File Note

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Project title	Bristol Avon Flood Strategy	Job number	260498
cc		File reference	
Prepared by	Daniel Bevan Damien Canning	Date	19 October 2020
Subject	Carbon Assessment		

1 Introduction

Bristol City Council (BCC) commissioned Ove Arup and Partners Ltd. (Arup) to update the River Avon Tidal Flood Risk Management Strategy previously undertaken by AECOM ('the Strategy'). Arup has undertaken a review of the Strategy and an update to the flood risk modelling to include fluvial flood risk alongside the tidal flood risk previously included by AECOM. This acknowledges the interaction between both tidal and fluvial flows in Bristol and the need for flood defences given the potential for flood events resulting from exceptional flows of both or either systems.

As with any city located close to rivers and the sea, Bristol has experienced many flood events in its past and has a long history of interaction with the River Avon, the Severn Estuary and other waterbodies in the region. The city centre is largely developed around these key waterbodies and over the years has experienced increasing flood events that have been caused by increased river/fluvial flows during storm events and also through surges of water via the Severn Estuary creating a tidal food up the river system. In recent years, communities across the UK have experienced increased levels of flooding causing disruption, damage to infrastructure and danger to life. Increasing sea levels and storm events caused by climate change mean the risk of flooding is increasing. The impact would be felt across the West of England due to Bristol's regional importance for employment, transport, recreation, tourism and economic growth.

Bristol City Council is working with the Environment Agency and key stakeholders to create a vital long-term strategy to protect the city from increased flood events, supported by Arup. The Strategy includes the provision of flood defence infrastructure to manage the risk from River Avon flooding to the centre of Bristol with placemaking to seek opportunities for inclusive growth, quality of life, environment and resilience.

The amended Strategy has reviewed the preferred option through technical assessments and maintains the core approach of the preferred option comprising of the construction of Low and High defences, however the time periods in which they are implemented have been amended into the following two Epochs as outlined in Table 1. The Low defences will be constructed to a 1 in 200-year standard of protection for 2065. The upgraded High defences will provide a 1 in 200-year standard of protection for 2125.

Table 1 – Defences implemented by Epoch

AECOM Strategy 2017	Amended Arup Strategy 2020
Epoch 1 (Low defences) – 2015-2030	
Epoch 2 (Low defences) – 2030 to 2065	Epoch 1 (Low defences) – 2024 to 2065
Epoch 3 (High defences) – 2065 to 2115	Epoch 2 (High defences) – 2065 to 2125

2 Assessment boundary

The Environment Agency's (EA) 'ERIC' Carbon Planning tool used for this assessment enables whole-life carbon modelling across all lifecycle stages of constructed assets. The ERIC Carbon Modelling Tool (CMT) (see Appendix A1) provides a top-down whole-life carbon assessment, designed to be used at Strategic Outline Case (SOC) stage.

As design activities progress and more data becomes available, a detailed bottom-up assessment should be undertaken, using the Eric Carbon Calculator (CC) tool, and should be incrementally built up during the delivery phase, following selection of a preferred project solution option.

This will help ensure a balanced perspective by highlighting the gross size/scale of emissions and when they occur. In this way informed decisions can be made supporting optimum low carbon outcomes.

3 Basis of design

Two options – 'Option 1' and 'Option 2' – were considered as part of the assessment. Both options have been modelled for their footprint within the CMT. BCC wish to test the sensitivity of the preferred strategic approach (option 1), and a strategic approach whereby raised defences were combined with a tidal barrier (option 2). As such a comparator carbon assessment was considered.

Option 1 involves constructing defences in the 2020s which are to be raised further in 2065, the preferred strategic approach outlined above.

Option 2 involves constructing defences in 2020s as in Option 1, but then to construct a 'narrow' tidal barrier instead of raising the defences. A series of assets and quantities were included within the cost model build-up for Phase 1 of the build. Additionally, drawings of the Chocolate Path remedial works and the proposed tidal gate for Option 2 were provided. The key information used in the assessment is summarised in Table 2 in the next section

The raised defences are shown in Figure 1.

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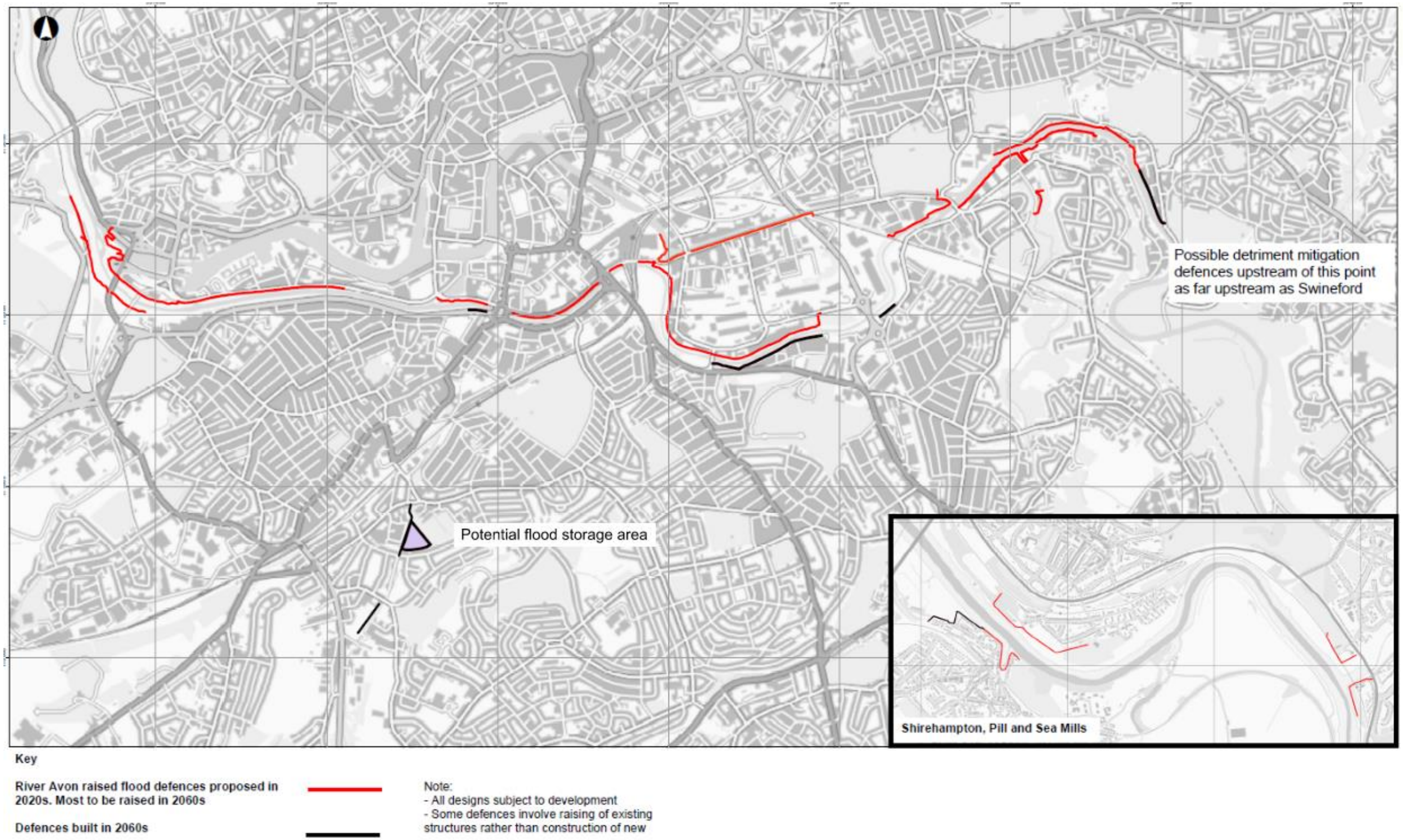


Figure 1: Flood defences for the preferred strategic option (option 1). Note no new defences would be built or existing defences raised in the 2060s for option 2

4 Methodology

4.1 Source information

Information to inform this carbon baseline assessment has been obtained from the following data sources:

- Costing of flood defences for Bristol Flood Strategy spreadsheet;
- Bristol Flood Strategy Required Costing Rates spreadsheet;
- Design drawings;
- Discussion/email correspondence with design teams;
- 2018 Bridgwater Barrier carbon assessment (currently being amended to take into account latest design in advance of OBC submission); and
- Pre-modelled packages for flood defence and other components available in the CMT (Version 7.2).

4.2 Tools used

The EA's Whole Life (Construction) Carbon Planning (ERIC) Tool provides a mechanism through which to assess carbon over the whole life of constructed assets. The ERIC tool is made up of two components:

- CMT: At SOC stage, the CMT is to be used to identify low carbon solutions that may be taken forward and to establish the carbon baseline for the project. A high-level carbon assessment 'top-down' approach is made using the CMT; and
- CC: At OBC stage, the CC allows for a detailed 'bottom-up' whole life carbon assessment, incrementally built up during the delivery phase, following selection of a preferred project solution option.

Appendix A2 details how the ERIC Carbon Planning Tools work and also contains a methodology document.

4.3 Cut-off rules

The following cut-off rules have been applied, where applicable, in accordance with best practice.

'Where robust data is not available, and the carbon equivalent impact of an activity is estimated to account for no more than 1% of the total impact of that module, that activity can be omitted from the assessment. Justification and supporting evidence for this estimation should be provided.

The proportion of total neglected activities within a module, e.g. per module A1-A3, A4-A5, C1-4 and module D (where calculated) will not exceed 5% of the total impact within that module.

Although this rule will be upheld where possible, at the screening stage not all details of the project will be known and this this cut-off criteria can be exceeded where the corresponding impact can be deemed negligible and justified.

Carbon emissions of complex composite items or systems, for example Signalling and telecoms and Fit-out of complex mechanical & electrical (M&E) building services with a high number of complex components, can be excluded providing justification is provided as to why this has taken place and is consistent.

Where project scope and contracted works includes both civil engineering and complex systems formal capital carbon assessment must be applied to the civil engineering works, but the elements involving complex services, need only be included on a voluntary basis.'

4.4 Footprinting approach

Table 2: Carbon footprint assessment approach

Option	Primary asset	Value[1]	Length (m)	ERIC tool benchmark	Notes/assumptions
Option 1 and 2 (Phase 1)	Reinforced Concrete wall (<1.2m)	5.77 m^3 per m length	320	Tidal Wall – Retaining - Concrete	Material breakdown not available. Assumed the same as RC wall on minipiles *without* piles. Source: Costing of flood defences for Bristol Flood Strategy spreadsheet; Bristol Flood Strategy Required Costing Rates spreadsheet.
	Reinforced Concrete wall (>1.2m)		218		
	Sheet Piled Wall (<100m length)	8.00m (height) per m	485		Source: Costing of flood defences for Bristol Flood Strategy spreadsheet; Bristol Flood Strategy Required Costing Rates spreadsheet.
	Sheet Piled Wall (>100m length)		2,694		
	1500d 23mL Contig Piled Wall	33,300 m^3	N/A		Source: Costing of flood defences for Bristol Flood Strategy spreadsheet
	1500d 19mL Contig Piled Wall	16,800 m^3	N/A		
	Terraced Wall on minipiles	64.9 m^3 per m length	495		Source: Costing of flood defences for Bristol Flood Strategy spreadsheet; Bristol Flood Strategy Required Costing Rates spreadsheet.
	RC wall on minipiles	8.52 m^3 per m length	942		
	RC wall on angled minipiles	3.48 m^3 per m length	1,301		

[1] Values reported to three significant figures

Option	Primary asset	Value[1]	Length (m)	ERIC tool benchmark	Notes/assumptions
	Floodgate	164 m^2 cross sectional area	N/A	Tidal Gate	Source: Bristol Flood Strategy Required Costing Rates spreadsheet.
	Ramps and embankments	284,000 m^3	N/A	Embankment - New	Source: Costing of flood defences for Bristol Flood Strategy spreadsheet.
	Floodwall on piles	16.0 m^3 per m length	858	Tidal Wall – Retaining - Concrete	Source: Costing of flood defences for Bristol Flood Strategy spreadsheet; Bristol Flood Strategy Required Costing Rates spreadsheet.
	Double Raked Piles	4.32 m^3 per m length	880		
	Lock gates	240 m^2 cross sectional area	N/A	Tidal Gate	Source: Bristol Flood Strategy Required Costing Rates spreadsheet.
	Brunel Dam raising	2,990 m^3	N/A	Tidal Wall – Retaining - Concrete	Source: Bristol Flood Strategy Required Costing Rates spreadsheet.
	Bathurst Dam raising	1,250 m^3	N/A		Source: Bristol Flood Strategy Required Costing Rates spreadsheet.
	Choc. Path remedials - Wall on piles	1,640 m^3	N/A		Source: Cumberland Road Works Information Drawings Vol 3 Pg. 6.
	Hard landscaping	3.00 m (width) per m length	270	Hard landscaping along section 1-8	Source: Discussion/email correspondence with Design Teams.
	Soft landscaping		7,715	Soft landscaping	
Option 1 (Phase 2/Wall raising)	Reinforced Concrete wall (<1.2m)	1.50 m^3 per m length	320		Assumption that walls are raised by 0.3 m as per correspondence with Design Team.

Option	Primary asset	Value[1]	Length (m)	ERIC tool benchmark	Notes/assumptions
	Reinforced Concrete wall (>1.2m)		218		
	1500d 23mL Contig Piled Wall	435 m^3	N/A		
	1500d 19mL Contig Piled Wall	265 m^3	N/A		
	RC wall on minipiles	1.50 m^3 per m length	942		
	RC wall on angled minipiles	1.20 m^3 per m length	1,301		
	Floodwall on piles	2.49 m^3 per m length	858		
	Terraced Wall on minipiles	0.30 m^3 per m length	495		Glass floodwall in designs, however there is no equivalent benchmark available in the ERIC tool. Wall raising therefore assumed with concrete.
	Double Raked Piles	2.54 m^3 per m length	880		
Option 2 (Phase 2)	Tidal barrier concept (Tidal walls)	83,500 m^3	N/A	Tidal Wall – Retaining - Concrete	Source (Tidal walls, control building, compound): Tidal Barrier Concept Design Source (Tidal gate): EA Bridgewater Barrier carbon assessment – footprint of 40 m wide Bridgewater Barrier multiplied by three to approximate that for the 120 m wide Bristol tidal gate.
	Tidal barrier concept (Tidal gate)	1,500 m^2	N/A	Tidal Gate	
	Tidal barrier concept	455 m^2	N/A	Control Building	

Option	Primary asset	Value[1]	Length (m)	ERIC tool benchmark	Notes/assumptions
	(Control building)				
	Tidal barrier concept (Compound)	7,600 m^2	N/A	Path / Track / Road	

5 Results

The carbon baseline developed in this study indicates that the total Whole Life Carbon (WLC) emissions for Option 1 and 2 amounts to approximately 1,540,000 tCO_2e and 2,250,000 tCO_2e, respectively (see Figure 1). The carbon footprint of the whole lifecycle of an infrastructure scheme refers to the capital/construction (A1-A5), operational (B1-B3), replacement (B4), refurbishment (B5), demolition (C1-C2) and residual (D) stages, where the lifecycle stage reference codes are based on those outlined in BS EN 15804, BS EN 15978 and PAS 2080.

Figure 2: Total WLC emissions for Option 1 and Option 2

This study demonstrates that the operational stage (which includes maintenance and repair) accounts for the largest proportion of carbon consumption for both Option 1 and 2 at approximately 1,230,000 tCO_2e and 1,800,000 tCO_2e, respectively (or 79.7% and 80.1% of the total WLC emissions). Construction accounts for 19.1% and 19.5% in both Option 1 and 2, respectively. Discounting the residual emissions, for which the CMT returned a net negative value (see Limitations), the demolition stage accounts for the smallest proportion of the WLC footprint at 308 tCO_2e and 456 tCO_2e for Option 1 and 2, respectively (or 0.02% in both cases). The remainder of the emissions can be seen summarised Table 3, Figure 3 and Figure 4.

Table 3: WLC emissions category summary

Emissions stage	Footprint, tCO_2e[2]	
	Option 1	Option 2
A1-A3 (Capital – Materials)	56,100	83,200
A4 (Capital – Transport)	63,600	96,900
A5 (Capital – Installation)	175,000	259,500
B1 (Operational - Use)	11.0	89.0
B2 (Operational – Maintenance)	1,090,000	1,590,000

[2] Values reported to three significant figures.

Emissions stage	Footprint, tCO_2e[2]	
	Option 1	**Option 2**
B3 (Operational – Repair)	143,000	209,000
B4 (Replacement)	19,500	19,200
B5 (Refurbishment)	474	-96.0
C1-C2 (Demolition)	308	456
D (Residual)	-1,260	-1,280
Whole Life Carbon (Total)	1,540,000	2,260,000

Figure 3: Option 1 WLC emissions category summary

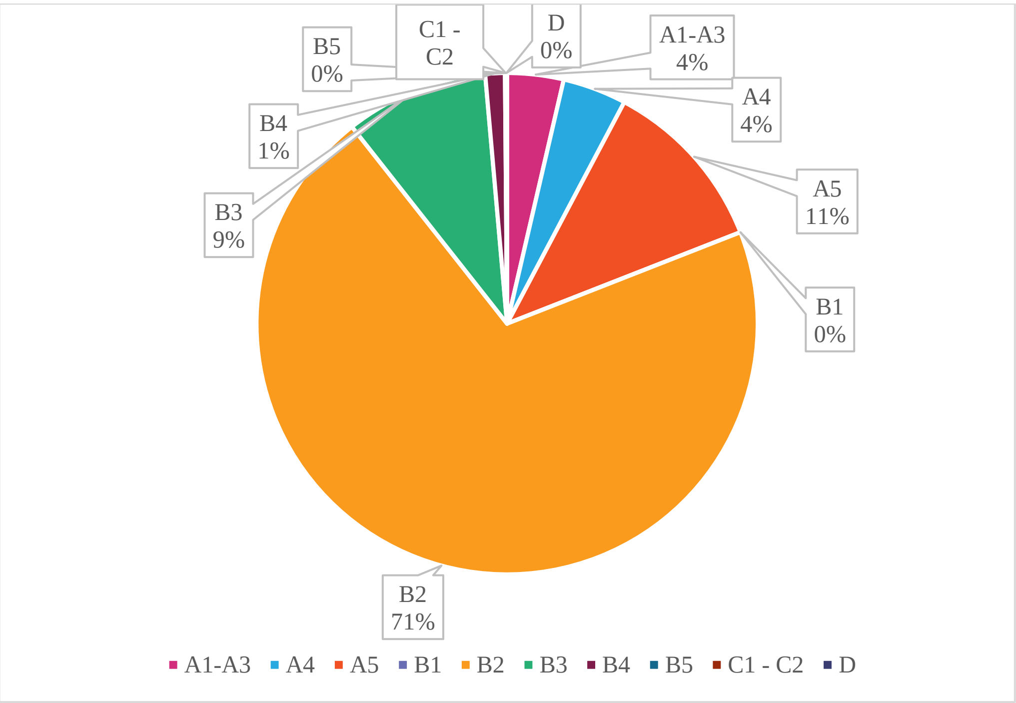
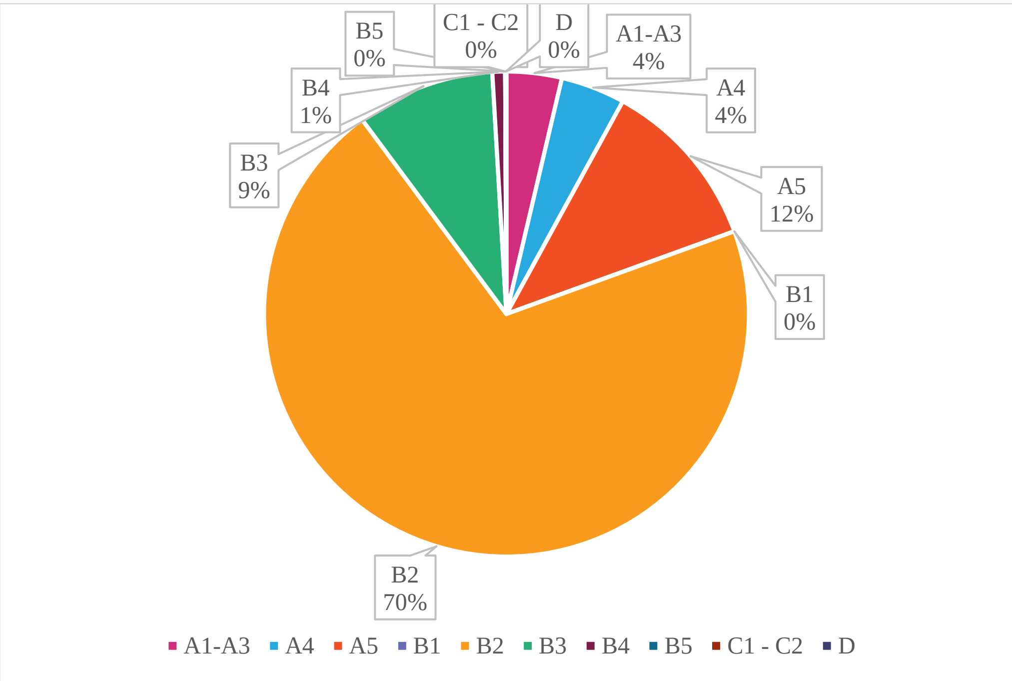


Figure 4: Option 2 WLC emissions category summary



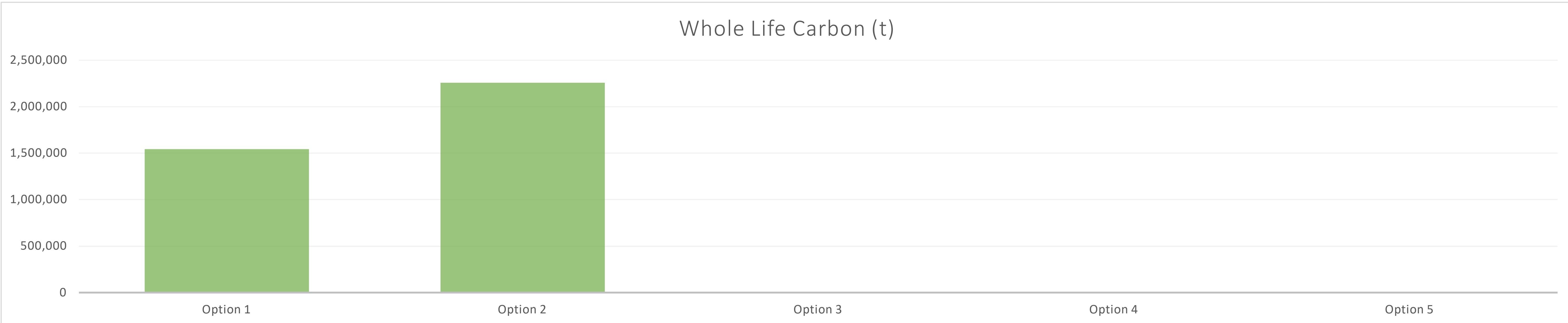
6 Limitations and next steps

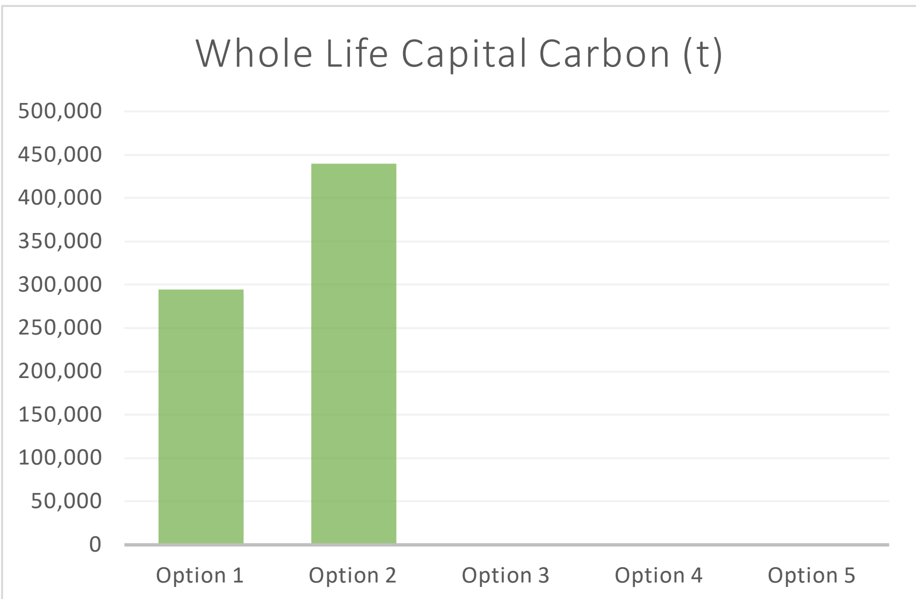
- This study is limited by the fact that the ERIC CMT only accounts for a limited number of built-in benchmarks and without a more specific Bill of Quantities, a more specific footprint profile is not able to be built;
- The CMT returns negative footprint values in a number of areas (total negative emissions stands at approximately 8.4 ktCO_2e for Option 1 and 13.7 ktCO_2e for Option 2) – this is a known fault in the model and is expected to be resolved in the newest revision of the tool due to be released by the end of 2020; and
- Benchmarks relating to soft landscaping (green infrastructure) were utilised for modelling the impact of landscape-related interventions. However, the benchmark only accounts for carbon emissions associated with the delivery and placing of materials and components and not for the impact these activities have on enhancing the associated increase in sequestration potential. An assessment of sequestration benefits is recommended in order to establish a holistic picture of the full impact/benefit of the scheme.

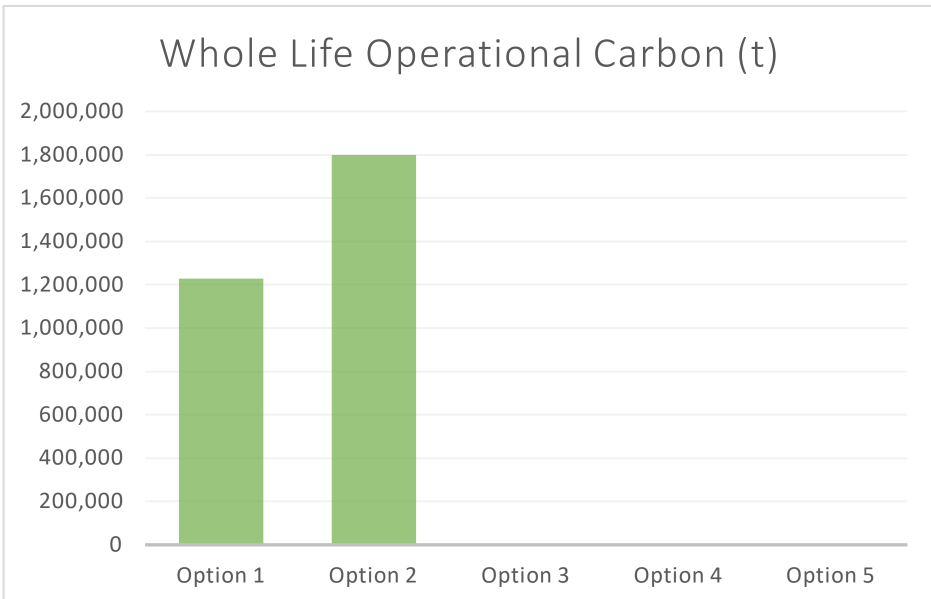
A1 Whole Life (Construction) Carbon Planning Tool - Carbon Modelling Tool

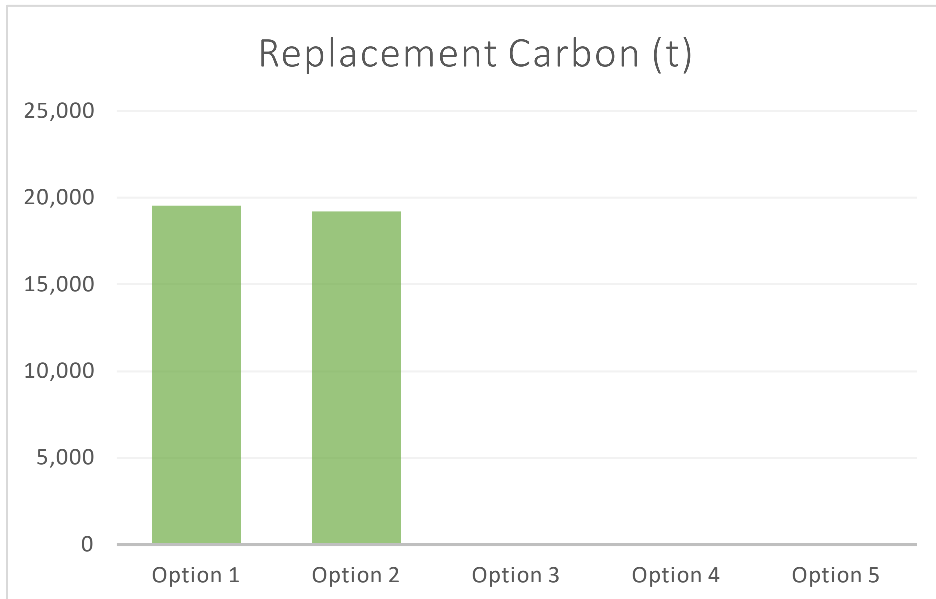
Carbon Optioneering Summary

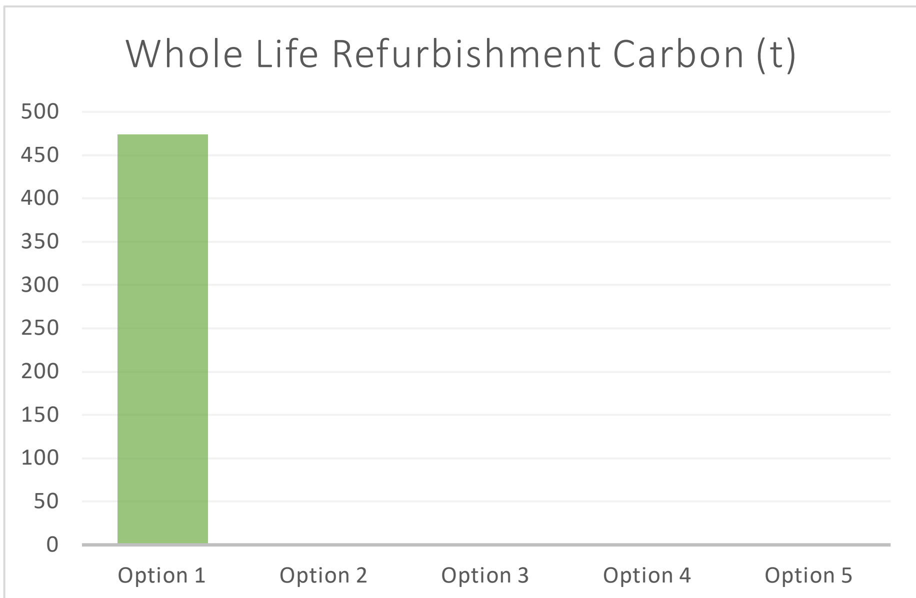
SOP	Contractor Name	Date Produced
		13/10/2020
Project Name	**Contractor Project No.**	**Version**
Bristol Flood Strategy		1
Project Manager	**Project Manger**	**Produced by**
		Daniel Bevan
Project Executive		

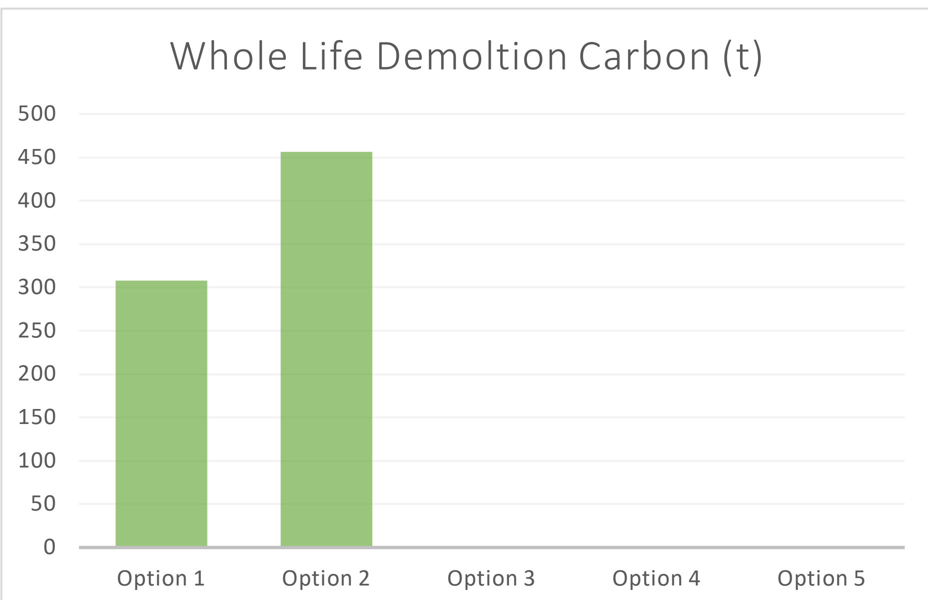


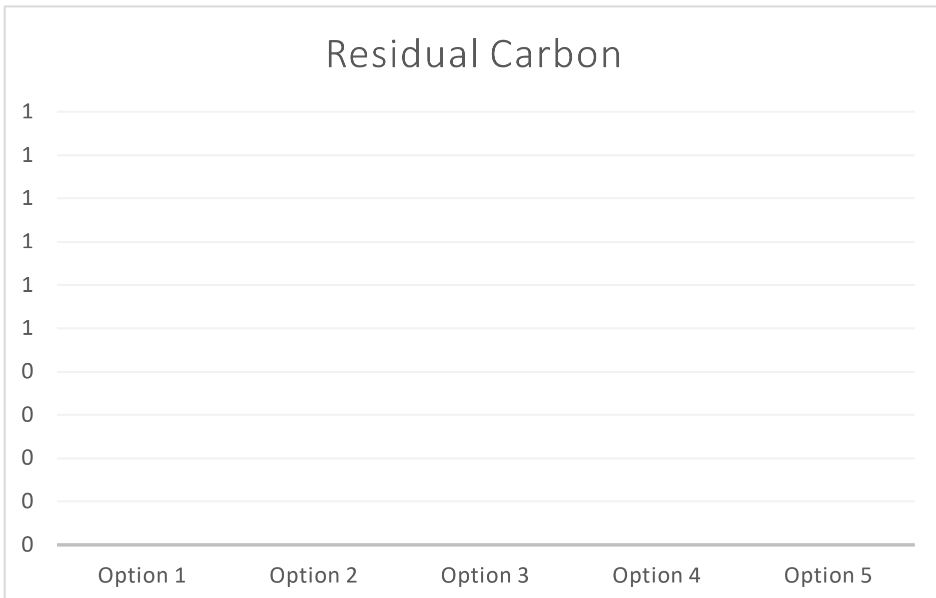












	Preferred Option				
Stage	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Capital carbon (A1-A5) (tCO2e)	294,478	439,561	0	0	0
Operational carbon (B1-B3) (tCO2e)	1,229,323	1,798,391	0	0	0
Replacement carbon (B4) (tCO2e)	19,543	19,215	0	0	0
Refurbishment carbon (B5) (tCO2e)	474	0	0	0	0
Demolition carbon (C) (tCO2e)	308	456	0	0	0
Residual carbon (D) (tCO2e)	0	0	0	0	0
Whole Life carbon (tCO2e)	1,543,350	2,256,747	0	0	0
Whole Life carbon - slope uncertainty (%)	35	35	0	0	0

Group All | Show

Select Preferred Option 1

		Capital - Materials (A1) (tonnes CO_2e)	Capital - Transport (A2) (tonnes CO_2e)	Capital - Installation (A5) (tonnes CO_2e)	Operational - Use (B1) (tonnes CO_2e)	Operational - Maintenance (B2) (tonnes CO_2e)	Operational - Repair (B3) (tonnes CO_2e)	Operational - Energy (B1) (tonnes CO_2e)	Replacement - Materials (B4) (tonnes CO_2e)	Replacement - Transport (B4) (tonnes CO_2e)	Replacement - Installation (B4) (tonnes CO_2e)	Refurbishment (B5) (tonnes CO_2e)	Demolition (C1 -C2) (tonnes CO_2e)	Residual (D) (tonnes CO_2e)	Whole Life Carbon (tonnes CO_2e)	Whole Life carbon - slope uncertainty
Option 1	**Preferred Option**	56,145	63,596	174,736	11	1,086,737	142,576	0	20,556	655	-1,668	474	308	-1,263	1,543,350	
Option 2		83,153	96,931	259,477	89	1,589,634	208,668	0	20,107	1,133	-2,025	-96	456	-1,279	2,256,747	
Option 3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Option 4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Option 5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Option 1 — Preferred Option

Add

Asset	Asset Description	Asset Unit	Asset Measurement	Capital - Materials	Capital - Transport	Capital - Installation	Operational - Use	Operational - Maintenance	Operational - Repair	Operational - Energy	Replacement - Materials	Replacement - Transport	Replacement - Installation	Refurbishment	Demolition	Residual	Whole Life Carbon	Whole Life carbon - slope uncertainty (%)
Tidal Wall - Retaining - Concrete	Reinforced Concrete wall (>1.2m)	m3	1258	399	522	1,436	0	8,847	1,179	0	-21	-3	-19	-21	-6	0	12,315	36
Tidal Wall - Retaining - Sheetpiled	Sheet Piled Wall (<100m length)	m2	3880	970	32	-4	2	-106	-13	0	1,625	129	21	300	105	-110	2,957	34
Tidal Wall - Retaining - Concrete	Reinforced Concrete wall (<1.2m)	m3	1846	586	766	2,108	0	12,987	1,731	0	-31	-4	-28	-30	-8	0	18,077	36
Tidal Wall - Retaining - Sheetpiled	Sheet Piled Wall (>100m length)	m2	21552	5,390	176	-23	10	-587	-70	0	9,027	719	115	1,664	584	-611	16,427	34
Tidal Wall - Retaining - Concrete	1500d 23mL Contig Piled Wall	m3	33328	10,579	13,825	38,058	0	234,438	31,254	0	-553	-79	-498	-547	-149	0	326,327	36
Tidal Wall - Retaining - Concrete	600d 10mL Contig Piled Wall	m3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36
Tidal Wall - Retaining - Concrete	1500d 19mL Contig Piled Wall	m3	16788	5,329	6,964	19,170	0	118,089	15,743	0	-279	-40	-251	-276	-75	0	164,375	36
Tidal Wall - Retaining - Concrete	750d 14mL Contig Piled Wall	m3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36
Tidal Wall - Retaining - Concrete	Terraced Wall on minipiles	m3	32111	10,193	13,320	36,668	0	225,877	30,113	0	-533	-76	-480	-527	-143	0	314,410	36
Tidal Wall - Retaining - Concrete	RC wall on minipiles	m3	8025	2,547	3,329	9,164	0	56,452	7,526	0	-133	-19	-120	-132	-36	0	78,579	36
Tidal Wall - Retaining - Concrete	RC wall on angled minipiles	m3	4527	1,437	1,878	5,170	0	31,847	4,246	0	-75	-11	-68	-74	-20	0	44,330	36
Tidal Gate	Floodgate	m2	164	23	25	54	0	0	35	0	28	22	51	102	28	-32	343	31
Embankment - New	Ramps & embankments	m3	284491	688	254	1,015	-1	17,841	-4	0	1,887	3	299	237	207	-437	22,389	38
Tidal Wall - Retaining - Concrete	Floodwall on piles (3)	m3	13685	4,344	5,677	15,627	0	96,264	12,833	0	-227	-33	-204	-225	-61	0	133,995	36
Tidal Wall - Retaining - Concrete	Double Raked Piles	m3	3802	1,207	1,577	4,341	0	26,741	3,565	0	-63	-9	-57	-62	-17	0	37,222	36
Tidal Gate	Lockgates at sections 1-5 and 8-7	m2	240	33	36	79	0	0	52	0	41	32	75	150	41	-48	504	31
Tidal Wall - Retaining - Concrete	Brunel Dam raising at section 1-9	m3	2993	950	1,242	3,418	0	21,055	2,807	0	-50	-7	-45	-49	-13	0	29,308	36
Tidal Wall - Retaining - Concrete	Bathurst Dam raising at section 4-	m3	1250	397	519	1,427	0	8,793	1,172	0	-21	-3	-19	-21	-6	0	12,239	36
Tidal Wall - Retaining - Concrete	Piled Wall (<100m length) capping	m3	2704	858	1,122	3,088	0	19,020	2,536	0	-45	-6	-40	-44	-12	0	26,474	36
Tidal Wall - Retaining - Concrete	Piled Wall (>100m length) capping	m3	15019	4,767	6,230	17,150	0	105,647	14,084	0	-249	-36	-224	-247	-67	0	147,056	36
Tidal Wall - Retaining - Concrete	Choc. Path remedials (wall)	m3	955	303	396	1,091	0	6,718	896	0	-16	-2	-14	-16	-4	0	9,351	36
Tidal Wall - Retaining - Concrete	Choc. Path remedials (piles)	m3	683	217	283	779	0	4,802	640	0	-11	-2	-10	-11	-3	0	6,684	36
Tidal Wall - Retaining - Concrete	ising - Reinforced Concrete wall (	m3	327	104	136	373	0	2,300	307	0	-5	-1	-5	-5	-1	0	3,202	36
Tidal Wall - Retaining - Concrete	ising - Reinforced Concrete wall (	m3	480	152	199	548	0	3,376	450	0	-8	-1	-7	-8	-2	0	4,700	36
Tidal Wall - Retaining - Concrete	raising - 1500d 23mL Contig Piled	m3	4347	1,380	1,803	4,964	0	30,579	4,077	0	-72	-10	-65	-71	-19	0	42,564	36
Tidal Wall - Retaining - Concrete	raising - 1500d 19mL Contig Piled	m3	2651	841	1,100	3,027	0	18,646	2,486	0	-44	-6	-40	-44	-12	0	25,954	36
Tidal Wall - Retaining - Concrete	Wall raising - RC wall on minipiles	m3	1413	449	586	1,613	0	9,939	1,325	0	-23	-3	-21	-23	-6	0	13,835	36
Tidal Wall - Retaining - Concrete	l raising - RC wall on angled minip	m3	1561	496	648	1,783	0	10,982	1,464	0	-26	-4	-23	-26	-7	0	15,286	36
Tidal Wall - Retaining - Concrete	Wall raising - Flood wall on piles	m3	2136	678	886	2,440	0	15,028	2,003	0	-35	-5	-32	-35	-10	0	20,918	36
Tidal Wall - Retaining - Concrete	/all raising (glazed) - Terraced Wa	m3	149	47	62	170	0	1,045	139	0	-2	0	-2	-2	-1	0	1,454	36
Tidal Wall - Retaining - Concrete	raising (glazed) - Double Raked	m3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36
Hard Landscaping	ındscaping along section 1-8 (270	m2	810	779	8	3	0	119	0	0	10,473	111	43	517	23	-25	12,076	0
Soft Landscaping - Grassland	t landscaping along all other secti	m2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102
				56,145	63,596	174,736	11	1,086,737	142,576	0	20,556	655	-1,668	474	308	-1,263	1,543,350	

Option 2

Add Row

Asset	Asset Description	Asset Unit	Asset Measurement	Capital - Materials	Capital - Transport	Capital - Installation	Operational - Use	Operational - Maintenance	Operational - Repair	Operational - Energy	Replacement - Materials	Replacement - Transport	Replacement - Installation	Refurbishment	Demolition	Residual	Whole Life Carbon	Whole Life carbon - slope uncertainty (%)
Tidal Wall - Retaining - Concrete	Reinforced Concrete wall (>1.2m)	m3	1258	399	522	1,436	0	8,847	1,179	0	-21	-3	-19	-21	-6	0	12,315	36
Tidal Wall - Retaining - Sheetpiled	Sheet Piled Wall (<100m length)	m2	3880	970	32	-4	2	-106	-13	0	1,625	129	21	300	105	-110	2,957	34
Tidal Wall - Retaining - Concrete	Reinforced Concrete wall (<1.2m)	m3	1846	586	766	2,108	0	12,987	1,731	0	-31	-4	-28	-30	-8	0	18,077	36
Tidal Wall - Retaining - Sheetpiled	Sheet Piled Wall (>100m length)	m2	21552	5,390	176	-23	10	-587	-70	0	9,027	719	115	1,664	584	-611	16,427	34
Tidal Wall - Retaining - Concrete	1500d 23mL Contig Piled Wall	m3	33328	10,579	13,825	38,058	0	234,438	31,254	0	-553	-79	-498	-547	-149	0	326,327	36
Tidal Wall - Retaining - Concrete	600d 10mL Contig Piled Wall	m3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36
Tidal Wall - Retaining - Concrete	1500d 19mL Contig Piled Wall	m3	16788	5,329	6,964	19,170	0	118,089	15,743	0	-279	-40	-251	-276	-75	0	164,375	36
Tidal Wall - Retaining - Concrete	750d 14mL Contig Piled Wall	m3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36
Tidal Wall - Retaining - Concrete	Terraced Wall on minipiles	m3	32111	10,193	13,320	36,668	0	225,877	30,113	0	-533	-76	-480	-527	-143	0	314,410	36
Tidal Wall - Retaining - Concrete	RC wall on minipiles	m3	8025	2,547	3,329	9,164	0	56,452	7,526	0	-133	-19	-120	-132	-36	0	78,579	36
Tidal Wall - Retaining - Concrete	RC wall on angled minipiles	m3	4527	1,437	1,878	5,170	0	31,847	4,246	0	-75	-11	-68	-74	-20	0	44,330	36
Tidal Gate	Floodgate	m2	164	23	25	54	0	0	35	0	28	22	51	102	28	-32	343	31
Embankment - New	Ramps & embankments	m3	284491	688	254	1,015	-1	17,841	-4	0	1,887	3	299	237	207	-437	22,389	38
Tidal Wall - Retaining - Concrete	Floodwall on piles (3)	m3	13685	4,344	5,677	15,627	0	96,264	12,833	0	-227	-33	-204	-225	-61	0	133,995	36
Tidal Wall - Retaining - Concrete	Double Raked Piles	m3	3802	1,207	1,577	4,341	0	26,741	3,565	0	-63	-9	-57	-62	-17	0	37,222	36
Tidal Gate	Lockgates at sections 1-5 and 8-7	m2	240	33	36	79	0	0	52	0	41	32	75	150	41	-48	504	31
Tidal Wall - Retaining - Concrete	Brunel Dam raising at section 1-9	m3	2993	950	1,242	3,418	0	21,055	2,807	0	-50	-7	-45	-49	-13	0	29,308	36
Tidal Wall - Retaining - Concrete	Bathurst Dam raising at section 4-	m3	1250	397	519	1,427	0	8,793	1,172	0	-21	-3	-19	-21	-6	0	12,239	36
Tidal Wall - Retaining - Concrete	Piled Wall (<100m length) capping	m3	2704	858	1,122	3,088	0	19,020	2,536	0	-45	-6	-40	-44	-12	0	26,474	36
Tidal Wall - Retaining - Concrete	Piled Wall (>100m length) capping	m3	15019	4,767	6,230	17,150	0	105,647	14,084	0	-249	-36	-224	-247	-67	0	147,056	36
Tidal Wall - Retaining - Concrete	Choc. Path remedials (wall)	m3	955	303	396	1,091	0	6,718	896	0	-16	-2	-14	-16	-4	0	9,351	36
Tidal Wall - Retaining - Concrete	Choc. Path remedials (piles)	m3	683	217	283	779	0	4,802	640	0	-11	-2	-10	-11	-3	0	6,684	36
Tidal Wall - Retaining - Concrete	Tidal barrier concept (concrete)	m3	83543	26,519	34,654	95,398	0	587,661	78,344	0	-1,387	-198	-1,248	-1,371	-373	0	817,997	36
Other	Tidal barrier concept (gates)	m2	1500	4,034	4,034	4,034	0	0	0	0	698	698	698	582	455	0	15,234	0
Control Building	dal barrier concept (control buildir	m2	455	195	47	192	78	2,228	0	0	-19	-55	-5	-14	1	51	2,704	0
Path/Track/Road	Tidal barrier concept (compound)	m2	7600	406	19	34	0	4,903	0	0	42	2	3	19	7	-66	5,375	0
Hard Landscaping	ındscaping along section 1-8 (270	m2	810	779	8	3	0	119	0	0	10,473	111	43	517	23	-25	12,076	0
Soft Landscaping - Grassland	t landscaping along all other secti	m2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102
				83,153	96,931	259,477	89	1,589,634	208,668	0	20,107	1,133	-2,025	-96	456	-1,279	2,256,747	

Option 3

Add Row

Asset	Asset Description	Asset Unit	Asset Measurement	Capital - Materials	Capital - Transport	Capital - Installation	Operational - Use	Operational - Maintenance	Operational - Repair	Operational - Energy	Replacement - Materials	Replacement - Transport	Replacement - Installation	Refurbishment	Demolition	Residual	Whole Life Carbon	Whole Life carbon - slope uncertainty (%)
				0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Option 4

Add Row

Asset	Asset Description	Asset Unit	Asset Measurement	Capital - Materials	Capital - Transport	Capital - Installation	Operational - Use	Operational - Maintenance	Operational - Repair	Operational - Energy	Replacement - Materials	Replacement - Transport	Replacement - Installation	Refurbishment	Demolition	Residual	Whole Life Carbon	Whole Life carbon - slope uncertainty (%)
				0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Option 5

Add Row

Asset	Asset Description	Asset Unit	Asset Measurement	Capital - Materials	Capital - Transport	Capital - Installation	Operational - Use	Operational - Maintenance	Operational - Repair	Operational - Energy	Replacement - Materials	Replacement - Transport	Replacement - Installation	Refurbishment	Demolition	Residual	Whole Life Carbon	Whole Life carbon - slope uncertainty (%)
				0	0	0	0	0	0	0	0	0	0	0	0	0	0	

A2 Whole Life (Construction) Carbon Planning Tool User Guide

Whole Life (Construction) Carbon Planning Tool User Guide

Operational instruction 120_16 **Issued: 21/01/2019**

What's this document about?

This handbook aims to guide practitioners using the tool. The guide helps the user through the carbon target setting; whole life carbon calculation and recording and reporting of carbon data.

Who does this apply to?

This tool is applicable to all capital construction projects, except where the Construction (Design and Management) Regulations 2015 (CDM Regulations) do not apply.

Contact for queries and feedback

- **Technical Manager ncpms**
- Please give anonymous feedback for this document.

Contents

About this document

Purpose

The purpose of this document is to support the Eric Carbon Planning Tools by:

- Detailing the components of whole life carbon assessment**;**
- Explaining how carbon assessments fit into the existing capital delivery processes**;**
- Providing technical guidance on how to use the tools.

Carbon definition

'Carbon' is referred to throughout this document. For the avoidance of doubt, all references to 'carbon' in respect of the tool mean Carbon Dioxide Equivalent (CO_2e), expressed in tonnes (t).

Guidance

This document does not aim to be a methodology document. A methodology document for ERIC is available within the Appendix of this guidance. Users who want to gain and understanding of how the tools work should refer to this section .

Whole Life (Construction) Carbon Planning Tool

Objectives

The objectives of this tool are:

- To provide a mechanism through which to assess carbon over the whole life of constructed assets**;**
- To align with the Project Cost Tool (PCT) to enable a link between carbon and cost;
- To enable solution optioneering on a carbon basis through development of whole life carbon models;
- To capture data and monitor carbon targets**.**
- To support the delivery of the 40% reduction in construction carbon emissions.

Components

The two components of the Carbon Planning Tool are:

- **Carbon Modelling Tool -** top-down whole life carbon assessment and optioneering, used during the project appraisal phase to enable quick and simple carbon assessment to inform the solution selection process. LINK
- **Carbon Calculator -** detailed bottom-up whole life carbon assessment, incrementally built up during the delivery phase, following selection of a preferred project solution option. The final Carbon Calculator assessment is used to create data points in the carbon models within the Carbon Modelling Tool. LINK

Carbon planning tool and the capital delivery process

Overview

The tool promotes low carbon solutions and informs decision making through the design, construction and operation of the asset.

The sections below outline how the tool is to be used at each stage of delivery to support this, as well as outlining key responsibilities and accountabilities of project team members. These responsibilities are to be incorporated into supply chain contracts where relevant.

Carbon target setting

Project Level Carbon Targets

The carbon target for all Environment Agency constructior reduction of the total capital carbon associated with the pr between SOC (using the CMT) and RFS (using the final C

As part of our 2020 vision, the carbon target is set for the programme.

Carbon target setting

Project level Carbon Targets

The carbon target for all Environment Agency construction projects is the reduction in the total capital carbon associated with the projects between Strategic Outline Case (Using the Carbon modelling tool) and Readiness For Service (End of construction final Carbon calculator).

As part of our 2020 vision, the carbon target is set for the whole construction programme.

Strategic Outline Case (SOC)

At Strategic Outline Case (SOC) stage, the Carbon Modelling Tool (CMT) is to be used to identify low carbon solutions that may be taken forward and to establish the carbon baseline for the project.

A high-level carbon assessment ‘top down’ approach is made using the CMT. While there is no requirement at SOC to identify a preferred option, the PM must take what is considered the most likely option to proceed selecting the relevant option of the CMT sheet.

- Output: The CMT results are a mandatory input into all SOC’s. Shortlisted project solution options are entered into the CMT, producing an asset based forecast of whole life carbon for each option. A section of the SOC will present a summary of the output figures. The most likely preferred option, selected on the options sheet and highlighted on the summary sheet will form the baseline for the project level target;
- Accountable: The Environment Agency Project Executive is accountable for ensuring that the CPT is used and the results factored into the selection of the preferred solution;
- Responsible: The Environment Agency Project Manager is responsible for ensuring that the tool and outputs are applied correctly and the CMT output is forwarded to carbonplanningtool@environment-agency.gov.uk

Outline Business Case (OBC)

The Appraisal stage presents the greatest opportunity for driving low carbon solutions. This is the point in the delivery process when fundamental decisions are made with regard to solutions selected to address particular risks and project objectives. It is essential that carbon impact is a central consideration in this decision-making process

The Carbon Calculator (CC) 'bottom up' approach must always be used for the preferred option. This first iteration of the CC is supported by the Carbon Optimisation Report (COR).

This assessment forms a baseline against which the solution is developed. The assessment will highlight the key carbon drivers within the preferred option at OBC and FBC, and the team applies this information to consider alternative options that could reduce the carbon impact, both in appraisal, construction and operation.

- Output: The CC results and COR are a mandatory input into all OBC, the preferred option is to identify the optimal low carbon overall solution available, detailing how the results have influenced the selection of the preferred option. Initially it is likely that assumptions will need to be made with regard to certain aspects of the design, construction process and operational factors, summary sections within the tool have been applied to support this;
- Accountable: The Environment Agency Project Executive is accountable for ensuring that the CMT is used (where appropriate) and the CC is used for the preferred solution;
- Responsible: The Environment Agency Project Manager is responsible for ensuring that the tool and outputs are applied correctly and the CC and report are forwarded to carbonplanningtool@environment-agency.gov.uk;
- The template for the Carbon Optimisation Report (COR) can be found in Appendix 2

Full Business Case (FBC)

Following the selection of the preferred option, the CC and COR is to be completed and included as part of the Full Business Case (FBC).

- Output: The CC results and COR are a mandatory input into all FBC, the preferred option is to identify the optimal low carbon overall solution available, detailing how the results have influenced the selection of the preferred option;
- Accountable: The Environment Agency Project Executive is accountable for ensuring that the CC is used and the COR updated for the preferred solution;
- Responsible: The Environment Agency Project Manager is responsible for ensuring that the tool and outputs is applied correctly and the CC and COR are forwarded to carbonplanningtool@environment-agency.gov.uk.

There is no specific template for the COR. However, it must contain the information identified under reporting headings.

Tenders

The latest CC and COR is to be included within the tender documents for construction (or design and build) tenders. The carbon output is to be also be listed as a data requirement via the BIM Implementation Plan. Relevant information on the low carbon decisions that have been made during the appraisal and design stage and communicated with the delivery contractor, is an essential part of the project lifecycle.

The Carbon Optimisation Report contains details of:

Carbon Optimisation Report

(COR)

- the key carbon drivers of the solution;
- steps taken to reduce carbon through the design process (including an assessment of the reduction in whole life carbon based on comparison between the latest CC assessment and the baseline CMT assessment);
- a schedule of carbon actions/opportunities considered prior to construction completion.

For ncpms projects this information along with the carbon calculator are utilised within the local Carbon Reduction Plan to evidence where a project is looking to achieve its 40% carbon reduction. The COR template can be found in Appendix 2

Readiness for Service

(RFS)

Following appointment of the main contractor for the works, the CC assessment is used and developed as the project progresses. For design and construction contracts, the contractor is responsible for the continuing use of the CC to inform design decisions. The selection of construction methodologies for all types of construction contract is informed by the carbon impact assessed in the CC.

The final CC will be used to calculate the capital carbon saving against the CMT baseline for the project. The Whole Life carbon data at baseline and final CC will be used to calculate the Carbon Efficiency savings at a project level.

- Output: The final CC assessment is appended to the Final Carbon Report;
- Submission of the Final Carbon Report is a requirement of completion under the construction contract. The Final Carbon Report and CC will be submitted by the contractor to carbonplanningtool@environment-agency.gov.uk for reporting purposes and filed on Asite along with the projects data files. The FCR template can be found in Appendix 3.

Final Carbon Report

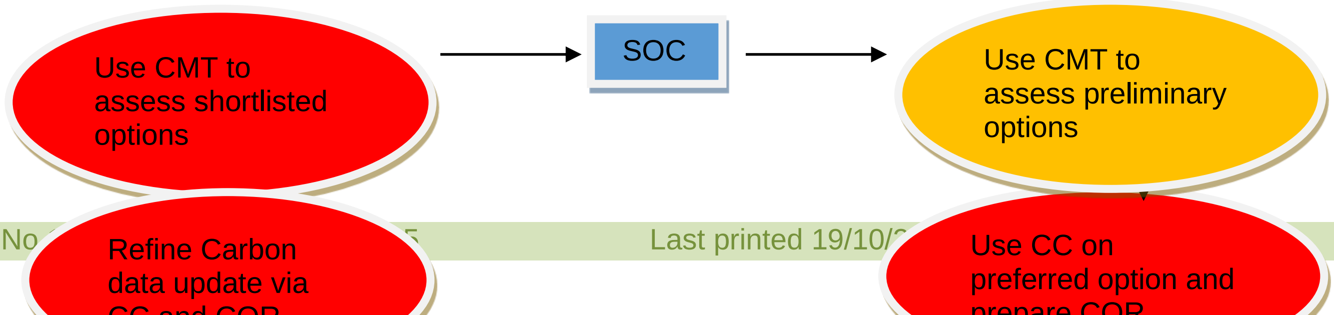
(FCR)

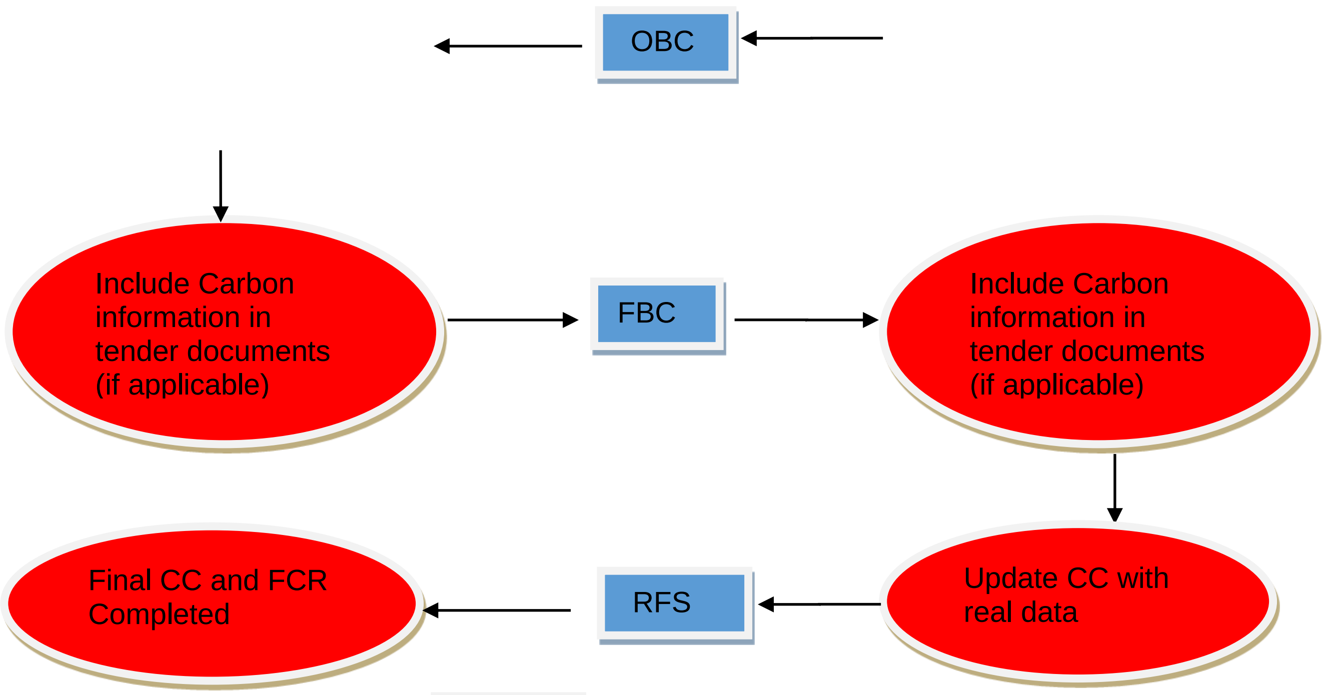
Upon completion of the construction works, a Final Carbon Report (FCR) supported by the final CC will be completed and submitted by the contractor to carbonplanningtool@environment-agency.gov.uk. The FCR report builds upon the contents of the COR and contain details of:

- the key carbon drivers of the solution;
- steps taken to reduce carbon through the design development (where relevant);
- steps taken to reduce carbon through the construction process (including an assessment of the reduction in whole life carbon based on comparison between the latest CC assessment and both the baseline CMT assessment SOC and the CC assessment at OBC); and
- the final CC assessment is appended to the FCR.

The FCR template can be found in Appendix 3. Final carbon calculators will not be accepted for reporting without the associated FCR, this is due to the requirement to provide a commentary to support the carbon data.

Flow Chart





5 Case business model stage — Applied Carbon Process, red is mandatory, yellow is not mandatory.

CMT = Carbon Modelling Tool	CC = Carbon Calculator
COR = Carbon Optimisation Report	FCR = Final Carbon Report
SOC = Strategic Outline Case	OBC = Outline Business Case
FBC = Full Business Case	RFS = Readiness For Service (Prince 2 term, note this is end of construction)

Assurance

Monitoring and supporting

Full use of the CPT and compliance with the associated processes will be monitored and supported by the Environment Agency. This is to ensure that:

- Low carbon solutions are being sought throughout the delivery process
- Carbon data is being captured and reported effectively
- The tools and methodologies can be updated effectively going forward.

Submitted CMT and CC will not be used for reporting progress against the e:Mission target unless the it has been checked for completeness and approved by the Environment Agency Carbon Planning Manager.

The Environment Agency Carbon Planning Manager provides a Quarterly update of progress against the embodied carbon 40% reduction target.

How will carbon data be used?

Data use

Carbon data created through use of the CPT will be used as follows:

Use	Description
Low carbon	Carbon data will be used by project teams to drive low whole life carbon solutions during the capital delivery process, as outlined above.
Carbon models	Carbon data contained within final CC assessments completed at RFS will be used to update the carbon models contained within the CMT. The Carbon Models will be updated periodically and the CMT republished. For this reason, the latest version of the CMT must always be **downloaded** when a new appraisal is being undertaken.
Carbon reporting	A wide range of information will be reported with regard to carbon emissions. The structured data contained within the CC, will be reported at SOC, OBC and RFS (when the works are completed).
Carbon targets	The asset carbon data collected from completed projects will be used to report to Defra and set carbon targets on future projects. This target setting process will incentivise suppliers to exceed the targets that are set.

Carbon Modelling Tool (CMT) User Guidance

Overview

This section of the guidance document provides guidance to users of the CMT to enable whole life carbon estimates during the early stages of the project development process. The tool allows detailed project information to be built up by asset, for up to 5 project options.

General instructions

Before using the CMT, please refer to the instructions sheet contained within the tool. These instructions are summarised below:

Step	Instructions
1	Before starting, make sure that Macros are enabled in Microsoft Excel.
2	Complete the Details section at the top of the Optioneering Summary page. All green cells should be completed.
3	Build up each project solution option assets by selecting assets from the drop-down asset list and entering an Asset Measure for the item. An Asset Description may also be added to identify the item within your project. All the green cells within each option should be completed. If the asset selected in the asset list is 'Other', additional information needs to be included (the asset unit, and the tCO_2e for the asset at each Lifecyle stage). The 'Other' option has been included as it's possible that an asset may not be included in the asset list. As such the tCO_2e from the asset at each Lifecyle stage can be calculated in the CC and be added to the CMT to ensure that the assessment is complete.

4	Once all options have been completed the preferred option should be selected using the drop down numbering (1-5) at the top of the Options page, this will then highlight the preferred option being taken forward on the Options tab and the Optioneering Summary tab.
5	The Optioneering Summary tab will show the carbon output for each option entered in both chart and number format, this information is used to support low carbon decision making when deciding the preferred option. The preferred option is also highlighted in the numbers table.
6	The Model Viewer can be used to view the data for individual asset models. In the Model Viewer sheet, select an asset from the drop-down list at the top of the page and the charts and data table will refresh with all data relating to that asset.

Carbon Calculator (CC) User Guidance

Overview

This section of the document provides users of the CC, guidance to support the full and accurate completion of carbon assessments.

The information below is provided in support the guidance contained within the CC itself. The CC includes a General Instructions page which provides basic information about how the tool functions and how it is to be completed, as well as specific instructions that appear whenever a user clicks on a field that must be manually filled in.

Emissions sources

The CC estimates emissions from a variety of sources covering the whole life of a project. These emissions sources are described below, and are split into capital carbon (which occurs, at the time of project implementation - most often the construction of the project, which is known as the first intervention), and lifecycle carbon (which occurs over the asset's lifetime, which is 100 years within ERIC).

Capital Carbon

Category	Description
Materials	Carbon associated with materials used for the project, including extraction, processing, manufacture and distribution – this is also known as cradle to gate embodied carbon.
Transport	Carbon associated with the transportation of resources. Three subcategories are assessed: • Materials - delivery to site • People - travel associated with both contractor and non-contractor personnel to site • Plant - delivery of plant from supplier to site Carbon associated with the manufacture, servicing and repair of plant is not included within the calculator.

Installation	Carbon associated with the construction process. Three subcategories are assessed: • Site establishment - fuel/energy use during construction • Plant use - fuel use during construction • Waste - transportation off-site to dispose of excess materials and other construction process waste such as arising from the site. Carbon associated with the final disposal of waste is not included within the calculator.

Lifecyle Carbon

Category	Description
Operational carbon	Carbon associated with the ongoing operation of each asset/sub-asset. Four subcategories are assessed: • Use - use/manning of assets, based on travel to/from the site • Maintenance - planned maintenance activities, based on an assessment of travel to/from the site and use of plant and materials where required • Repair - an assessment of unplanned repair activities, based on an assessment of travel to/from the site and use of plant and materials where required • Energy - power consumption
Refurbishment carbon	Carbon associated with interventions at the end of an asset/sub-asset's useful life that extend the useful life.
Replacement carbon	Carbon associated with re-building an asset/sub-asset at the end of it's useful (or if refurbished, extended useful) life.
Demolition carbon	Carbon associated with the demolition of life-expired asset/sub-assets. Three subcategories are assessed: • Materials Waste - transportation off-site of demolished materials • People - travel to/from site • Plant - transportation to/from site and fuel use Carbon associated with the final disposal of waste is not included within the calculator.
Residual carbon	The carbon emissions associated with assets that extend beyond the 100-year project lifespan. The residual carbon is presented and subtracted from the whole life carbon total to produce a total net emissions figure for the project.

General instructions

Before completing a CC assessment, please refer to the Instructions sheet contained within the CC. It is important that macros are enabled.

Only certain parts of the whole life carbon assessment require manual entry of information. The other parts are automatically generated by the calculator based on the information entered. This includes the summary information. The automatically generated information is only created when the manual entry parts are completed in full, and the green button entitled 'Recalculate and create summary' on the Calculator sheet is pressed. It is therefore important that the following general steps are followed within the Calculator sheet to create an accurate whole life carbon assessment.

The CC is made up of 4 user sheets:

- The Instructions sheet, which provides useful user information;
- The Summary sheet, which provides a results summary;
- The Model sheet which stores data to be transferred to the Calculator sheet;
- The Calculator sheet, which is where the user must enter project information, and the calculations are undertaken. In the Calculator sheet all green cells must be completed, except where the column is heading includes 'Overwrite', these cells are optional, and should be used when more accurate data is known than the data automatically generated by the calculator. Where there are more rows than items to add to the calculator, these cells can also be left blank. (note if an overwrite item is entered the source of the information should be included as part of your final carbon calculator submission.
- Sometimes cells may turn red, this is because either vital information is missing, or an error has been detected. There are instructions related to each data entry cell. Please refer to these when troubleshooting errors.

Below are summary instructions of how to use the CC:

Step	Instructions
1	Complete the Project Details section at the top of the Calculator sheet. Complete this in full before proceeding as some of this information informs calculations in the sheet.
2	Complete the Assets section. This must contain all standard Environment Agency Assets that form part of the project. It is only possible to add new Assets using the 'Other' option, as this enables the future calculation of emissions within the CMT. It should also be noted that it is vital that the asset value is added at this point. The asset value is used to apportion non-asset emissions to assets, which means if these cells are left blank the CC underestimates emissions.
3	Complete the Sub-Assets sections. This section allows assets to be broken down into separate parts that each have different useful lives, enabling the whole life calculation to function. All sub-assets relating to each asset must be entered. If an asset does not need to be broken down into sub-assets, enter a single sub-assets item for that asset.
4	Complete the Capital Carbon section. Use the instructions provided for each data entry field for support and refer to the guidance below for further information.

5	Complete the Operational Carbon section. Again, use the instructions provided for each data entry field for support and refer to the guidance below for further information. Note if you are competing and Operational and Maintenance manual, much of the information required is also relevant for the Operational carbon section of the tool.
6	Click the green 'Recalculate and create summary' button at the top-left of the Calculator sheet. Depending on how large your project is, the calculator will take a few seconds to process the information. The button runs a macro that summarises data. Please minimise how many times this macro is run, as it impacts upon some formulas that use this summarised data. You will then be taken to the Summary sheet where you can analyse the whole life carbon for your project. At this point, all whole life carbon figures will be filled in within the Calculator sheet as well.
7	You may subsequently amend the information entered in the Calculator sheet. Following any amendments, click the 'Recalculate and create summary' button to refresh the whole life carbon figures.

Project Details

This section contains general information about the carbon assessment and provides a link to the relevant project.

The cost and programme fields are particularly important as they are used within some of the calculations in the sheet. Please therefore calculate these as accurately as possible.

The Project Location field does not relate to any Environment Agency geographical location categories - it simply relates to the geographical location of the project.

Assets

All projects assessed within the CC must be broken down into assets. There are three primary purposes for this:

- **To enable carbon models to be created for use in the CMT.**
- **To enable analysis of carbon and cost using information from the PCT, which also uses this asset break down.**
- **To support the carbon reporting process.**

All individual project assets are to be entered separately in the Assets table. Note: Where a project includes multiple items of the same asset, these can be entered separately or combined - it is left to the discretion of the user to determine the most appropriate option based on how the carbon assessment will be made and how the data aligns with the asset types identified within the contract.

The Asset Measure field represents the functional measurement of the item for use in the asset carbon model. The Asset Unit is therefore fixed.

The Asset Value field is an estimate of the construction cost associated with that asset. This value is to be align with the PCT entry and the total value of all assets must equal the Total Construction Cost.

Management/supervision and site overheads and temporary works costs are split appropriately across the asset. Design costs are not to be included.

As outlined above it is imperative that the asset value is included as the asset value is used to apportion non-asset emissions to assets, which means if these cells are left blank the CC underestimates emissions.

Sub-Assets

At least one sub-asset is to be entered for each asset. The sub-asset is to be linked to the relevant asset using the drop-down box provided and allocated to the most appropriate sub-asset category. This returns a standard useful life for that sub-asset category.

The user must then complete the following fields:

- First intervention - this is for the capital works that are being undertaken as part of the current construction project;
- Expected new build life – this is the actual design life of the sub-asset from new. The assumed standard useful life may be used if this is not known (the assumed standard life appears in the previous column to first intervention and must be added to the expected new build life column for it to be used). For temporary works, or if demolition is selected as first intervention this column does not need to be completed – as refurbishment will not be possible;
- Refurbishment type - at the end of the sub-asset's useful life, the user must enter what level of refurbishment will be undertaken, or state that refurbishment is not possible. For temporary works, or if demolition is selected as first intervention this column does not need to be completed – as refurbishment will not be possible;
- Expected refurbished life - the expected additional useful life that will be created from the refurbishment. Leave blank if refurbishment is not possible. For temporary works, or if demolition is selected as first intervention this column does not need to be completed – as refurbishment will not be possible.

The information entered here is extremely important to how the CC models estimates carbon over the 100-year time horizon. Where certain parts of this information are unknown at the time of assessment, a reasonable estimate is to be undertaken, including consultation with a relevant member of the design team if possible.

In order to calculate an accurate whole life carbon assessment, the useful life of everything being constructed must be considered. This enables the CC to determine when, during the 100-year time horizon, refurbishment, replacement and demolition is to be assessed, along with the calculation at the end of the period to account for any residual asset life.

Materials

In the materials section all the materials used for the first intervention need to be listed.

Use the Sub-Asset Description field to link the materials to an individual sub-asset. If a material is used on more than one sub-asset, separate items must be entered.

If a suitable item is not contained in the standard materials list, select the item that most closely represents the material required (which will enable an approximate assessment of carbon) and report this to the carbonplanningtool@environment-agency.gov.uk email. This information is collated and used for the next release of the CC which will aim to add in frequently used materials items that are not currently covered.

For some materials items, the measurement units can be changed by selecting from the drop-down list. You may only use a unit that is contained in the list provided.

Ultimately it is the quantity entered that determines the volume of carbon - every effort must be made to enter the most accurate quantity possible, however users are to be pragmatic in their approach to this.

When temporary works are selected, the user must also complete the Temporary Works - project reuse frequency column. Because materials used in temporary works are often reused on multiple projects, this column requires the user to enter the number of times the temporary works will be reused, to apportion the correct quantity of embodied emissions to the project being assessed.

Adjacent to the Materials table is a Waste table and a Transport of Materials table. These sections are to be completed, however note the information entered is used to inform calculations elsewhere in the sheet rather than affecting the Materials carbon figures.

Waste % represents the amount of excess material brought to site but not used in the works. The Waste section enables assessment of the transportation needed to remove the waste materials from site.

The Transport of Materials section assumes that all materials will be transported to site by road so an entry must be made here, but it also allows the assessment of a secondary transportation mode if required - this latter section is to be left blank if not applicable.

Transport

The transport section provides an option to complete either a Summary or a Detailed assessment within the carbon calculation. This selection can be made against the Method Used heading, which changes the data entry fields depending on which option is selected.

The Summary method may be used for the initial detailed carbon calculator and during the early stages of construction. However, a detailed assessment must be completed along with the Final Carbon Report at Readiness for service (Gateway 4). It is recommended that the detailed assessment is undertaken as early as possible and used to inform the construction process.

- Summary - if this option is selected, the user does not need to enter anything further, as long as the Transport of Materials table has been completed above, as everything is calculated automatically.
- Detailed - if this option is selected, the user makes an assessment for both People and Plant using the matrices provided. It is recognised that estimating and recording travel and transportation distances for People and Plant is disproportionately onerous considering the level of associated carbon - these matrices have been designed to enable an informed and structured assessment in a relatively simple and pragmatic manner.

Installation

The installation section provides an option to complete either a Summary or a Detailed assessment within the carbon calculation. This selection can be made against the Method Used heading, which changes the data entry fields depending on which option is selected.

The Summary method may be used for the initial detailed carbon calculator and during the early stages of construction. However, a detailed assessment must be completed along with the Final Carbon Report at Readiness for service (Gateway 4). It is recommended that the detailed assessment is undertaken as early as possible and used to inform the construction process.

- Summary - if this option is selected, some entry is still required from the user as follows:

- Site establishment - no entry required - automatic calculation;
- Plant use - enter an estimate of the number of litres of fuel used by construction plant (this excludes anything relating to the site establishment such as diesel generators as these are included elsewhere);
- Materials waste - no entry required, as long as the Materials Waste table has been completed above;
- Other construction waste - enter an approximation of the types and quantities of existing materials from the site that need to be removed. If any such material is to be reused on site, enter this as such - no carbon volume will be assigned to the item but this information may be used in the future. This table should be used to account for demolition waste when demolition is undertaken as the first intervention.

Detailed - if this option is selected, entry is required from the user as follows:

- Site establishment - enter the consumption figures for the various types of fuel/power listed;
- Plant use - enter details of the individual items of construction plant utilised during construction. Only select items contained in the drop-down lists provided. Each item must be allocated to a specific sub-asset, based on the sub-asset most relevant to that item of plant. Enter multiple items to capture use of the same plant item on multiple sub-assets if it is practical to do so. Average utilisation rates for each plant item are provided by the calculator, however users may manually amend this if required. In addition, if the litres of fuel to be used are know these can be added to the overwrite column;
- It is recognised that allocating the use of plant to individual sub-assets requires additional time and effort in order to both capture the data accurately and complete the table in the calculator. The benefit of the detailed assessment is that carbon associated with plant use can be directly allocated to individual sub-assets, which makes the carbon models more accurate - the summary option performs an arbitrary *pro rata* allocation which is likely to be less accurate. In completing the detailed plant use table, users are asked to use their professional judgement and pragmatism to determine the level of accuracy required;
- Materials waste - as above for the summary option;
- Other construction waste - as above for the summary option.

Use

The Use section relates to operation/manning of individual assets. For many assets, this section will not be relevant and for those that it is, it is likely that this will mainly relate to flooding incidents.

Users of the CC are to consult with the asset owners in order to determine what is to be entered in this section.

The CC assesses carbon associated with Use based on the travel distances of people operating assets. Users are required to enter all Use items relevant to a single year of operation and the calculator models this across the 100 year time horizon.

In order to complete a single line entry, you must provide the following information:

- Link the item to a specific asset by selecting form the drop-down list;
- Enter a free text description for what is being done;
- Select the mode of transport and fuel type (if relevant);
- Enter the number of people travelling separately, along with the number of days per year and an approximate return distance travelled.

Maintenance

The Maintenance section relates to planned maintenance of individual sub-assets. For Environment Agency assets the Maintenance Standards provide some useful information about the types of maintenance relevant to different types of assets and the frequency at which they are undertaken. Users of the CC are required to consult with the Asset owner (Asset Performance teams for the Environment Agency) in order to determine precisely what is to be entered in this section.

The CC assesses carbon associated with Maintenance based on travel distances of people undertaking the maintenance, along with a basic assessment of plant and materials. Scope has been built into the template to assess waste and overheads (e.g. depots) in the future but these items are currently excluded for the calculation.

In order to complete a single line entry, you must provide the following information:

- Link the item to a specific sub-asset by selecting form the drop-down list;
- Select the maintenance category from the drop-down list. It does not affect the calculation;
- Enter a free text description for what is being done;
- Select the mode of transport and enter the approximate return transport distance;
- Select the level of Materials and Plant use for the maintenance activity from the drop-down lists. Selection of the options applies a percentage of the capital works Materials/Plant Use to the maintenance item as follows - Not applicable: 0.0%, Low: 0.1%, Medium: 1.0%, High: 5%;
- Judgement is required from the user of CC to determine what to select here, with reference to the entries in the Capital section of the calculator;
- Select an Annual Intervention Frequency from the drop-down list as follows:
    - a) > 1 per year - you must then enter how many interventions per year.
    - b) Every year to Every 5 years - no further entry required.
    - c) Exceptional - you must then enter which year within the 100-year model the intervention will take place.

Repair

The Repair section relates to unplanned and unforeseen repair work that could reasonably be expected to be required during the life of a sub-asset. The nature of this section is such that it requires engineering judgement and reference to historic trends, along with reference to the level of planned maintenance that has been allowed for. For this reason, it is vital that users of the CC always consult with the with the Asset owner (Asset Performance teams for the Environment Agency) in order to determine precisely what is required to be entered in this section.

The Repair section is to be completed in the same way as outlined above for the Maintenance section.

Energy

The Energy section relates to the power consumed during the operation of individual sub-assets. Users are required to assess the annual power consumption and the calculator then profiles this out over the 100-year time horizon.

Whilst it is envisaged that designers will know the design criteria of items entered in this section, and will therefore be able to complete the section in full, it is recommended that users of the CC always consult with the Environment Agency Asset Performance teams to agree what is to be entered in this section.

In order to complete a single line entry, you must provide the following information:

- Link the item to a specific sub-asset by selecting form the drop-down list;
- Enter the name plate value of the item - this is the stated size/power level of the item specified;
- Enter an overall efficiency rating - based on the item itself and the environment in which it is being used, a percentage efficiency is to be entered that represents the additional power required to achieve the name plate output (most items will have an efficiency that is less than 100% - e.g. a 10kW pump that is 50% efficient will use 20kW);
- Enter a load rating - a percentage that represents the amount of the item's output that is used in its intended operation (e.g. a 10kW pump may be specified but only half of its output may be used in the intended operation - this would equate to a load rating of 50%). The load is often designed to optimise the efficiency of the item;
- Enter a use factor - this represents the proportion of hours during a typical year when the item will be in operation (e.g. 100% means 24 hours per day, 365 days per year).

If the annual energy consumption is known, this can be added in the annual energy overwrite column.

Replacement Carbon

When a sub-asset's useful life has expired, if possible refurbishment will take place. If refurbishment is not possible, or after refurbishment, the sub-asset must be replaced at the end of its useful life. The CC automatically calculates the carbon associated with the replacement, based on what is entered within the Capital section.

If the Capital project includes the refurbishment of existing sub-assets that will subsequently need to be replaced, the calculator automatically applies an uplift on the capital carbon to represent the extra work associated with replacement compared to refurbishment. The level of uplift is determined by the Refurbishment Type stated in the Sub-Asset table (e.g. if minor refurbishment has been undertaken, a greater uplift is applied to establish the replacement carbon than if major refurbishment was undertaken).

The Calculator sheet shows the total amount of carbon associated with sub-asset replacement across the 100-year time horizon, excluding any replacement work completed as part of the capital works.

Refurbishment Carbon

When a sub-asset's useful life has expired, the CC assumes that one refurbishment can be undertaken in order to extend the useful life before the sub-asset must be replaced. This is calculated automatically without any manual entry.

If a sub-asset cannot be refurbished, 'Not Possible' is entered under Refurbishment Type in the Sub-Asset table and the calculator assumes replacement every time upon expiry of the useful life.

If a sub-asset can be refurbished, the user enters the scale of refurbishment that will be applicable in the Sub-Asset table. This selection determines the proportion of the capital carbon that is allowed for refurbishment, as follows:

- Minor refurbishment - 10%
- Moderate refurbishment - 25%
- Major refurbishment - 50%

The Calculator sheet shows the total amount of carbon associated with Sub-Asset refurbishment across the 100-year time horizon.

Demolition Carbon

The CC accounts for demolition during the first intervention, by users entering data for capital carbon normally (for example the plant associated with demolition can be added to the plant section). For demolition waste, this needs to be added to the Other construction waste table.

In this instance, the carbon associated with the demolition is included within the Capital Carbon total and not in the Demolition Carbon section under Lifecycle Carbon.

When an asset is demolished as part of the capital works, the model assumes that no replacement or refurbishment will occur subsequently. Unless an asset is demolished as the first intervention, the model within the calculator assumes that each asset will be refurbished or replaced upon expiry of the useful life throughout the 100-year time horizon. It is not possible to represent demolition within the model duration unless it is the first intervention.

Demolition upon refurbishment and replacement is calculated automatically, without user entry, in two separate parts of the 100-year whole life carbon model as follows:

- When an asset is replaced, the calculator assumes that the existing life expired asset will need to be demolished before the new asset is constructed to replace the old one. In this instance, the carbon associated with the demolition is shown under the Demolition Carbon section.
- Demolition carbon is calculated automatically based on the resources entered for the capital works by taking a proportion of the total carbon for each sub-asset. If the first intervention is refurbishment, the calculator automatically applies an uplift on the capital carbon first (to represent the carbon associated with a new/replacement intervention), before calculating the demolition carbon from this.
- Many of the major sub-assets relevant to Environment Agency capital projects have useful lives in excess of 100 years, therefore demolition and indeed replacement/refurbishment will not be relevant and carbon will not be included within these totals shown.

Emissions factor overwrite	For materials and electricity use, users have the option of entering their own emissions factors if they are known. This is done in the emissions factor overwrite columns next to the material and electricity input tables. This is to account for the use of innovative materials, and renewable energy use. The use of these overwrites means that the CC uses the user-defined emissions factors, rather than the default emissions factors included in the CC. As such these overwrites should only be used when the specific emissions factors are known. In addition, the emissions factor units and the units of materials or electricity must correspond. It should also be noted that the emissions from these sources are discounted in the future in line with expected changes to future carbon emissions, using the same methodology as for other sources.

Appendix 1 Methodology

What's this document about?

This methodology document aims to detail the methods used within the ERIC suit of tools. This will provide users with the background necessary to understand the processes within the ERIC tool.

Who does this apply to?

This tool is applicable to all capital construction projects, except where the Construction (Design and Management) Regulations 2015 (CDM Regulations) do not apply.

Contact for queries and feedback

- **Technical Manager ncpms**
- Please give anonymous feedback for this document.

About this document

Purpose

The purpose of this document is to support the implementation of the Carbon Planning Tool by:

- Recoding the methods used in the ERIC suit of tools in line with best practice; and
- Providing users with background to the mechanics of the tool.

Carbon definition

'Carbon' is referred to throughout this document. For the avoidance of doubt, all references to 'carbon' in respect of the tool mean Carbon Dioxide Equivalency (CO2e), expressed in tonnes (t).

Guidance

This document does not aim to be a user guide. A user guide for the tool is also available and should be referred to by users to gain and understanding of how to use the tool. It is suggested this document is read in conjunction with the ERIC tools. These contain all of the calculations summarised here, and can be used in their own right to further understand the methods implemented within the tool.

Whole Life (Construction) Carbon Planning Tool

Objectives

The objectives of this tool are:

- To provide a mechanism through which to assess carbon over the whole life of constructed assets.
- To align with the Project Cost Tool (PCT) to enable a link between carbon and cost.
- To enable solution optioneering on a carbon basis through development of whole life carbon models.
- To capture data and monitor carbon targets.

Components The two components of the Carbon Planning Tool are:

- **Carbon Modelling Tool (CMT) -** top-down whole life carbon assessment and optioneering tool, used during the project appraisal phase to enable quick and simple carbon assessment to inform the solution selection process. LINK
- **Carbon Calculator (CC) -** detailed bottom-up whole life carbon assessment tool, incrementally built up during the delivery phase, following selection of a preferred project solution option. The final Carbon Calculator assessment is used to create data points in the carbon models within the Carbon Modelling Tool. LINK

Carbon Modelling Tool (CMT)

Overview

The CMT is designed to be used at the beginning of project development. At the early stages of a project, it is unlikely that detailed design information will be available (for example, the quantities of materials that will be used). In general, carbon assessments of projects require detailed design information. The CMT has been designed to resolve this issue, enabling the assessment of EA projects at the beginning of the project development process.

The CMT achieves this by using previous EA data to estimate emissions from the limited detail design information that is likely to be available during project's early stages. It does this by using data for individual EA assets produced by the Carbon Calculator (CC). The data consists of an asset measure, which is asset dependant (for example, the area of a penstock), and the carbon emissions at each lifecycle stage (Construction materials, operational energy etc).

Within the CMT, the available data for each asset is used to calculate a linear emissions rate (carbon emissions / asset measure). This enables the user to enter the asset measure, for each asset within each option, to estimate emissions for the design(s). Therefore, the emissions estimates produced by the CMT will utilize available project information during the early stages of a project and calculate the emission estimates based on similar previous project data, stored in the database.

The remainder of this section details the methods used within the CMT. The aim of this is to provide users with an understanding of the methods employed, whilst also reporting the methods transparently in line with best practice.

Data Import

The data import process extracts data from the CC and adds it to the Model Data sheet using a macro. The data is presented on an individual asset basis with the asset measure and carbon emissions from each lifecycle stage (this is the same format as produced by the CC on the Model sheet). This data is then summarised onto separate sheets for each asset using a macro. This process means that as more data is added to the CMT, the accuracy of CMT will be continually refined to reflect recent real-world project examples.

Rate Calculation

To calculate the emissions rate, the data that has been summarised onto separate sheets, is then pulled from each sheet to the Carbon Curve Data sheet using Excel's slope function. This produces a linear regression of carbon emissions from each lifecycle stage against asset measure, for each asset where data is available.

Emissions Calculation

When the user selects the asset and enters the asset measure on the Options sheet, the asset measure is multiplied by the rate for each lifecycle stage (the linear regression). This results in the estimated emissions by asset for each lifecycle stage, displayed next to each asset entered on the Options sheet.

Data Summarisation

The results of the emissions calculations are displayed on the Optioneering Summary sheet. The table at the bottom of the sheet is the sum of the emissions presented on the Options sheet, by option and lifecycle stage. These results are then displayed on the graphs above.

Model Viewer

The Model Viewer sheet provides the user with the ability to view the underlying data used in the emissions calculations. It does this by pulling out the data on an individual asset basis in the table at the bottom of the sheet, depending on the asset selected in the drop-down menu. This data is then graphed with the asset measure on the X axis and carbon emissions on the Y axis for each lifecycle stage, with a linear regression line added. The linear regression line is equal to the rate used in the emissions calculation.

Uncertainty Calculation

For some assets the correlation between the data extracted from the CC is relatively poor and as such this means that there is some uncertainty associated with the linear regression (which is the emissions rate used to estimate emissions). To provide users with an understanding of the carbon data produced by the CMT, the uncertainty associated with the linear regression has been calculated and presented.

To do this, for each asset slope uncertainty is calculated using Excel's LINEST function on the Uncertainty Calculator sheet. Slope uncertainty is considered the most appropriate statistical test to understand the uncertainty associated with the linear regression. Slope uncertainty is a percentage, calculated from the standard deviation of the slope and the slope itself. As such it gives a % measure of the variability of the slope within a 95% confidence interval.

The calculation is only applied to whole life carbon, because applying slope uncertainty to all the Lifecyle stages, would be harder for users to interpret, and because whole life carbon captures the slope uncertainty across all lifecycle stages, allows for a single uncertainty figure to be presented.

By calculating slope uncertainty for all assets, means it is possible to give an uncertainty value for each option. This is done using a weighted average based on whole life carbon and slope uncertainty, a slope uncertainty is then calculated for each option, which is presented on the Optioneering Summary sheet.

Carbon Calculator (CC)

Overview

The CC is designed to be used for the preferred option for the Outline Business Case, and for carbon assessment for the remainder of the project development process. As such the CC is designed to use detailed design information, to produce a carbon assessment of the project that is as accurate as possible.

The remainder of this section details the methods used within the CC. The aim of this is to provide users with an understanding of the methods employed, whilst also reporting the methods transparently in line with best practice.

Scope

The CC quantifies emissions from the following emissions sources:

- Materials (cradle to gate) – A1
- Transport of materials – A2
- Transport of construction waste – A5
- Use of plant – A5
- Transport of people to site – A4
- Transport of plant to site – A4
- Site establishment – A5
- Transport of people to site during operation – B1
- Transport for maintenance – B2
- Materials (cradle to gate) for maintenance – B2
- Plant for maintenance – B2
- Transport for repair – B3
- Materials (cradle to gate) for repair – B3
- Plant for repair – B3
- Energy use during operation – B1
- Replacement materials (cradle to gate) – B4
- Replacement transport of materials – B4
- Replacement transport of construction waste – B4
- Replacement use of plant – B4
- Replacement transport of people to site – B4
- Replacement transport of plant to site – B4
- Replacement site establishment – B4
- Refurbishment materials (cradle to gate) – B5
- Refurbishment transport of materials – B5
- Refurbishment transport of construction waste – B5
- Refurbishment use of plant – B5
- Refurbishment transport of people to site – B5
- Refurbishment transport of plant to site – B5
- Refurbishment site establishment – B5
- Transport of demolition waste – C2
- Transport of people to demolition site – C2
- Plant for demolition – C1

The tool is designed to calculate all emissions within the project boundary. It is the responsibility of the user to ensure that all data for items within the project boundary is added to the tool.

Asset Hierarchy

ERIC (both the CC and CMT) has been designed to align with the Project Cost Tool (PCT) and provides an appropriate level of granularity. As such assets are derived directly from the standard schedule of assets used in the PCT in most instances.

This means that emissions at each lifecycle stage are associated with an asset measure. This enables the emissions calculation within the CMT, because this information is imported to the CMT from the CC, where it forms the basis for CMT carbon assessment. To enable this a macro in the CC summarised the relevant data on the Model sheet, from where the CMT imports the data.

When using the Carbon Calculator, assessment of carbon for a full project can be undertaken but it must align with the following three-tier work breakdown structure:

- Level 1: Project - the highest level of information contained in a single Carbon Calculator assessment.
- Level 2: Assets - all carbon assessed within a project is allocated to individual asset. Carbon data is used to populate the carbon models on a periodic basis.
- Level 3: Sub-Assets - some Environment Agency Assets have discreet sub-asset that each have a different useful life. These must be identified in order to drive the 100 year model. Where multiple Sub-Assets are not relevant to an Asset, a single Sub-Asset item must be entered.

Emissions are allocated to this asset hierarchy. For some emissions sources, the emissions are directly related to a sub-asset (and therefore asset). For example, materials are directly related to a sub-asset, as it is possible to associate the materials used to a sub-asset, and as such when adding materials, a sub-asset also needs to be selected.

However, in some cases emissions are not directly related to a sub-asset. For example, site establishment is not directly related to an asset. Site establishment is required for the whole site not just for an individual asset, as such a sub-asset or asset does not need to be related to the data.

For emissions that are directly related to an asset, the emissions are allocated to that asset. However, if the design includes more than one asset that is the same, a weighted average based on asset value is used to apportion emissions to these assets. For emissions that are not directly related to an asset, a weighted average based on asset value is used to apportion emissions to all assets.

Emissions Calculation

The calculation of emissions within the CC is undertaken either directly or indirectly. When emissions are calculated directly, the data entered by the user is used to produce emissions estimates. When emissions are calculated indirectly, the product of the direct emissions calculations are used in conjunction with assumptions to produce the emissions estimates.

The table below details which types of calculation are used for each emissions source.

Direct	Indirect
Materials (cradle to gate) – A1	Materials (cradle to gate) for maintenance – B2
Transport of materials – A2	Plant for maintenance – B2
Transport of construction waste – A5	Materials (cradle to gate) for repair – B3
Use of plant – A5	Plant for repair – B3
Transport of people to site – A4	Replacement materials (cradle to gate) – B4
Transport of plant to site – A4	Replacement transport of materials – B4
Site establishment – A5	Replacement transport of construction waste – B4
Transport of people to site during operation – B1	Replacement use of plant – B4
Transport for maintenance – B2	Replacement transport of people to site – B4

Transport for repair – B3	Replacement transport of plant to site – B4
Energy use during operation – B1	Replacement site establishment – B4
Transport of demolition waste – C2	Refurbishment materials (cradle to gate) – B5
N/A	Refurbishment transport of materials – B5
N/A	Refurbishment transport of construction waste – B5
N/A	Refurbishment use of plant – B5
N/A	Refurbishment transport of people to site – B5
N/A	Refurbishment transport of plant to site – B5
N/A	Refurbishment site establishment – B5
N/A	Transport of people to demolition site – C2
N/A	Plant for demolition – C1

Direct Emissions Calculations

The calculation of direct emissions follows the following logic:

Activity Data x Emissions Factor = Emissions (CO_2e)

Where:

- Activity Data = detailed project information (for example the mass of materials used)
- Emissions Factor = The quantity of emissions produced per unit of activity data.

The emissions factors used in each calculation depends on the type of activity data provided (for example, type of material used), and activity data units. The emissions factors used in the CC have been sourced from publicly available databases, or are based on project data. These are stored in hidden sheets within the tool and should be updated annually in line with the emissions factor update process. For embodied emissions and electricity use, it is possible to overwrite the default emissions factors if a more accurate emissions factor is known. This is not possible for other sources, as it is unlikely that the user would know specific emissions factors for these sources, and would increase the risk in errors.

Some direct emissions calculations only require the activity data to be multiplied by the emissions factor as above. However, for some calculations pre-processing is required. Pre-processing takes input data and converts it to the activity data required for the direct emissions calculation. The table below outlines which emissions sources do and do not require pre-processing.

Does not require pre-processing	Requires pre-processing
Materials (cradle to gate) – A1	Transport of materials – A2
Use of plant – A5	Transport of construction waste – A5

Site establishment – A5	Use of plant – A5
Transport for maintenance – B2	Site establishment – A5
Transport for repair – B3	Transport of people to site – A4
Energy use during operation – B1	Transport of plant to site – A4
N/A	Energy use during operation – B1
N/A	Transport of demolition waste – C2

Where emission sources appear in both columns in the above table, this is because the CC provides more than one methods to calculate emissions for the emissions source. Where pre-processing is undertaken within the CC the methods used for this are presented below by emissions source.

Transport of materials: Before emissions can be calculated for the transport of materials, the number of journeys to transport the quantity of materials specified, must be calculated. This first requires the quantity of materials in tonnes to be calculated. When tonnes of materials are entered into the CC this is already completed. However, when the units are m3 or 'item' this needs to be calculated. For m3 the embodied emissions CO2e result is divided by the tonne emissions factor to convert the quantity to tonnes. When 'item' is selected, it is assumed each item weights a tonne. Once the mass to be transported has been calculated, the number of journeys needs to be calculated. This is done by assuming vans will transport 3.5 tonnes and HGVs will transport 33 tonnes. As such the total mass of materials is divided by 3.5 or 33 depending on the vehicle type selected. This results in number of journeys. This is multiped by the journey distance, which results in the total distance travelled. This is then multiped by the emissions factor to calculate emissions.

Transport of construction waste: Before emissions can be calculated for the transport of construction waste, the quantity of construction waste must be calculated. This is done by first calculating the quantity of materials as per the method for the transport of materials. Then the percentage waste entered by the user is applied, resulting in the quantity of construction waste. This is multiplied by the distance to the waste disposal site (which is selected by the user in line with the following assumptions; Local – 20km, Regional – 100km, National – 300km, European - 1500km). This results in tonne-kilometres of material transported, (a tonne-kilometre is a unit of measure which represents the transport of one tonne over one kilometre). It is assumed that waste will be transported by HGV, which enables the tonnes-kilometres to be multiplied by the HGV tonnes-kilometres emissions factor to calculate emissions. It is also possible to add additional construction waste in the 'other construction waste' section. Here the quantity of waste is multiplied by the distance to the waste disposal site (which is selected by the user), which results in tonne-kilometres of waste transported. It is assumed that waste will be transported by HGV, which enables the tonnes-kilometres to be multiples by the HGV tonnes-kilometres emissions factor to calculate emissions.

Use of plant: There are two possible methods for calculating emissions from plant. The first is to enter the total litres of fuel to be combusted in the plant – this method does not require pre-processing. The other method requires pre-processing to estimate the total litres of fuel to be combusted. The CC has a database of plant types, their fuel consumption rate and their utilisation rate. The user then selects the type of plant and how long it's on site for. The CC then multiplies the hours on site, by the fuel consumption of the plant, and the plant utilisation rate, which results in total litres of fuel to be combusted. This is then converted to emissions by multiplying the appropriate emissions factor for the fuel type.

Site establishment: There are two possible methods for calculating emissions from site establishment. The quantity of fuel/energy/water to be used can be entered – this method does not require pre-processing. The other method uses the construction start date and construction finish date to calculate how long the site will be established for. This is then multiplied by an emissions factor for site establishment, which results in emissions.

Transport of people to site: There are two possible methods for calculating emissions from transport of people to site. Both require pre-processing. The first method involves entering the number of journeys transporting people within different distance bands. Each distance band is assigned an average distance. This is multiplied by the number of journeys to give total distance travelled. This is then multiplied by the appropriate emissions factor to calculate emissions. The second method uses the construction start date and construction finish date to calculate how long construction will take. This is then multiplied by an emissions factor for people transport, which results in emissions.

Transport of plant to site:

There are two possible methods for calculating emissions from transport of plant to site. Both require pre-processing. The first method involves entering the quantity of journeys transporting plant within different distance bands. Each distance band is assigned an average distance. This is multiplied by the number of journeys to give total distance travelled. This is then multiplied by the appropriate emissions factor to calculate emissions. The second method uses the construction start date and construction finish date to how long construction will take. This is then multiplied by an emissions factor for plant transport, which results in emissions.

Energy use during operation: There are two possible methods for calculating emissions from energy use during operation. The annual electricity consumption can be entered – this method does not require pre-processing. The other method calculates annual electricity consumption on an individual item basis. This is done by taking the name plate power rating of the item, dividing this by the efficiency rating, and then multiplying this by the load rating and the use factor to provide and actual power rating. This is then multiplied by annual usage to calculate annual electricity consumption. This is then multiplied by an emissions factor for electricity, which results in emissions

Transport of demolition waste: Before emissions can be calculated for the transport of demolition waste, the quantity of construction waste must be calculated. This is done by first calculating the quantity of materials as per the method for the transport of materials. For refurbishment and replacement, it is then assumed that the materials that have not been removed as construction waste will become demolition waste. As such the total mass of construction materials, minus construction waste is assumed to be the mass of demolition waste. This is multiplied by the distance to the waste disposal site (which is selected by the user in line with the following assumptions; Local – 20km, Regional – 100km, National – 300km, European - 1500km). This results in tonne-kilometres of material transported. It is assumed that waste will be transported by HGV, which enables the tonnes-kilometres to be multiples by the HGV tonnes-kilometres emissions factor to calculate emissions. If the first intervention is demolition, then the demolition waste should be entered into the 'other construction waste' section. Here the quantity of waste is multiplied by the distance to the waste disposal site (which is selected by the user), which results in tonne-kilometres of waste transported. It is assumed that waste will be transported by HGV, which enables the tonnes-kilometres to be multiples by the HGV tonnes-kilometres emissions factor to calculate emissions.

Indirect Emissions Calculations

As outlined above, indirect emissions calculations estimate emissions by assuming that a proportion of directly calculated emissions will be emitted for each emissions source. This depends on two dependant variables, the first variable is the type of intervention that is being undertaken at project outset (new build, refurbishment, replacement, demolition) – this is known as the first intervention. The second variable is the emissions source being calculated.

The first variable changes the size of the emissions that are to be apportioned, whilst the second variable changes the size of the apportionment. So, for example, If the first intervention was a refurbishment, the emissions from refurbishing the sub-asset would likely be very different, when compared to if the first intervention was a new build. As such, when the CC estimates emissions by assuming a proportion of direct emissions, which are emissions from the first intervention, this needs to be taken into consideration.

To do this, when different first interventions are selected, different methods are used as indicated below.

- When the first intervention is new build, the assumed proportion of directly calculated emissions is used.
- When the first intervention is refurbishment, the direct emissions are factored up, in line with the assumed proportion of directly calculated emissions for refurbishment. This uplifts the direct emissions calculated from emissions for refurbishment to emissions for new build.
- When the first intervention is replacement, the direct emissions are factored down, in line with the assumed proportion of directly calculated emissions for replacement. This reduces the direct emissions calculated from emissions for refurbishment to new build.
- When the first intervention is demolition, there is no need to factor this onto a new build basis, as indirect emissions calculations do not need to be undertaken, as the sub-asset will not exist to produce emissions.

By putting the direct emissions from first interventions onto a new build basis, this enables the proportion of first intervention direct calculation emissions assumption to be applied consistently. The assumptions used are presented below by emissions source category below. The replacement and refurbishment assumptions as used to put the first intervention direct calculation emissions on a new build basis, and as with the other emissions source categories, are also used to assume a proportion of first intervention direct calculation emissions that are emitted.

Maintenance and Repair (materials and plant)

Maintenance and Repair Level	Value	Source
Low	0.10%	EA Assumption
Medium	1.00%	EA Assumption
High	5.00%	EA Assumption
Not applicable	0.00%	EA Assumption

Replacement (all sources)

Replacement is assumed to result in the same emissions, except for the transport of people to site and the transport of plant to site which are assumed to be double.

Refurbishment (all sources)

Refurbishment Level	Value	Source
Minor Refurbishment	10%	EA Assumption
Moderate Refurbishment	25%	EA Assumption
Major Refurbishment	50%	EA Assumption
Not Possible	0%	EA Assumption

Demolition (use of plant and transport of people)

Emissions source	Value	Source
Plant	50%	EA Assumption
Transport of people	50%	EA Assumption

Worked Example

The logic of how these assumptions fit together is somewhat complex. As such a worked example has been provided below.

Replacement transport of people to site

Input parameters:

- First intervention: moderate refurbishment
- First intervention direct calculation emissions of transport of people to site: 10tCO2e

Step 1:

First intervention direct calculation emissions are put on a new build basis:

(First intervention emissions / moderate refurbishment percentage) X 100 = The emissions that would have occurred if the first intervention was a new build rather than a refurbishment.

(10 / 25) X 100 = 40

Step 2:

The proportion of directly calculated emissions assumed to be emitted for Replacement transport of people to site is applied.

The product of step 1 X 2

40 X 2 = 80

The result is that emissions from replacement transport of people to site is 80tCO2e

Project lifespan

Every project is assessed on a 100 year lifespan. Where assets are not expected to last for 100 years, it has been assumed that they will be replaced. The emissions from first intervention occur in year zero, which is assumed to be the current year. Energy is on an annual basis for every year after year zero over the full 100 years. Repair and maintenance depends on frequency selected by the user, and starts after year zero and continues for the full 100 years.

Replacement and refurbishment depend on the project life and refurbishment life entered. New build and replacement are assumed to be followed by refurbishment (if it's possible), which is assumed to be followed by replacement. If refurbishment is not possible New build and replacement are assumed to be followed by replacement. Where this results in a lifespan over 100 years, the residual emissions associated with this are calculated and allocated to the project (for more information on residual emissions see the residual emissions section below). In this way all projects are assessed on the same basis

Demolition can only be selected as a first intervention, and when its selected no refurbishment of replacement are possible. To account for demolition waste due to refurbishment or replacement the CC assumes that all new materials leave the site as waste (some as construction waste, and the rest as demolition waste to account for the items that are being replace that are removed).

Residual Emissions

When new build, replacement, or refurbishment life extends beyond the assumed 100 year project lifespan, to maintain comparability with projects, the emissions associated with this period are calculated, presented and subtracted from the emissions total to project a net emissions rate.

Residual emissions are calculated by first working out if the last intervention is a replacement or a refurbishment. Then the remaining life is calculated using when this replacement happened, and the expected newbuild/replacement life, or the expected refurbishment life, depending on the last intervention. The emissions from the last intervention are then divided by the lifespan of the last intervention, and then multiplied by the remaining life. This results in the residual emissions.

Future Emissions

Changes to the mix of electricity generation capacity in the future are expected to change the quantity of emissions due to electricity use. In addition, the efficiency of vehicles and plant, and the mix of vehicles on the roads are also expected to change in the future. To ensure that this is considered over the 100-year project lifespan, factors have been produced to reflect this in the CC.

This was done by taking publicly available data on the future emissions rates of the electricity grid published by the UK treasury, and data on the efficiency and future mix of vehicles published by the department for transport. Using this data factors were calculated on a proportional basis where year zero is one.

For emissions sources other than electricity, plant and transport, a combination of these sources was used. For embodied emissions an analysis of the Inventory of Carbon and Energy (ICE) database was used. This showed that 50% of the energy embodied in materials came from electricity use, and as such the other 50% was due to plant and transport. Therefore a 50% split between electricity and plant/transport was used for embodied materials. For site establishment the same rate was used (as site establishment causes emissions from plant, transport and electricity). For all other emissions sources a split of 20% electricity, 50% plant and transport, 10% commuting and 20% embodied emissions was used.

This was then implemented in the CC, by multiplying the results of the emissions calculations by the calculated factors, depending on which year the emissions are expected to take place. This means any overwrite emissions factor will also be discounted in line with this method. This results in future emissions estimates that are in line with publicly available future estimates. This means that emissions in the future are expected to be lower than they are today, which is in-line with expectations.

Data Summarisation

Data from direct emissions calculations are presented next to the data entry sheets. These are then summarised and placed on a 100 year basis using a macro. This is then used as the basis of the indirect emissions calculations. These are then apportioned to each asset as outlined in the asset hierarchy section. This data is then summarised by section on the Calculator sheet. In addition, data is also presented on the Summary sheet. The figures on this sheet are based on the same data as the calculator sheet. The graphs are based on pivot tables on a hidden sheet. The pivot tables summarise the same data as the calculator sheet uses, to be presented in the Summary sheet graphs.

Data export

Once the assessment is complete, data can be exported from the CC to the CMT. This is done through two steps, first the extract model data macro must be run. This summarises the data in the CC by asset on the Model sheet. Then once a new version of the CC has been saved, the macro in the CMT can be run to extract data from the CC.