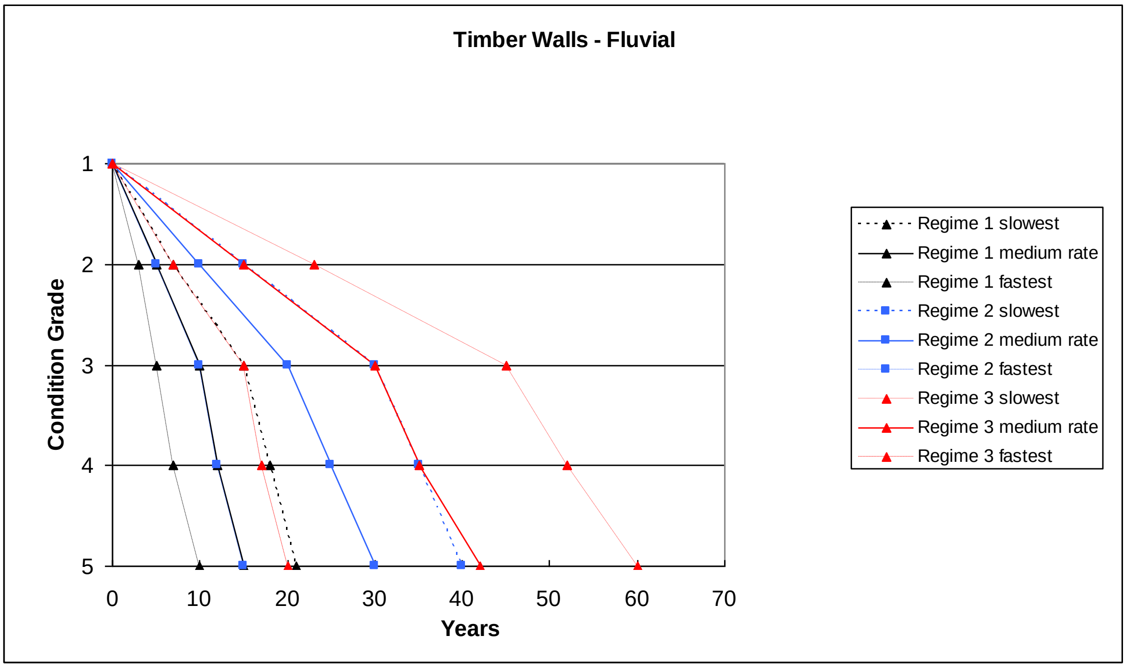
Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks carried out are visual inspections of the wall, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc), there is no maintenance of the asset. The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may be less than the 'design life' due to; environmental conditions, lack of maintenance, and or quality of materials/construction/design used. In this case the maintenance is basic as stated above. The expected deterioration mechanisms would be; abrasion, water ingress, mortar cracking/loss, loss of brick/blockwork, toe erosion and the lack of repair. The asset is assumed to reach CG 5 in year 30.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include joint repair, re-pointing, sealant replacement/repair, replacement of backfill, scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may be less than the 'design life' due to; environmental conditions, and or quality of materials/construction/design used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms would be through; abrasion, water ingress, mortar cracking/loss, loss of brick/blockwork. The asset is assumed to reach CG 5 in year 40.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.1.3 Timber (fluvial and coastal/estuarine)

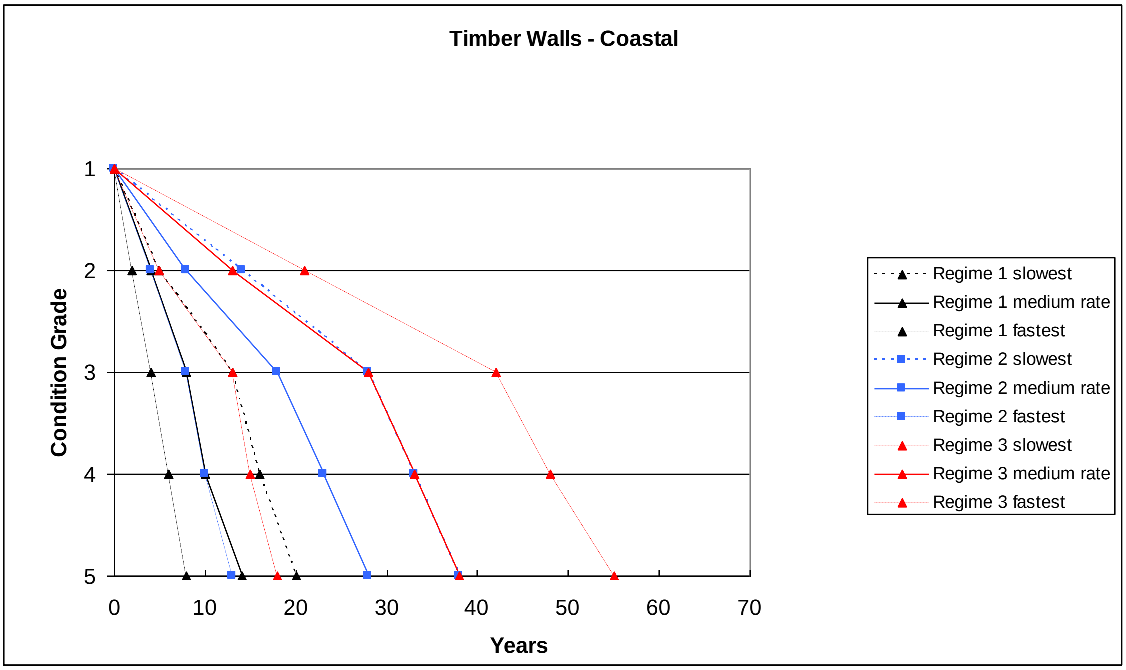
AIMS asset classification: Defence/wall

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



Assumptions:

Deterioration: The deterioration processes affecting these assets include:

Those that compromise the integrity of the asset overall, e.g.:

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 condition: 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.

Maintenance Regime 1: Low/Basic ‘do minimum’. 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 minor timber, joint and fixings repair/treatment and scour protection/backfill replacement offsets material 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 25 years (fluvial) and 23 years (coastal) on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor timber, joint and fixings repair/treatment 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). Able to maintain at CG 2 (or better) for 30 years (fluvial) and 28 years (coastal) on this basis (at medium deterioration rate).

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, and 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.

Notes on model construction – vertical walls timber

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Not applicable
Phase 1 interview	N	Not applicable
NFCDD database	Y	The data extracts generally supported the deterioration curves developed for this asset. A 6-year-old asset with CG 4 was, however, inconsistent with the curves
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Not applicable
Phase 1 interview	N	Not applicable
NFCDD database	Y	One asset of 62 years age was recorded with a CG 4. This is not consistent with the deterioration curves, which suggest that the oldest CG asset would be 55 years old. This is not considered a major anomaly
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: vertical walls timber

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through rotting of individual timbers, corrosion and failure of fixings, and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 20 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include timber, joint and fixings repair, sealant replacement/repair, replacement of backfill, scour protection, timber treatment, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms would be rotting of individual timbers, corrosion and failure of fixings. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 40 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Rate	Maintenance Regime	Assumptions
Medium	1	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. The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through rotting of individual timbers, corrosion and failure of fixings, and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 15 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include timber, joint and fixings repair, sealant replacement/repair, replacement of backfill, scour protection, timber treatment, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms would be rotting of individual timbers, corrosion and failure of fixings. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 30 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Rate	Maintenance Regime	Assumptions
Fastest	1	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. The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through rotting of individual timbers, corrosion and failure of fixings, and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 10 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include timber, joint and fixings repair, sealant replacement/repair, replacement of backfill, scour protection, timber treatment, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms would be rotting of individual timbers, corrosion and failure of fixings. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 15 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms could be through; rotting of individual timbers, fugal decay, infestations of marine borers, corrosion and failure of fixings, and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 20 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include timber, joint and fixings repair, sealant replacement/repair, replacement of backfill, scour protection, timber treatment, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms could be rotting of individual timbers, fungal decay, infestations of marine borers, corrosion and failure of fixings. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 40 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Rate	Maintenance Regime	Assumptions
Medium	1	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. The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through rotting of individual timbers, fungal decay, infestations of marine borers, corrosion and failure of fixings, and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 15 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include timber, joint and fixings repair, sealant replacement/repair, replacement of backfill, scour protection, timber treatment, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms would be rotting of individual timbers, fungal decay, infestations of marine borers, corrosion and failure of fixings. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 30 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

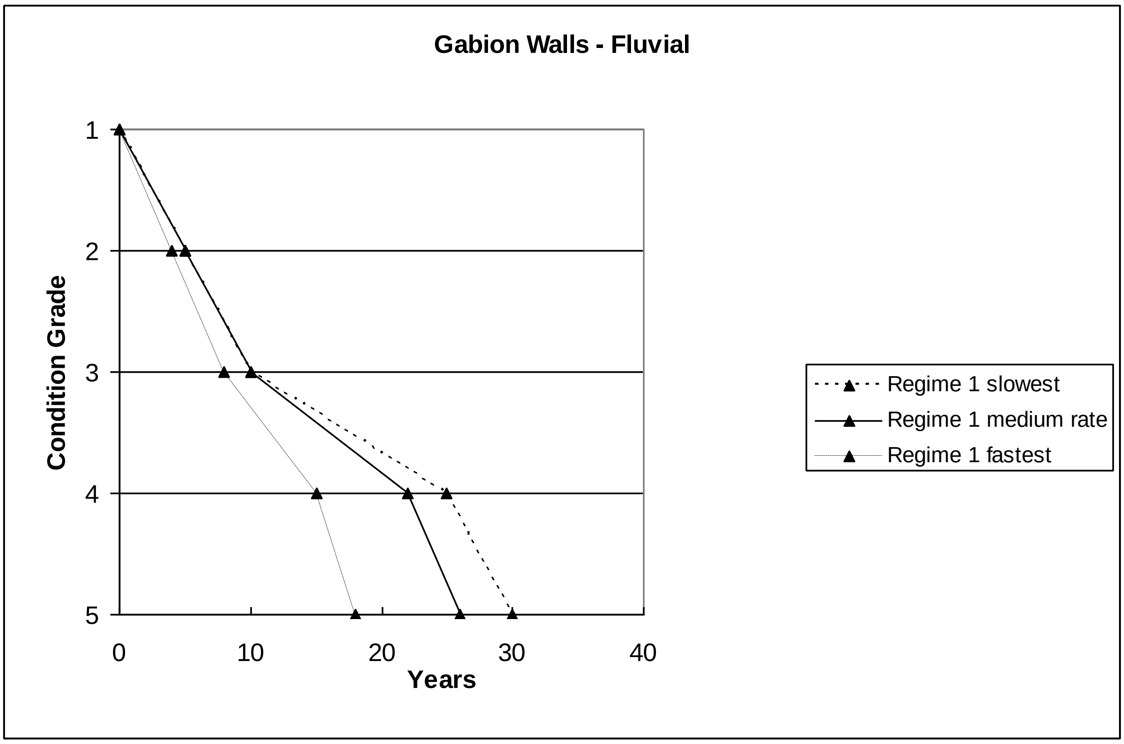
Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks carried out are visual inspections of the wall, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc), there is no maintenance of the asset. The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the maintenance is basic as stated above. The deterioration mechanisms would be through rotting of individual timbers, fungal decay, infestations of marine borers, corrosion and failure of fixings, and lack of repairs. It is assumed that the materials used and construction techniques are appropriate for the location. The asset is assumed to reach CG 5 in year 10 before the asset needs to be replaced.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include timber, joint and fixings repair, sealant replacement/repair, replacement of backfill, scour protection, timber treatment, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is typically 25 years based on normal engineering practice. The life of such an asset may vary from the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case the appropriate maintenance is undertaken. The deterioration mechanisms would be rotting of individual timbers, fungal decay, infestations of marine borers, corrosion and failure of fixings. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable. The asset is assumed to reach CG 5 in year 15 before the asset needs to be replaced.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.1.4 Gabion (fluvial and coastal/estuarine)

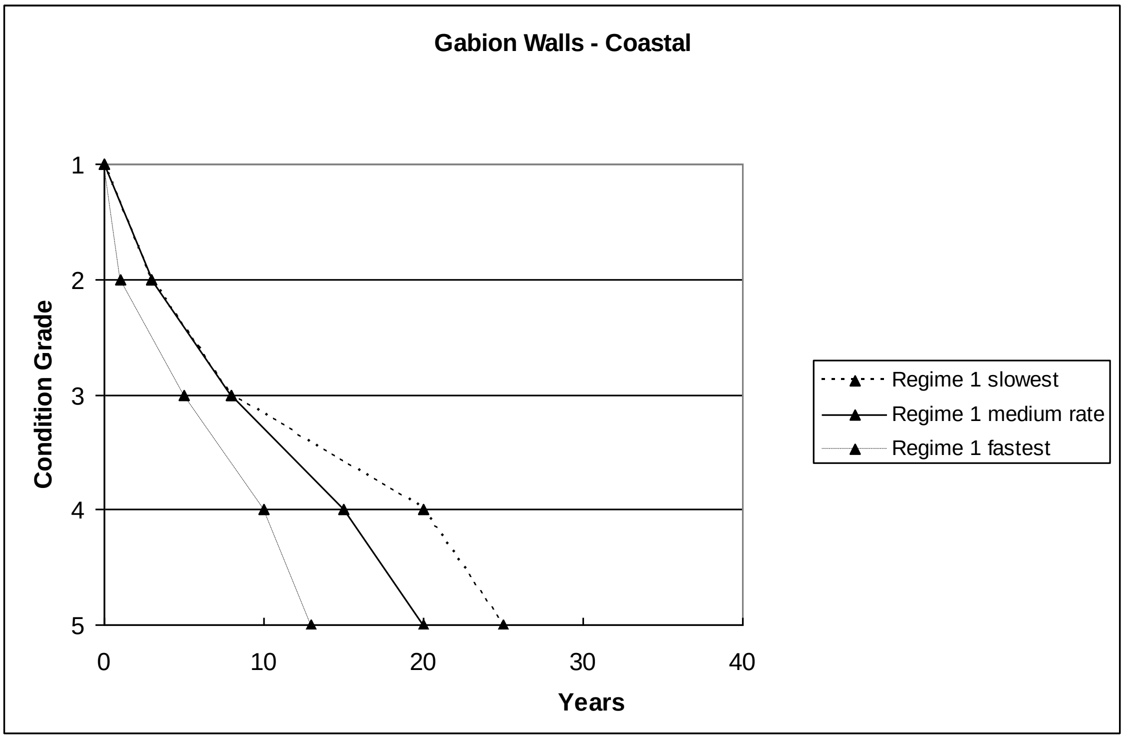
AIMS asset classification: Defence/wall/gabions

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				



Assumptions:

Deterioration: The deterioration processes affecting these assets include:

Those that compromise the integrity of the asset overall, e.g.:

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 condition: 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.

Maintenance: 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'. 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

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.

Notes on model construction – vertical walls gabion

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Deterioration curves have same values as Phase 1 curve. Assumptions presented in Phase 1 report were accepted as correct and reasonable
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	The data extracts indicated higher asset ages at grade transitions, e.g. 28, 49, 44 and 48 years for CG 1 to 4 respectively
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Not applicable Note: Coastal curve for gabion walls has been constructed so that it predicts faster deterioration than equivalent fluvial assets (as would be appropriate with the more aggressive environment). The Phase 1 gabion wall fluvial curves have been adopted for this phase of the work and therefore provide the benchmark for the coastal assets
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	The data extracts indicated a CG 4 asset as being 60 years old, considerably higher than the maximum of 25 years to Grade 5 transition indicated by the deterioration curves (slowest rate with high maintenance)
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: vertical walls gabion

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	The data and text used in Phase 1 is appropriate and we would not disagree with it. Only maintenance tasks likely to 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.
	2	Undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
	3	As per Regime 2 undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
Medium	1	The data and text used in Phase 1 is appropriate and we would not disagree with it. Only maintenance tasks likely to 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.
	2	Undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
	3	As per Regime 2 undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
Fastest	1	The data and text used in Phase 1 is appropriate and we would not disagree with it. Only maintenance tasks likely to 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.
	2	Undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
	3	As per Regime 2 undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	It is highly unlikely and inappropriate to use gabions in a coastal/estuarine environment. The life of these would indeed be very short as reflected in the curve. Only maintenance tasks likely to 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.
	2	As per fluvial environment, undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
	3	As per Regime 2 undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
Medium	1	It is highly unlikely and inappropriate to use gabions in a coastal/estuarine environment. The life of these would indeed be very short as reflected in the curve. Only maintenance tasks likely to 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.
	2	As per fluvial environment, undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
	3	As per Regime 2 undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
Fastest	1	It is highly unlikely and inappropriate to use gabions in a harsh/exposed coastal/estuarine environment. The life of these would indeed be very short as reflected in the curve. Only maintenance tasks likely to 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.

Rate	Maintenance Regime	Assumptions
	2	As per fluvial environment, undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.
	3	As per Regime 2 undertaking effective maintenance is very difficult on gabions, any replacement of gabions would be categorised as refurbishment, therefore any curve for this regime would be the same as Regime 1.

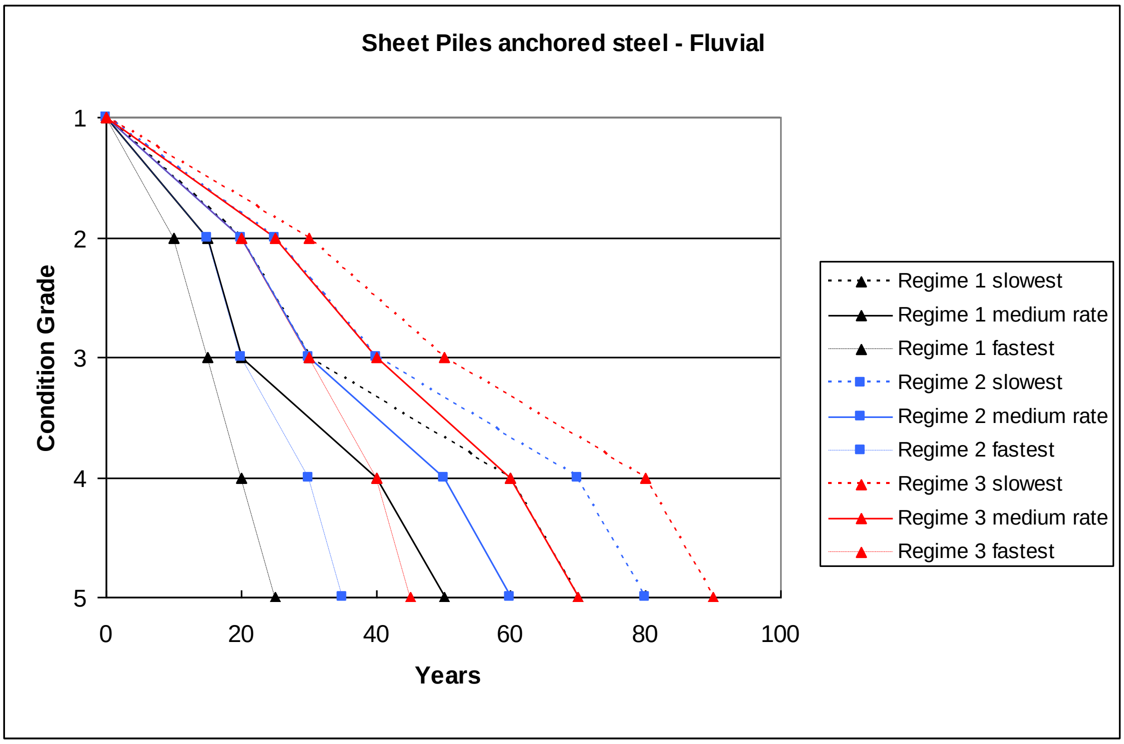
A.2.2 Sheet piled structures

A.2.2.1 Anchored steel (fluvial and coastal/estuarine)

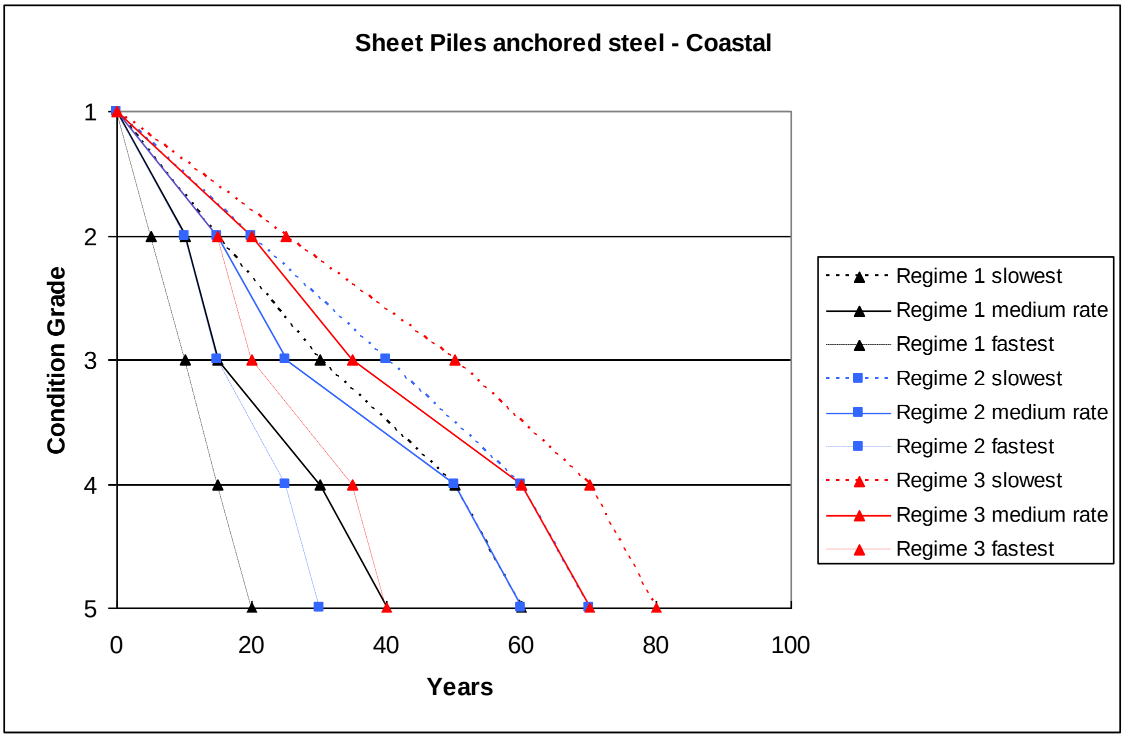
AIMS asset classification: Defence/wall/Piling

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



Assumptions:

Deterioration: The deterioration processes affecting these assets include:

Those that compromise the integrity of the asset overall, e.g.:

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 condition: 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.

Maintenance Regime 1: Low/Basic ‘do minimum’. 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 minor repair, corrosion prevention and timber treatment (to timber components) and scour protection/backfill replacement offsets material 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 50 years (fluvial) and 50 years (coastal) on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, corrosion prevention 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). Able to maintain at CG 2 (or better) for 40 years (fluvial) and 35 years (coastal) on this basis (at medium deterioration rate).

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 and 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.

Notes on model construction – sheet piled structures: anchored steel

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Adjustment of age at grade transitions for all deterioration rate scenarios to give an overall shorter life (of between 50 and 90 years depending upon deterioration rate/exposure). The review process for Phase 2 suggested that the Phase 1 curves may be too optimistic with a consequent significant reduction in asset life. Note: Phase 1 curves for sheet steel structures assumed no differences between '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
Phase 1 interview	Y	Interviews recorded asset life as up to 100 years. The deterioration curves predict a maximum of 90 years (to CG 5 transition)
NFCDD database	Y	The data extracts broadly supported the deterioration curves developed for this asset, although some low age assets recorded poor condition grades, e.g. 17 years CG 4 and 9 years CG 3
Site survey	N	Not applicable
Workshop	Y	General agreement, although workshop indicated longer life to CG 5 transition (100 years cf. 90 years from deterioration curve (slowest rate)

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	For maintained assets, age transitions are generally consistent with Phase 1 deterioration curves. For non-maintained assets, there has been some adjustment of age at earlier grade transitions for all deterioration rate scenarios to give a slower initial deterioration (CG 1 to 2). Phase 2 curves predict earlier transitions to later grades giving a slight decrease in predicted overall life (between 10 to 20 years depending upon deterioration rate/exposure).
Phase 1 interview	N	Not applicable

Evidence	Available Y/N?	Comments
NFCDD database	Y	Variable agreement for data extract. Extreme values in dataset (i.e. CG 4 assets of 14 to 110 years and a 28-year-old CG 1 asset) are not consistent with the deterioration curve
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: sheet piled structures: anchored steel

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 70.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 80.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 90.
Medium	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 50.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 60.

Rate	Maintenance Regime	Assumptions
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 70.
Fastest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 25.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 35.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 45.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 60.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 70.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 80.
Medium	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 40.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 60.

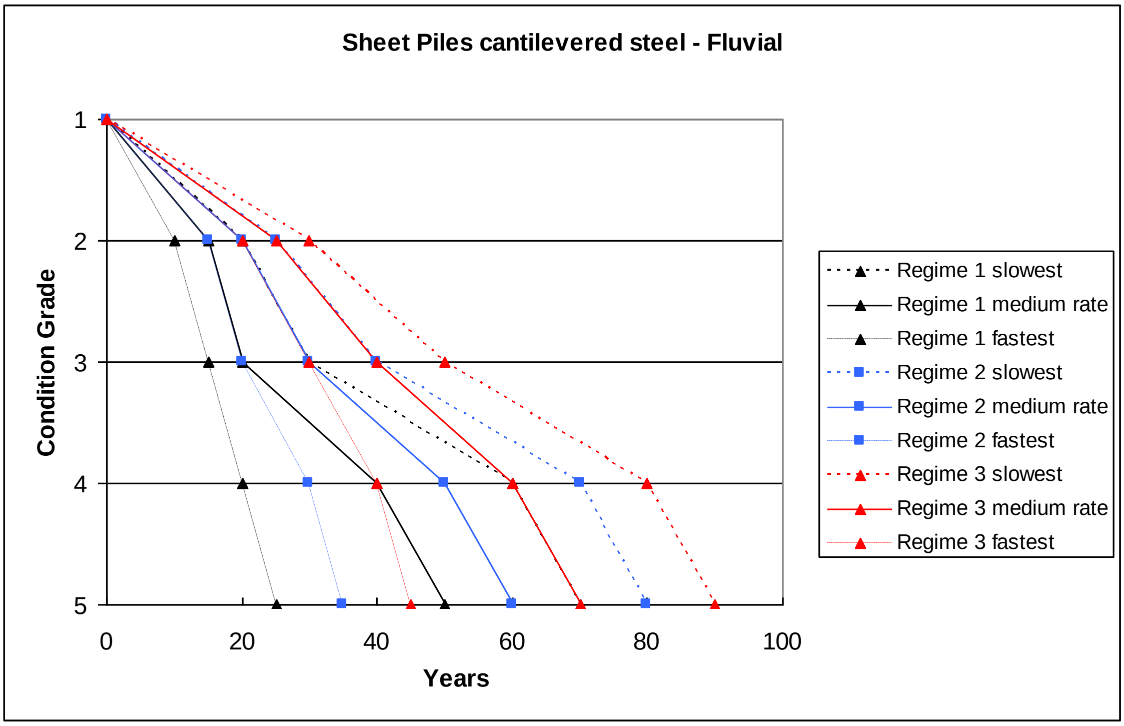
Rate	Maintenance Regime	Assumptions
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 70.
Fastest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 20.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 30.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 40.

A.2.2.2 Cantilevered steel (fluvial and coastal/estuarine)

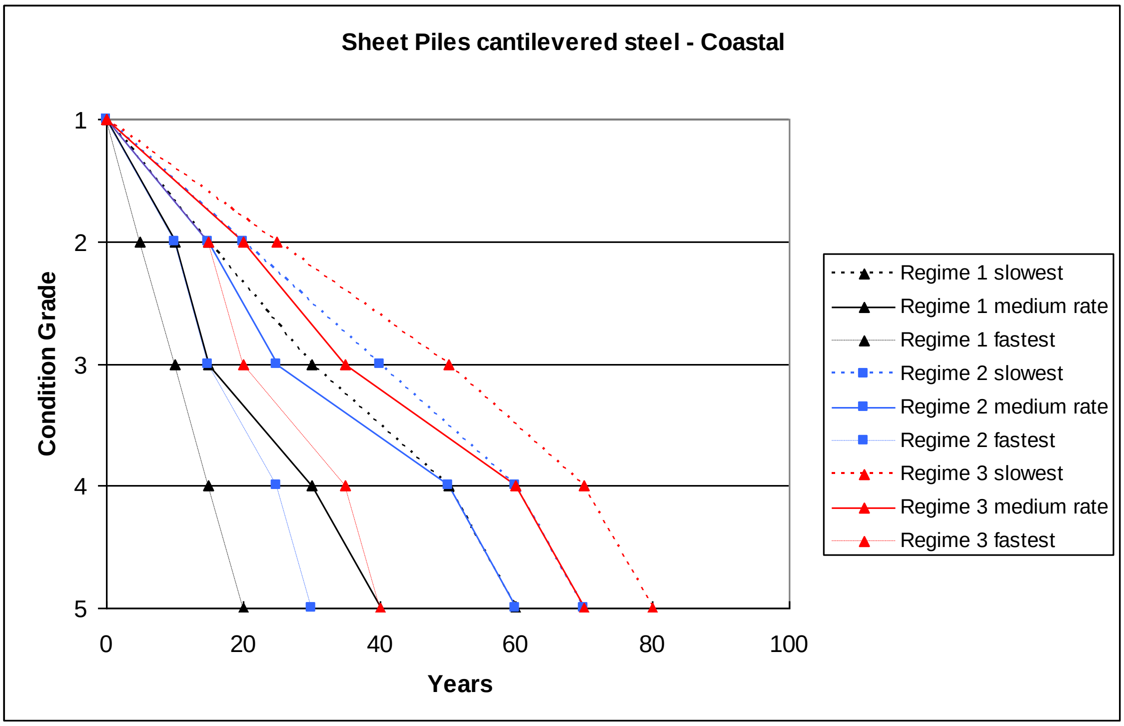
AIMS asset classification: Defence/wall/Piling

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



Assumptions:

Deterioration: The deterioration processes affecting these assets include:

Those that compromise the integrity of the asset overall, e.g.:

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 (to timber components) 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 condition: 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.

Maintenance Regime 1: Low/Basic ‘do minimum’. 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 minor repair, corrosion prevention and timber treatment (to timber components) and scour protection/backfill replacement offsets material 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 50 years (fluvial) and 50 years (coastal) on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, corrosion prevention 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). Able to maintain at CG 2 (or better) for 40 years (fluvial) and 35 years (coastal) on this basis (at medium deterioration rate).

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.

Notes on model construction – sheet piled structures: cantilevered steel

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Adjustment of age at grade transitions for all deterioration rate scenarios to give an overall shorter life (of between 50 and 90 years depending upon deterioration rate/exposure). The review process for Phase2 suggested that the Phase 1 curves may be too optimistic with a consequent significant reduction in asset life. Note: Phase 1 curves for sheet steel structures assumed no differences between '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
Phase 1 interview	Y	Interviews recorded asset life as up to 100 years. The deterioration curves predict a maximum of 90 years (to CG 5 transition)
NFCDD database	Y	The data extracts broadly supported the deterioration curves developed for this asset, although some low age assets recorded poor condition grades, e.g. 17 years CG 4 and 9 years CG 3
Site survey	N	Not applicable
Workshop	Y	General agreement, although workshop indicated longer life to CG 5 transition (100 years cf. 90 years from deterioration curve (slowest rate))

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	For maintained assets, age transitions at are generally consistent with deterioration curves. For non-maintained assets, there has been some adjustment of age at earlier grade transitions for all deterioration rate scenarios to give a slower initial deterioration (CG 1 to 2). Phase 2 curves predict earlier transitions to later grades giving a slight decrease in predicted overall life (between 10 to 20 years depending upon deterioration rate/exposure

Evidence	Available Y/N?	Comments
Phase 1 interview	N	Not applicable
NFCDD database	Y	Variable agreement for data extract. Extreme values in dataset (i.e. CG 4 assets of 14 to 110 years and a 28-year-old CG 1 asset) are not consistent with the deterioration curve
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: sheet piled structures: cantilevered steel

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 70.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 80.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 90.
Medium	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 50.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 60.

Rate	Maintenance Regime	Assumptions
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 70.
Fastest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 25.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (e.g. painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 35.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 45.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 60.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 70.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 80.
Medium	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 40.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 60.

Rate	Maintenance Regime	Assumptions
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 70.
Fastest	1	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. The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 20.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, minor repair works which include replacement of backfill, corrosion protection (painting), timber treatment (to timber components), scour protection, visual inspections of the wall from land, actions include review of H&S provisions and their repair/replacement (signs, hand railings, etc). Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 30.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The design life of such an asset is 50 years based on normal engineering practice. The asset is assumed to reach CG 5 in year 40.

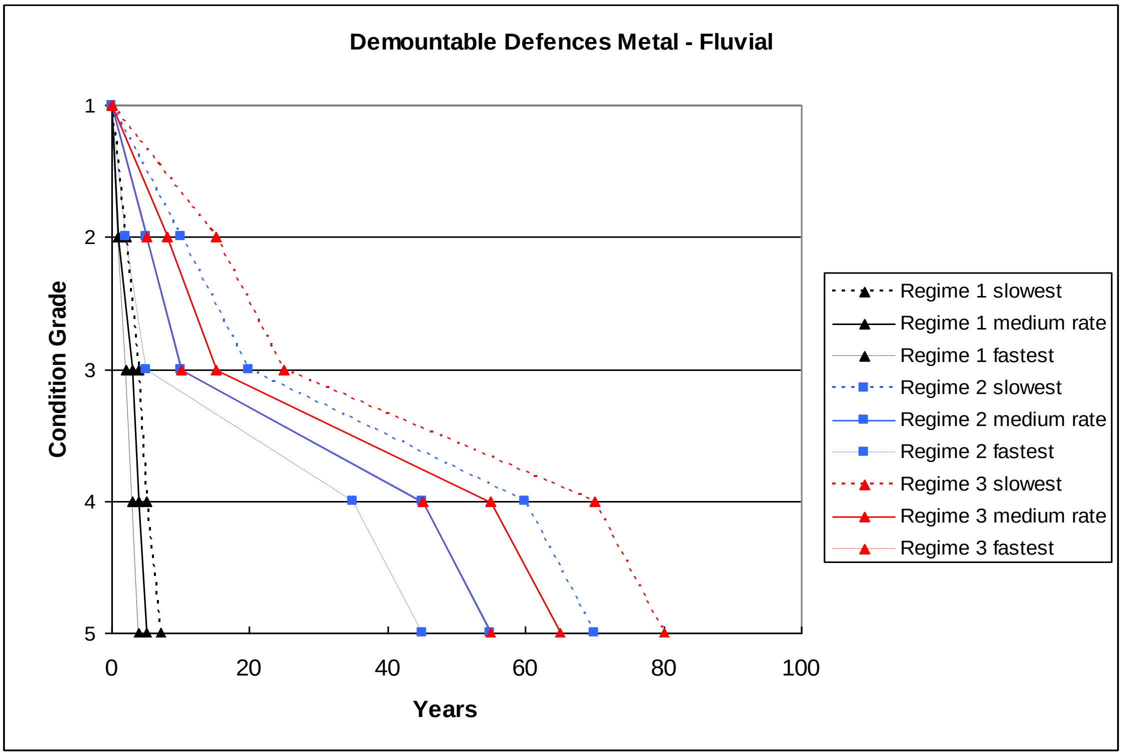
A.2.3 Demountable defences

A.2.3.1 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



Assumptions:

Values based upon Workshop activity 18 April 2011

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 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 condition: A coastal environment is likely to result in more rapid deterioration of the demountable defence due to wave action and increased abrasion. The saline marine environment will have a detrimental effect on the steel components leading to more rapid corrosion and functional loss.

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.

Able to maintain at CG 3 (or better) for 45 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance as above but with increased frequency and more stringent criteria for repair. Able to maintain at CG 2 (or better) for 15 years on this basis (at medium deterioration rate).

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

Notes on model construction – demountable defences: metal

Fluvial:

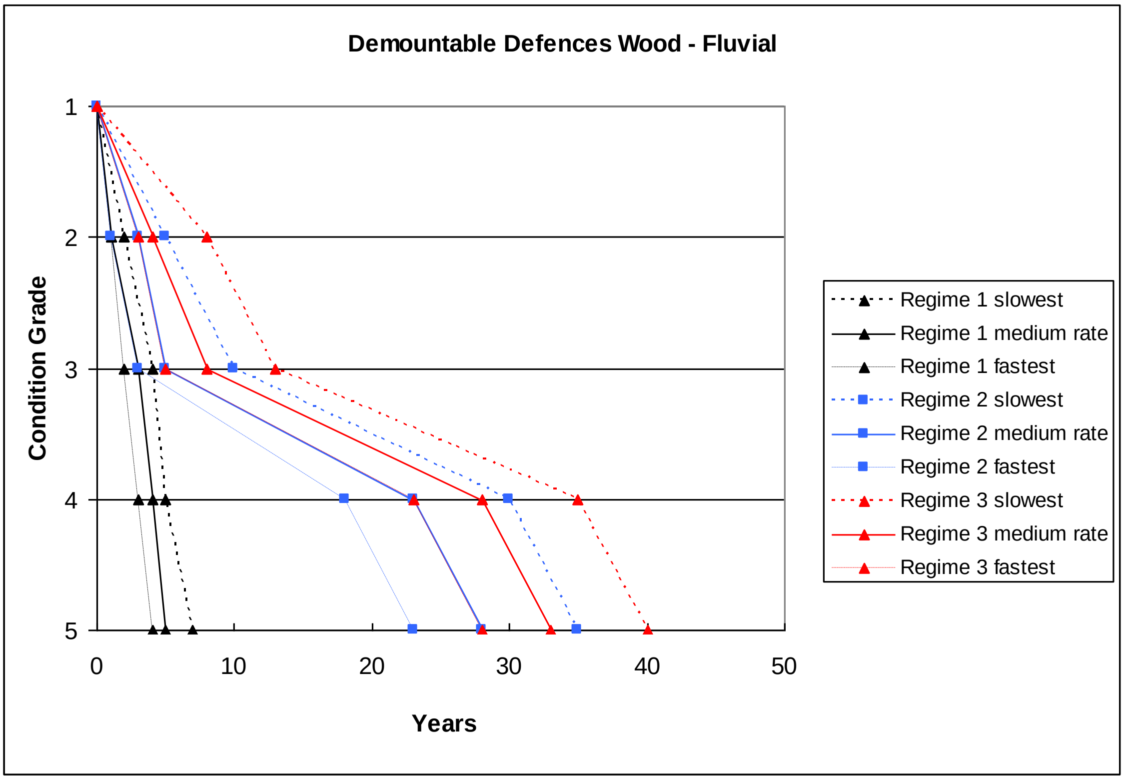
Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Not applicable
Phase 1 interview	N	Not applicable
NFCDD database	N	Not applicable
Site survey	N	Not applicable
Workshop	Y	Deterioration curve constructed from workshop data

A.2.3.2 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



Assumptions:

Values based upon Demountable defences – metal – as follows:

- Regime 1 as for metal defences.

- Regimes 2 and 3 assumed to be half time (rounded up) of metal defences. Timber is considered to be less durable than steel under maintenance conditions.

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 condition: A coastal environment is likely to result in more rapid deterioration of the demountable defence due to wave action and increased abrasion. The saline marine environment will have a detrimental effect on the steel components leading to more rapid corrosion and functional loss.

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.

Able to maintain at CG 3 (or better) for 23 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance as above but with increased frequency and more stringent criteria for repair. Able to maintain at CG 2 (or better) for 8 years on this basis (at medium deterioration rate).

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

Notes on model construction – demountable defences: wood

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Not applicable
Phase 1 interview	N	Not applicable
NFCDD database	Y	The data extracts in agreement with the deterioration curve
Site survey	N	Not applicable
Workshop	N	Deterioration curve constructed from demountable defences – metal curve (which is based upon workshop activities). Rules are as follows: • Regime 1 as for metal defences • Regimes 2 and 3 assumed to be half time (rounded up) of metal defences

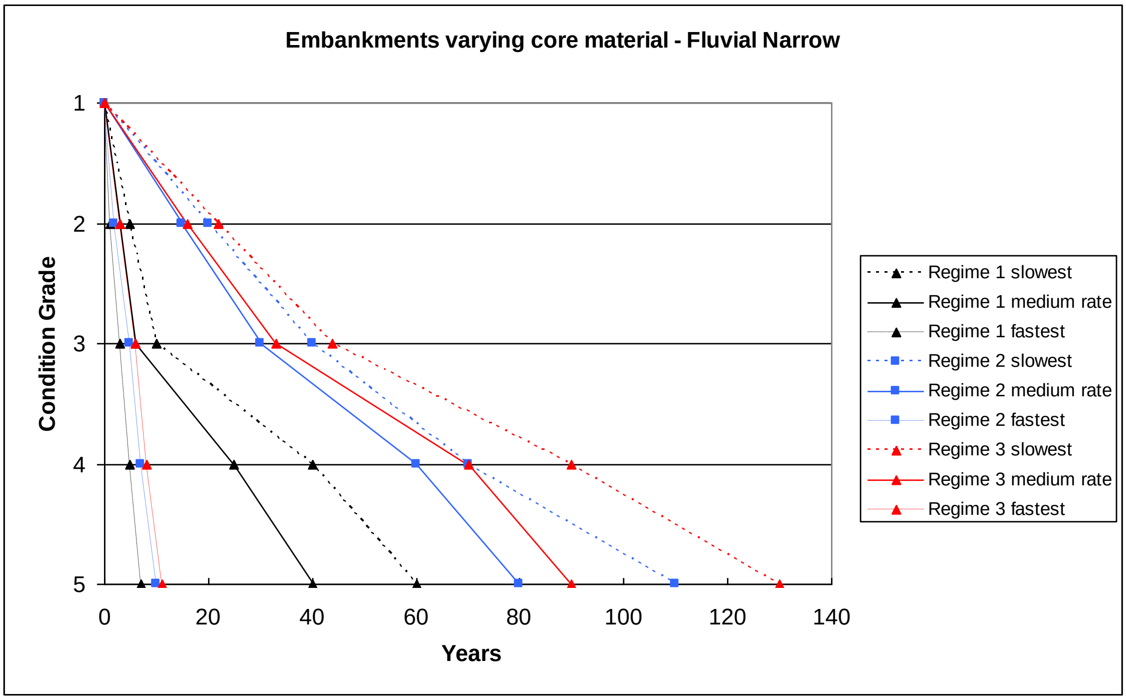
A.2.4 Earth dykes or embankments

A.2.4.1 Varying core material, e.g. clay, shale (fluvial and coastal/estuarine)

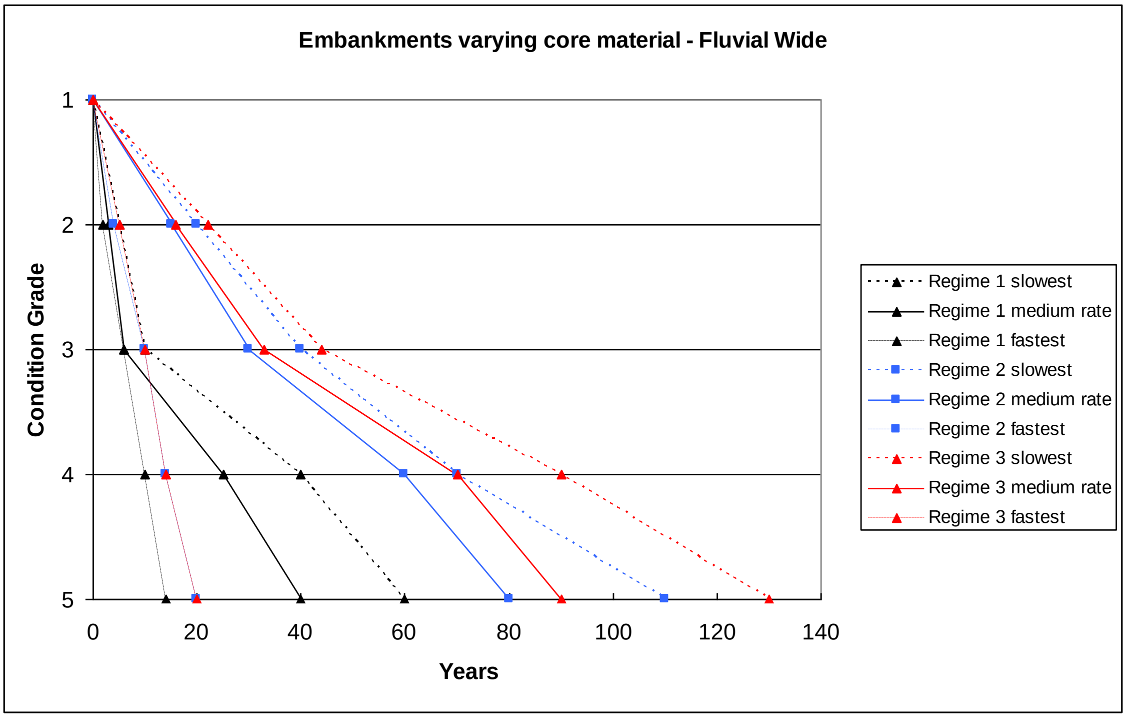
AIMS asset classification: Defence/embankment

Models:

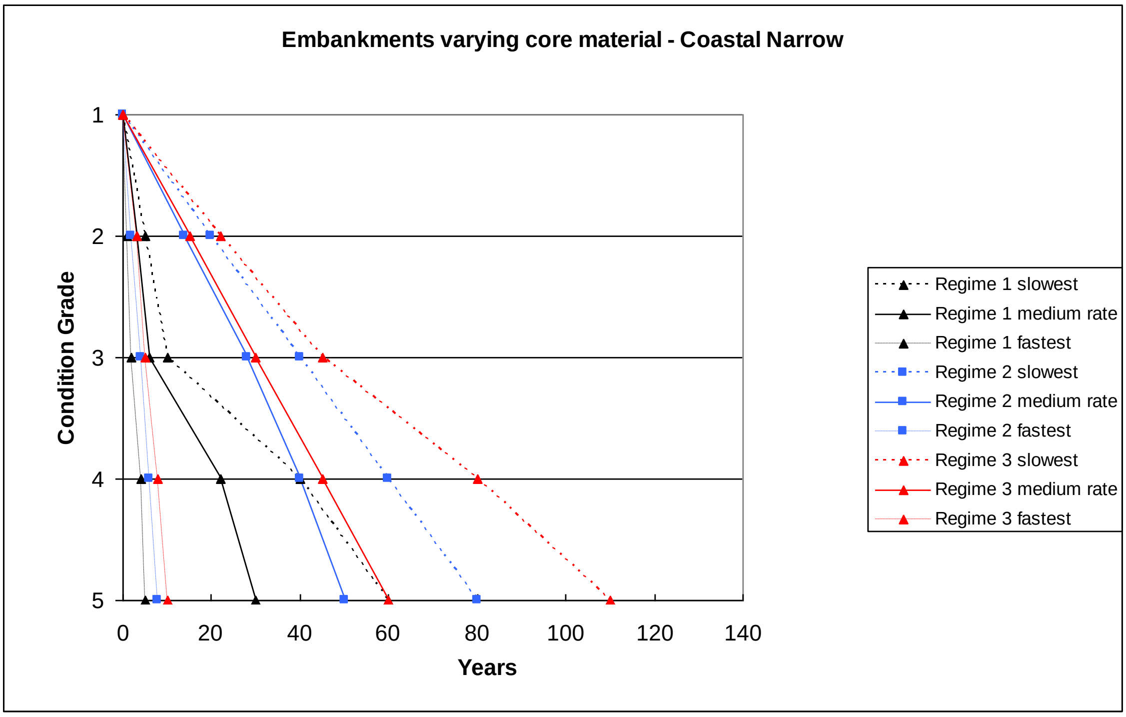
Earth Dykes and Embankments varying core material – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	5	10	40	60
2 – Medium	0	20	40	70	110
3 – High	0	22	44	90	130
Medium rate					
1 – Low/Basic	0	3	6	25	40
2 – 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



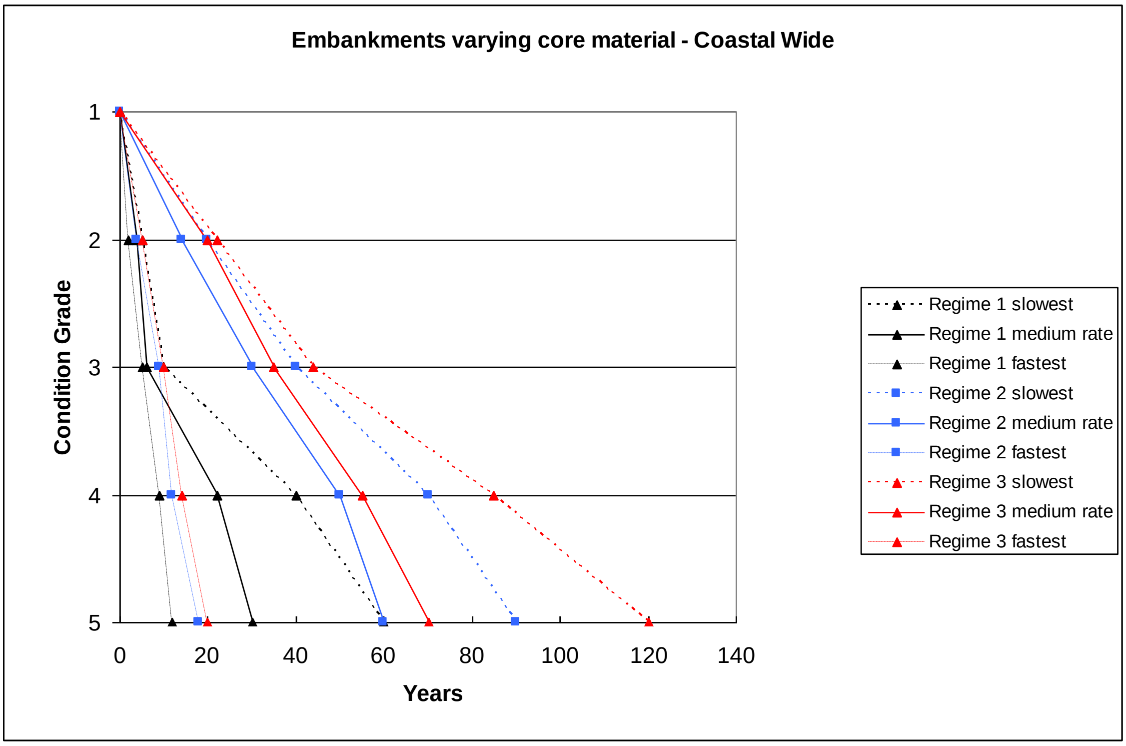
Earth Dykes and Embankments varying core material – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	5	10	40	60
2 – Medium	0	20	40	70	110
3 – High	0	22	44	90	130
Medium rate					
1 – Low/Basic	0	3	6	25	40
2 –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



Assumptions:

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 environmental condition: 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.

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.

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). Able to maintain at CG 3 (or better) for 60 years (fluvial, narrow and wide) and 40/50 years (coastal narrow/wide) on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 33 years (fluvial, narrow and wide) and 30/35 years (coastal narrow/wide) on this basis (at medium deterioration rate).

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.

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

Notes on model construction – earth dykes and embankments: varying core material

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	The Phase 1 turf embankments/no maintenance deterioration curves for narrow and wide structures were adopted as Phase 2 deterioration curves for these assets with no maintenance. The Phase 1 turf embankments with maintenance curves were adopted for fastest deterioration Maintenance Regime 2 only. The condition grade transitions at poorer grades for other deterioration rates were adjusted to give shorter asset lives overall (cf. Phase 1 maintained) The deterioration curves predict a difference between wide and narrow structures at the fastest deterioration rate only (as for Phase 1 curves)
Phase 1 interview	Y	One interviewee reported failure of a 38-year-old embankment, broadly consistent with condition grade transition at 40 years for medium rate deterioration/no maintenance scenario.
NFCDD database	Y	The data extracts broadly supported the deterioration curves developed for this asset, although some high age assets recorded good condition grades, e.g. 41 years CG 1 and 51 years CG 2 (the maximum from the deterioration curves being 22 and 44 years respectively) and notably a 184-year-old asset at CG 4
Site survey	Y (15 assets)	All condition grades (survey and historical) in agreement with age range suggested by deterioration curves
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Not applicable. Phase 1 fluvial turf embankment curves were used as a benchmark for the fluvial deterioration curves for these assets. Coastal asset curves were derived from the fluvial with an assumption of shorter time to transition because of the more extreme environment
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group

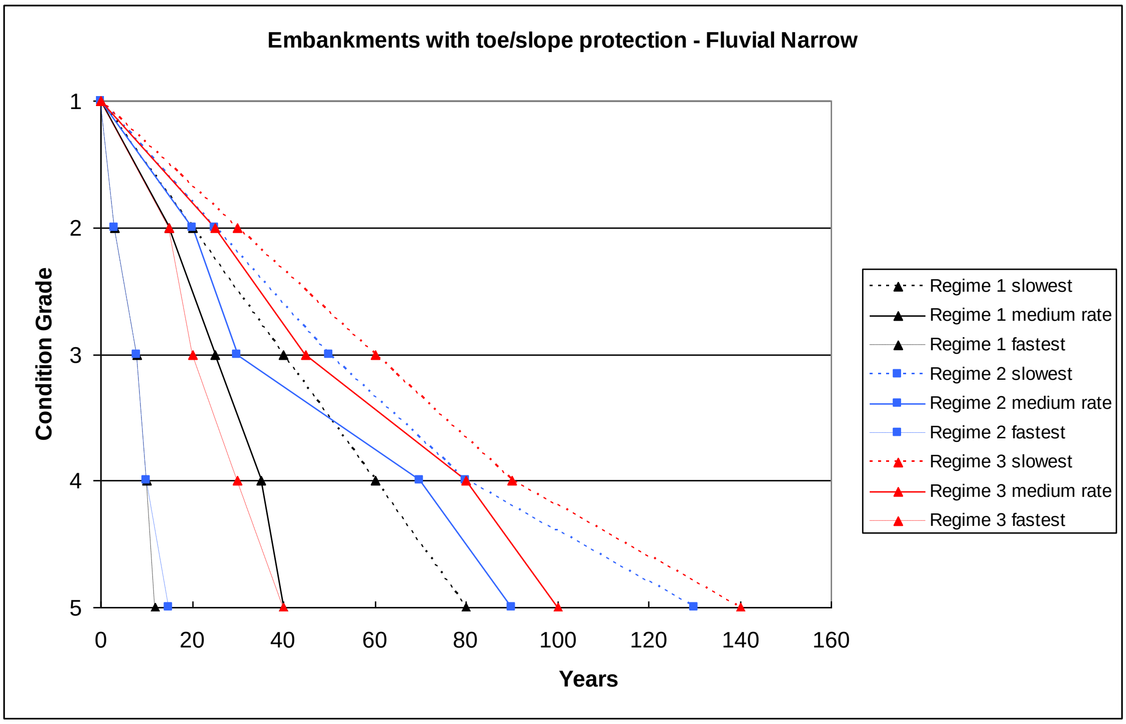
Evidence	Available Y/N?	Comments
NFCDD database	Y	The data extracts broadly supported the deterioration curves developed for this asset, although one short age CG 5 asset of 2 years age appeared as an outlier in the dataset
Site survey	Y (2 assets)	Condition grades (survey and historical) in agreement with age range suggested by deterioration curves
Workshop	N	Not applicable

A.2.4.2 With slope/toe protection or revetment (fluvial and coastal/estuarine)

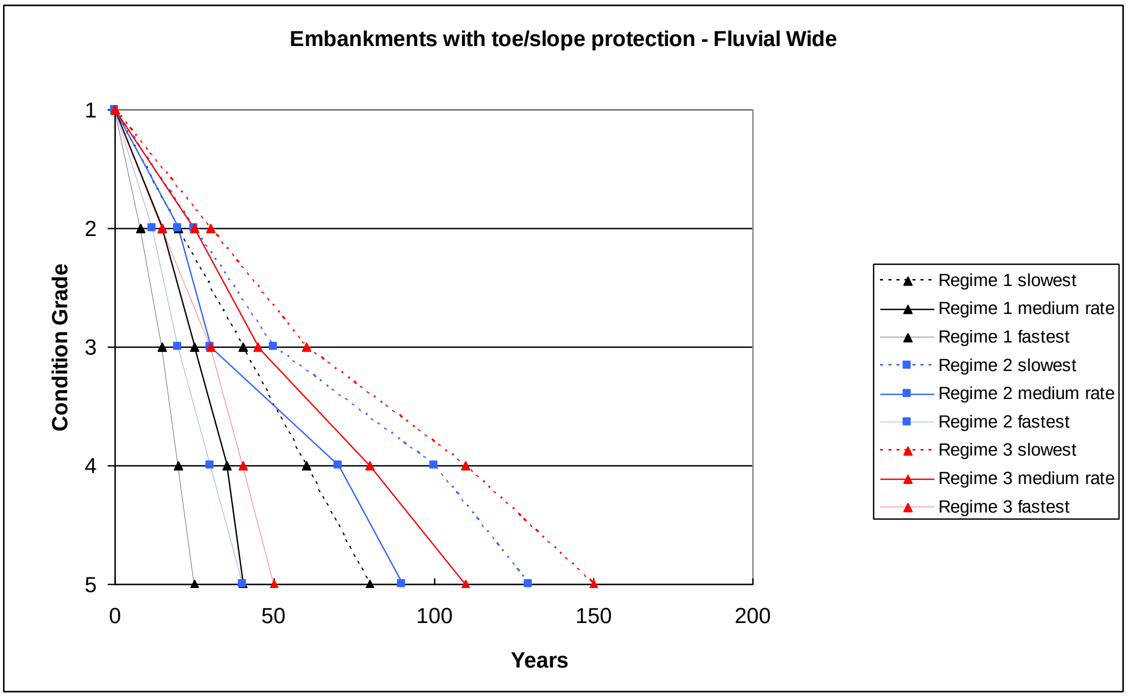
AIMS asset classification: Defence/embankment

Models:

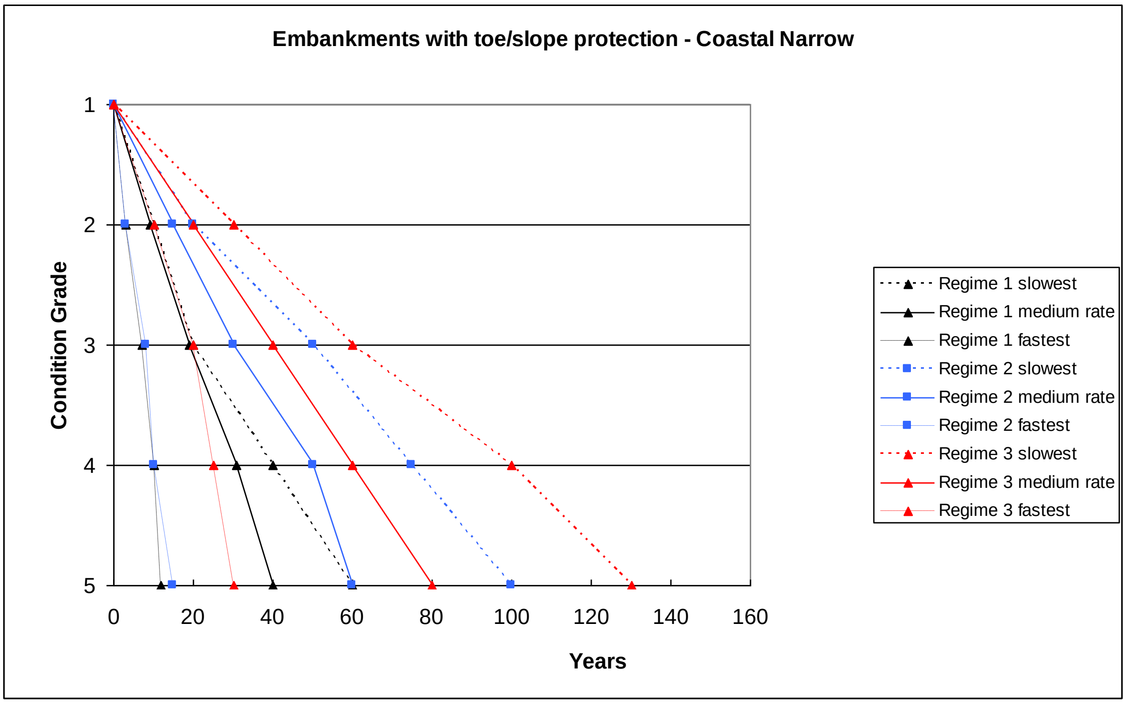
Earth Dykes and Embankments with toe/slope protection – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	20	40	60	80
2 – Medium	0	25	50	80	130
3 – High	0	30	60	90	140
Medium rate					
1 – Low/Basic	0	15	25	35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



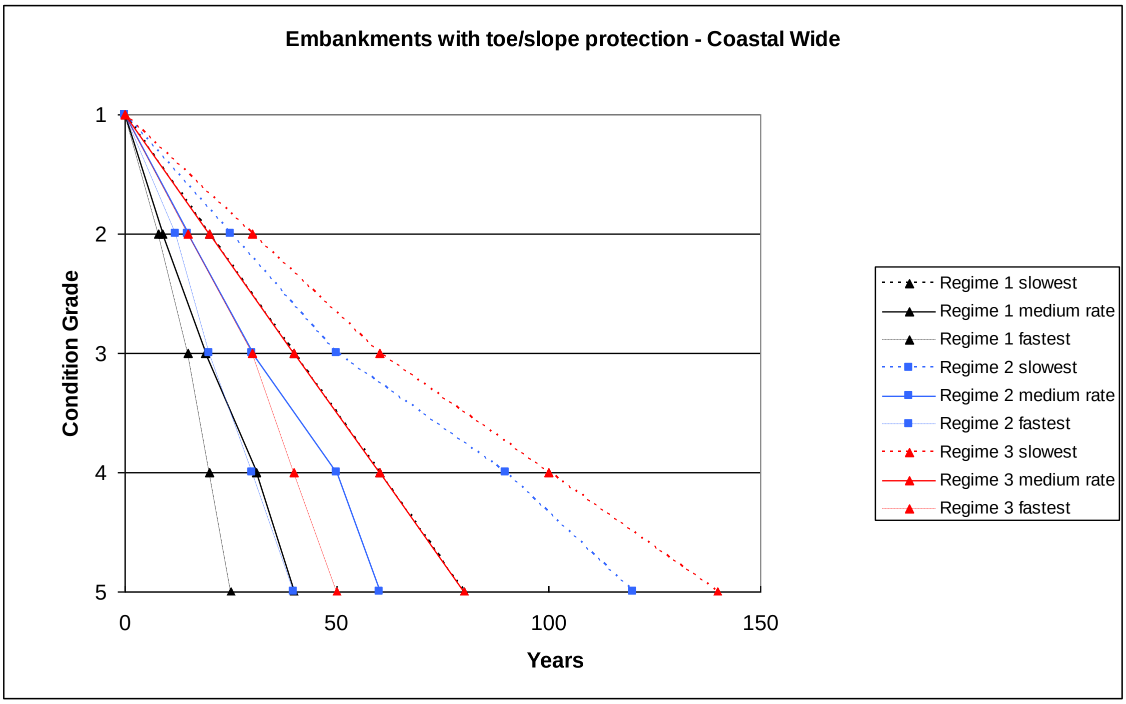
Earth Dykes and Embankments with toe/slope protection – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	20	40	60	80
2 – Medium	0	25	50	100	130
3 – High	0	30	60	110	150
Medium rate					
1 – Low/Basic	0	15	25	35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



Assumptions:

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 environmental condition: 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.

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.

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). Able to maintain at CG 3 (or better) for 70 years (fluvial, narrow and wide) and 50 years (coastal, narrow and wide) on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 50 years (fluvial, narrow and wide) and 40 years (coastal, narrow and wide) on this basis (at medium deterioration rate).

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.

Notes on model construction – earth dykes and embankments with toe/slope protection

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	The following Phase 1 curves were considered in the model build for this asset type (all options in both narrow and wide): • Embankment rigid fluvial • Rip-rap fluvial • Flexible fluvial Deterioration curves are in broad agreement with these Phase 1 models. Maximum life (i.e. CG 5 transition) for this asset is predicted to be 150 years (slowest rate/high maintenance) cf. 160 years for maintained rip-rap/wide structure asset
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	The data extracts supported the deterioration curves developed for this asset. Note: Only two assets listed in the database extract aligned with the asset description: embankment with slope protection
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	The following Phase 1 curves were considered in the model build for this asset type (all options in both narrow and wide): • Embankments impermeable revetments coastal • Embankments permeable revetments coastal Deterioration curves were broadly similar to Phase 1 curves (as listed above) with the exception of fastest rate/no maintenance where shorter life was predicted (12 years cf. 23 years for Phase 1) and with longer life for high maintenance at medium rate (80 years cf. 50 years for Phase 1). The overall maximum life is also slightly reduced (140 years cf. 150 years for Phase 1)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	The data extracts supported the deterioration curves developed for this asset
Site survey	N	Not applicable

Evidence	Available Y/N?	Comments
Workshop	N	Not applicable

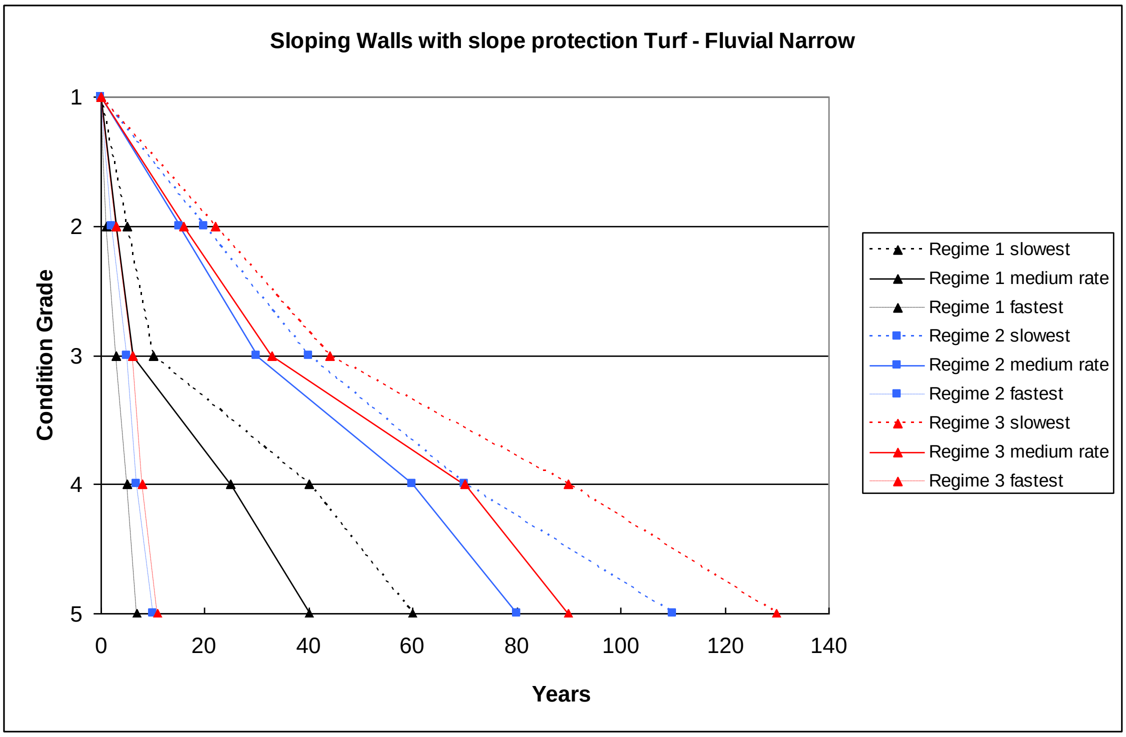
A.2.5 Sloping walls with slope protection or revetment

A.2.5.1 Turf (fluvial and coastal/estuarine)

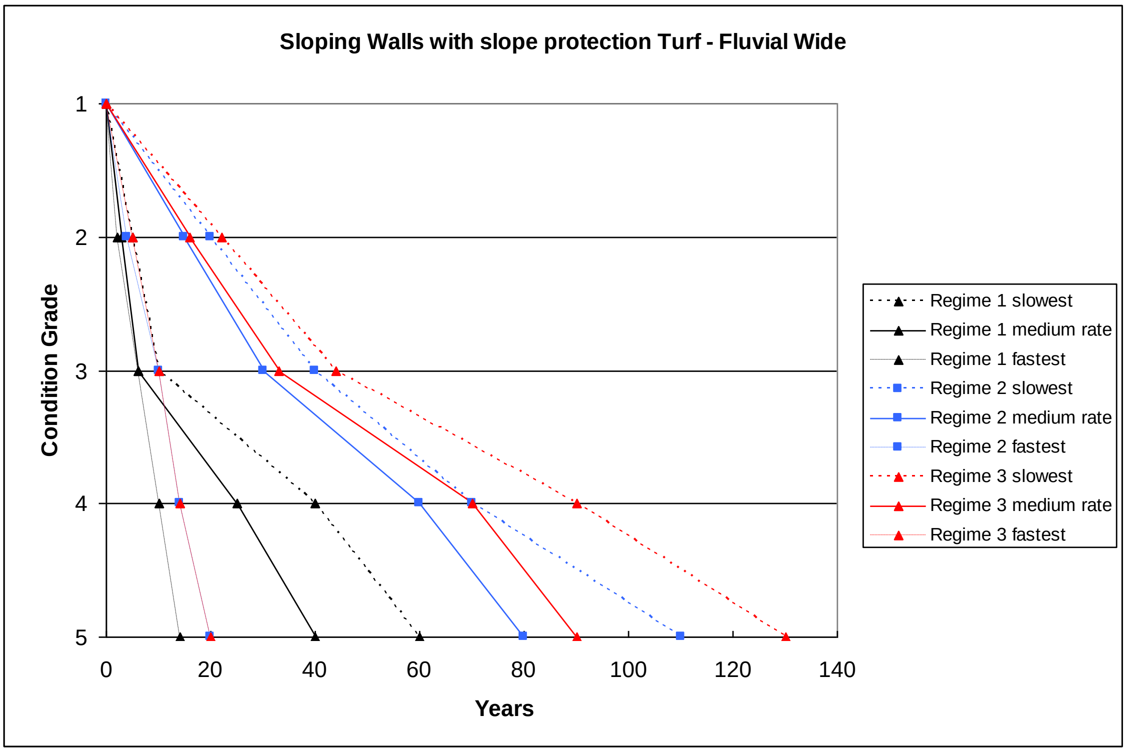
AIMS asset classification: Defence/embankment

Models:

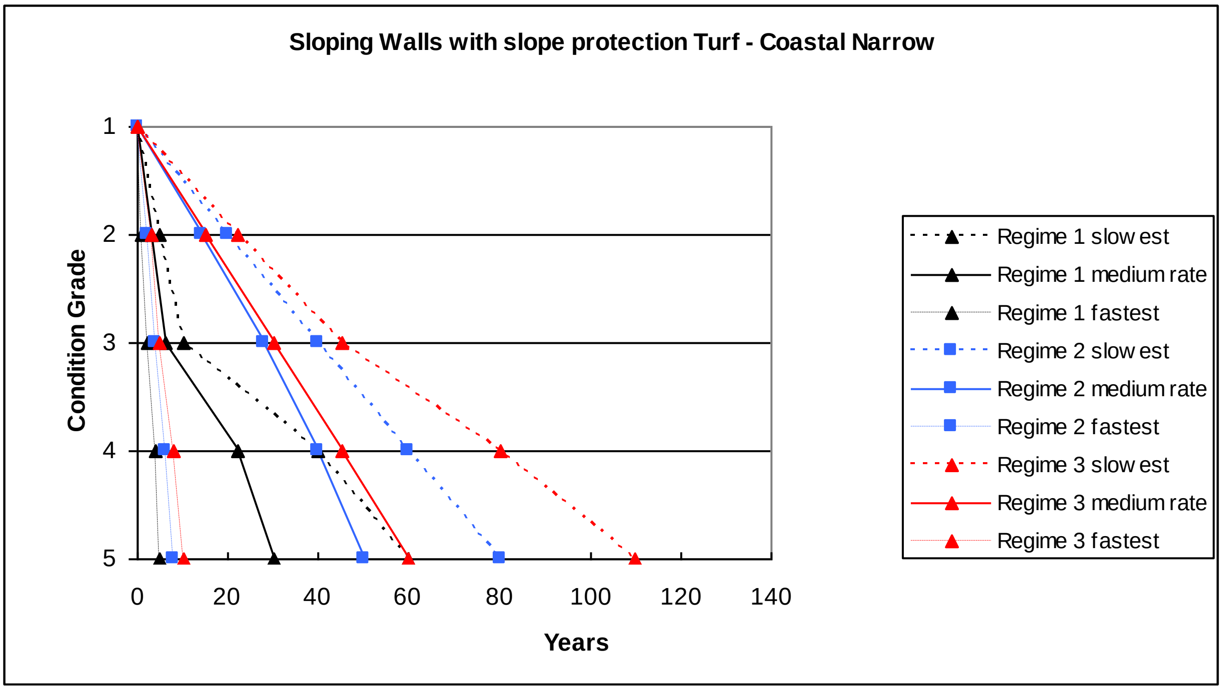
Sloping walls with slope protection or revetment Turf – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	5	10	40	60
2 – Medium	0	20	40	70	110
3 – High	0	22	44	90	130
Medium rate					
1 – Low/Basic	0	3	6	25	40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



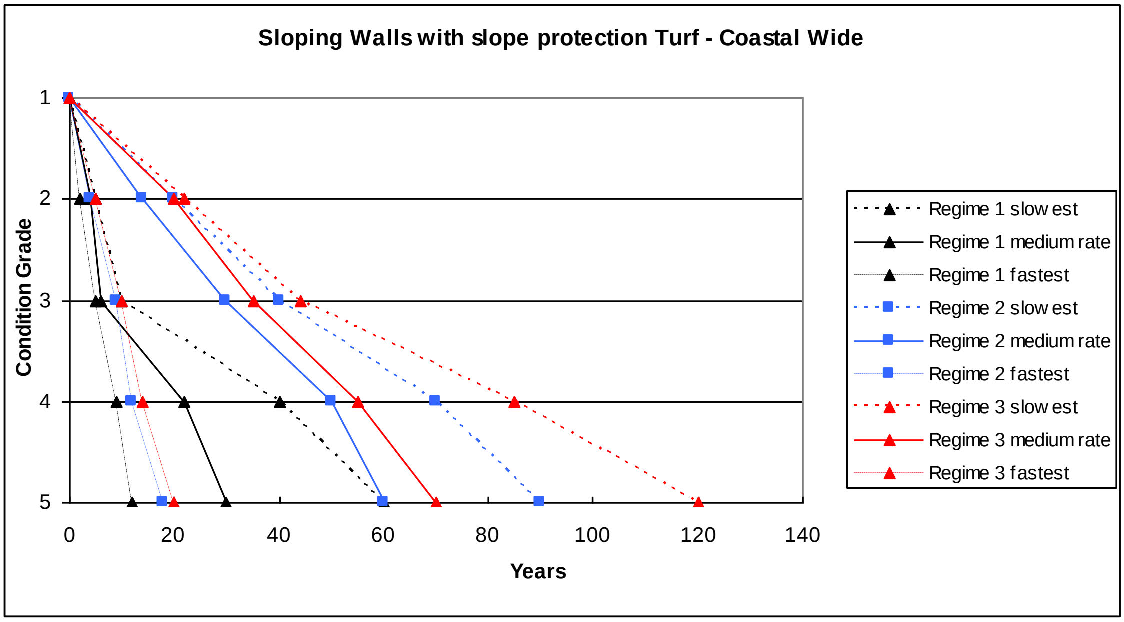
Sloping walls with slope protection or revetment Turf – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	5	10	40	60
2 – Medium	0	20	40	70	110
3 – High	0	22	44	90	130
Medium rate					
1 – Low/Basic	0	3	6	25	40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



Assumptions:

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 environmental condition: 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.

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.

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). Able to maintain at CG 3 (or better) for 60 years (fluvial, narrow and wide) and 40/50 years (coastal narrow/wide) on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 33 years (fluvial, narrow and wide) and 30/35 years (coastal narrow/wide) on this basis (at medium deterioration rate).

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.

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

Notes on model construction – sloping walls with slope protection or revetment: turf

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Phase 1 curves adopted for No maintenance deterioration curves (wide and narrow). With maintenance the later transitions to CG 4 and 5 have been adjusted to shorter times frames giving a shorter life asset overall (cf. Phase 1)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Variable agreement for data extract. Extreme values in dataset (i.e. CG 3 and CG 4 assets of 2 years and a 50-year-old CG 1 asset) are not consistent with the deterioration curve
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	No Phase 1 curve available for coastal assets of this type but the following were considered appropriate as a basis for the model build: • Turf embankment fluvial (accounting for adverse environmental effects – i.e. increased deterioration) • Permeable revetment coastal Deterioration curves were broadly similar to Phase 1 curves (as listed above and with adjustment for coastal environment) although the overall maximum life is reduced (120 years cf. 150 years for Phase 1 permeable/maintained)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Variable agreement for data extract. Some old assets have been recorded e.g. CG 4 at 200 years, CG 3 at 184 years which are not consistent with the deterioration curves
Site survey	N	Not applicable
Workshop	Y	In almost full agreement

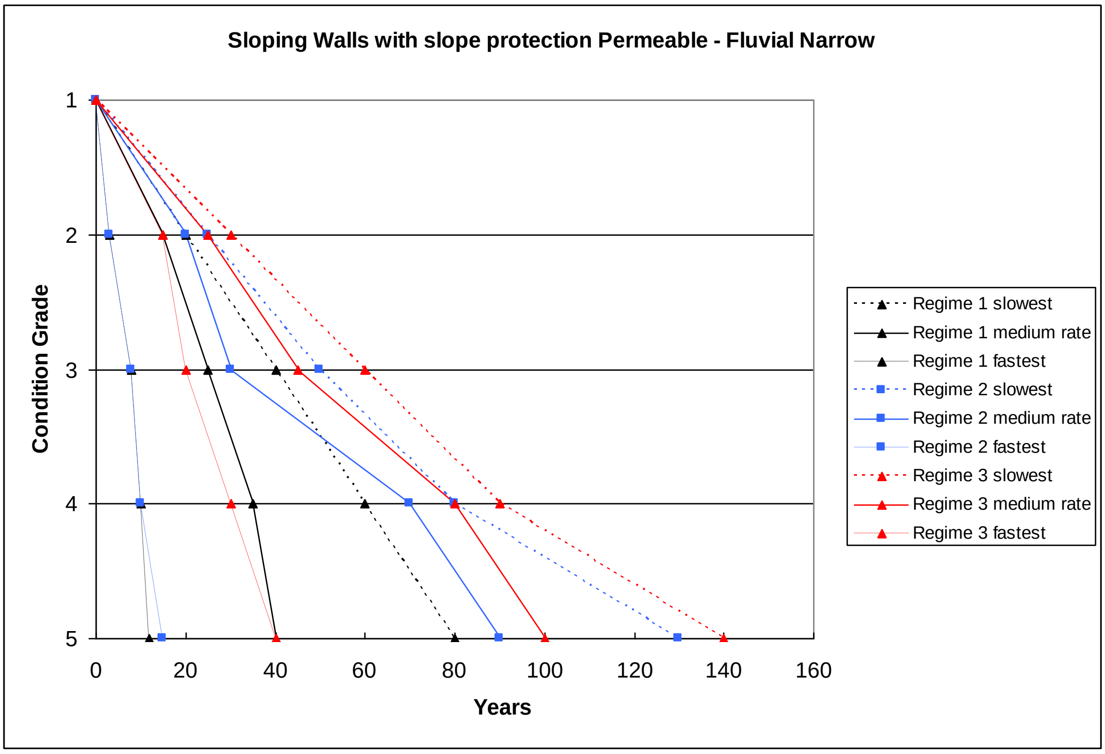
A.2.5.2 Permeable revetments (fluvial and coastal/estuarine)

AIMS asset classification: Defence/embankment

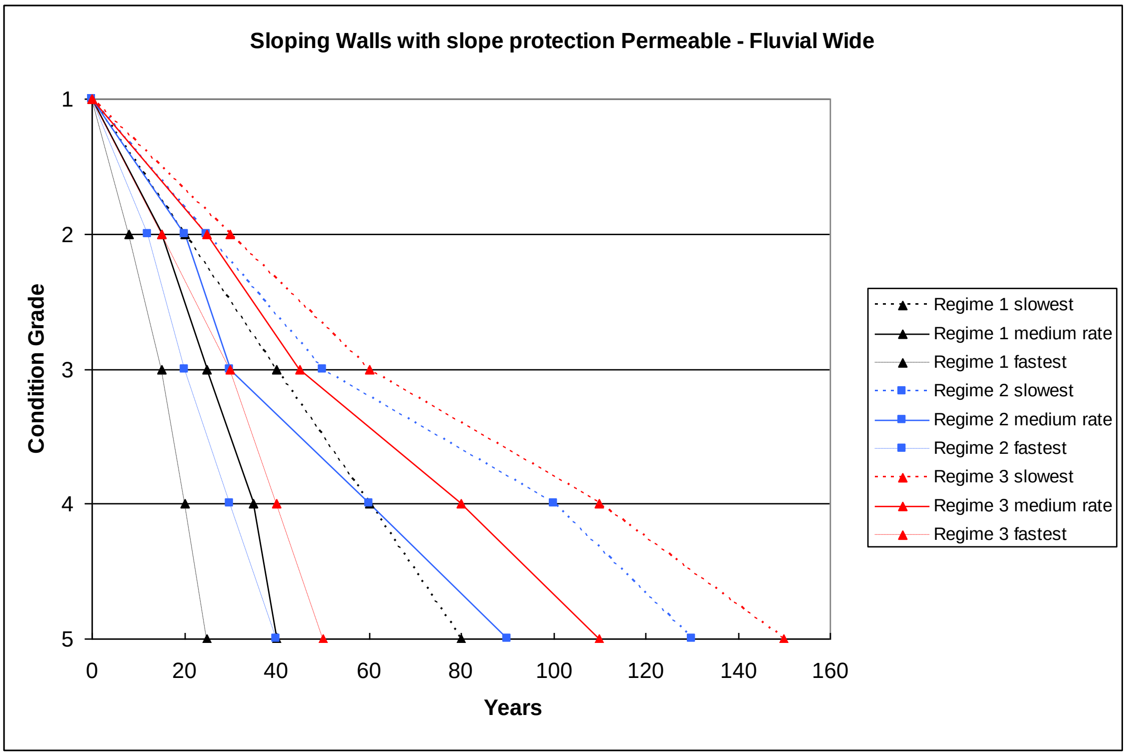
Examples: rip-rap/rock armour, free, interlocking or cable-tied concrete blockwork, concrete mattress, armour flex, etc

Models:

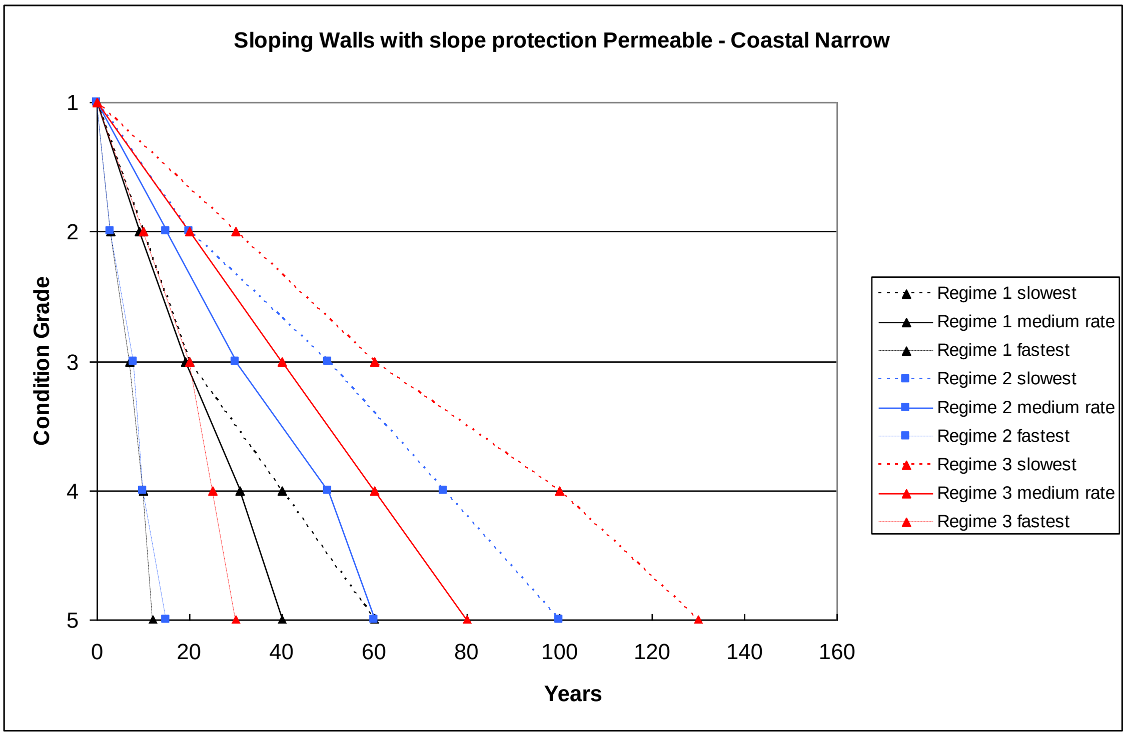
Sloping walls with slope protection or revetment Permeable revetments – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	20	40	60	80
2 – Medium	0	25	50	80	130
3 – High	0	30	60	90	140
Medium rate					
1 – Low/Basic	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



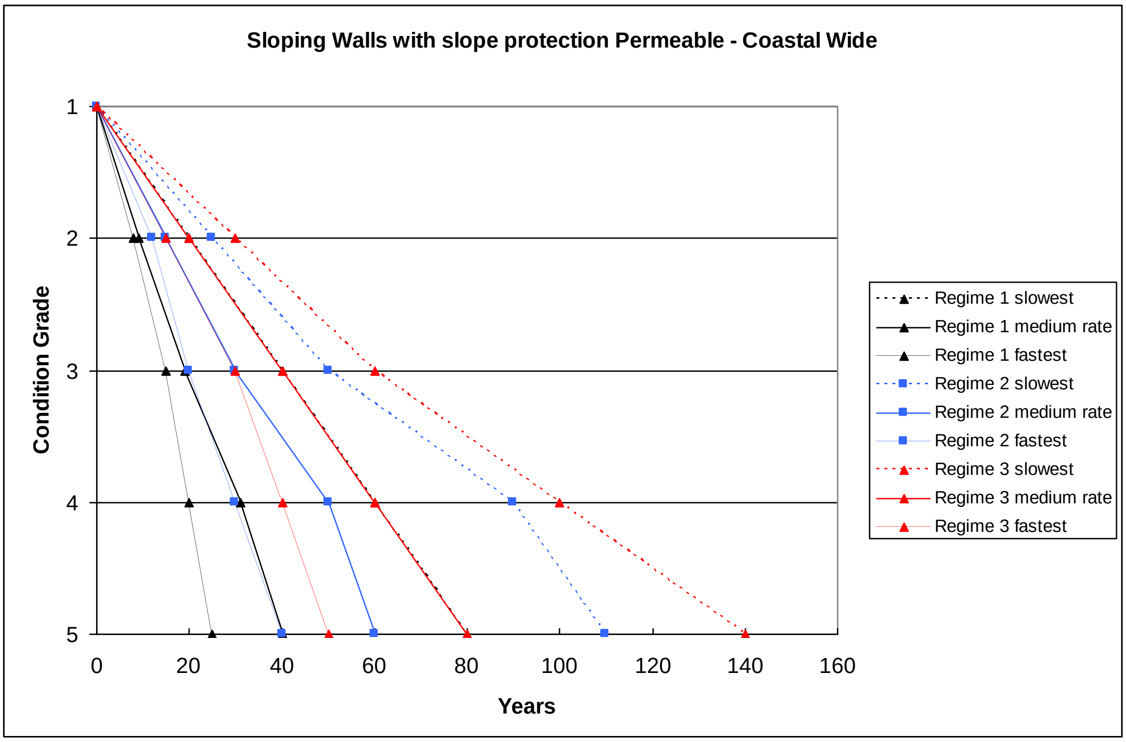
Sloping walls with slope protection or revetment Permeable revetments – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	20	40	60	80
2 – Medium	0	25	50	100	130
3 – High	0	30	60	110	150
Medium rate					
1 – Low/Basic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



Assumptions:

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 environmental condition: 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.

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 4 and 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.

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). Able to maintain at CG 3 (or better) for 70/60 years (fluvial narrow/wide) and 50 years (coastal, narrow and wide) on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 45 years (fluvial narrow/wide) and 40 years (coastal, narrow and wide) on this basis (at medium deterioration rate).

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.

Notes on model construction – sloping walls with slope protection or revetment: permeable revetment

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	No Phase 1 curve available for coastal assets of this type but the following were considered appropriate as a basis for the model build (all options both wide and narrow): • Rip-rap fluvial • Flexible fluvial • Rigid fluvial • Embankment turf fluvial Broad alignment with the Phase 1 curves, with similar asset life values
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in broad agreement with deterioration curves. Some extreme values such as 15-year-old asset at CG 5 and 7-year-old asset at CG 4
Site survey	Y (2 assets)	No age data for assets
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Coastal Permeable curve available from Phase 1. Current deterioration curve in broad agreement with Phase 1, although grade transitions occur a little later giving a slightly longer asset life (for medium and fastest rate curves only)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in broad agreement with deterioration curve, although some extreme values were noted, e.g. CG 4 assets of ages 7 and 201. These are considered be outliers
Site survey	Y (1 asset)	Condition grades (survey and historical) in agreement with age range suggested by deterioration curves
Workshop	N	Not applicable

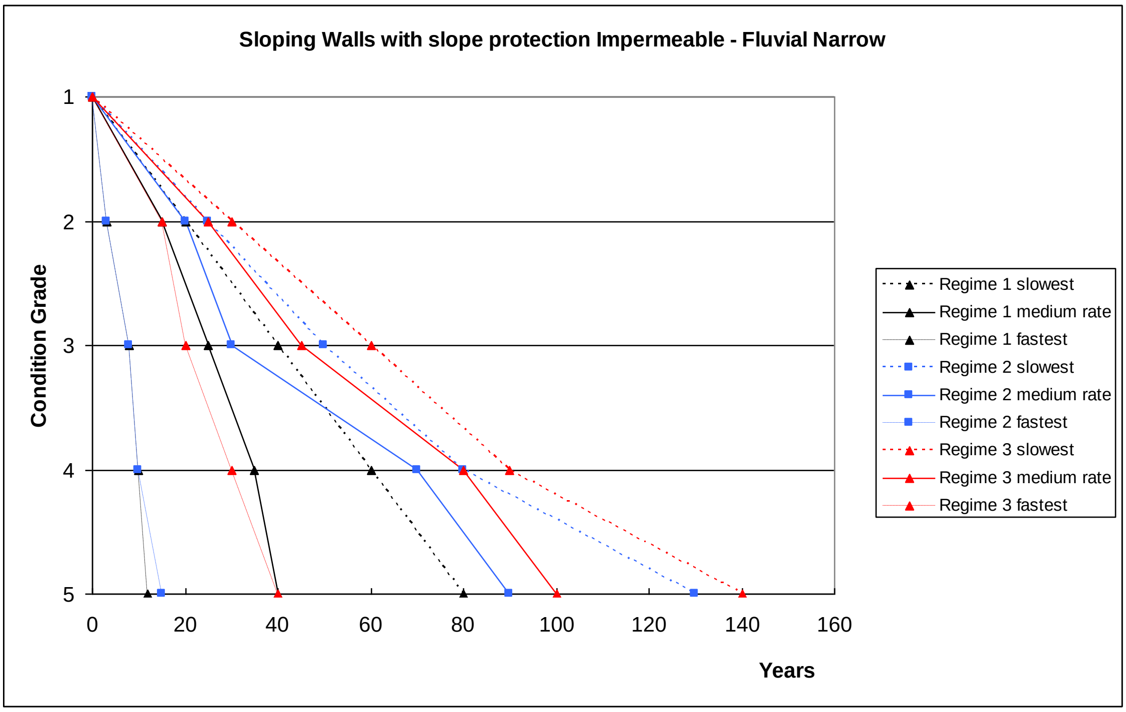
A.2.5.3 Impermeable revetments (fluvial and coastal/estuarine)

AIMS asset classification: Defence/embankment

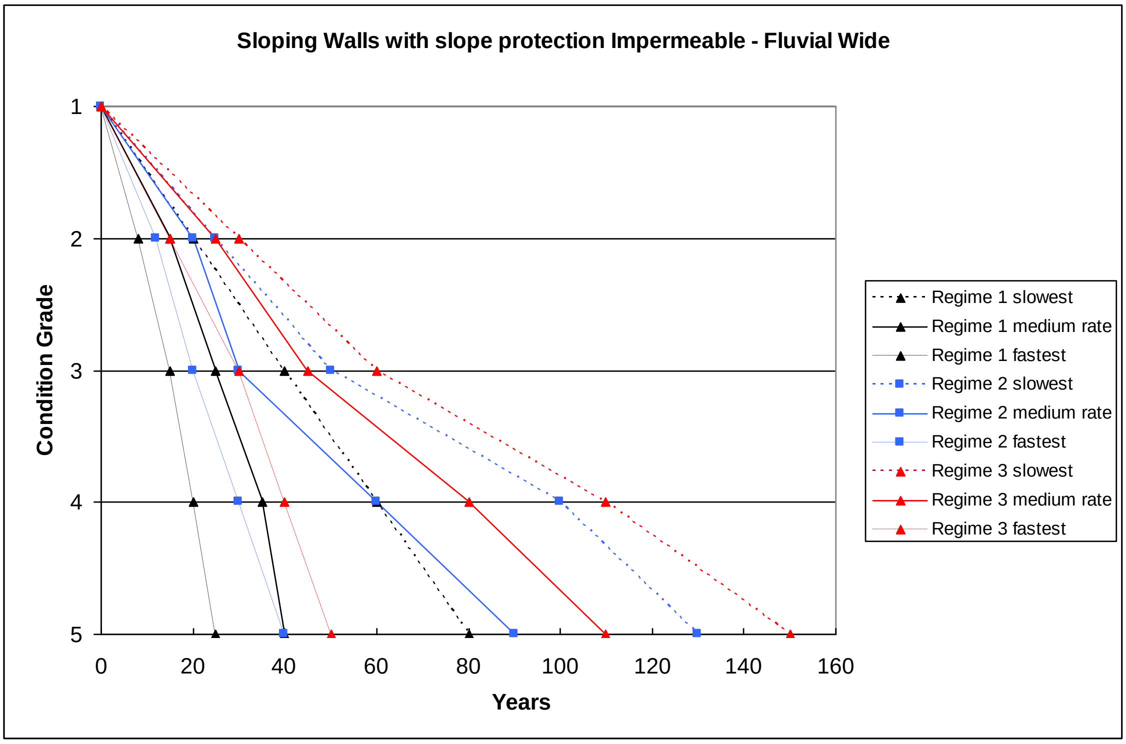
Examples: grouted stone, asphalt, asphaltic concrete, stone asphalt, etc

Models:

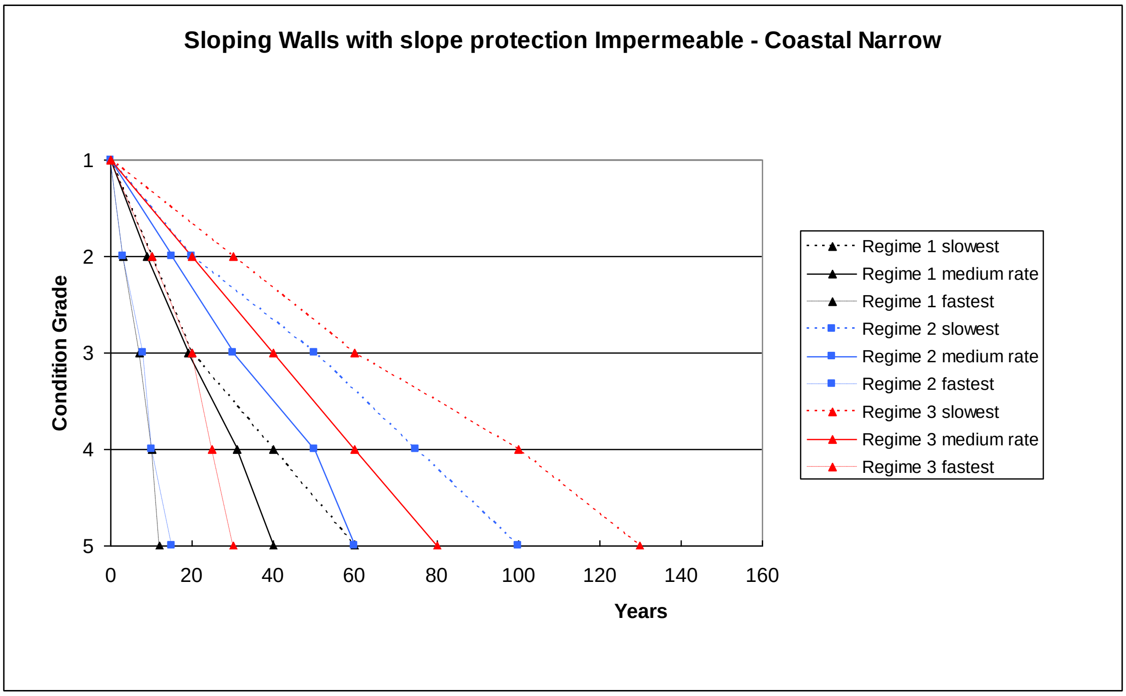
Sloping walls with slope protection or revetment Impermeable revetments – Fluvial Narrow					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	20	40	60	80
2 – Medium	0	25	50	80	130
3 – High	0	30	60	90	140
Medium rate					
1 – Low/Basic	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



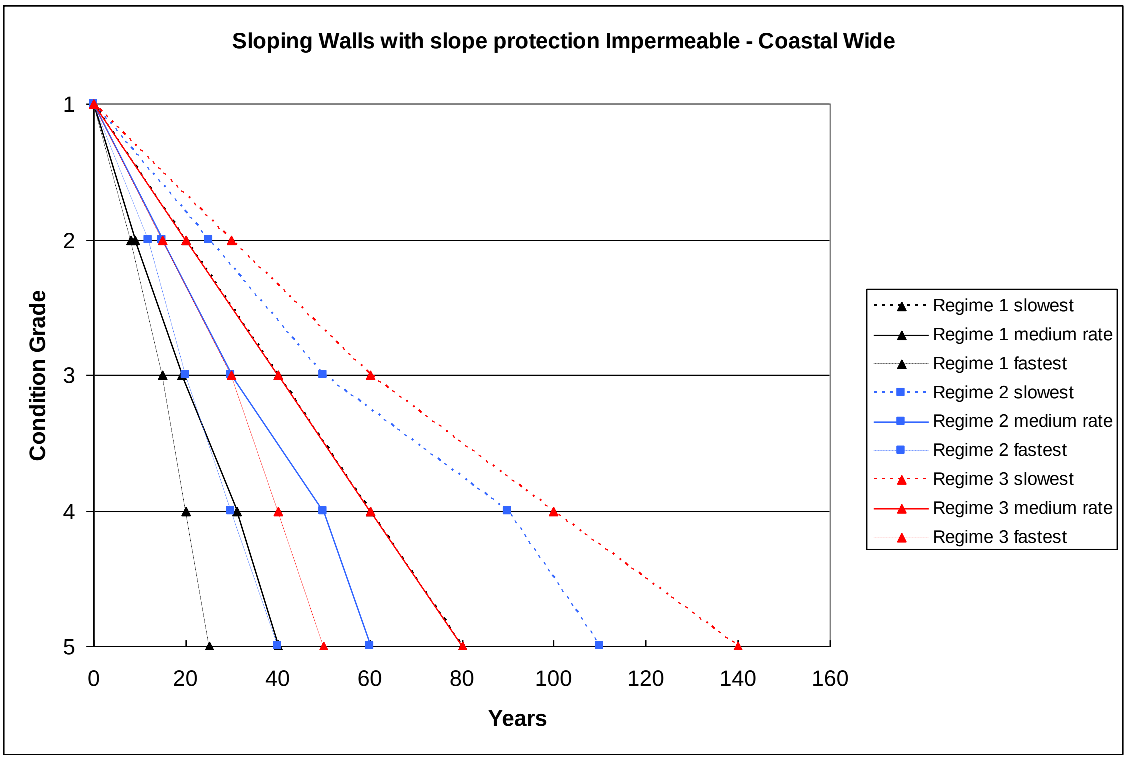
Sloping walls with slope protection or revetment Impermeable revetments – Fluvial Wide					
Maintenance Regime	**Condition Grade Transition (years)**				
	1	**2**	**3**	**4**	**5**
Slowest rate					
1 – Low/Basic	0	20	40	60	80
2 – Medium	0	25	50	100	130
3 – High	0	30	60	110	150
Medium rate					
1 – Low/Basic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



Assumptions:

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 environmental condition: 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.

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 4 and 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.

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). Able to maintain at CG 3 (or better) for 70/60 years (fluvial narrow/wide) and 50 years (coastal, narrow and wide) on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 45 years (fluvial narrow/wide) and 40 years (coastal, narrow and wide) on this basis (at medium deterioration rate).

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.

Maintenance Regime 1: Low/Basic 'do minimum'.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3.

Maintenance Regime 3: High, maintain CG 2.

Notes on model construction – sloping walls with slope protection or revetment: impermeable revetment

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	No Phase 1 curve available for fluvial assets of this type but the following were considered appropriate as a basis for the model build (all options both wide and narrow): • Flexible fluvial • Rigid fluvial • Embankment turf fluvial Broad alignment with the Phase 1 curves, with similar asset life values, although early grade transitions occur over slightly longer timescales with a change in the profile of the curve
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in agreement with deterioration curves
Site survey	Y (2 assets)	No age data for assets
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Coastal Impermeable curve available from Phase 1. Current deterioration curve for medium rate deterioration in broad agreement with Phase 1. Fastest and slowest rates of deterioration have grade transitions occurring earlier with a shorter overall asset life
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in agreement with deterioration curves
Site survey	Y (12 assets)	Condition grades (survey and historical) in agreement with age range suggested by deterioration curves
Workshop	N	Not applicable

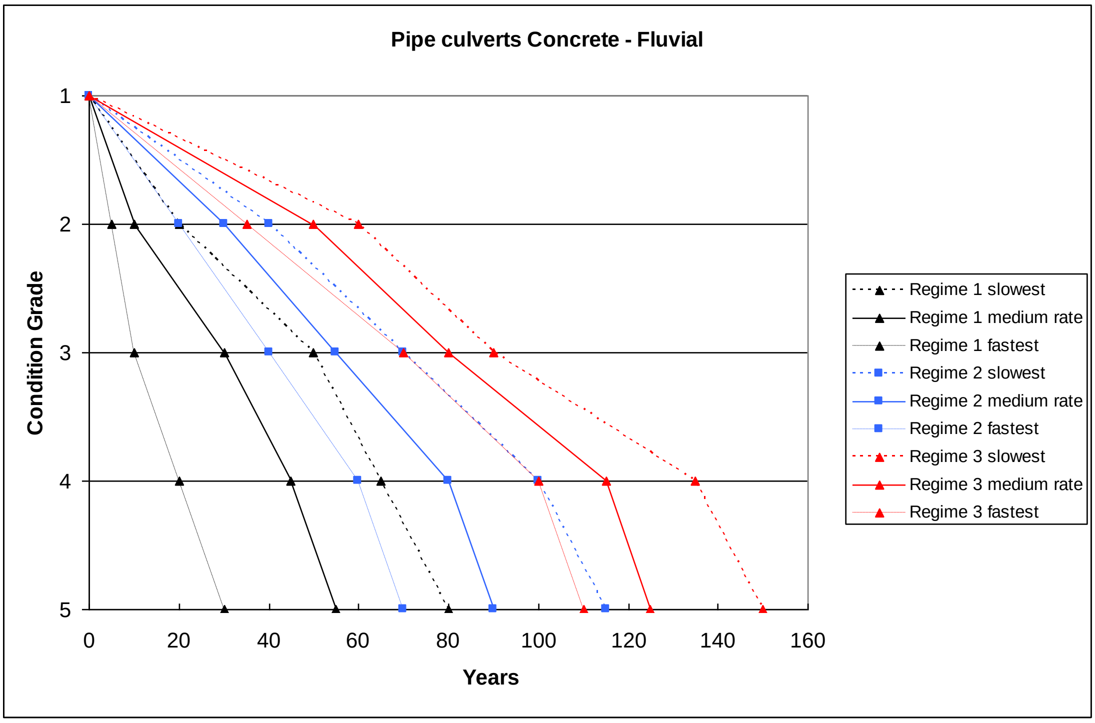
A.2.6 Culverts – pipe, box, arch (all fluvial)

A.2.6.1 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



Assumptions:

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

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. These 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.)

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 minor repair, silt and obstruction removal and vegetation clearance 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). Able to maintain at CG 3 (or better) for 80 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, silt and obstruction removal and vegetation clearance 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). Able to maintain at CG 2 (or better) for 80 years on this basis (at medium deterioration rate).

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) the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

Notes on model construction – culverts: concrete

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Phase 1 curve available – Culvert (note this curve was based upon brick/masonry and concrete walls) Some adjustments have been made: The current no maintenance deterioration curves show extended life for fastest rates of deterioration, but a lower life for medium and slowest rates. Life values for maintained structures are similar to Phase 1 values, except for the extended life for fastest rates
Phase 1 interview	Y	Life values of 100+ years identified during interview are consistent with the deterioration curves
NFCDD database	Y	Data extract in general agreement with deterioration curves. There are a small number of low age assets at CG 4 (notably age 5 years), which are considered to be outliers
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: culverts – concrete

Rate	Maintenance Regime	Assumptions
Slowest	1	The data used in Phase 1 was combined with brickwork/masonry culverts. The assets have now been separated. Only maintenance tasks likely to 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. The design life of such an asset is based on the service life of concrete pipes, this is typically between 100 and 120 years, but there is a body of evidence gathering which suggests that pipes may last longer (based on literature from Concrete Pipeline Systems Association).
	2	As reported in Phase 1 of the project, there is little actual maintenance that can be done to the culvert pipe. Maintenance tasks over and above those in Regime 1 include: inspections, CCTV surveys, clearing debris and vegetation, de-silting, joint repairs (and downstream scour protection). In some larger diameter pipes man-access can be gained for survey and repair. The design life of such an asset is based on the service life of concrete pipes, this is typically between 100 and 120 years, but there is a body of evidence which suggests that pipes will last longer (based on Concrete Pipeline Systems Association).
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	Only maintenance tasks likely to 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. The design life of such an asset is based on the service life of concrete pipes, this is typically between 100 and 120 years, but there is a body of evidence gathering which suggests that pipes may last longer (based on literature from Concrete Pipeline Systems Association).
	2	As reported in Phase 1 of the project, there is little actual maintenance that can be done to the culvert pipe. Maintenance tasks over and above those in Regime 1 include: inspections, CCTV surveys, clearing debris and vegetation, de-silting, joint repairs (and downstream scour protection). In some larger diameter pipes man-access can be gained for survey and repair. The design life of such an asset is based on the service life of concrete pipes, this is typically between 100 and 120 years, but there is a body of evidence which suggests that pipes will last longer (based on Concrete Pipeline Systems Association).
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

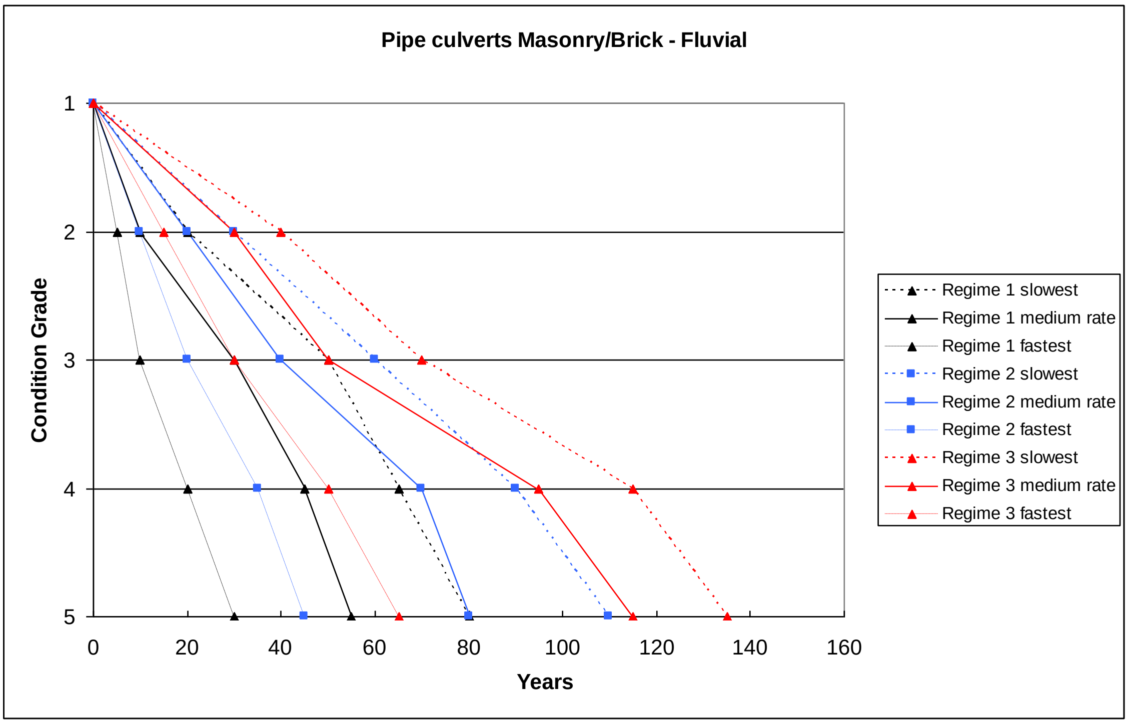
Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks likely to carried out on the culvert are inspection/review of H&S provisions and their repair/replacement (signs, hand railings, etc), there is no maintenance of the asset. The design life of such an asset is based on the service life of concrete pipes, this is typically between 100 and 120 years, but there is a body of evidence gathering which suggests that pipes may last longer (based on literature from Concrete Pipeline Systems Association).
	2	As reported in Phase 1 of the project there is little actual maintenance that can be done to the culvert pipe. Maintenance tasks over and above those in Regime 1 include: inspections, CCTV surveys, clearing debris and vegetation, de-silting, joint repairs (and downstream scour protection). In some larger diameter pipes man-access can be gained for survey and repair. The design life of such an asset is based on the service life of concrete pipes, this is typically between 100 and 120 years, but there is a body of evidence which suggests that pipes will last longer (based on Concrete Pipeline Systems Association).
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.6.2 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



Assumptions:

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 brick work 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

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. These Phase 1 curves form the basis of the curves presented here with account taken of specific materials. Basic maintenance curves were as for concrete. With maintenance, grade transitions and end of asset life occurred slightly earlier for brick and masonry culverts compared to concrete assets. 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.)

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 minor repair, re-pointing and brick work repair, sealant replacement, joint repair, debris/vegetation clearance and removal of silt 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). Able to maintain at CG 3 (or better) for 70 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, re-pointing and brick work repair, sealant replacement, joint repair, debris/vegetation clearance and removal of silt 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). Able to maintain at CG 2 (or better) for 50 years on this basis (at medium deterioration rate).

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) the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

Notes on model construction – culverts: brick and masonry

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Phase 1 curve available – Culvert (note this curve was based upon brick/masonry and concrete walls) The current deterioration curves for no maintenance scenario are the same as for concrete culverts. However, the maintained brick and masonry assets are predicted to have generally more rapid deterioration and hence shorter lives overall
Phase 1 interview	Y	Life values identified during interview are broadly consistent with the deterioration curves, e.g. badly built assets were reported to last only 50 years. Maximum life values of 200 years exceeds the maximum indicated by the curves (130 years)
NFCDD database	Y	Data extract in general agreement with deterioration curves. There are a small number of low age assets at CG 4 (notably age 5 years), which are considered to be outliers. A CG 4 asset of 160 years was also recorded, an age which the deterioration curves would indicate a CG 5 even in the most favourable conditions (slowest rate/high maintenance)
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: culverts – brick and masonry

Rate	Maintenance Regime	Assumptions
Slowest	1	The data used in Phase 1 was combined with concrete culverts. The assets have now been separated. Only maintenance tasks likely to 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. 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.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation and debris clearance, de-silting, re-pointing work, minor repair works which include *ad hoc* joint repair and brick replacement (in those large enough to safely access) (and downstream scour protection). The life of these assets when well maintained will exceed their design life; this in part is probably due to the conservative approach of the original design parameters and assumptions.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	The data used in Phase 1 was combined with concrete culverts. The assets have now been separated. Only maintenance tasks likely to 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. 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.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation and debris clearance, de-silting, re-pointing work, minor repair works which include *ad hoc* joint repair and brick replacement (in those large enough to safely access) (and downstream scour protection). The life of these assets when well maintained may exceed their design life; this in part is probably due to the conservative approach of the original design parameters and assumptions.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

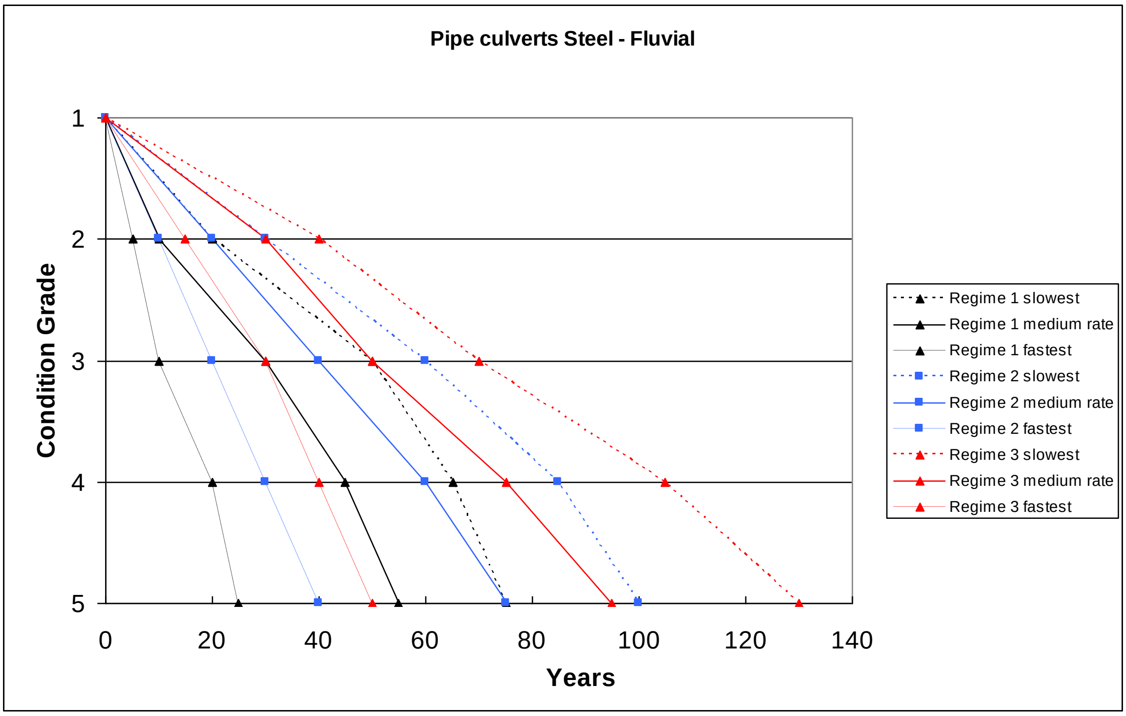
Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks likely to carried out on the culvert are inspection/review of H&S provisions and their repair/replacement (signs, hand railings, etc), there is no maintenance of the asset. These asset types are typically quite old as newer assets are 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.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation and debris clearance, de-silting, re-pointing work, minor repair works which include *ad hoc* joint repair and brick replacement (in those large enough to safely access) (and downstream scour protection). The life expectancy of these assets is impacted on by the aggressive environment they are located in, even when they are well maintained. They are likely to require early refurbishment which reduces their life to CG 5.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.6.3 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



Assumptions:

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.

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

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

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 minor repair and corrosion prevention, sealant replacement, joint repair, debris/vegetation clearance and removal of silt 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). Able to maintain at CG 3 (or better) for 60 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair and corrosion prevention, sealant replacement, joint repair, debris/vegetation clearance and removal of silt 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). Able to maintain at CG 2 (or better) for 50 years on this basis (at medium deterioration rate).

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) the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

Notes on model construction – culverts: steel

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Phase 1 curve available – Culvert (note this curve was based upon brick/masonry and concrete walls, so is not considered relevant to steel structures). The current deterioration curves were derived from consideration of deterioration mechanisms applicable to steel structures (in particular corrosion)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in full agreement with deterioration curves
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: culverts – steel

Rate	Maintenance Regime	Assumptions
Slowest	1	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. 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.
	2	As reported in Phase 1 of the project there is little actual maintenance that can be done to the culvert pipe. Maintenance tasks over and above those in Regime 1 include: inspections, CCTV surveys, clearing debris and vegetation, de-silting and joint repairs (and downstream scour protection). In some larger diameter pipes man-access can be gained for survey and repair. 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.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	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. 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.
	2	As reported in Phase 1 of the project there is little actual maintenance that can be done to the culvert pipe. Maintenance tasks over and above those in Regime 1 include: inspections, CCTV surveys, clearing debris and vegetation, and de-silting (and downstream scour protection). In some larger diameter pipes man-access can be gained for survey and repair. 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.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

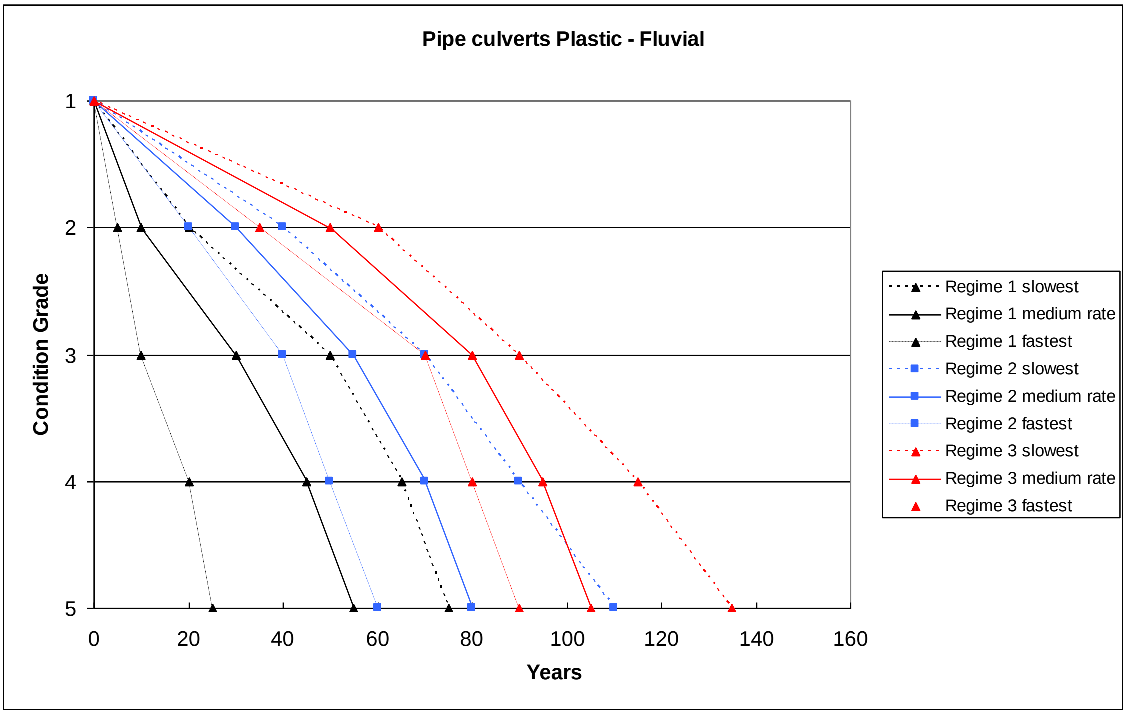
Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks carried out are inspections of H&S provisions and their repair/replacement (signs, hand railings, etc), there is no maintenance of the culvert. The design life of such an asset is based on material degradation, for galvanised corrugated steel pipe this is typically between 100 and 120 years, but to achieve this would require a systematic management of the asset.
	2	Maintenance tasks over and above those in Regime 1 include: inspections, CCTV surveys, clearing debris and vegetation, and de-silting (and downstream scour protection). In some larger diameter pipes man-access can be gained for survey and repair. The life expectancy of these assets is impacted on by the aggressive environment they are located in, even when they are well maintained. They are likely to require early refurbishment which reduces their life to CG 5.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.6.4 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



Assumptions:

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

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, 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

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

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 minor repair, silt and obstruction removal and vegetation clearance 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). Able to maintain at CG 3 (or better) for 60 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, silt and obstruction removal and vegetation clearance 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). Able to maintain at CG 2 (or better) for 50 years on this basis (at medium deterioration rate).

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) the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

Notes on model construction – culverts: plastic

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Phase 1 curve available – Culvert (note this curve was based upon brick/masonry and concrete walls, so is not considered relevant to plastic structures). The current deterioration curves were derived from consideration of deterioration mechanisms applicable to plastic structures and typical design life for assets made of these materials
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in broad agreement with deterioration curves. There were some inconsistencies with short life assets reaching CG 4 (e.g. 5 years) and CG 5 (14 years)
Site survey	N	Not applicable
Workshop	Y	In full agreement

Additional comments: culverts – plastic

Rate	Maintenance Regime	Assumptions
Slowest	1	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. Pipes can be obtained in most diameters and are typically supplied in 6 m lengths reducing the number of joints in a culvert, joints are normally fusion welded. A culvert is typically defined has being >900 mm diameter (<900 mm is a pipe and not considered here). 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).
	2	As reported in Phase 1 of the project there is little actual maintenance that can be done to the culvert pipe other than CCTV surveys, clearing vegetation and de-silting (and downstream scour protection). In larger diameter pipes man-access can be gained to undertake joint repairs; however, as the number joints are minimised and they are typically fusion welded the need to repair should be minimised. Maintenance tasks over and above those in Regime 1 include: CCTV inspections/surveys, vegetation and debris clearance, de-silting and joint repairs. 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 replaced (based on Polypipe Ridgestorm XL). This would curtail the asset life at 100 years.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	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. Pipes can be obtained in most diameters and are typically supplied in 6 m lengths reducing the number of joints in a culvert, joints are normally fusion welded. A culvert is typically defined has being >900 mm diameter (<900 mm is a pipe and not considered here). 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).
	2	As reported in Phase 1 of the project there is little actual maintenance that can be done to the culvert pipe other than CCTV surveys, clearing vegetation and de-silting (and downstream scour protection). In larger diameter pipes man-access can be gained to undertake joint repairs; however, as the number joints are minimised and they are typically fusion welded the need to repair should be minimised. Maintenance tasks over and above those in Regime 1 include: CCTV inspections/surveys, vegetation and debris clearance, de-silting and joint repairs.

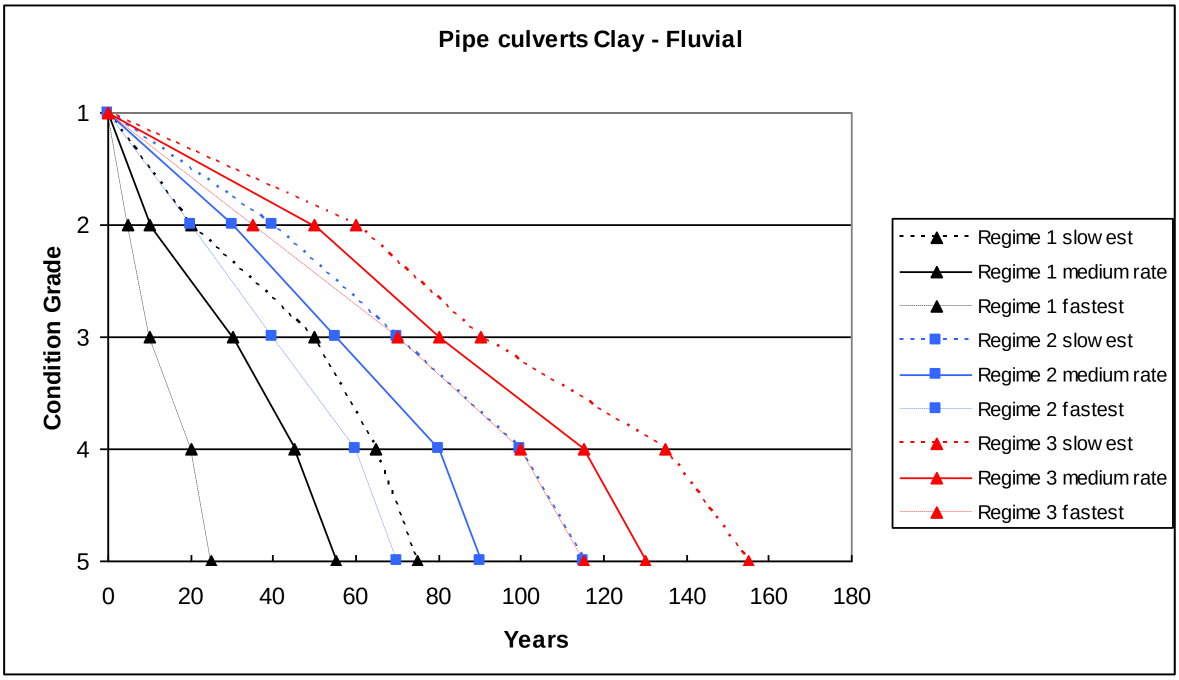
Rate	Maintenance Regime	Assumptions
		The design life of such an asset is based on material degradation, for plastic pipes this is typically 100 years before they need to be replaced (based on Polypipe Ridgestorm XL). This would curtail the asset life at 100 years.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Fastest	1	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. Pipes can be obtained in most diameters and are typically supplied in 6 m lengths reducing the number of joints in a culvert, joints are normally fusion welded. A culvert is typically defined has being >900 mm diameter (<900 mm is a pipe and not considered here). 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).
	2	As reported in Phase 1 of the project there is little actual maintenance that can be done to the culvert pipe other than CCTV surveys, clearing vegetation and de-silting (and downstream scour protection). In larger diameter pipes man-access can be gained to undertake joint repairs; however, as the number joints are minimised and they are typically fusion welded the need to repair should be minimised. Maintenance tasks over and above those in Regime 1 include: CCTV inspections/surveys, vegetation and debris clearance, de-silting and joint repairs. 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 replaced (based on Polypipe Ridgestorm XL). This would curtail the asset life at 100 years.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.6.5 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



Assumptions:

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

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

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 minor repair, silt and obstruction removal and vegetation clearance 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). Able to maintain at CG 3 (or better) for 80 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including minor repair, silt and obstruction removal and vegetation clearance 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). Able to maintain at CG 2 (or better) for 80 years on this basis (at medium deterioration rate).

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) the upstream channel is heavily vegetated and is subject to high silt volumes. The culvert may suffer from poor quality materials/construction/or design.

Notes on model construction – culverts: clay

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	Phase 1 curve available – Culvert (note this curve was based upon brick/masonry and concrete walls). Deterioration curve assumed to be as for concrete culverts
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in broad agreement with deterioration curves. There were some inconsistencies with short life assets reaching CG 4 (e.g. 5 years)
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: culverts – clay

Rate	Maintenance Regime	Assumptions
Slowest	1	Assumed same as concrete pipes
	2	Assumed same as concrete pipes
	3	Assumed same as concrete pipes
Medium	1	Assumed same as concrete pipes
	2	Assumed same as concrete pipes
	3	Assumed same as concrete pipes
Fastest	1	Assumed same as concrete pipes
	2	Assumed same as concrete pipes
	3	Assumed same as concrete pipes

A.2.7 Beaches

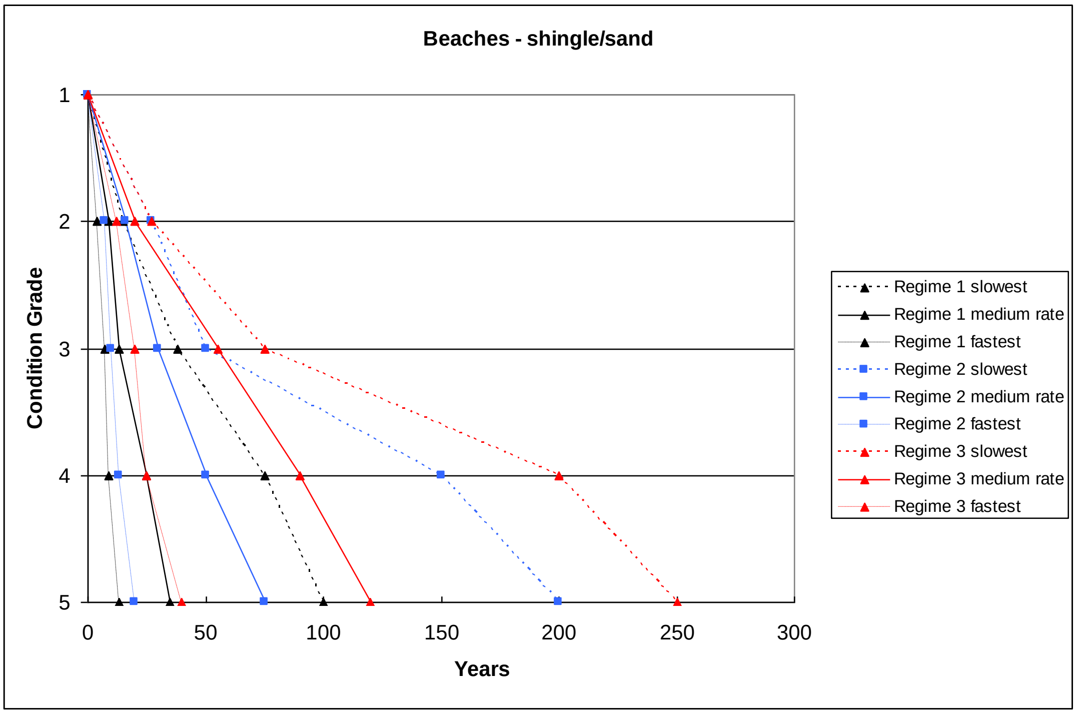
With and without beach control structures (rock/timber groynes, offshore breakwaters (rock), breastwork (timber) and crib walls (timber)

A.2.7.1 Shingle/sand (coastal/estuarine)

AIMS asset classification: Defence/beach

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



Assumptions:

Deterioration: The deterioration processes for these assets are:

- Continuous reduction in cross-sectional area or extent over the long term
- Extensive reduction in cross-sectional area or extent due to extreme event
- Damage to control structures
- Gullying
- Percolation through the beach
- Third party damage, e.g. boat damage
- 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.

Maintenance Regime 1: Low/Basic ‘do minimum’. 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 slowest 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 no maintenance over the long term.

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

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.

Coastal 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.

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

Coastal 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.

Notes on model construction – beaches

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	The slowest and medium rate values have been adjusted to allow for the assumption of more stable beach assets. General agreement for the fastest rate scenarios
Phase 1 interview	Y	Estimated residual life provided 0 to 100+ years
NFCDD database	N	Although NFCDD includes these assets, information on these is rarely recorded
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: beaches

Rate	Maintenance Regime	Assumptions
Slowest	1	Only maintenance tasks carried out are inspections. 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. It is assumed that as no maintenance work will be undertaken, that 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. The asset is assumed to be able to be maintained at CG 3 for a significant period of time naturally. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 100 assuming that increased sea level rise and wave storminess may reduce the sediment balance stability.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, asset repair and maintenance works including frequent recycling and renourishment, and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). It is expected that as the beach is stable/accreting, then ongoing recycling and renourishment can address deterioration on this beach and ensure a condition grade 3 can be maintained over the longer term. The asset is assumed to be able to be maintained at CG 3 for a significant period of time with recycling and renourishment. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 200 assuming that increased sea level rise and wave storminess may reduce the sediment balance stability.
	3	Maintenance tasks are as per Regime 2. Increased frequency of recycling and renourishment may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). It is expected that as the beach is stable/accreting, then ongoing recycling and renourishment can address deterioration on this beach and ensure a condition grade 2 can be maintained over the longer term. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with recycling and renourishment. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 250 assuming that increased sea level rise and wave storminess may reduce the sediment balance stability.

Rate	Maintenance Regime	Assumptions
Medium	1	Only maintenance tasks carried out are inspections. Assuming a stable beach with periods of erosion, there may be a slow reduction in beach volume and therefore deterioration of performance. It is assumed that as no maintenance work will be undertaken, that isolated locations of beach narrowing may occur, i.e. at the down drift ends of groyne fields, etc. The possibility that a storm may rapidly deteriorate the beach has been assumed. It has been assumed that CG 5 will be reached in year 35.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, asset repair and maintenance works including frequent recycling and renourishment, and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). Ongoing recycling and renourishment can address deterioration on this beach 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. It has been assumed that CG 5 will be reached in year 20.
	3	Maintenance tasks are as per Regime 2. Increased frequency of recycling and renourishment may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). Ongoing recycling and renourishment can address deterioration on this beach 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. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with recycling and renourishment. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 120.

Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks carried out are inspections. Assuming an eroding beach which lies in an exposed area, there may be a very rapid change in condition, primarily in relation to storm events. It is assumed that as no maintenance work will be undertaken, that isolated locations of beach narrowing may occur, i.e. at the down drift ends of groyne fields, etc. The Phase 1 deterioration rates have been adopted unchanged for this scenario. The possibility that a series of storms over a short number of years may rapidly deteriorate the beach has been assumed. It has been assumed that CG 5 will be reached in year 13.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, asset repair and maintenance works including frequent recycling and renourishment, and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). Ongoing recycling and renourishment can address deterioration on this beach 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. The Phase 1 deterioration rates for a maintain option have been adopted unchanged for this scenario. It has been assumed that CG 5 will be reached in year 20.
	3	Maintenance tasks are as per Regime 2. Increased frequency of recycling and renourishment may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). Ongoing recycling and renourishment can address deterioration on this beach 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. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with recycling and renourishment. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. For example, an eroded beach fronting a seawall becomes more reflective as the beach slope flattens, accelerating further erosion. It has been assumed that CG 5 will be reached in year 40.

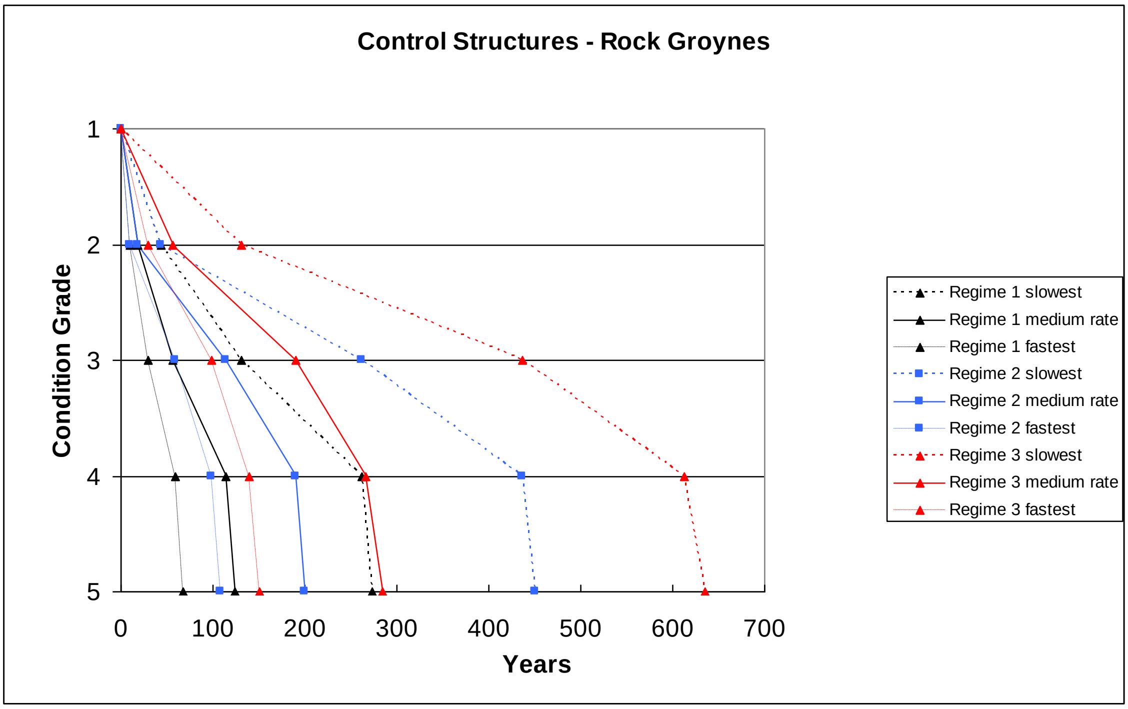
A.2.8 Control structures (coastal)

A.2.8.1 Rock groynes

AIMS asset classification: Beach structure/Groyne

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



Assumptions:

Deterioration: The deterioration processes affecting these assets include (as for rock offshore breakwaters):

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 layer 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

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). Able to maintain at CG 3 (or better) for 190 years on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 190 years on this basis (at medium deterioration rate). 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

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.

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

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

Notes on model construction – control structures: rock groynes

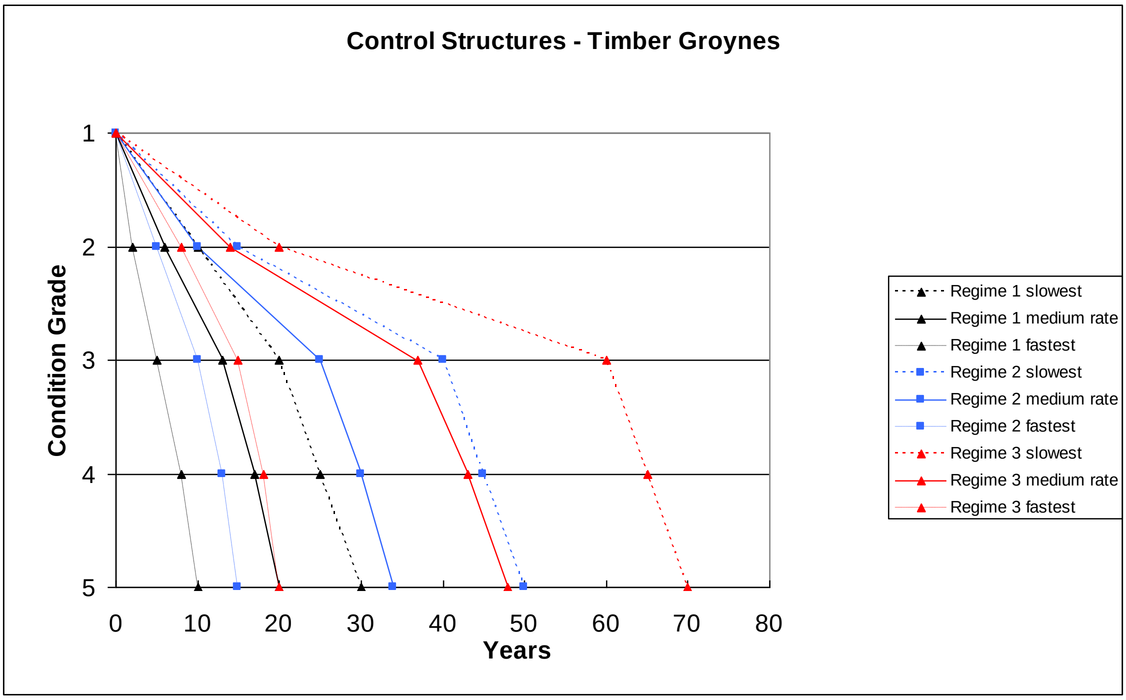
Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curve developed from consideration of deterioration processes for structures of this type (settlement and movement of the rocks) and the rate at which this occurs under different environment/material/maintenance scenarios
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in broad agreement with deterioration curves. There were some inconsistencies with short life assets reaching CG 4 (e.g. 6 years)
Site survey	N	Not applicable
Workshop	N	Not applicable

A.2.8.2 Timber groynes

AIMS asset classification: Beach structure/Groyne

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



Assumptions:

Deterioration: 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

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). Able to maintain at CG 3 (or better) for 30 years on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 37 years on this basis (at medium deterioration rate).

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.

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

Notes on model construction – control structures: timber groynes

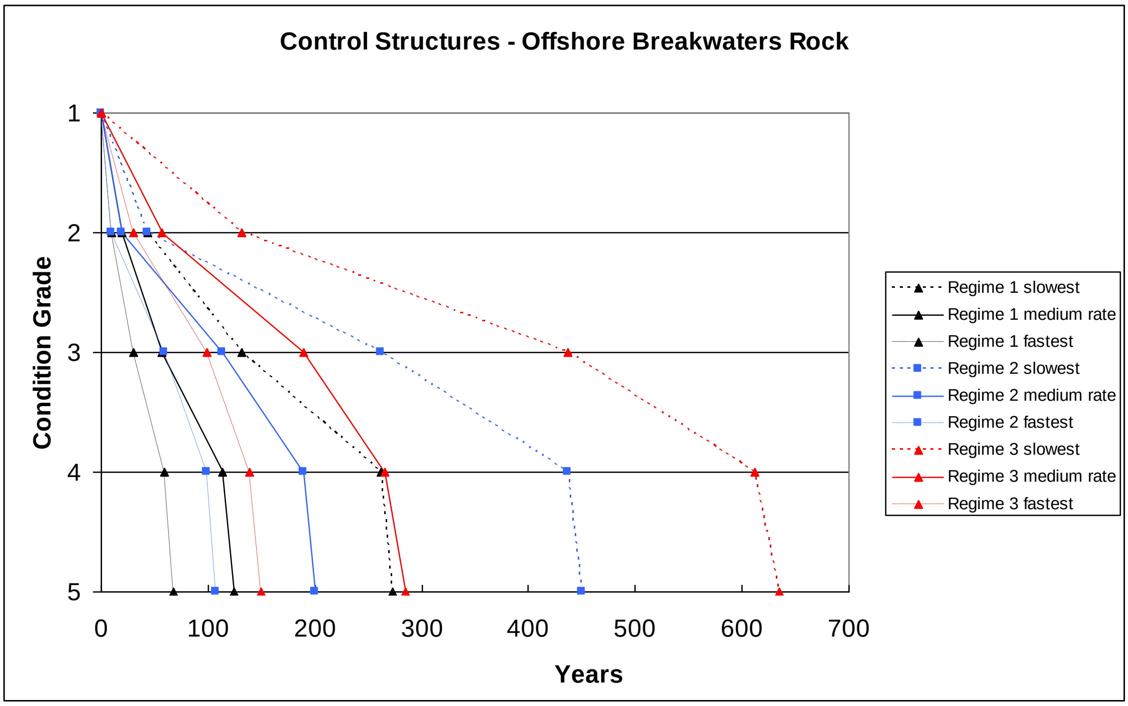
Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curve developed from consideration of deterioration processes for structures of this type (rotting and marine borers, plus warping/twisting of components) and the rate at which this occurs under different environment/material/maintenance scenarios. Grade transitions similar to timber walls
Phase 1 interview	Y	Asset maximum life values (softwoods 15 to 25 years/Douglas fir 10 years) consistent with deterioration curves. Maximum of 70 years was also consistent with the slower deterioration rates and high maintenance
NFCDD database	Y	Data extract in full agreement with deterioration curves
Site survey	Y (4 assets)	Condition grades (survey and historical) in broad agreement with age range suggested by deterioration curves
Workshop	N	Not applicable

A.2.8.3 Offshore breakwaters (rock)

AIMS asset classification: Beach structure/breakwaters

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



Assumptions:

Deterioration: The deterioration processes affecting these assets include (as for rock groynes):

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

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). Able to maintain at CG 3 (or better) for 190 years on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 190 years on this basis (at medium deterioration rate). 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.

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.

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

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

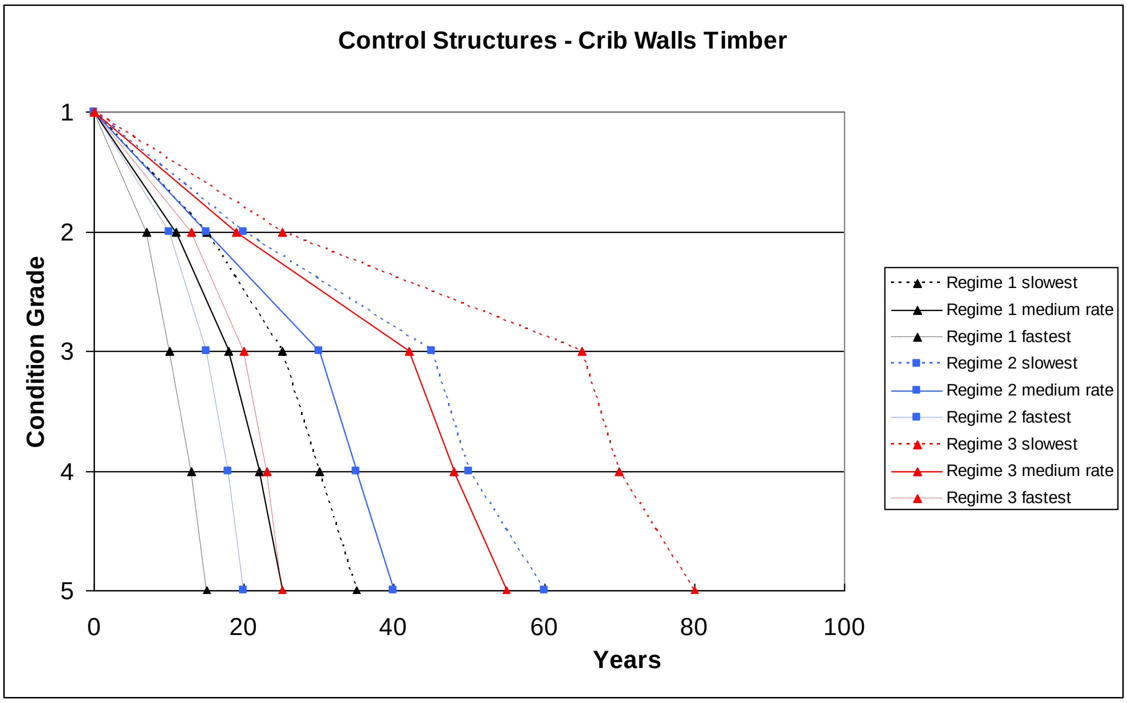
Notes on model construction – control structures: offshore breakwaters (rock)

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves same as for rock groynes
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. One CG 4 asset was 40 years old which is short age even with fastest rates of deterioration and one CG 1 asset of 120 years old, which is consistent with the slowest rate of deterioration curves
Site survey	N	Not applicable
Workshop	N	Not applicable

A.2.8.4 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



Assumptions:

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

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 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

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). Able to maintain at CG 3 (or better) for 35 years on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 42 years on this basis (at medium deterioration rate).

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.

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

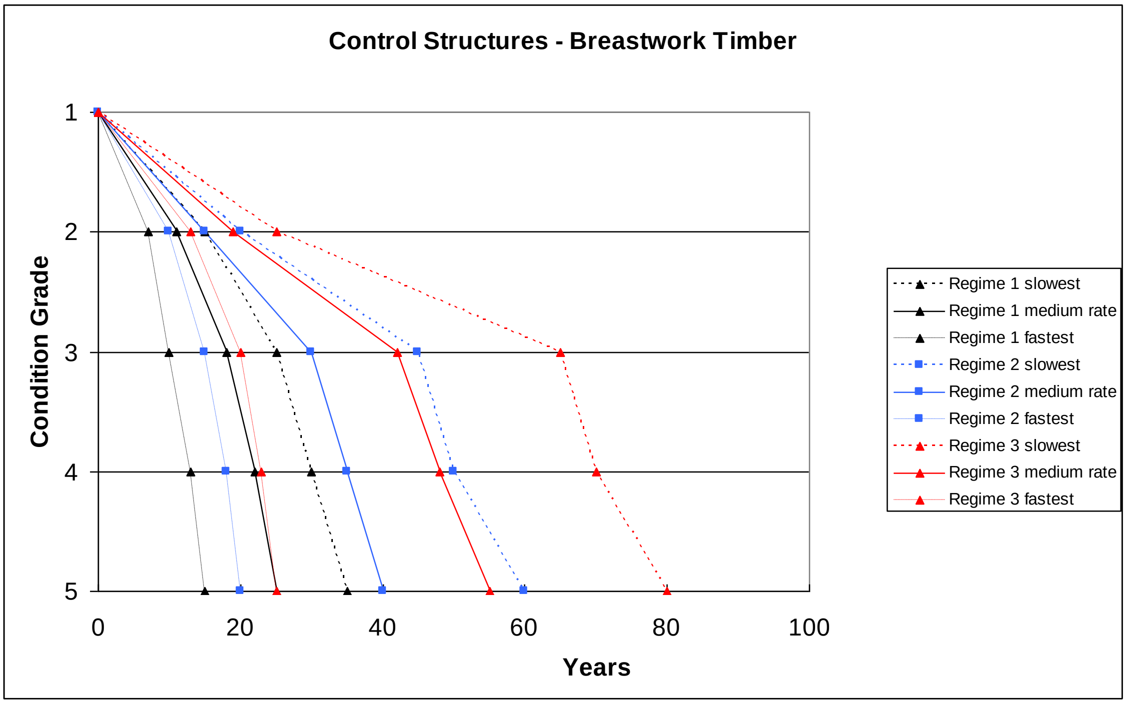
Notes on model construction – control structures: crib wall (timber)

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curve based upon timber groynes with slightly delayed transition times giving a slightly longer life asset overall. The lower rate of deterioration of these structures, cf. groynes, is considered to arise from their construction style and less exposed location
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. One CG 4 asset was 6 years old, which is short age even with fastest rates of deterioration
Site survey	N	Not applicable
Workshop	N	Not applicable

A.2.8.5 Breastwork – timber

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



Assumptions:

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:

5. Missing or damaged planks
6. Missing or damaged ties, walings and fixings
7. Groyne no longer able to arrest drift of beach material
8. 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

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). Able to maintain at CG 3 (or better) for 35 years on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 42 years on this basis (at medium deterioration rate).

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.

Coastal 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.

Notes on model construction – control structures: breastwork (timber)

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curve same as for crib walls (timber)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. One CG 4 asset was 6 years old, which is short age even with fastest rates of deterioration
Site survey	N	Not applicable
Workshop	N	Not applicable

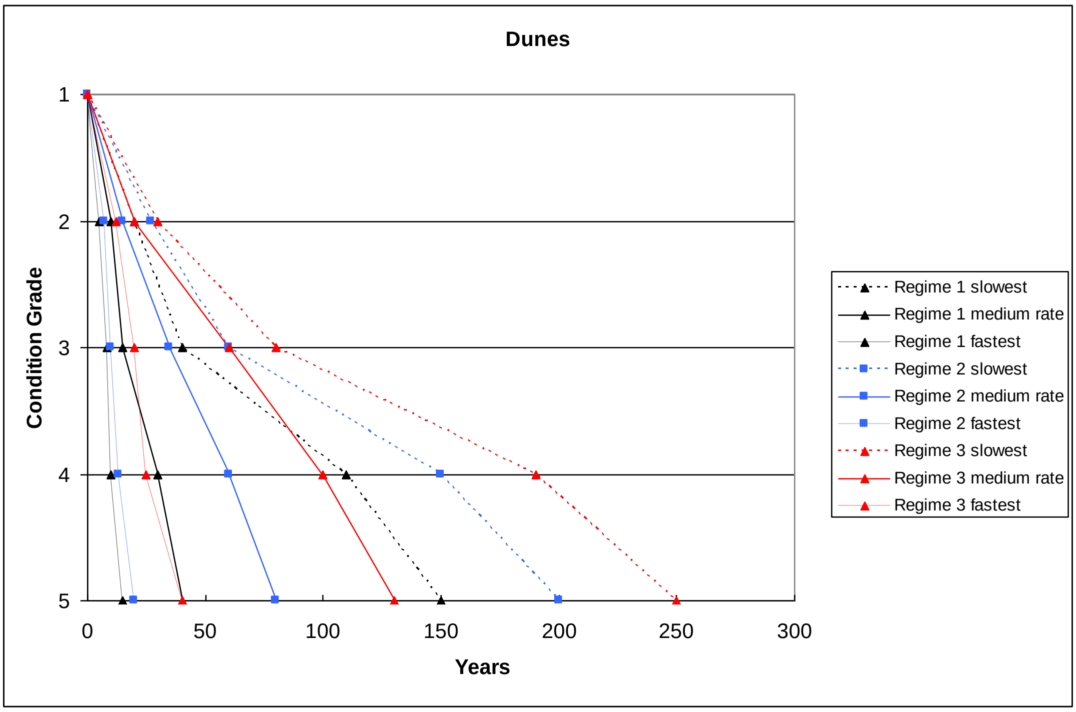
A.2.9 Dunes and saltmarshes

A.2.9.1 Dunes – with or without holding structures (coastal)

AIMS asset classification: Defence/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



Assumptions:

Deterioration: The signs of deterioration for these assets are:

- Narrow or flat dune system
- Damage or loss of vegetation
- Low beach fronting dunes
- Erosion or collapse of seaward dune slope
- Evidence of overtopping, i.e. runnels
- Damage to control structures
- Third party damage, e.g. boat damage
- 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.

Maintenance Regime 1: Low/Basic 'do minimum'. Without ongoing dune management, including the installation of wind traps, planting of marram grass, etc, relic 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.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance includes 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 events.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance includes 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 events.

Coastal 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.

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

Coastal 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.

Notes on model construction – dunes

Coastal:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	Y	The slowest and medium rate values have been adjusted to allow for the assumption of more stable beach assets. General agreement for the fastest rate scenarios
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	N	Although NFCDD includes these assets, information on these is rarely recorded
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: dunes

Coastal:

Rate	Maintenance Regime	Assumptions
Slowest	1	Only maintenance tasks carried out are inspections. 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. It is assumed that as no maintenance work will be undertaken, that isolated locations of vegetation loss or erosion of the dune front slope may occur. This would reduce the performance of the asset. The asset is assumed to be able to be stable at CG 2 to 4 for a significant period of time naturally. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 150.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, asset repair and maintenance works including installation of control structures and planting, and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). It is expected that as the dune is stable/accreting, then ongoing maintenance of control structures and replanting can address deterioration on this dune and ensure a condition grade 3 can be maintained over the longer term. The asset is assumed to be able to be maintained at CG 3 for a significant period of time with monitoring and maintenance. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 200 assuming that increased sea level rise, wave storminess and wind climate variability may reduce the dune sediment balance stability.
	3	Maintenance tasks are as per Regime 2. Increased frequency of maintenance of control structures and replanting may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). It is expected that as the dune is stable/accreting, then ongoing maintenance of control structures and replanting can address deterioration on this dune and ensure a condition grade 2 can be maintained over the longer term. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with monitoring and maintenance. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 250 assuming that increased sea level rise, wave storminess and wind climate

Rate	Maintenance Regime	Assumptions
		variability may reduce the dune sediment balance stability.
Medium	1	Only maintenance tasks carried out are inspections. Assuming a stable dune with periods of erosion, there may be a slow reduction in dune volume and therefore deterioration of performance. It is assumed that as no maintenance work will be undertaken, that isolated locations of vegetation loss or erosion of the dune front slope may occur, i.e. near access paths, outfalls, etc. The possibility that a storm may rapidly deteriorate the dune and fronting beach has been assumed. It has been assumed that CG 5 will be reached in year 40.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, asset repair and maintenance works including installation of control structures and planting, and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). Ongoing maintenance of control structures and replanting 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. Therefore there is an increased risk of dune deterioration. It has been assumed that CG 5 will be reached in year 80.
	3	Maintenance tasks are as per Regime 2. Increased frequency of maintenance of control structures and replanting may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). Ongoing maintenance of control structures and replanting 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. Therefore there is an increased risk of dune deterioration. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with monitoring and maintenance. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 130.

Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks carried out are inspections. Assuming an eroding dune which lies in an exposed area, there may be a very rapid change in condition, primarily in relation to storm events. It is assumed that as no maintenance work will be undertaken, that isolated locations of vegetation loss or erosion of the dune front slope may occur, i.e. near access paths, outfalls, etc. The Phase 1 deterioration rates have been adopted unchanged for this scenario. The possibility that a series of storms over a short number of years may rapidly deteriorate the dune has been assumed. It has been assumed that CG 5 will be reached in year 15.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, asset repair and maintenance works including frequent recycling and renourishment, and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). Ongoing maintenance of control structures and replanting 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. Therefore there is an increased risk of rapid dune deterioration. The Phase 1 deterioration rates for a maintain option have been adopted unchanged for this scenario. It has been assumed that CG 5 will be reached in year 20.
	3	Maintenance tasks are as per Regime 2. Increased frequency of maintenance of control structures and replanting may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). Ongoing maintenance of control structures and replanting 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. Therefore there is an increased risk of rapid dune deterioration. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with monitoring and maintenance. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 40.

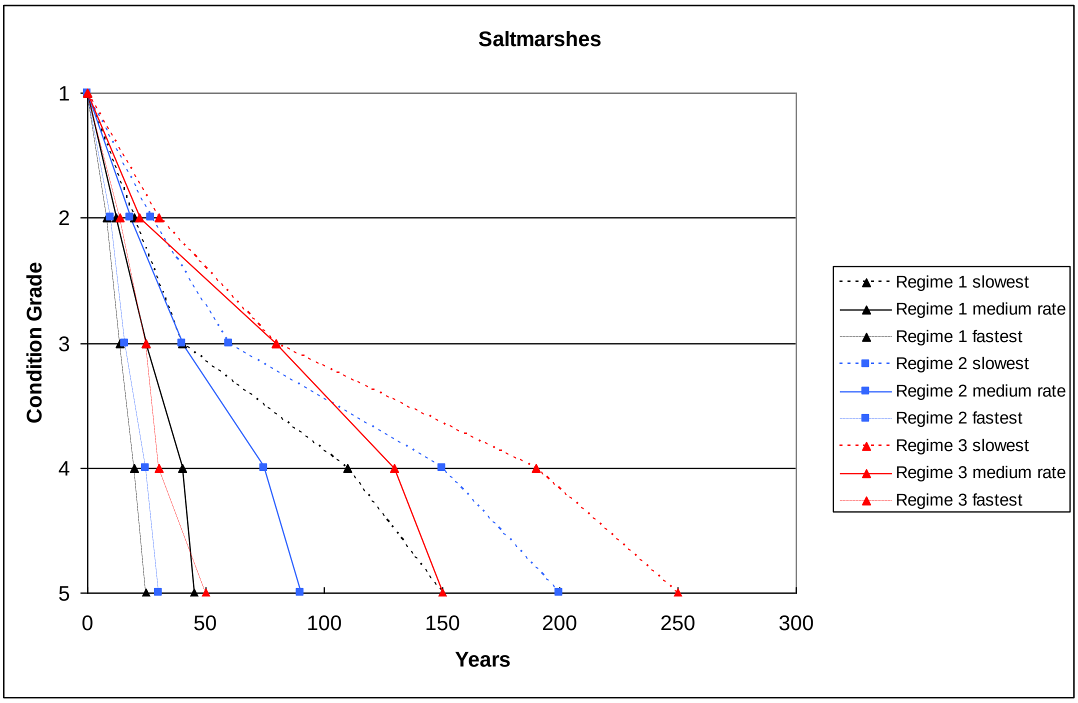
A.2.9.2 Saltmarshes

AIMS asset classification: Land/Saltmarsh

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

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



Assumptions:

Deterioration: The signs of deterioration for these assets are:

- Steep and narrow slope
- Erosion of marsh toe
- Widening and lengthening of creek system
- Vegetation loss or damage
- Third party damage, e.g. grazing
- Exposed underlying mud flat
- 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.

Maintenance Regime 1: Low/Basic 'do minimum'. 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.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance includes 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.

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance includes 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.

Coastal slowest rate: The saltmarsh lies in a sheltered area and is stable/accreting.

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

Coastal fastest rate: The saltmarsh is small in extent and lies in an exposed area.

Notes on model construction – saltmarshes

Coastal:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Not applicable
Phase 1 interview	N	Not applicable
NFCDD database	N	Although NFCDD includes these assets, information on these is rarely recorded
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: saltmarshes

Coastal environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	Only maintenance tasks carried out are inspections. 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). It is assumed that as no maintenance work will be undertaken, that isolated locations of vegetation loss or erosion of the saltmarsh may occur. This would reduce the performance of the asset. The asset is assumed to be able to be stable at CG 2 to 4 for a significant period of time naturally. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 150.
	2	Maintenance tasks over and above those in Regime 1 include vegetation clearance, asset repair and maintenance works including the installation of scour protection and protection of vegetation, etc. and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). It is expected that as 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 3 can be maintained over the longer term. The asset is assumed to be able to be maintained at CG 3 for a significant period of time with monitoring and maintenance. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 200 assuming that increased sea level rise and wave storminess may reduce the ability of the saltmarsh to survive.
	3	Maintenance tasks are as per Regime 2. Increased frequency of maintenance of control structures and vegetation maintenance may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). It is expected that as 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 2 can be maintained over the longer term. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with monitoring and

Rate	Maintenance Regime	Assumptions
		maintenance. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 250 assuming that increased sea level rise and wave storminess may reduce the ability of the saltmarsh to survive.
Medium	1	Only maintenance tasks carried out are inspections. Assuming a stable saltmarsh with periods of erosion, there may be a slow reduction in saltmarsh extent and therefore deterioration of performance. It is assumed that as no maintenance work will be undertaken, that isolated locations of vegetation loss or erosion of the saltmarsh front slope may occur, i.e. near access paths, outfalls, etc. The possibility that ongoing erosion may rapidly deteriorate the saltmarsh has been assumed. It has been assumed that CG 5 will be reached in year 45.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, asset repair and maintenance works including the installation of scour protection and protection of vegetation, etc, and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). Ongoing maintenance of control structures and vegetation maintenance can address deterioration to a certain degree. However, as it is sensitive to erosion, there may be occasions where the asset performance is reduced. Therefore there is an increased risk of saltmarsh deterioration. It has been assumed that CG 5 will be reached in year 90.
	3	Maintenance tasks are as per Regime 2. Increased frequency of maintenance of control structures and vegetation maintenance may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). Ongoing maintenance of control structures and vegetation maintenance can address deterioration to a certain degree. However, as it is sensitive to erosion, there may be occasions where the asset performance is reduced. Therefore there is an increased risk of saltmarsh deterioration. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with monitoring and maintenance. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 150.

Rate	Maintenance Regime	Assumptions
Fastest	1	Only maintenance tasks carried out are inspections. 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. It is assumed that as no maintenance work will be undertaken, that isolated locations of vegetation loss or erosion of the saltmarsh front slope may occur, i.e. near access paths, outfalls, etc. The possibility that a series of storms or ongoing boat wake, vegetation disease, etc, over a short number of years may rapidly deteriorate the saltmarsh has been assumed. It has been assumed that CG 5 will be reached in year 25.
	2	Maintenance tasks over and above those in Regime 1 include: vegetation clearance, asset repair and maintenance works including the installation of scour protection and protection of vegetation, etc, and frequent inspections and monitoring. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). Ongoing maintenance of control structures and vegetation maintenance can address deterioration to a certain degree. However, as it is prone to erosion, there may be occasions where the asset performance is reduced. Therefore there is an increased risk of rapid saltmarsh deterioration. The Phase 1 deterioration rates for a maintain option have been adopted unchanged for this scenario. It has been assumed that CG 5 will be reached in year 30.
	3	Maintenance tasks are as per Regime 2. Increased frequency of maintenance of control structures and vegetation maintenance may assist further in maintaining asset performance. Maintenance activities would target maintaining the asset to CG 2 (Environment Agency Target Condition Grade for assets). Ongoing maintenance of control structures and vegetation maintenance can address deterioration to a certain degree. However, as it is prone to erosion, there may be occasions where the asset performance is reduced. Therefore there is an increased risk of rapid saltmarsh deterioration. The asset is assumed to be able to be maintained at CG 2 and then CG 3 for a significant period of time with monitoring and maintenance. Once the asset deteriorates to grade 4 it is likely that deterioration to grade 5 will be quicker. It has been assumed that CG 5 will be reached in year 50.

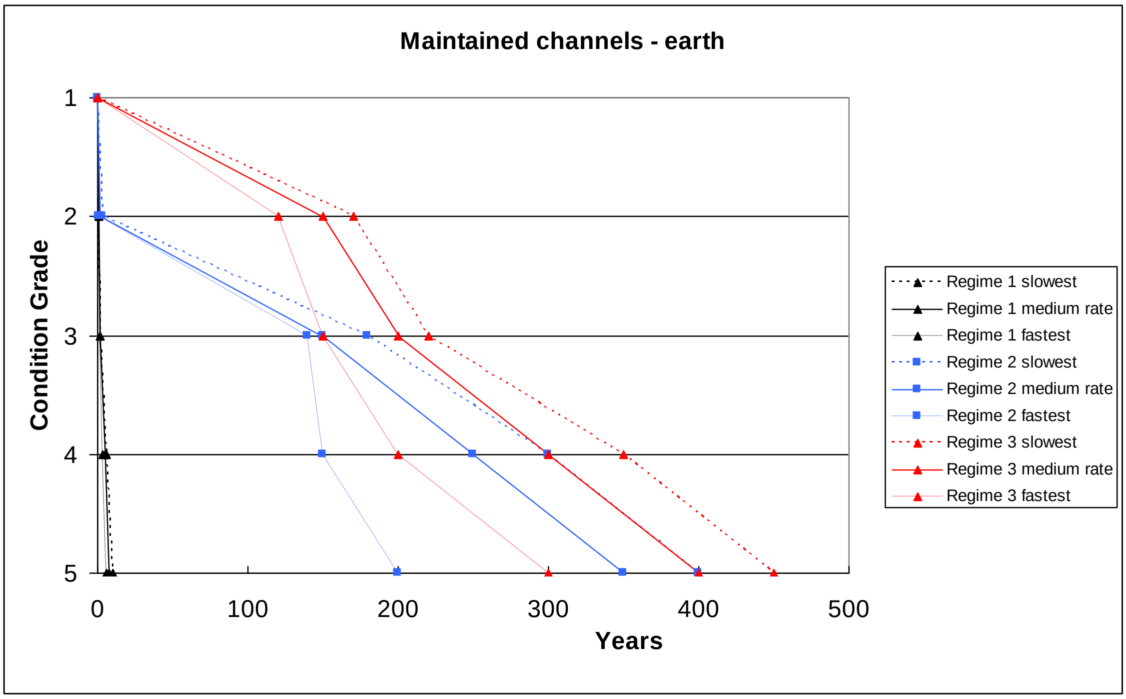
A.2.10 Maintained channels (fluvial)

A.2.10.1 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



Assumptions:

Values based upon Workshop activity 18 April 2011.

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

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). Able to maintain at CG 3 (or better) for 250 years on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 200 years on this basis (at medium deterioration rate).

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.

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).

Notes on model construction – maintained channels: earth

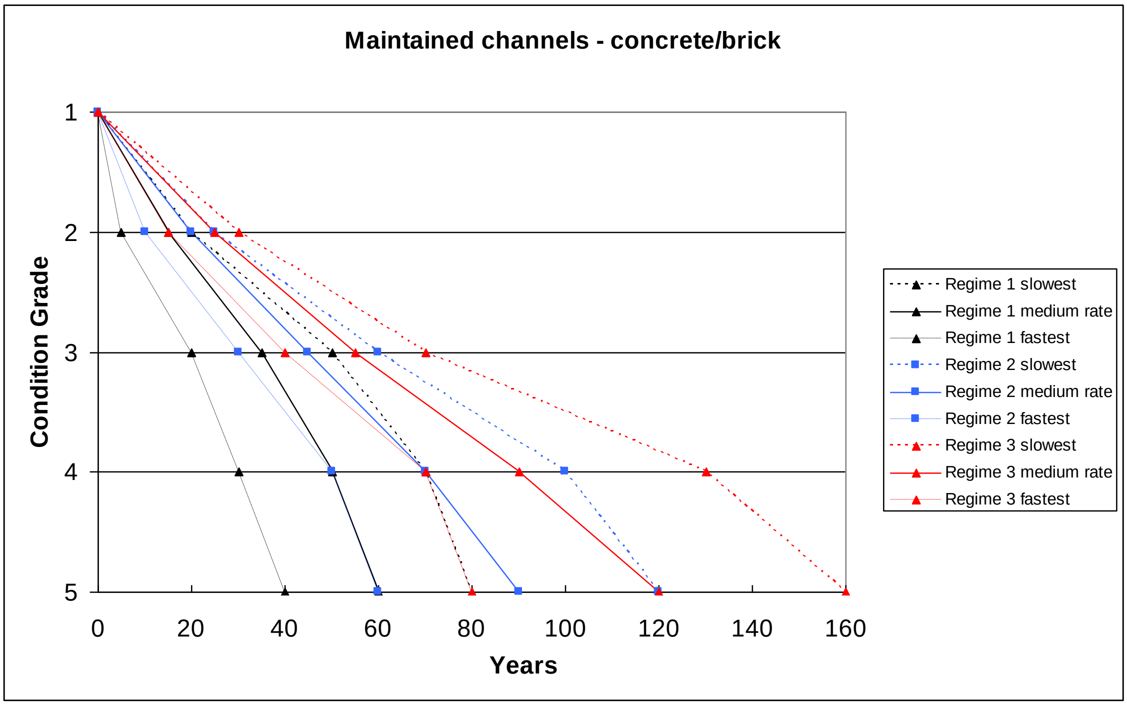
Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Not applicable
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in agreement with deterioration curves. One CG 2 asset was recorded as 271 years old
Site survey	N	Not applicable
Workshop	Y	Deterioration curve constructed from Workshop data. Non-maintained channels deteriorate very rapidly. Maintenance has a significant impact with considerable increase in times to grade transition. It is felt that the channels can be held almost indefinitely in CG 3 or better

A.2.10.2 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



Assumptions:

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

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

Maintenance Regime 2: Undertake maintenance to maintain at CG 3. Regular maintenance including vegetation clearance, concrete/sealant/joint repair, 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). Able to maintain at CG 3 (or better) for 70 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including vegetation clearance, concrete/sealant/joint repair, 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). Able to maintain at CG 2 (or better) for 55 years on this basis (at medium deterioration rate).

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.

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

Notes on model construction – maintained channels: concrete/brick

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	No Phase 1 curve available. Deterioration curves developed through consideration of deterioration processes in these structures. Other deterioration curves useful for this asset included: concrete/brick walls, culverts (concrete/brick)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. Some CG 4 assets were of short age (e.g. 5 years) and some CG 5 assets similarly (21 years) which are inconsistent with the deterioration curves
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: maintained channels – concrete/brick

Rate	Maintenance Regime	Assumptions
Slowest	1	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. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. The maintenance is basic as stated above. The deterioration mechanisms would be through loss of capacity, joint failures, and lack of repairs.
	2	Maintenance tasks over and above those in Regime 1 include: inspections/surveys of the structure/channel, vegetation and debris clearance on and around the structure, de-silting, and minor repairs to the crest, wing walls, apron and scour protection., repair of concrete, sealant replacement/repair, Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets) The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case appropriate maintenance is undertaken. The deterioration mechanisms would be at the joints. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula.
Medium	1	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. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. The maintenance is basic as stated above. The deterioration mechanisms would be through loss of capacity, joint failures, and lack of repairs.
	2	Maintenance tasks over and above those in Regime 1 include: inspections/surveys of the structure/channel, vegetation and debris clearance on and around the structure, de-silting, and minor repairs to the crest, wing walls, apron and scour protection., repair of concrete, sealant replacement/repair. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). The design life of such an asset is 50 years based on normal engineering practice.

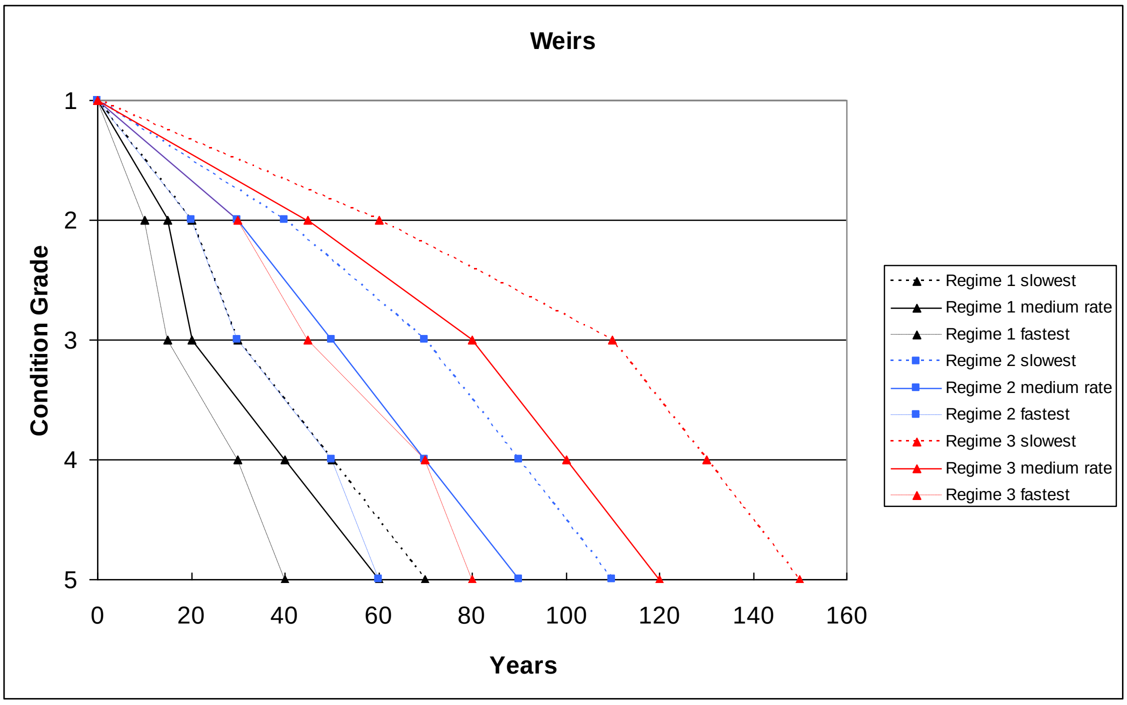
Rate	Maintenance Regime	Assumptions
		The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case appropriate maintenance is undertaken. The deterioration mechanisms would be at the joints. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula.
Fastest	1	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. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. The maintenance is basic as stated above. The deterioration mechanisms would be through loss of capacity, joint failures, and lack of repairs.
	2	Maintenance tasks over and above those in Regime 1 include: inspections/surveys of the structure/channel, vegetation and debris clearance on and around the structure, de-silting, and minor repairs to the crest, wing walls, apron and scour protection., repair of concrete, sealant replacement/repair. Maintenance activities would target maintaining the asset to CG 3 (Environment Agency Target Condition Grade for assets). The design life of such an asset is 50 years based on normal engineering practice. The life of such an asset may extend beyond the 'design life' but this is dependent upon: environmental conditions, maintenance applied, and materials used. In this case appropriate maintenance is undertaken. The deterioration mechanisms would be at the joints. It is assumed that the materials used and construction techniques are appropriate for the location and that the foundation is stable.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula.

A.2.11 Weirs (fluvial)

AIMS asset classification: Structure/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



Assumptions:

The deterioration curves apply to fixed weirs only. They do not include moving weirs.

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

Maintenance Regime 1: Low/Basic ‘do minimum’. 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 debris/vegetation clearance, repair of damaged elements, scour protection work, backfill replacement, 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). Able to maintain at CG 3 (or better) for 70 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including debris/vegetation clearance, repair of damaged elements, scour protection work, backfill replacement, 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). Able to maintain at CG 2 (or better) for 80 years on this basis (at medium deterioration rate).

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/or design. Deterioration would be shown by; movement of elements, cracks/erosion, uneven flows, upstream build up of sediments, etc.

Note: 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).

Notes on model construction – weirs

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	No Phase 1 curve available. Deterioration curves developed through consideration of deterioration processes in these structures. Other deterioration curves useful for this asset included: culverts (concrete/brick), maintained channels (concrete)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. Some CG 4 assets were of short age (e.g. 5 years) and some CG 1 assets of long age (155 years) which are inconsistent with the deterioration curves
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: weirs

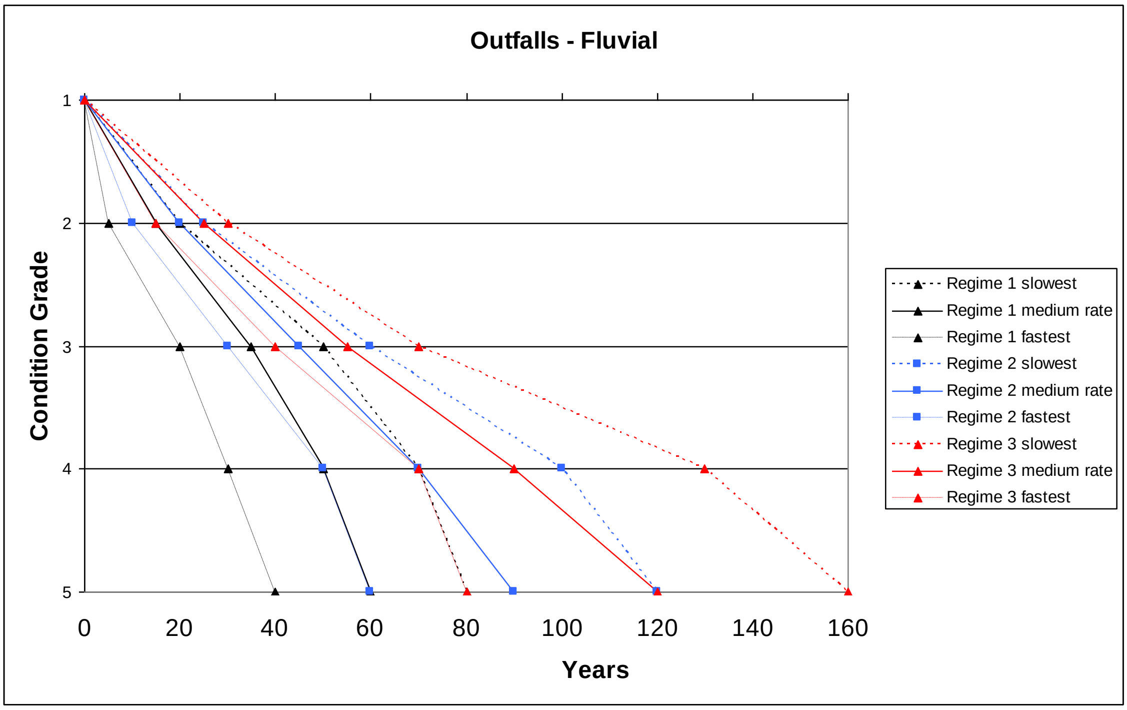
Rate	Maintenance Regime	Assumptions
Slowest	1	Only maintenance tasks carried out are inspections of H&S provisions and their repair/replacement (signs, hand railings, etc), there is no maintenance of the weir, wing walls, apron or scour protection. The design life of such an asset is estimated at 100 years (based in Phase 1 interview notes).
	2	Maintenance tasks over and above those in Regime 1 include: inspections/surveys of the structure, vegetation and debris clearance on and around the structure, de-silting, and minor repairs to the crest, wing walls, apron and scour protection.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	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. The design life of such an asset is estimated at 100 years (based in Phase 1 interview notes).
	2	Maintenance tasks over and above those in Regime 1 include: inspections/surveys of the structure, vegetation and debris clearance on and around the structure, de-silting, and minor repairs to the crest, wing walls, apron and scour protection.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Fastest	1	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. The design life of such an asset is estimated at 100 years (based in Phase 1 interview notes).
	2	Maintenance tasks over and above those in Regime 1 include: inspections/surveys of the structure, vegetation and debris clearance on and around the structure, de-silting, and minor repairs to the crest, wing walls, apron and scour protection.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade). The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.12 Outfalls (fluvial and coastal/estuarine)

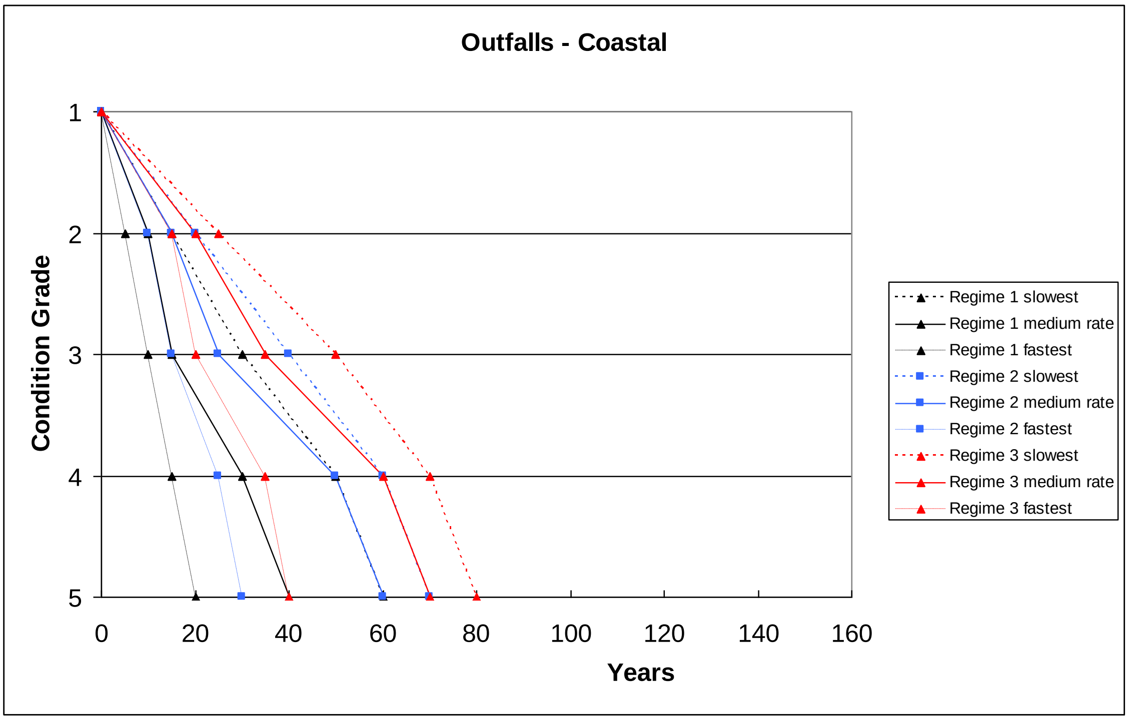
AIMS asset classification: Structure/outfall

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



Assumptions:

General: These structures are normally constructed from a mixture of elements which may include: pipework (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.

Deterioration: The deterioration processes affecting these assets include:

1. Pipe broken or blocked
2. Discharge outlet buried or blocked
3. Movement or settlement
4. Scour or undermining
5. Cracks in main structural elements
6. Broken timbers
7. Leaking pipe
8. Loss of thickness of piles due to corrosion, abrasion, etc
9. 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

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). Able to maintain at CG 3 (or better) for 70 years (fluvial) and 50 years (coastal) on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) for 55 years (fluvial) and 35 (coastal) on this basis (at medium deterioration rate).

Deterioration fluvial: 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: 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.

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).

Notes on model construction – outfalls

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	No Phase 1 curve available. Deterioration curves developed through consideration of deterioration processes in these structures. Other deterioration curves useful for this asset included: culverts (concrete/brick), maintained channels (concrete) and weirs
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. Some CG 4 and CG 3 assets were of short age (e.g. 5 and 11 years respectively) which are inconsistent with the deterioration curves
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

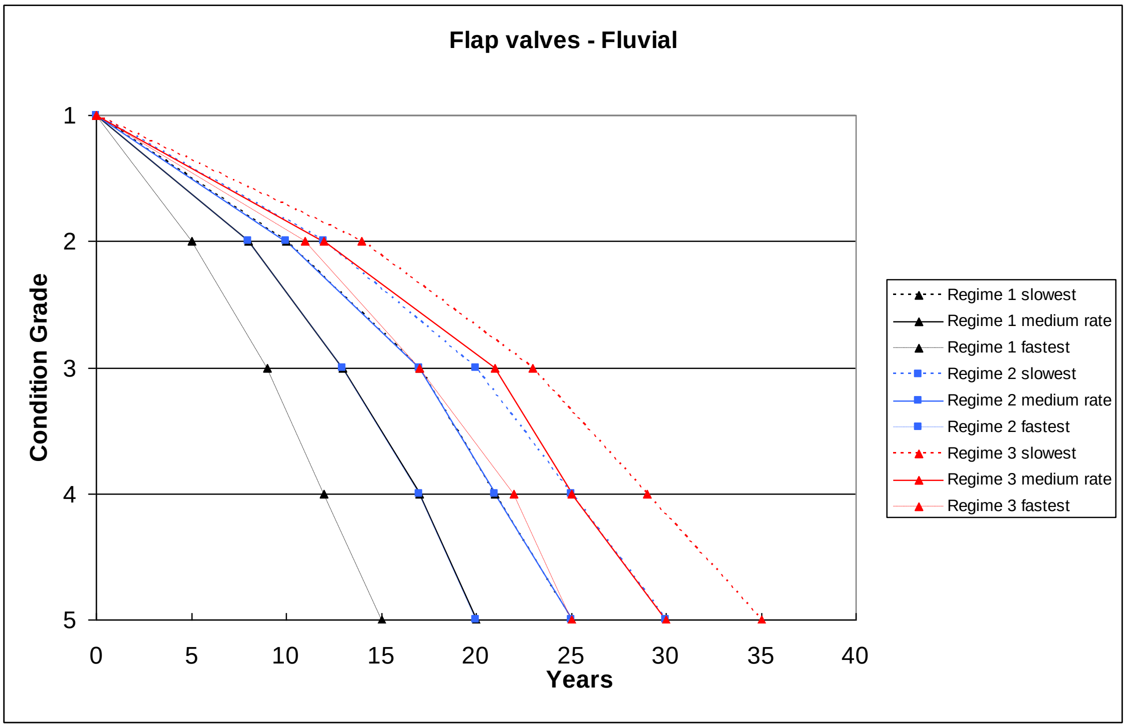
Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from fluvial with increased deterioration due to more severe environment
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. Some CG 4 and CG 3 assets were of short age (e.g. 15 and 4 years respectively) which are inconsistent with the deterioration curves which predict longer timescales to achieve these condition grades
Site survey	N	Not applicable
Workshop	Y	In full agreement with deterioration curves

A.2.13 Flap valves (fluvial and coastal/estuarine)

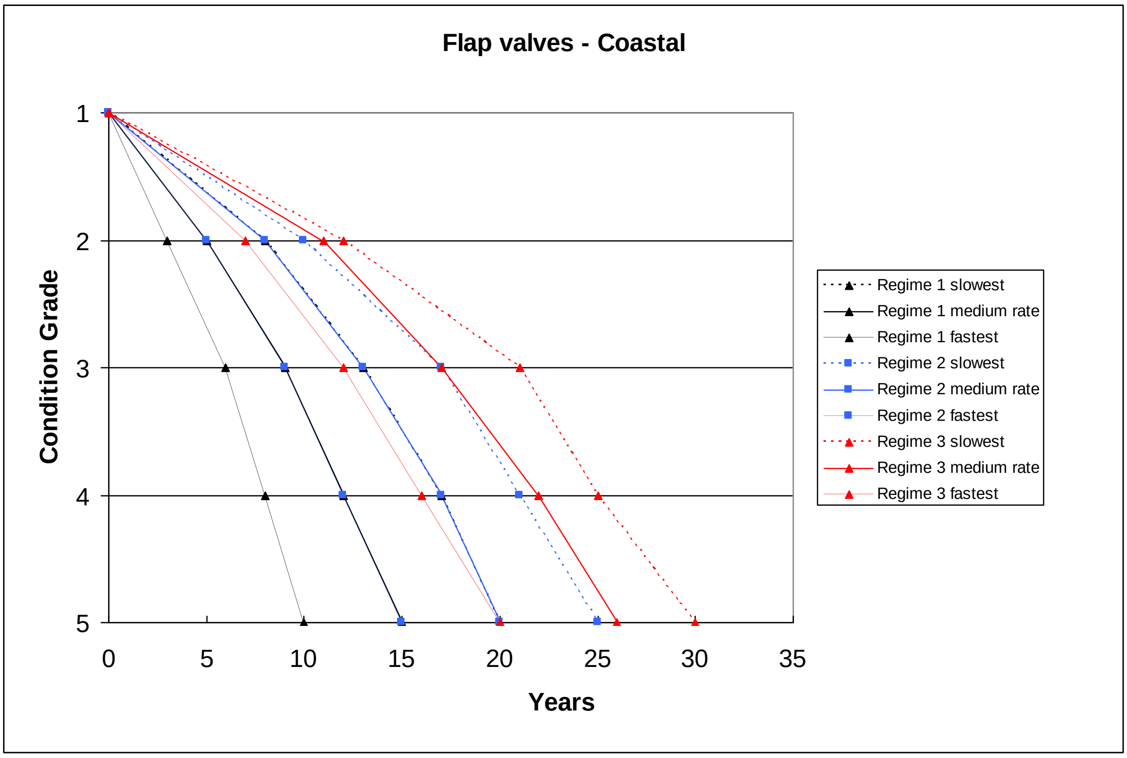
AIMS asset classification: Structure/control gate

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



Assumptions:

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

Maintenance Regime 1: Low/Basic 'do minimum'. 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 cleaning, replacing damaged elements, lubrication of moving parts, 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). Able to maintain at CG 3 (or better) for 21 years (fluvial) and 17 years (coastal) on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including cleaning, replacing damaged elements, lubrication of moving parts, 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). Able to maintain at CG 2 (or better) for 21 years (fluvial) and 17 (coastal) on this basis (at medium deterioration rate).

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, and 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, and 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 the extremes of usage. Construction/design and/or quality/materials may not be appropriate. Deterioration mechanisms would 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 a harsh environment, and subject to the extremes of usage. Construction/design may not be appropriate, 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.

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).

Notes on model construction – flap valves

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	No Phase 1 curve available. Considered to be short life assets. Deterioration curves developed through consideration of deterioration processes in these structures with design life of 25 years
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract suggests that assets can have longer life than deterioration curve predicts, e.g. CG 2 at 32 years and CG 4 at 57 years
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from fluvial with increased deterioration due to more severe environment
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract suggests that assets can have longer life than deterioration curve predicts, e.g. CG 2 at 75 years and CG 4 at 58 years
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: flap valves

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: 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 as a break down maintenance activity in order to keep the valve operational. With low/basic maintenance the asset life at CG 5 could be 25 years.
	2	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made; The Environment Agency's 'Maintenance Standards Manual' does not cover maintenance of specific M&E (Mechanical & Electrical) assets, hence maintenance assumptions based on manufacturer's guidelines and industry standards. For this model the following inspection and maintenance tasks have been assumed: H&S maintenance (surrounding structure), channel and flap clearance, hinge and flap inspection and maintenance including greasing of hinges. With appropriate maintenance the asset life at CG 5 could be 30 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: 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 as a break down maintenance activity in order to keep the valve operational. With low/basic maintenance the asset life at CG 5 could be 20 years.

Rate	Maintenance Regime	Assumptions
	2	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: The Environment Agency's 'Maintenance Standards Manual' does not cover maintenance of specific M&E assets, hence maintenance assumptions based on manufacturer's guidelines and industry standards. For this model the following inspection and maintenance tasks have been assumed: H&S maintenance (surrounding structure), channel and flap clearance, hinge and flap inspection and maintenance including greasing of hinges. With appropriate maintenance the asset life at CG 5 could be 25 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Fastest	1	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: 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 as a break down maintenance activity in order to keep the valve operational. With low/basic maintenance the asset life at CG 5 could be 15 years.
	2	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: The Environment Agency's 'Maintenance Standards Manual' does not cover maintenance of specific M&E assets, hence maintenance assumptions based on manufacturer's guidelines and industry standards.For this model the following inspection and maintenance tasks have been assumed: H&S maintenance (surrounding structure), channel and flap clearance, hinge and flap inspection and maintenance including greasing of hinges. With appropriate maintenance the asset life at CG 5 could be 20 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: 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 as a break down maintenance activity in order to keep the valve operational. With low/basic maintenance the asset life at CG 5 could be 20 years.
	2	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: The Environment Agency's 'Maintenance Standards Manual' does not cover maintenance of specific M&E assets, hence maintenance assumptions based on manufacturer's guidelines and industry standards. For this model the following inspection and maintenance tasks have been assumed: H&S maintenance (surrounding structure), channel and flap clearance, hinge and flap inspection and maintenance. With appropriate maintenance the asset life at CG 5 could be 25 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: 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 as a break down maintenance activity in order to keep the valve operational.

Rate	Maintenance Regime	Assumptions
		With low/basic maintenance the asset life at CG 5 could be 15 years.
	2	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: The Environment Agency's 'Maintenance Standards Manual' does not cover maintenance of specific M&E assets, hence maintenance assumptions based on manufacturer's guidelines and industry standards. For this model the following inspection and maintenance tasks have been assumed: H&S maintenance (surrounding structure), channel and flap clearance, hinge and flap inspection and maintenance. With appropriate maintenance the asset life at CG 5 could be 20 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1
Fastest	1	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: 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 as a break down maintenance activity in order to keep the valve operational. With low/basic maintenance the asset life at CG 5 could be 10 years.
	2	Based on outfalls in the Environment Agency Maintenance Standards manual and requirements of the model the following assumptions were made: The Environment Agency's 'Maintenance Standards Manual' does not cover maintenance of specific M&E assets, hence maintenance assumptions based on manufacturer's guidelines and industry standards. For this model the following inspection and maintenance tasks have been assumed: H&S maintenance (surrounding structure), channel and flap clearance, hinge and flap inspection and maintenance. With appropriate maintenance the asset life at CG 5 could be 15 years.

Rate	Maintenance Regime	Assumptions
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

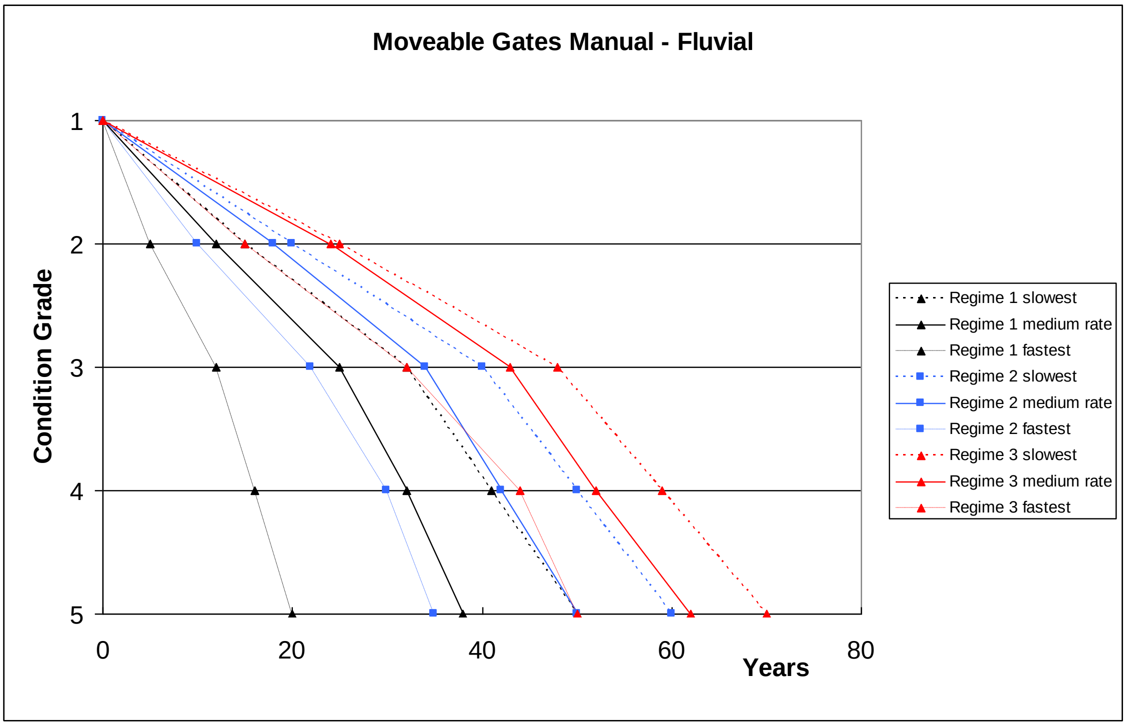
A.2.14 Moveable gates (fluvial and coastal/estuarine)

A.2.14.1 Moveable gates – manual

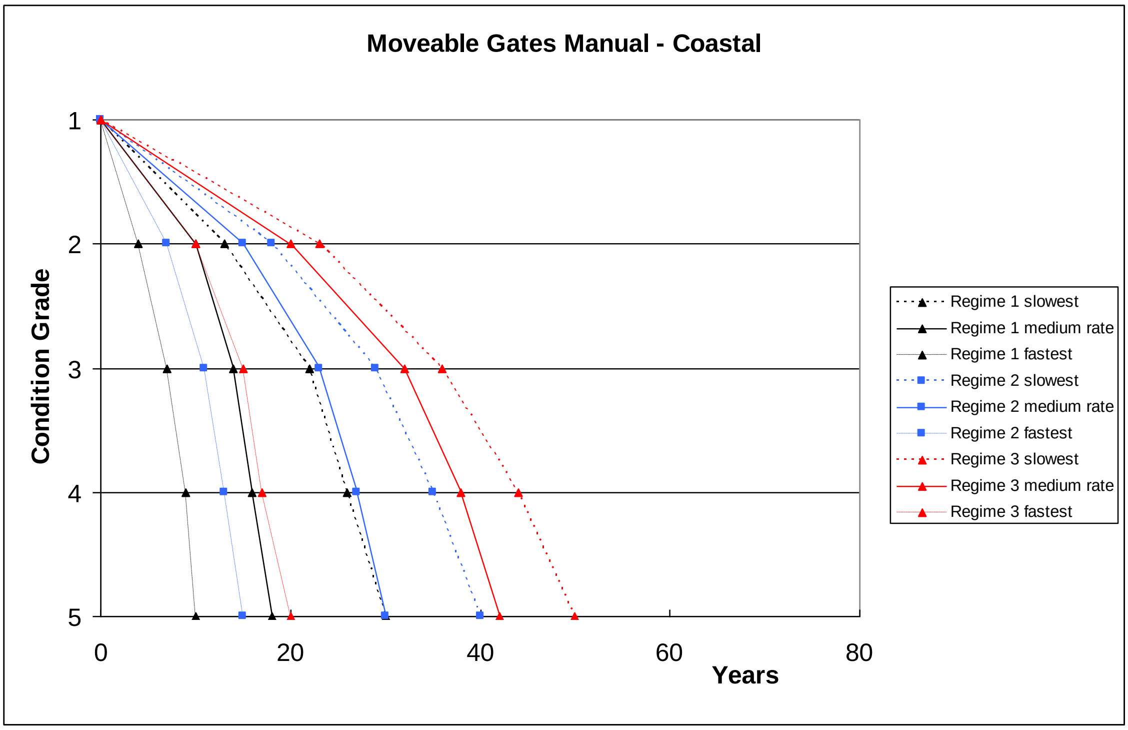
AIMS asset classification: Structure/control gate

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



Assumptions:

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

Maintenance Regime 1: Low/Basic ‘do minimum’. 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 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 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 42 years (fluvial) and 27 years (coastal) on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent 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 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) for 43 years (fluvial) and 32 (coastal) on this basis (at medium deterioration rate).

Fluvial slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, and 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, and 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.

Maintenance Regime 1: Low/Basic ‘do minimum’.

Maintenance Regime 2: Undertake maintenance to maintain at CG 3.

Maintenance Regime 3: High, maintain CG 2.

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

Notes on model construction – moveable gates: manual

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	No Phase 1 curve available. Deterioration curves developed through consideration of deterioration processes in these structures
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract suggests that assets can have longer life than deterioration curve predicts e.g. CG 1 at 155 years and CG 2 at 60 years, otherwise general agreement. (Note: Data set does not distinguish between manual and electrical assets)
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from fluvial with increased deterioration due to more severe environment
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. One CG 4 asset at 7 years indicates more rapid deterioration than the fastest deterioration rate model. (Note: Data set does not distinguish between manual and electrical assets)
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: moveable gates: manual

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. With low/basic maintenance the asset life at CG 5 could be 50 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal and clearance, maintenance of the headworks, gates and frames and minor repairs to the corrosion protection systems. Mechanical maintenance has been assumed to include such activities as routine lubrication, oil level checks, oil/filter replacement, chain drive tensioning and replacing gate seals, etc. 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. With appropriate manufacturer's maintenance the asset life at CG 5 could be 60 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	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. With low/basic maintenance the asset life at CG 5 could be 38 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal and clearance, maintenance of the headworks, gates and frames and minor repairs to the corrosion protection systems. Mechanical maintenance has been assumed to include such activities as routine lubrication, oil level checks, oil/filter

Rate	Maintenance Regime	Assumptions
		replacement, chain drive tensioning and replacing gate seals, etc. 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. With appropriate manufacturer's maintenance the asset life at CG 5 could be 50 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Fastest	1	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. With low/basic maintenance the asset life at CG 5 could be 20 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal and clearance, maintenance of the headworks, gates and frames and minor repairs to the corrosion protection systems. Mechanical maintenance has been assumed to include such activities as routine lubrication, oil level checks, oil/filter replacement, chain drive tensioning and replacing gate seals, etc. 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. With appropriate manufacturer's maintenance the asset life at CG 5 could be 35 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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. With low/basic maintenance the asset life at CG 5 could be 30 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal and clearance, maintenance of the headworks, gates and frames and minor repairs to the corrosion protection systems. Mechanical maintenance has been assumed to include such activities as routine lubrication, oil level checks, oil/filter replacement, chain drive tensioning and replacing gate seals, etc. 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. With appropriate manufacturer's maintenance the asset life at CG 5 could be 40 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	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. With low/basic maintenance the asset life at CG 5 could be 18 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal and clearance, maintenance of the headworks, gates and frames and minor repairs to the corrosion protection systems. Mechanical maintenance has been assumed to include such activities as routine lubrication, oil level checks, oil/filter replacement, chain drive tensioning and replacing gate seals, etc.

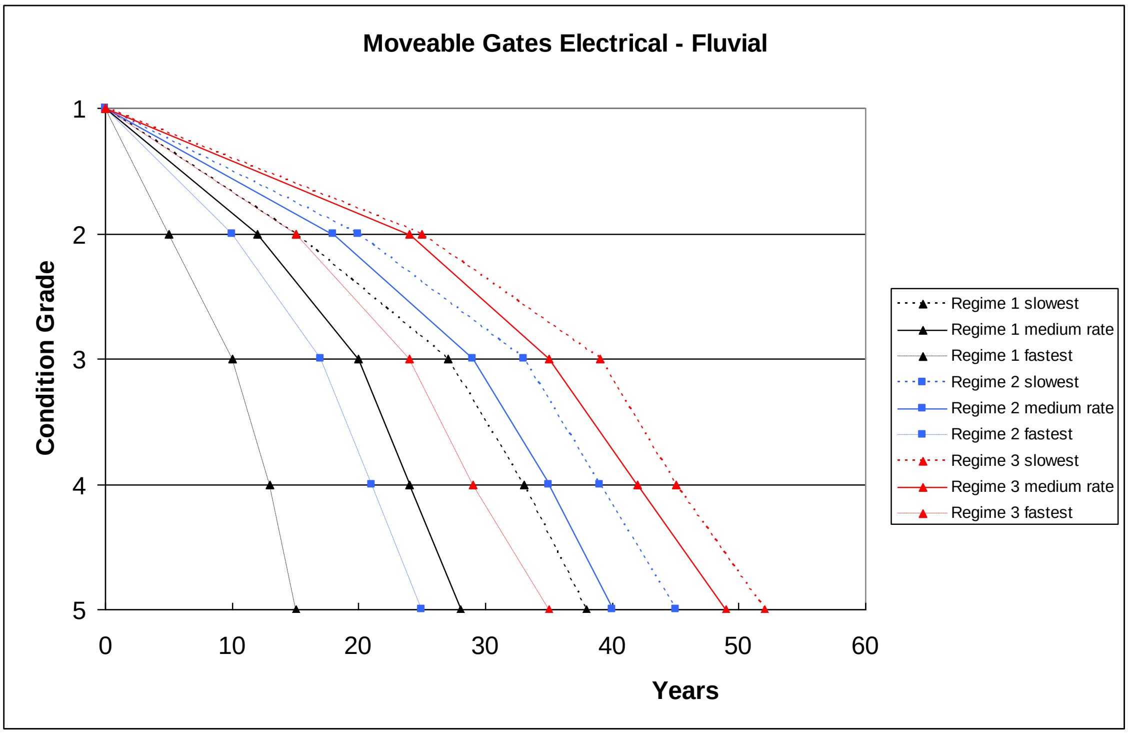
Rate	Maintenance Regime	Assumptions
		Replacement of corrosion protection systems and major components such as gates, gearboxes, spindles or bearings requiring significant temporary works is considered a refurbishment activity and therefore not counted. With appropriate manufacturer's maintenance the asset life at CG 5 could be 30 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Fastest	1	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. With low/basic maintenance the asset life at CG 5 could be 10 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal and clearance, maintenance of the headworks, gates and frames and minor repairs to the corrosion protection systems. Mechanical maintenance has been assumed to include such activities as routine lubrication, oil level checks, oil/filter replacement, chain drive tensioning and replacing gate seals, etc. 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. With appropriate manufacturer's maintenance the asset life at CG 5 could be 15 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.14.2 Moveable gates – electrical

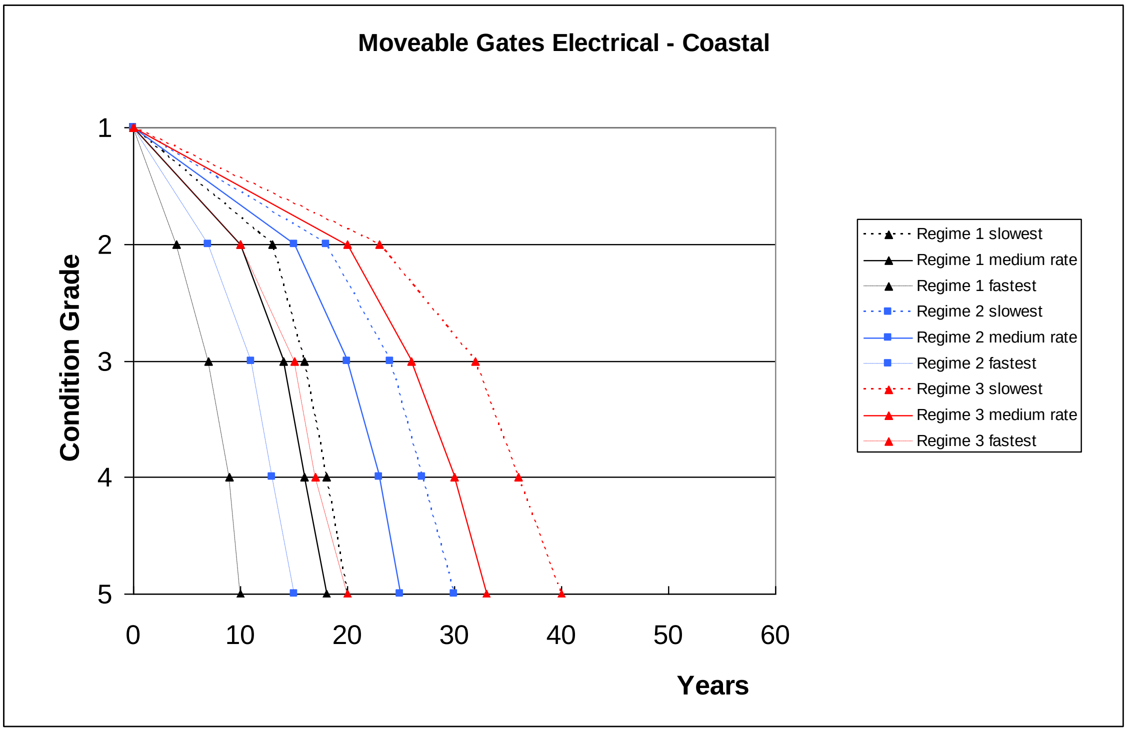
AIMS asset classification: Structure/control gate

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



Assumptions:

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

Maintenance Regime 1: Low/Basic 'do minimum'. 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 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, switches, bulbs, sensors and batteries), 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). Able to maintain at CG 3 (or better) for 35 years (fluvial) and 23 years (coastal) on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent 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, switches, bulbs, sensors and batteries), 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). Able to maintain at CG 2 (or better) for 38 years (fluvial) and 26 (coastal) on this basis (at medium deterioration rate).

Fluvial slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, and 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, and 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.

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

Notes on model construction – moveable gates: electrical

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from moveable gates manual with shorter times to transitions for poorer grades leading to shorter life assets overall.
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract suggests that assets can have longer life than deterioration curve predicts, e.g. CG 1 at 155 years and CG 2 at 60 years, otherwise general agreement. (Note: Data set does not distinguish between manual and electrical assets)
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from fluvial with increased deterioration due to more severe environment
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves. One CG 4 asset at 7 years indicates more rapid deterioration than the fastest deterioration rate model. (Note: Data set does not distinguish between manual and electrical assets)
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: moveable gates: electrical

Fluvial environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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 the Wiring Regulations. With low/basic maintenance the asset life at CG 5 could be 38 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal/clearance, minor repairs to the corrosion protection systems, routine lubrication, oil level checks, oil/filter/breather replacement, chain drive tensioning, replacing gate and oil seals and replacing small motors (<4kW), telemetry, PLCs (Programmable Logic Controllers), switches, bulbs, sensors and batteries, etc. 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 is considered a refurbishment activity and therefore not counted. With appropriate manufacturer's maintenance the asset life at CG 5 could be 45 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	For the purpose of this model, only the basic H&S maintenance has been applied. No channel or gate maintenance is applied. With low/basic maintenance the asset life at CG 5 could be 28 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris

Rate	Maintenance Regime	Assumptions
		removal/clearance, minor repairs to the corrosion protection systems, routine lubrication, oil level checks, oil/filter/breather replacement, chain drive tensioning, replacing gate and oil seals and replacing small motors (<4kW), telemetry, PLCs, switches, bulbs, sensors and batteries, etc. 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 is considered a refurbishment activity and therefore not counted. With appropriate manufacturer's maintenance the asset life at CG 5 could be 40 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Fastest	1	For the purpose of this model, only the basic H&S maintenance has been applied. No channel or gate maintenance is applied. With low/basic maintenance the asset life at CG 5 could be 15 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal/clearance, minor repairs to the corrosion protection systems, routine lubrication, oil level checks, oil/filter/breather replacement, chain drive tensioning, replacing gate and oil seals and replacing small motors (<4kW), telemetry, PLCs, switches, bulbs, sensors and batteries, etc. 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 is considered a refurbishment activity and therefore not counted. With appropriate manufacturer's maintenance the asset life at CG 5 could be 25 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

Coastal/estuarine environment:

Rate	Maintenance Regime	Assumptions
Slowest	1	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 the Wiring Regulations. With low/basic maintenance the asset life at CG 5 could be 20 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal/clearance, minor repairs to the corrosion protection systems, routine lubrication, oil level checks, oil/filter/breather replacement, chain drive tensioning, replacing gate and oil seals and replacing small motors (<4kW), telemetry, PLCs, switches, bulbs, sensors and batteries, etc. 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 is considered a refurbishment activity and therefore not counted. With appropriate manufacturer's maintenance the asset life at CG 5 could be 30 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Medium	1	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 the Wiring Regulations. With low/basic maintenance the asset life at CG 5 could be 18 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris

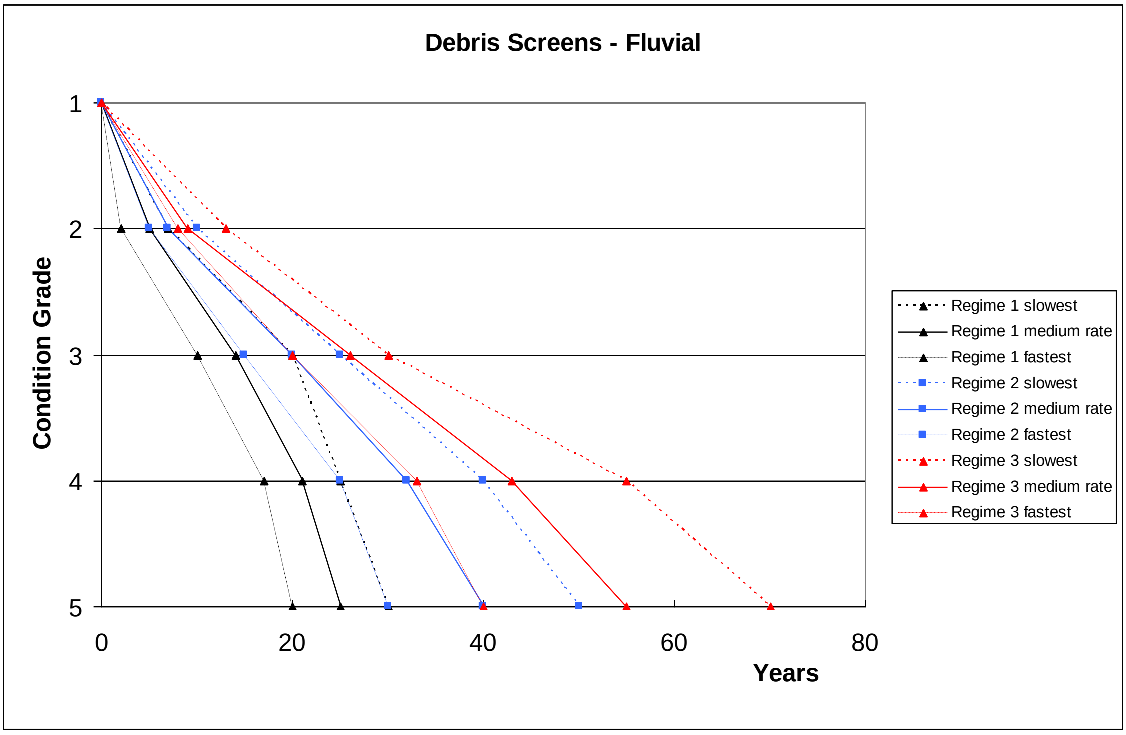
Rate	Maintenance Regime	Assumptions
		removal/clearance, minor repairs to the corrosion protection systems, routine lubrication, oil level checks, oil/filter/breather replacement, chain drive tensioning, replacing gate and oil seals and replacing small motors (<4kW), telemetry, PLCs, switches, bulbs, sensors and batteries, etc. 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 is considered a refurbishment activity and therefore not counted. With appropriate manufacturer's maintenance the asset life at CG 5 could be 25 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.
Fastest	1	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 the Wiring Regulations. With low/basic maintenance the asset life at CG 5 could be 10 years.
	2	The Environment Agency 'Maintenance Standards Manual' does not cover these types of asset. Therefore maintenance/inspections assumptions are based on manufacturer/industry requirements. For this model the following inspection and maintenance tasks have been assumed (additional to those in Regime 1): Debris removal/clearance, minor repairs to the corrosion protection systems, routine lubrication, oil level checks, oil/filter/breather replacement, chain drive tensioning, replacing gate and oil seals and replacing small motors (<4kW), telemetry, PLCs, switches, bulbs, sensors and batteries, etc. 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 is considered a refurbishment activity and therefore not counted. With appropriate manufacturer's maintenance the asset life at CG 5 could be 15 years.
	3	The curve for this regime has been derived by formula – Regime 3 is an improvement on Regime 2, as Regime 2 is on Regime 1.

A.2.15 Debris screens (fluvial)

AIMS asset classification: Structure/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



Assumptions:

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

Maintenance Regime 1: Low/Basic 'do minimum'. 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 minor repair works, surface damage repair, bar replacement, fixing point repair and headwall repair 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 32 years on this basis (at medium deterioration rate).

Maintenance Regime 3: High, maintain CG 2. Frequent maintenance including 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). Able to maintain at CG 2 (or better) for 26 years on this basis (at medium deterioration rate).

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 continued 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 at the extreme ends of use (either high or no flow) 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.

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).

Notes on model construction – debris screens

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	No Phase 1 curve available. Deterioration curves developed through consideration of deterioration processes in these structures
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract suggests variable asset performance which is not always consistent with deterioration curves. For example CG 4 asset at 5 years of age and CG 3 asset at 4 years of age. Contrary to this a CG 1 asset recorded at 22 years of age.
Site survey	N	Not applicable
Workshop	N	Not applicable

Additional comments: debris screens

Rate	Maintenance Regime	Assumptions
Slowest	1	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. However, reactive obstruction removal is undertaken otherwise screens would block up and the asset would become inoperable.
	2	Maintenance tasks over and above those in Regime 1 include: inspections, headwall and screen repairs (including; surface repairs, fixing point repairs, headwall repairs, etc), regular clearance of debris and vegetation from the screen and the surrounding channel, and de-silting. 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. Refurbishment is: replacement of screens and fixings and major works to the headwall.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade).
Medium	1	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. However, reactive obstruction removal is undertaken otherwise screens would block up and the asset would become inoperable.
	2	Maintenance tasks over and above those in Regime 1 include: inspections, headwall and screen repairs (including; surface repairs, fixing point repairs, headwall repairs, etc), regular clearance of debris and vegetation from the screen and the surrounding channel, and de-silting. 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. Refurbishment is: replacement of screens and fixings and major works to the headwall.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade).
Fastest	1	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. However, reactive obstruction removal is undertaken otherwise screens would block up and the asset would become inoperable.
	2	Maintenance tasks over and above those in Regime 1 include: inspections, headwall and screen repairs (including; surface repairs, fixing point repairs, headwall repairs, etc), regular clearance of debris and vegetation from the screen and the surrounding channel, and de-silting.

Rate	Maintenance Regime	Assumptions
		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. Refurbishment is: replacement of screens and fixings and major works to the headwall.
	3	Maintenance tasks are as per Regimes 1 and 2. Maintenance activities would target maintaining the asset to CG 2 (Target Condition Grade).

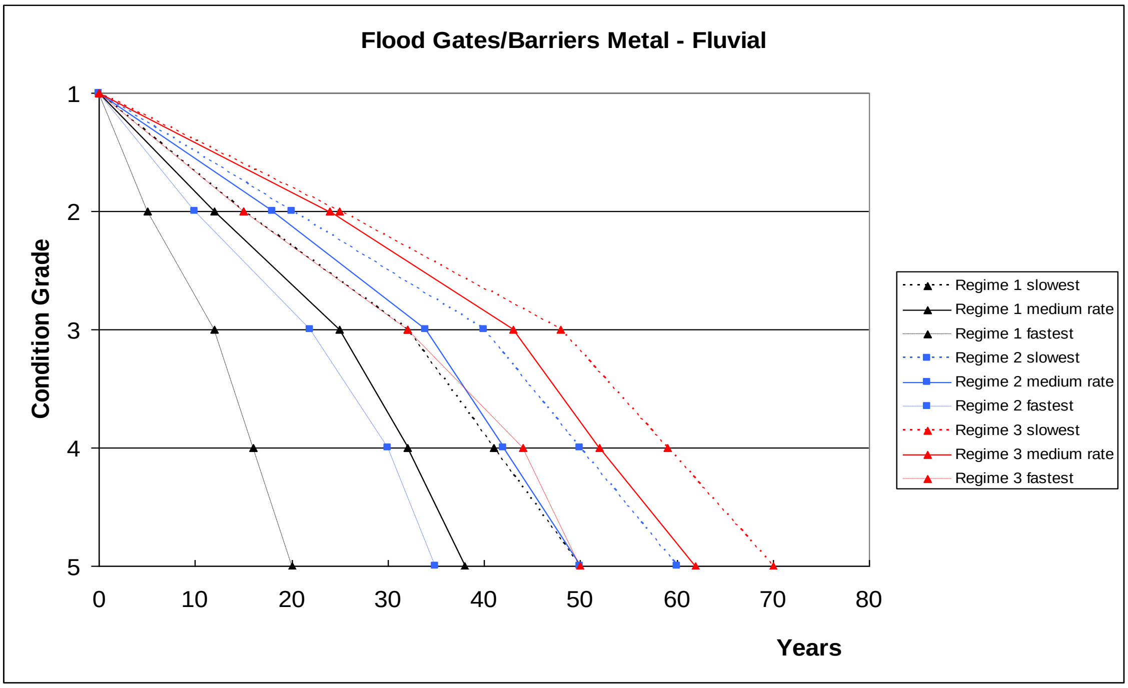
A.2.16 Flood gates and barriers (fluvial and coastal/estuarine)

A.2.16.1 Metal

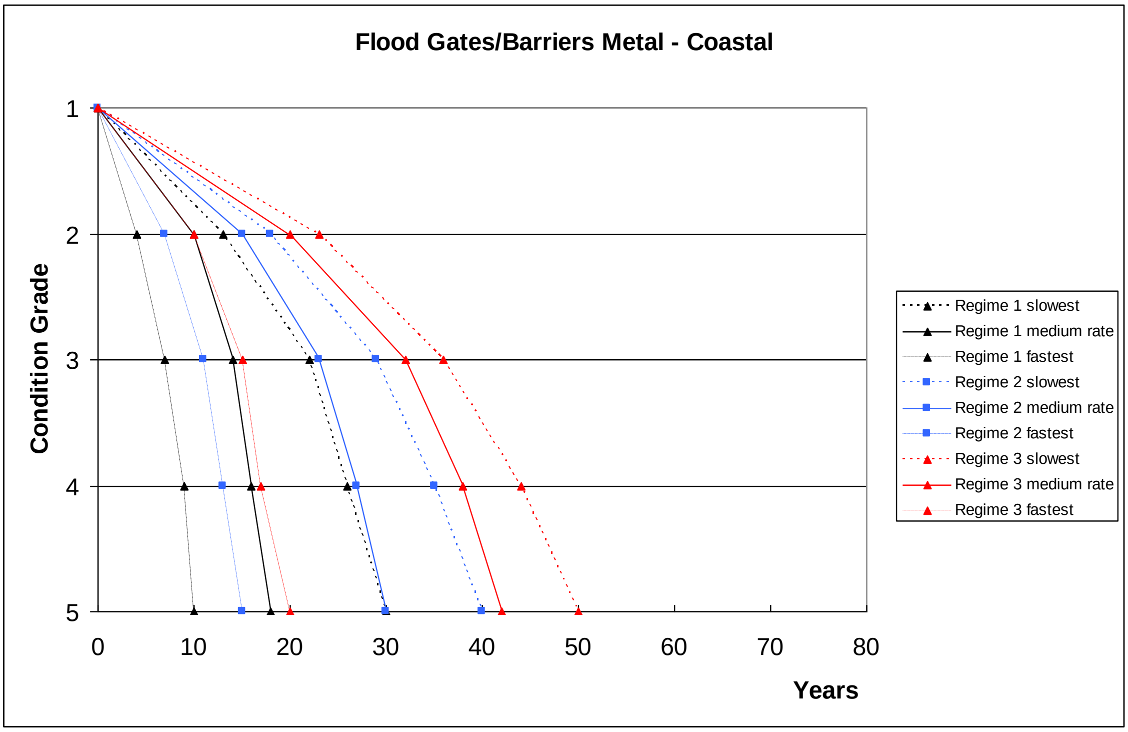
AIMS asset classification: Structure/control gate

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



Assumptions:

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.

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

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). Able to maintain at CG 3 (or better) for 42 years (fluvial) and 27 years (coastal) on this basis (at medium deterioration rate).

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). Able to maintain at CG 2 (or better) 43 years (fluvial) and 32 years (coastal) on this basis (at medium deterioration rate).

Fluvial slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, and 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, and 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

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

Notes on model construction – flood gates and barriers: metal

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from moveable gates manual
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Some low life assets recorded at CG 4 (e.g. 5 years of age), otherwise general agreement
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

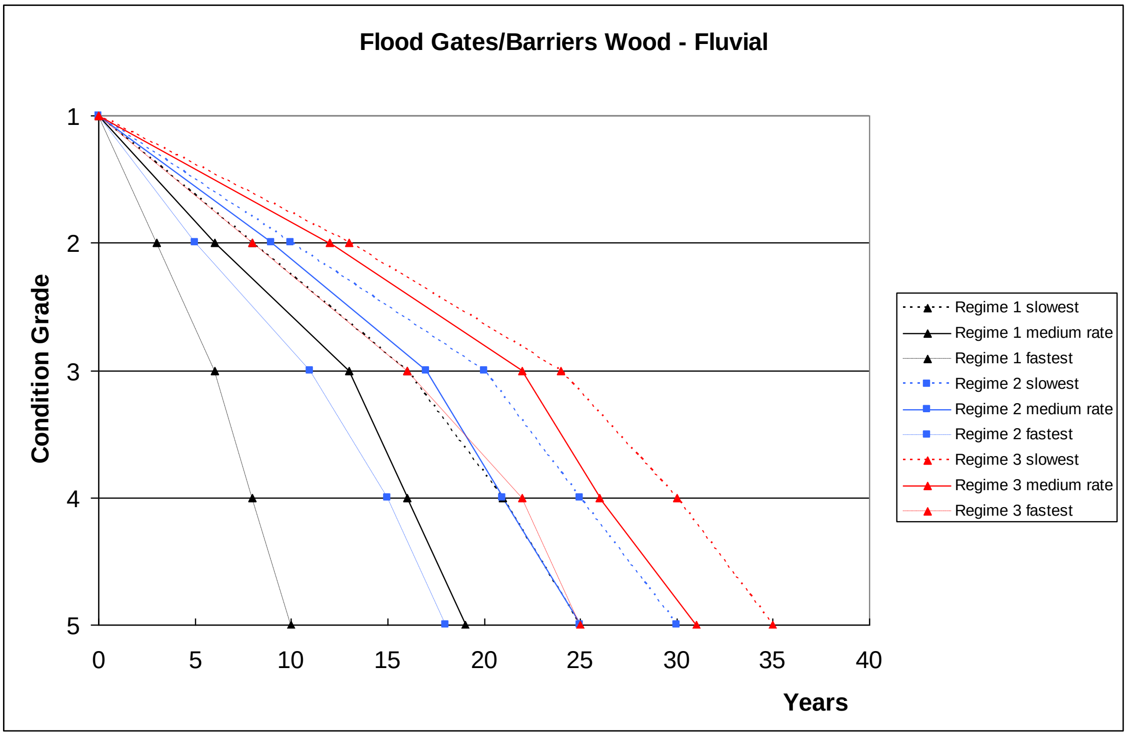
Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from fluvial with increased deterioration due to more severe environment (equivalent to moveable gates – metal coastal)
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves although long life assets recorded at CG 4 (57 years old)
Site survey	N	Not applicable
Workshop	N	Not applicable

A.2.16.2 Wood

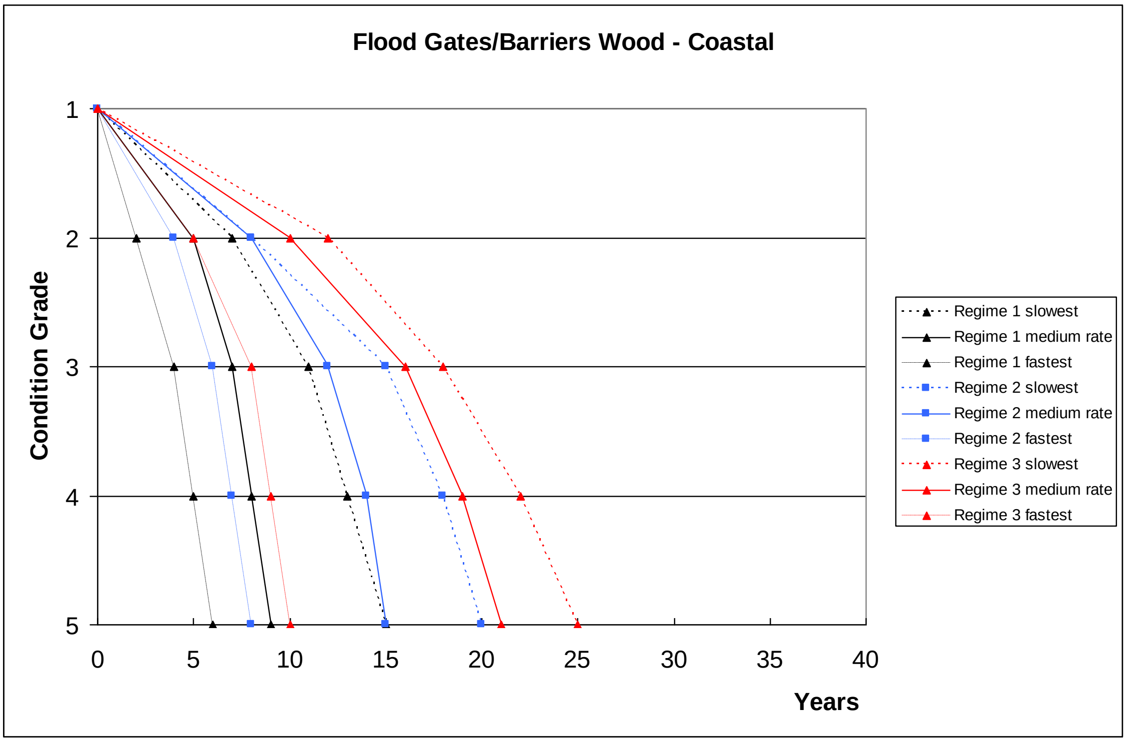
AIMS asset classification: Structure/control gate

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



Assumptions:

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.

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

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).

Fluvial slowest rate: The gate material quality is appropriate for the environment/location, construction is of a good quality, and 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, and 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.

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

Notes on model construction – flood gates and barriers: wood

Fluvial:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from Flood Gates and barriers metal (fluvial), assumed to be half time (rounded up) of these metal defences
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Some long life assets recorded at CG 3 (e.g. 52 years of age), otherwise general agreement
Site survey	N	Not applicable
Workshop	N	Not applicable

Coastal/estuarine:

Evidence	Available Y/N?	Comments
Phase 1 curve and commentary	N	Deterioration curves developed from flood gates and barriers metal (coastal), assumed to be half time (rounded up) of these metal defences
Phase 1 interview	Y	Interviews provided no relevant information for constructing deterioration curves for this asset group
NFCDD database	Y	Data extract in general agreement with deterioration curves
Site survey	N	Not applicable
Workshop	N	Not applicable

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