

Annotated example of an automated calculation of CO2e content of structural elements for two structures.

Formulae to calculate quantity of each element in the absence of detailed dimensions. These formulae use engineering judgement to estimate quantity.

Additional assumption links back to engineering judgement made to calculate quantity of each element.

Links element back to the parent structure.

The only structure dimensions available (limited records).

Element name.

Calculated quantity of each element.

Identifier of Structure	Element	Length (m) of Structure	Average Width (m) of Structure	Average headroom	Formula	Additional assumption	Unit calculation	Units	Maintenance activity	Rate	CO2e [kg]
A40 10 - 1	Br01. Primary Deck Element	9.1	13.03	5.77	Length x Average Width x Additional assumption	0.8	94.86	m3	Concrete repairs	944.12	89557.71
A40 10 - 1	Br03. Secondary Deck Element	9.1	13.03	5.77	Length x Average Width x Additional assumption	0.2	23.71	m3	Concrete repairs	944.12	22385.43
A40 10 - 1	Br06. Parapet Beam or Cantilever	9.1	13.03	5.77	Length x 0.7 x 2 x Additional assumption	0.5	6.37	m3	Concrete repairs	944.12	6014.08
A40 10 - 1	Br08. Foundations	9.1	13.03	5.77	Length x Average width x 0.3 x 2	2	71.14	m3	Foundations: repair	944.12	67168.28
A40 10 - 1	Br09. Abutments (incl. Arch Springing)	9.1	13.03	5.77	Average Critical Headroom x Average Width x 2 x Additional assumption	0.5	75.18	m3	Concrete repairs	944.12	70981.87
A40 10 - 1	Br15. Superstructure Drainage	9.1	13.03	5.77	Length x 2 x Additional assumption	0.023	0.42	m3	Drainage: Maintenance	3165.4	1325.04
A40 10 - 1	Br16. Substructure Drainage	9.1	13.03	5.77	Additional assumption x 4 x (Average Critical Headroom + Br09. Additional assumption) + Additional assumption x 2 x Average Width	0.003357577	0.17	m3	Drainage: Maintenance	3165.4	543.52
A40 10 - 1	Br17. Waterproofing	9.1	13.03	5.77	Length x Average Width x Additional assumption	0.003	0.36	m3	Waterproofing: Replacement	456.4	162.35
A40 10 - 1	Br18. Expansion Joints	9.1	13.03	5.77	Average width x Additional assumption	0.106	1.38	m3	Expansion Joint Replacement: Asphaltic Plug	1565.536	2162.29
A40 10 - 1	Br21. Finishes: Parapets/Safety Fences	9.1	13.03	5.77	Length* Additional assumption	0.0078359	0.07	m3	Finishes: Wet/Dry surface preparation and re-application of finish	22248	1586.43
A40 10 - 1	Br23. Handrail/Parapets/Safety Fences	9.1	13.03	5.77	Length x Additional assumption	0.024	0.22	m3	Metalwork repair	18942	4136.93
A40 10 - 1	Br24. Carriageway surfacing	9.1	13.03	5.77	Length x Average Width x Additional assumption	0.0936	11.10	m3	Carriageway surfacing: maintenance	152	1686.96
A40 10 - 1	Br25. Footway/verge/footbridge surfacing	9.1	13.03	5.77	Length x Additional assumption	1	9.10	m3	Footway surfacing: maintenance	267.8	2436.98
A40 10 - 1	Br30. Revetment/Batter Paving	9.1	13.03	5.77	Average Width x Average Critical Headroom x 5%/2 x 2 x Additional Assumption	0	0.00	m3	Revetments: Maintenance (Cable-Tied Block Mattresses)	1378.28	0.00
A40 10 - 1	Br31. Wing Walls	9.1	13.03	5.77	Average Critical Headroom x 5 x 4 x Additional assumption	0.5	57.70	m3	Concrete repairs	944.12	54475.72
A40 10 - 1	Br33. Embankments	9.1	13.03	5.77	Length x Average Critical Headroom x 0.2 x 1/2 x 2 x Additional Assumption	0	0.00	m3	Embankments/Earthworks: Maintenance	1925.65	0.00
A40 10 - 1	Br35. Approach Rails/Barriers/Walls	9.1	13.03	5.77	Length x 0.2 x Additional Assumption	0.024	0.04	m3	Concrete repairs	944.12	41.24
A40 10 - 1	Br36. Signs	9.1	13.03	5.77		0	0.00	0	Signs: Maintenance	0	0.00
A40 10 C50 - 1	Br01. Primary Deck Element	74	2.2	2.2	Length x Average Width x Additional assumption	0.8	130.24	m3	Concrete repairs	944.12	122962.19
A40 10 C50 - 1	Br08. Foundations	74	2.2	2.2	Length x Average width x 0.3 x 2	2	97.68	m3	Foundations: repair	944.12	92221.64
A40 10 C50 - 1	Br10. Spandrel Wall/Head Wall	74	2.2	2.2	Average Critical Headroom x Length x 2/3 x Additional Assumption	0.5	54.27	m3	Concrete repairs	944.12	51234.25
A40 10 C50 - 1	Br16. Substructure Drainage	74	2.2	2.2	Additional assumption x 4 x (Average Critical Headroom + Br09. Additional assumption) + Additional assumption x 2 x Average Width	0.003357577	0.05	m3	Drainage: Maintenance	3165.4	161.55
A40 10 C50 - 1	Br17. Waterproofing	74	2.2	2.2	Length x Average Width x Additional assumption	0.003	0.49	m3	Waterproofing: Replacement	456.4	222.91
A40 10 C50 - 1	Br18. Expansion Joints	74	2.2	2.2	Average width x Additional assumption	0.106	0.23	m3	Expansion Joint Replacement: Asphaltic Plug	1565.536	365.08
A40 10 C50 - 1	Br23. Handrail/Parapets/Safety Fences	74	2.2	2.2	Length x Additional assumption	0.024	1.78	m3	Metalwork repair	18942	33640.99
A40 10 C50 - 1	Br24. Carriageway surfacing	74	2.2	2.2	Length x Average Width x Additional assumption	0.0936	15.24	m3	Carriageway surfacing: maintenance	152	2316.19
A40 10 C50 - 1	Br25. Footway/verge/footbridge surfacing	74	2.2	2.2	Length x Additional assumption	1	74.00	m3	Footway surfacing: maintenance	267.8	19817.20
A40 10 C50 - 1	Br26. Invert/River Bed	74	2.2	2.2	Length x Average Width x 0.1 x 2 x Additional assumption	0.5	16.28	m3	Invert repair	62	1009.36
A40 10 C50 - 1	Br29. River Training Works	74	2.2	2.2	assumption	20	176.00	m3	Concrete repairs	944.12	166165.12
A40 10 C50 - 1	Br31. Wing Walls	74	2.2	2.2	Average Width x 2 x 2 x Additional assumption	0.5	22.00	m3	Concrete repairs	944.12	20770.64

Asset owners can review specific elements of each structure to identify embodied carbon within each structure.

This provides insight into the contribution of different elements .

All the elements that comprise one span of a bridge, A40 10 - 1.

All the elements that comprise one span of a culvert, A40 10 C50 -1.

Quantity calculations defined and agreed with SAVI leads for 36 different bridge elements.

Relevant unit for quantity.

Maintenance activity for each element.

Carbon rate for each maintenance activity. E.g 1m³ of concrete repairs is equivalent to 944.12kg of CO2e.

CO2e replacement cost for each element of each structure.

The tool developed calculates the CO2e for each element. Currently this is being used for the WG asset stock with ~ 5000 structures and ~ 60,000 different elements.

This is an extract of the Carbon Dashboard. The dashboard is the front end interface of the calculation tool. This provides interpretation of the data and allows the asset owner to draw conclusions and make asset management decisions.

Provides a breakdown of the condition score of the structures. This is based off BCI scores. Informs asset owner of a snapshot of the condition breakdown across the network.

Summary of input structures and elements.

Headers to simplify the dashboard.

Breakdown of structure types.

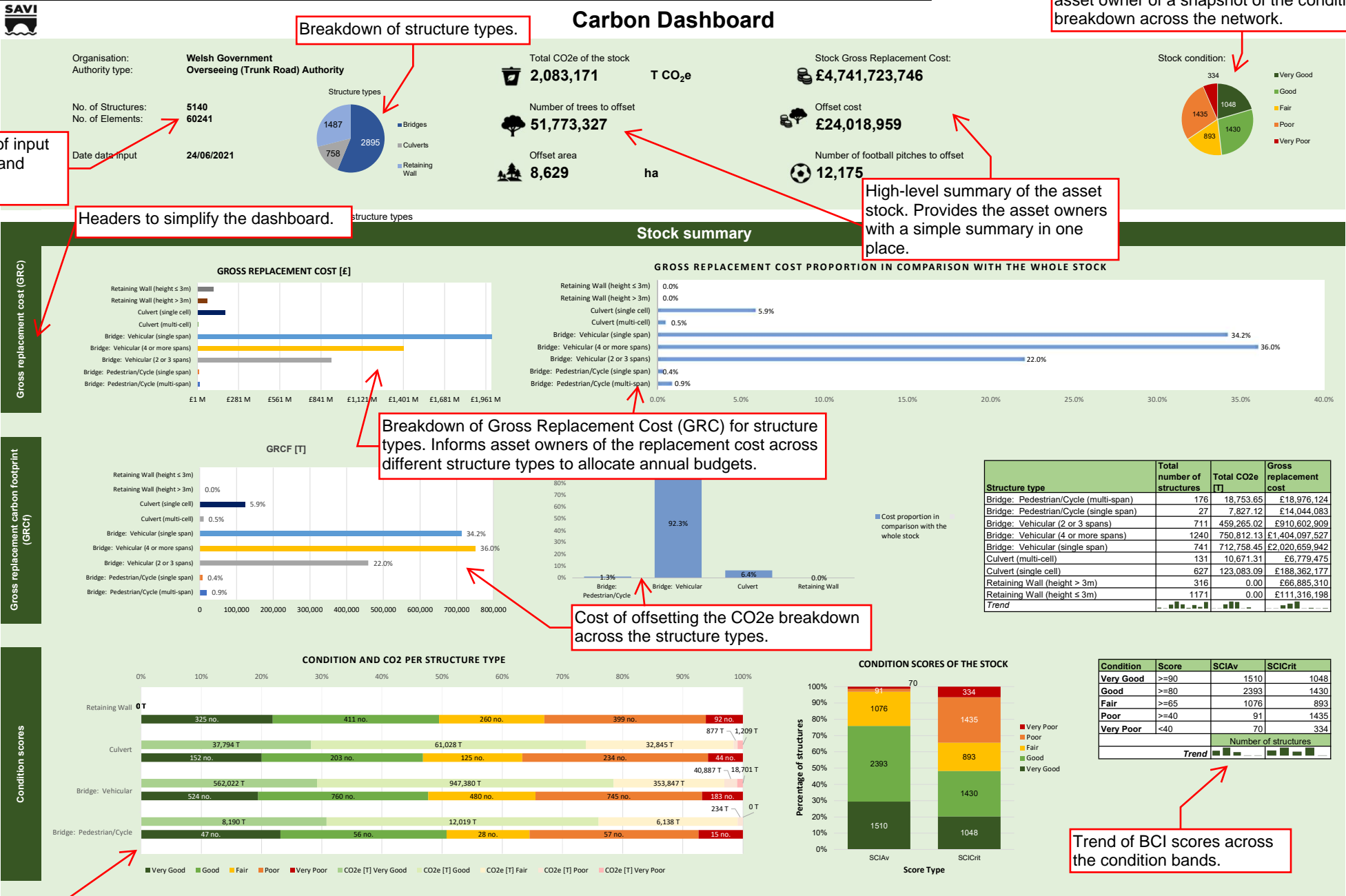
## Carbon Dashboard

High-level summary of the asset stock. Provides the asset owners with a simple summary in one place.

Breakdown of Gross Replacement Cost (GRC) for structure types. Informs asset owners of the replacement cost across different structure types to allocate annual budgets.

Cost of offsetting the CO2e breakdown across the structure types.

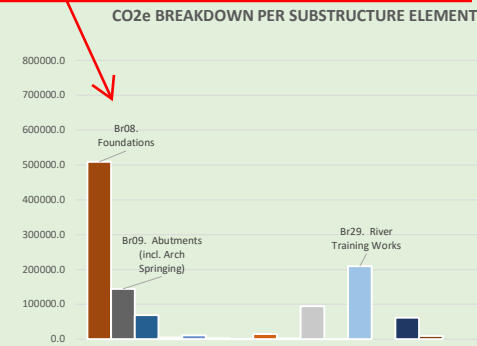
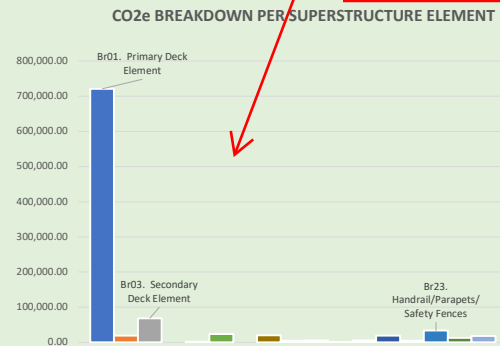
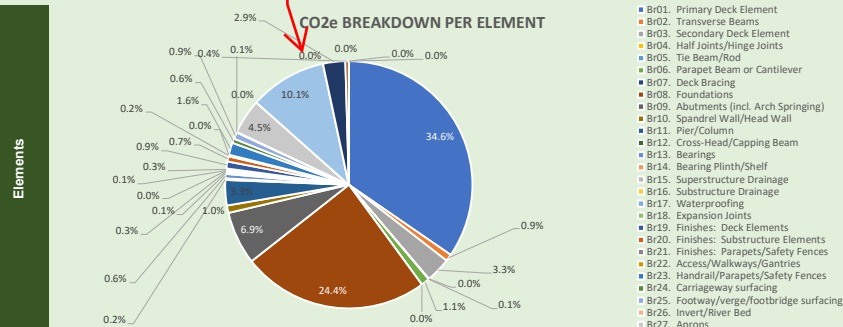
Trend of BCI scores across the condition bands.



Comparison of the condition of the structure stock vs. the Gross Replacement Carbon footprint (GRCf). Allows asset owners to understand the embodied carbon in the best and worst condition structures and prioritise funding accordingly.

Breakdown of the 36 bridge elements and the CO2e for each element. This allows the asset owners to understand the embodied carbon across different parts of the structures.

Breakdown of the key elements that contribute to the overall GRCf of each structure. Allows asset owners to focus long-term asset management planning.



### Substandard structures

Number of substandard structures  
**199**

Total CO2e of the substandard stock  
**52,267 T CO<sub>2</sub>e**

Number of trees to offset  
**1,298,992**

Number of football pitches to offset  
**305**

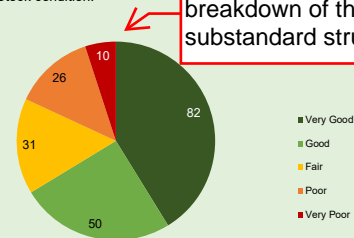
Stock Gross Replacement Cost:  
**£73,726,561**

Offset cost  
**£602,635**

Offset area  
**216 ha**

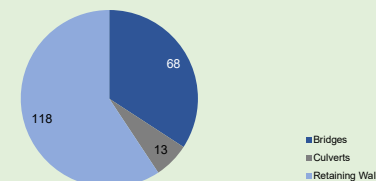
Provide an easily understandable comparison to a football pitch (0.71ha).

Stock condition:



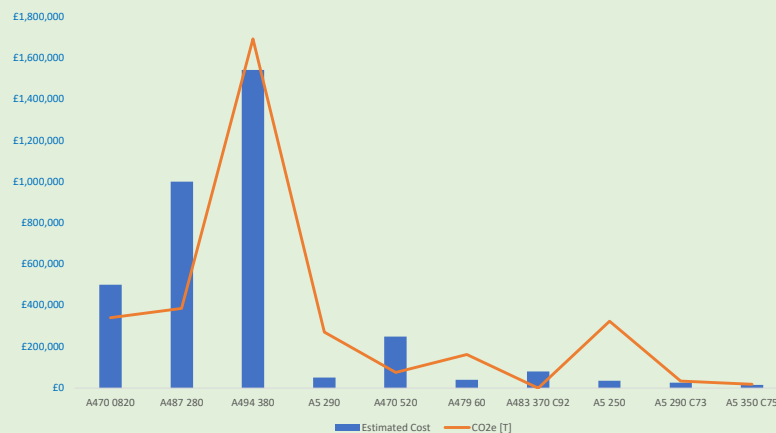
BCI structure condition breakdown of the substandard structures

Structure types:



Top 10 highest-risk structures to allow the asset owners to focus on the required works to the structures and the CO2e impacts.

### COST AND CO2e OF THE SUBSTANDARD CRITICAL STRUCTURES



Critical structures						
Risk Rating	Ref	Structure Name	Type	Route out of CS 470	Cost	CO2e [T]
12	A470 0820	Caersws Bridge	Bridge	Works	£500,000	1,134.92
12	A487 280	Pont ar Dyfi	Bridge	Works	£1,000,000	1,286.10
12	A494 380	Queensferry Bp River	Bridge	Works	£1,542,423	5,643.97
10	A5 290	Pont Ty Hyll	Bridge	Works	£50,000	905.72
6	A470 520	Pont Llysiog	Bridge	Works	£250,000	251.18
6	A479 60	Bronllys Castle	Bridge	Works	£40,000	540.05
6	A483 370 C92	Ashbrook House	Culvert	Works	£80,000	0.00
6	A5 250	Glan Conwy House	Bridge	Repairs and reassessment	£35,000	1,081.90
6	A5 290 C73	Afon Bedol	Culvert	Repairs and reassessment	£25,000	111.50
6	A5 350 C75	Tan y Bryn Culvert	Culvert	Repairs and reassessment	£15,000	62.21

Comparison of Gross Replacement Cost (GRC) with Gross Replacement Carbon footprint (GRCf). This allows asset owners to understand the embodied carbon in the most at-risk structures on the network.