AECOM

Appendix G – Greenhouse Gas (GHG) Emissions Assessment Report

Hereford Eastern River Crossing (ERiC) (SOC)

Herefordshire Council

July 2023

Delivering a better world

Quality information

Prepared by	Checked by	Verified by	Approved by
Eleri Brown Sustainability Consultant	Nichola Egan Senior Air Quality Consultant	Ian Davies Technical Director	Darren Abberley Associate Director

Revision History

Revision	Revision date	Details	Authorized	Name	Position

Distribution List

# Hard Copies	PDF Required	Association / Company Name

Prepared for:

Herefordshire Council

Prepared by:

AECOM Infrastructure & Environment UK Limited
The Colmore Building
20 Colmore Circus Queensway,
Birmingham B4 6AT
aecom.com

Table of Contents

Figures

Tables

1. Introduction

1.1 The purpose of this Green House Gas (GHG) assessment is to provide a high-level indicative estimate and comparison of the GHG emissions associated with two road alignment options, with two different speed limit options for the Hereford Eastern River Crossing (ERiC). The road development is being delivered by Herefordshire Council as part of their detailed masterplan for Hereford which aims to make the city a greener, healthier, and safer place to live, work and visit, with better connections to nearby villages, towns, and counties by all transport modes. Herefordshire Council has recently undertaken a review of the Hereford Transport Strategy (2016-2031), with a preferred strategy comprising of four packages of measures for the future Hereford transport system being identified:

- Walking and cycling measures;
- Improving public transport;
- Managing traffic demand; and
- Providing a new river crossing.

1.2 An additional river crossing is deemed as essential in providing an alternative route for addressing the resiliency issues across the city centre's transport network and facilitating the future growth of the city.

1.3 A key output from the Hereford Transport Strategy Review (2020) was the resolution to stop progress with the western bypass and southern link road. Plans for this route would have included a crossing of the River Wye to the west of the city centre. Instead, the Review committed to develop further proposals for a river crossing to the east of the city, and this has shaped the location of the proposals put forward as part of this review.

1.4 The GHG assessment report presents the results of the high level GHG emissions assessment of each of the four road alignment options (1a, 1b, 3a & 3b), and analyses the variability in the lifecycle carbon emissions for each option. This report states the methods used to estimate carbon emissions from the project and records key assumptions made, followed by outlining the project carbon emissions and opportunities for improvement.

Project Location

1.5 The broad study area and potential location for the eastern river crossing is presented in Figures 1 and 2. It is expected that the crossing will be a multi-modal corridor which will include dedicated provision for active travel modes.

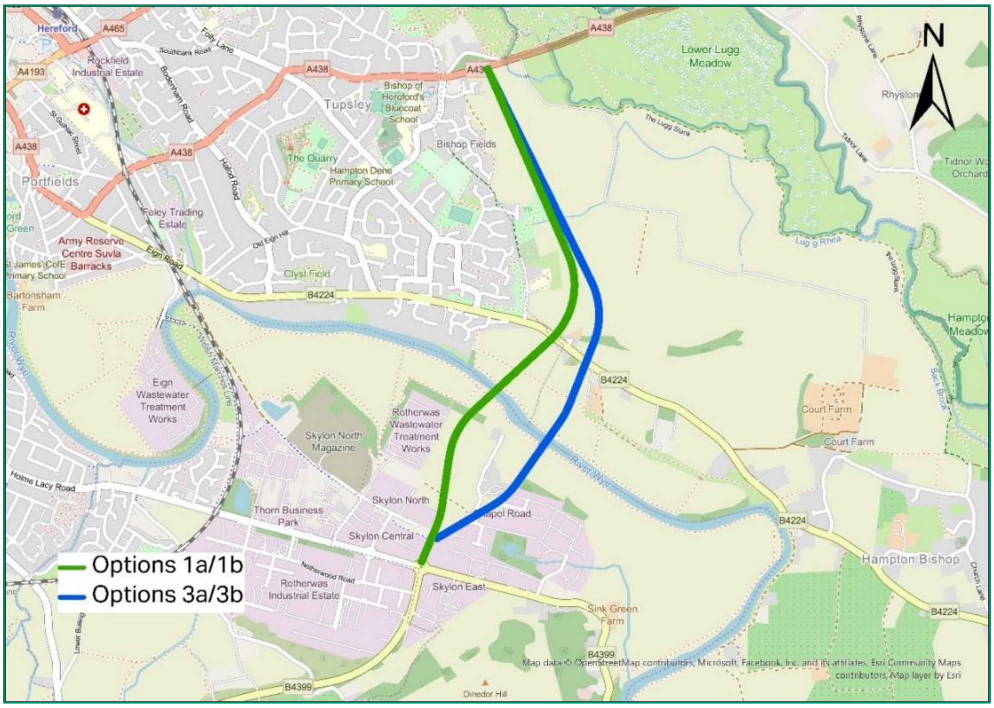

Figure 1: Aerial image of Alignment 1 and 3 across the River Wye.

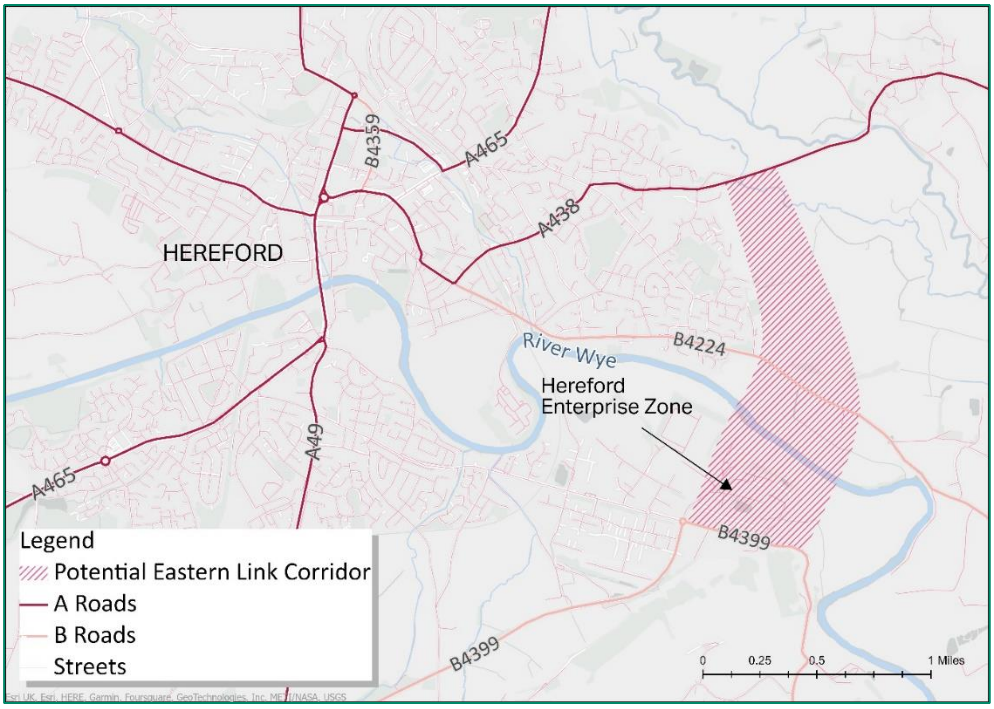

Figure 2 Study area and broad location of the eastern river crossing.

Project Description

1.6 This GHG assessment has been undertaken to provide a quantitative assessment of the variability in carbon emissions between the four road options considered. These include:

1.6.1 Option 1a: A 2.7km single carriageway road, 6.5m in width with a speed limit of 30mph and dedicated provision for active travel facilities in the form of a footpath, 2m in width, and cycleway, 3m in width. Option 1a requires a structure in the form of a bridge to be built over the River Wye.

1.6.2 Option 1b: A 2.7km single carriageway road, 7.3m in width with a speed limit of 40mph and dedicated provision for active travel facilities in the form of a footpath, 2m in width, and cycleway, 3m in width. Option 1b requires a structure to be built over the River Wye. The alignment for Option 1b would be wider than 1a to accommodate the faster speeds of the 40mph road.

1.6.3 Option 3a: A 2.7km single carriageway road, 6.5m in width with a speed limit of 40mph and dedicated provision for active travel facilities in the form of a footpath, 2m in width, and cycleway, 3m in width. Alignment 3 utilises 300m of existing road but will need upgrading as part of the scheme. Option 3a requires a structure in the form of a bridge to be built over the River Wye. It is expected that the bridge structure for Option 3a will be greater in length due to the wider floodplain along the route.

1.6.4 Option 3b: A 2.7km single carriageway road, 7.3m in width with a speed limit of 40mph and dedicated provision for active travel facilities in the form of a footpath, 2m in width, and cycleway, 3m in width. Option 3b utilises 300m of existing road but will need upgrading as part of the scheme. The alignment for Option 3b would be wider than Option 3a to accommodate the faster speeds of the 40mph road. It is expected that the bridge structure for Option 3b will be greater in length than the bridge structure for Option 1a/1b due to the wider floodplain along the route.

1.7 This GHG assessment report provides the high-level indicative estimate of greenhouse gas emissions associated with the production of materials used, transportation of materials to site, transportation of workers to site, waste disposal of the materials used and construction activities on site.

2. Methodology

2.1 The GHG assessment was conducted in alignment to PAS2080 (2023)[1] guidelines, which provides best practice for carbon management in buildings and infrastructure in the UK. PAS 2080 sets out a modular approach to GHG emissions Life Cycle Assessment (LCA) boundaries, as shown in Figure 3.

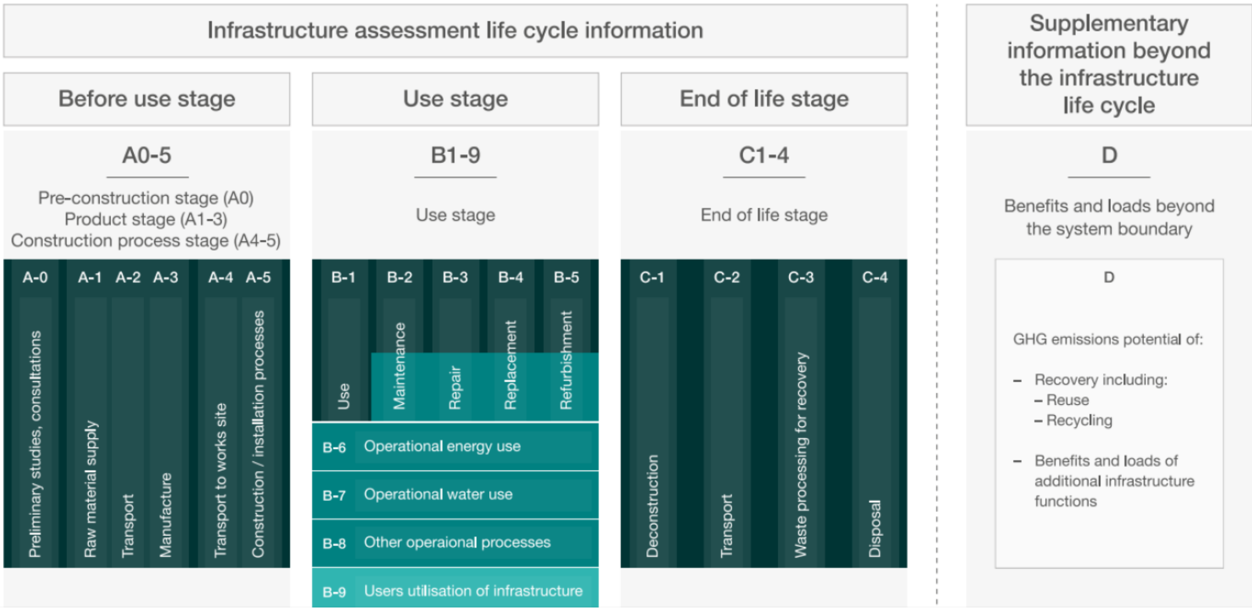

Figure 3 PAS 2080 GHG Life Cycle Assessment (LCA) Boundaries[1].

2.2 The purpose of this GHG assessment is to conduct a high-level comparison of the GHG emissions associated with the different road alignment options for the new Hereford Eastern River Crossing Road (ERiC). The Lifecycle Carbon Assessment modules covered in this study were selected so that the GHG emissions of each road alignment option could be sufficiently compared.

[1] PAS 2080: 2023. Carbon Management in Buildings & Infrastructure Revised PAS 2080:2023 | BSI (bsigroup.com)

2.3 Therefore, this assessment covers:

- A1-A3 – Product carbon emissions
- A4 (1) – Transportation of construction materials and equipment
- A4 (2) – Transportation of construction workers
- A5 (1) – Waste
- A5 (3) – Construction activities
- B2 – Maintenance
- B6 – Operational energy use

2.4 Where benchmarks are available, such as for Maintenance (B2) and Energy Use (B6), data has been included to provide an indication of the emissions associated with the lifecycle stage. Due to the unavailability of data for modules B1, 3, 4, 5, 7, 8 & 9 of the Use Stage, a qualitative assessment has been provided around how the emissions of such lifecycle stages can impact a project and the type of data that would be required to quantify such emissions.

2.5 The End-of-Life Stage (C1-C4) has been scoped out of this assessment. Roads that have reached the end of their functional life are either refurbished or decommissioned through road closure. However, this stage is rarely encountered in UK road infrastructure, and so has been excluded from this assessment.

2.6 This GHG assessment has been undertaken as a high-level approach. Where quantitative data was not available, benchmarks and proxy data were used to provide an indicative estimate of carbon emissions associated with each alignment option. Where proxy data has been used from previous project experience, suitable emissions factors were applied from the following sources:

- DEFRA BEIS 2023 emissions factors[2]
- National Highways Carbon Tool v2.5[3]
- Inventory of Carbon & Energy (ICE) v3.0[4]

3. Assumptions and Limitations

3.1 This section outlines any gaps in the data, and any assumptions made to address such issues.

A1-3 Product Stage

3.2 For the A1-A3 Product Stage carbon emissions calculations, a series of benchmarks and proxy data were used to provide an estimate of the emissions associated with the product stage of each alignment option. It should be noted that, as a BoQ Hereford ERiC alignment options was not available at the time this GHG assessment was conducted, the GHG emissions results for this stage should be used as a high-level, indicative estimate of emissions ranges, and not as an accurate representation of the emissions associated with the alignment options.

3.3 To provide an estimate of the materials used within the road construction, a benchmark developed by the Engineering and Physical Research Council and DecarboN8 in partnership with Transport for the North (TfN)[5], was used to provide an estimate of the quantity of materials used in an average 1km single carriageway asphalt pavement over a service period of 40 years.

3.4 Data on material and highway design considerations for the asphalt pavement were developed by the developed by the Engineering and Physical Research Council and DecarboN8 in partnership with Transport

[2] DEFRA BEIS 2023 emissions factors Greenhouse gas reporting: conversion factors 2023 - GOV.UK (www.gov.uk)
[3] National Highways Carbon Tool v2.5 Carbon emissions calculation tool - National Highways
[4] Inventory for Carbon and Energy (ICE) database (v3.0) Bath Inventory of Carbon and Energy (ICE) | GHG Protocol
[5] Lokesh, K., Densley-Tingley, D. and Marsden, G. (2022) Measuring Road Infrastructure Carbon: A 'critical' in transport's journey to net-zero. Leeds: DecarboN8 Research Network.Available at: *Measuring-Road-Infrastructure-Carbon.pdf (decarbon8.org.uk) [Accessed on 21.06.2023].

for the North (TfN) and based on published scientific industrial literature and the UK highway pavement guidance published by the National Highways.

3.5 The road structure is assumed to be made from four distinct layers which include the surface layer, asphalt binder, sub-base, and the sub-grade layer[1].

3.6 Option 1a (30mph) assumed to be 12.5m wide by 2410m long (including footpath, cycle lane, segregation). This is in addition to the bridge construction which is assumed to be 290m in length.

3.7 Option 1b (40mph) assumed to be 13.8m wide by 2410m long (including footpath, cycle lane, segregation). This is in addition to the bridge construction which is assumed to be 290m in length.

3.8 Option 3a (30mph) assumed to be 12.5m wide by 2215m long (including footpath, cycle lane, segregation). This is in addition to the bridge construction which is assumed to be 485m in length.

3.9 Option 3b (40mph) assumed to be 13.8m wide by 2215m long (including footpath, cycle lane, segregation). This is in addition to the bridge construction which is assumed to be 485m in length.

3.10 It is assumed that the road structure is made from four layers which include the surface layer, asphalt binder, sub-base, and the sub-grade layer[1].

- The thickness of the surface layer assumed to be 45mm.
- The thickness of the binder course assumed to be 55mm.
- The thickness of the base course assumed to be 90mm.
- The thickness of the sub-base layer assumed to be 150mm.
- The thickness of the sub-grade layer assumed to be 200mm.

3.11 All material quantities provided by the benchmark were assigned a suitable emissions factor from the ICE v3 database to calculate the carbon emissions associated with each quantity of material.

3.12 As Option 3 utilises 300m of existing road, the product stage carbon of Option 3 was assumed to be 10% lower than Option 1 (as 300m is approximately 10% of 2.7km).

3.13 There are two bridge options being considered as part of the Hereford ERiC project. Specific details of the bridge options, including materials and quantities were not available at the time of this GHG assessment. The Design Team provided high level description of the bridge design and indicative figures for bridge length and width based on a previous project of similar scale. Assumptions provided by the Design Team for both bridge options 1a and 1b and 3a and 3b include:

- Alignment 1a and 1b: The bridge deck will be formed of composite steel beams with an in-situ deck. Dimensions for 1a assumed to be 290m in length and 15.3m in width, and 1b assumed to be 290m in length and 15.8m in width, with 14 culverts (average dimensions for each culvert: 6.4m wide by 3.4m deep and 40m long).
- Alignment 3a and 3b: The bridge deck will be formed of composite steel beams with an in-situ deck. Dimensions 3a assumed to be 485m in length and 15.3m in width, and 3b assumed to be 485m in length and 15.8m in width. No culverts included.

3.14 The AECOM Highways Carbon Toolkit was used to calculate the emissions associated with the proposed bridge development based on the area dimensions provided by the Design Team, which assumes 2 tonnes of CO_2e per square meter of bridge area. A high level GHG assessment was conducted on both bridge options and has been included within the material lifecycle stage assessment for Options 1 and 3. The benchmark used to determine the bridge construction emissions also accounts for the transport of bridge materials to the construction site. As such, the transport of bridge materials has been excluded from module A4(1) Transport of Construction Materials, to avoid double counting of emissions.

3.15 Due to the unavailability of specific data relating to additional structures within each alignment option, such as embankments, viaducts, this stage of the GHG assessment only considers the emissions associated with the road construction and the emissions associated with the bridge construction. All other structures have been excluded from this assessment.

A4 (1) Transportation of Construction Materials

3.16 For the A4 (1) lifecycle module, the transport of materials to the construction site was calculated using benchmarks as exact information on the material quantities, distance to the construction site and the mode of transport were not available.

3.17 The total mass of materials was calculated from the quantities of materials used in the product stage (A1-3). The mass and distance were multiplied by the emissions factor for average rigid HGV average laden from the DEFRA BEIS 2023. Transportation of waste is included in the waste disposal emissions factors, so is assumed to be included in the 'Waste (construction)' calculations.

3.18 Transportation emissions have been calculated on a 'tonne km' basis, using the quantities of the materials used in the product stage (A1-3). Specific modes of transport for delivery of products were not available at this stage so it has been assumed that all materials are transported using Heavy Goods Vehicles (HGVs). The default transport distance for suppliers of the road construction material is assumed to be 50km (locally sourced). This is based on the Royal Institution of Chartered Surveyors (RICS) Whole Life Carbon Assessment for the Built Environment guidance[6]. For all assets, HGV was used for the transportation mode emissions factor for average rigid HGV average laden and Well To Tank (WTT) from the DEFRA BEIS 2023 has been applied. The transport of materials for the bridge construction has been accounted for within the benchmark used for the bridge material construction within the Product Stage (A1-3), as stated previously. As such, the transport of bridge materials has been excluded from module A4(1) Transport of Construction Materials, to avoid double counting of emissions.

A4 (2) Transportation of Construction Workers

3.19 For the A4(2) lifestyle module, the emissions from worker transport have been considered as a result of fuel use in vehicles used to travel to and from the site. For this lifecycle module, proxy data from previous highways projects of a similar scale have been used to develop a high-level estimate of the emissions associated with transport of construction workers. The following data has been assumed in relation to worker travel:

- 50 construction workers
- 6 days worked per week
- 50 week of construction time

3.20 It has been assumed that the average transportation distance is 20km per worker one way with travel conducted as single occupancy by car. It has therefore calculated that the total number of vehicle movements both ways over the course of the project is 15,000 movements. The total travel distance for worker travel and number of journeys was then applied to the emissions factor for 'Car - Average - Unknown Fuel' from BEIS DEFRA 2023 to account for the unknown fuel type, including Well To Tank (WTT) emissions, which calculated the associated carbon emissions with worker travel to the construction site.

A5 (1) Construction Waste

3.21 For the A5(1) lifecycle module, due to the high-level nature of this GHG assessment, assumptions have been applied to the quantities of waste generated by the project. Due to the unavailability of data associated with material waste, a 2% uplift in GHG emissions has been included within the assessment to account for the waste associated with construction

3.22 The End-of-Life Stage (C1-C4) has been scoped out of this assessment. Roads that have reached the end of their functional life are either refurbished or decommissioned through road closure. However, this stage is rarely encountered in UK road infrastructure, and so end of life waste associated with this development has been excluded from this assessment.

[6] Royal Institution of Chartered Surveyors (RICS) (2017) Whole life carbon assessment for the built environment. Available at: whole_life_carbon_assessment_for_the_built_environment_1st_edition_rics (3).pdf [Accessed on 21.06.2023].

A5 (3) Construction Activity

3.23 For the A5(3) lifecycle stage, energy use for operational uses has been estimated using a benchmark developed by Engineering and Physical Research Council and DecarboN8 Research Council in partnership with Transport for the North (TfN), which provides an approximate figure in tCO2e for average construction activities associated with the development of 1km of asphalt pavement road in the UK[7]. The average tCO_2e was multiplied by the road areas for Options 1 and 3.

B2 & B6 Use Stage

3.24 Lifecycle stages including B1, 3, 4, 5, 7, 8 & 9 of the Use Stage have been excluded from this assessment. This is due to unavailability of data associated with the use stage of the lifecycle assessment.

3.25 A high-level estimate of the emissions associated with the life cycle stages of B2 and B6 have been determined using the benchmark developed by Engineering and Physical Research Council and DecarboN8 Research Council in partnership with Transport for the North (TfN), which provides an estimate of the emissions associated with energy consumption (B6) and maintenance (B2) for 1km of average single carriageway asphalt road in the UK. The main energy consuming aspect of road operation is road lighting. The benchmark assumes that 1km road is illuminated by LED road lights for 4,350 hours in a year, accounting for the seasonal changes in lighting hours. The benchmark used for maintenance accounts for activities that have a significant impact on embodied carbon over a road's lifetime, including fuel and material consumption for salt-gritting (approximately 12 times per year on average), patching of the road-surface, and routine road resurfacing (approximately every 5-10 years)[3].

3.26 The emissions associated with the maintenance element of the Use Stage of the life cycle assessment will contribute to the overall lifecycle carbon footprint of the project as the road will require maintenance every year over the lifetime. However, as specific data for the project was not provided, the emissions calculated for this stage should be as a high-level estimate, and not an accurate representation of the actual use stage emissions associated with the project. This stage should be considered for future reporting to allow for a more rounded overview and assessment of carbon emissions for projects.

[7] Lokesh, K., Densley-Tingley, D. and Marsden, G. (2022) Measuring Road Infrastructure Carbon: A 'critical' in transport's journey to net-zero. Leeds: DecarboN8 Research Network.Available at: *Measuring-Road-Infrastructure-Carbon.pdf (decarbon8.org.uk) [Accessed on 21.06.2023].

4. Results

4.1 This section outlines the results of the GHG Assessment.

Quantitative Results

4.2 The results in this section consider Option 1a (30mph) and 1b (40mph) and Option 3a (30mph) and 3b (40mph), to enable a comparison between the variation of emissions associated with the construction of roads with differing road speeds. Table 1 presents the forecast GHG emissions baseline for the Hereford ERiC for Options 1a/1b (30mph and 40mph) and 3a/3b (30mph and 40mph), broken down by the lifecycle modules outlined above.

Table 1: Comparison of GHG emissions for Alignment 1 and 3 for a 30mph road and 40mph road.

	Option 1a	Option 1a	Option 1b	Option 1b	Option 3a	Option 3a	Option 3b	Option 3b
	30mph	**30mph**	**40mph**	**40mph**	**30mph**	**30mph**	**40mph**	**40mph**
Reporting category	Carbon emissions (tCO_2e)	% of overall project emissions	Carbon emissions (tCO_2e)	% of overall project emissions	Carbon emissions (tCO_2e)	% of overall project emissions	Carbon emissions (tCO_2e)	% of overall project emissions
A1-3 – Product carbon emissions	9410	84%	9755	83%	15284	90%	15815	90%
A4 (1) – Transport of construction materials	1078	10%	1190	10%	891	5%	984	6%
A4 (2) – Transport of workers	63	1%	63	1%	63	0%	63	0%
A5 (1) – Waste	221	2%	230	2%	335	2%	347	2%
A5 (2) – Construction activities	51	0%	51	0%	51	0%	51	0%
B2 – Maintenance	99	1%	99	1%	99	1%	99	1%
B6 – Energy use	358	3%	358	3%	358	2%	358	2%
Total project emissions	**11,279**	**100%**	**11,746**	**100%**	**17,081**	**100%**	**17,717**	**100%**

4.3 As shown in Table 1 and illustrated in Figures 4 and 5, product carbon emissions (A1-A3) account for the highest proportion of overall forecast emissions for the project for all options, accounting for an average of 87% of emissions across the four alignment options considered as part of this assessment.

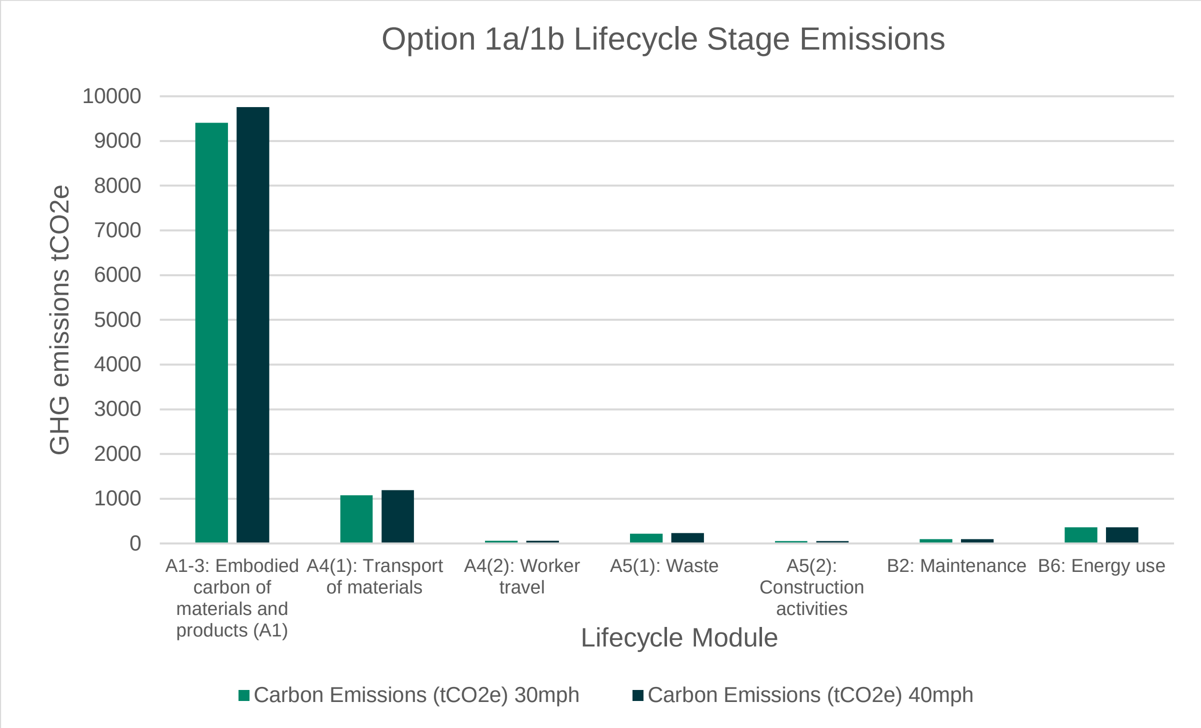

Figure 4 Lifecycle module carbon emissions for Option 1a (30mph) and 1b (40mph).

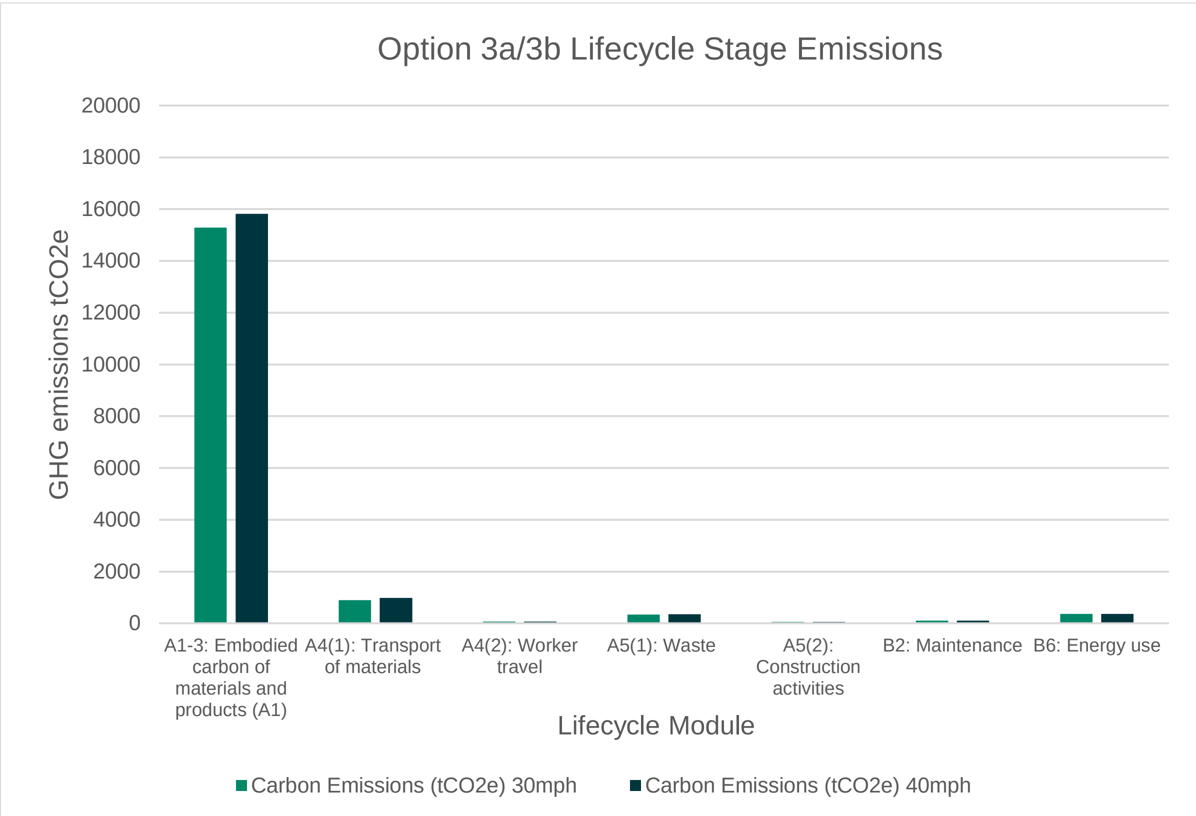

Figure 5 Lifecycle module carbon emissions for Option 3a (30mph) and 3b (40mph).

4.4 The GHG emissions associated with Option 3b are the highest in comparison with 1a, 1b, and 3a, with a variation in emissions of 636 tCO_2e between 3a and 3b. This is because Options 1b and 3b with a speed limit of 40mph are single carriageway roads 7.2m in width, whereas Options 1a and 3a with a speed limit of 30mph are single carriageway roads 6.5m in width, so have a greater surface area and so require a greater quantity of construction materials.

4.5 Within the carbon emissions lifecycle module (A1-A3), the materials associated with the bridge construction for both Alignment options 1 and 3 account for the greatest amount of carbon emissions followed by the road pavement materials, as seen in Table 2. Table 2 has been included to gain an understanding as to which materials contribute the most to the carbon emissions produced from the product materials category (A1-A3).

Table 2 Comparison of GHG emissions associated with the bridge materials and road materials for Options 1a/1b & 3a/3b.

Alignment	Bridge Material Carbon Emissions (tCO2e)	Road Materials Carbon Emissions (tCO2e)
Option 1a – 30mph	8,874	536
Option 1b – 40mph	9,164	591
Option 3a – 30mph	14,841	443
Option 3b – 40mph	15,326	489

4.6 The GHG emissions from transport of materials (A4 (1)) accounts for the second highest proportion of emissions for the project accounting for 10% of overall emissions for Options 1a and 1b, and 5% and 6% of overall emissions for Options 3a and 3b, as displayed in Figures 4 and 5. This is the result of the differences in material quantities between the different road alignment and road speed options which impacts upon the number of heavy goods vehicle trips required during the construction phase. These calculations are based on assumptions explained above and the application of average load emission factors for an average heavy goods freight vehicle and assumption that road materials were sourced 50km from the construction site and steel was sourced 300km from the construction site[8].

4.7 The GHG emissions from worker travel (A4 (2)) contribute 1% to the overall carbon forecast for the project for Options 1a/1b and 3a/3b, contributing 63 tCO_2e to overall emissions, as shown in Table 1. As assumptions based on previous project experience were used to provide an estimate for worker travel, emissions were the same for each alignment option regardless of road speed. Emissions associated with the transport modules of the lifecycle assessment are presented in Figures 4 and 5.

4.8 The GHG emissions from waste (A5 (1)) associated with the project are minor at only 2% of total carbon emissions, as shown in Table 1. Emissions from project waste have been assumed based on a 2% uplift in total GHG emissions of each option, as shown in Figures 4 and 5.

4.9 The GHG emissions from the maintenance during the use stage of the project (B2) contributes towards 1% or 99 tCO2e of the overall forecast carbon emissions for Options 1 and 3. The emissions associated with maintenance accounts for the overall carbon forecast maintenance of the road and energy consumption accounts for activities that have a significant impact on embodied carbon over a road's lifetime, including fuel and material consumption for salt-gritting (approximately 12 times per year on average), patching of the road-surface, and routine road resurfacing (approximately every 5-10 years).

4.10 The GHG emissions from the energy consumption during the use stage of the project (B6) contributes towards 3% or 358 tCO_2e for Option 1a/1b and 2% or 358 tCO2e for Option 3a/3b of the overall forecast carbon emission. The emissions associated with energy consumption accounts for the use of road lighting during the operational stage of the road. Maintenance and energy consumption emissions are presented in Figure 6.

[8] Royal Institution of Chartered Surveyors (RICS) (2017) Whole life carbon assessment for the built environment. Available at: whole_life_carbon_assessment_for_the_built_environment_1st_edition_rics (3).pdf [Accessed on 21.06.2023].

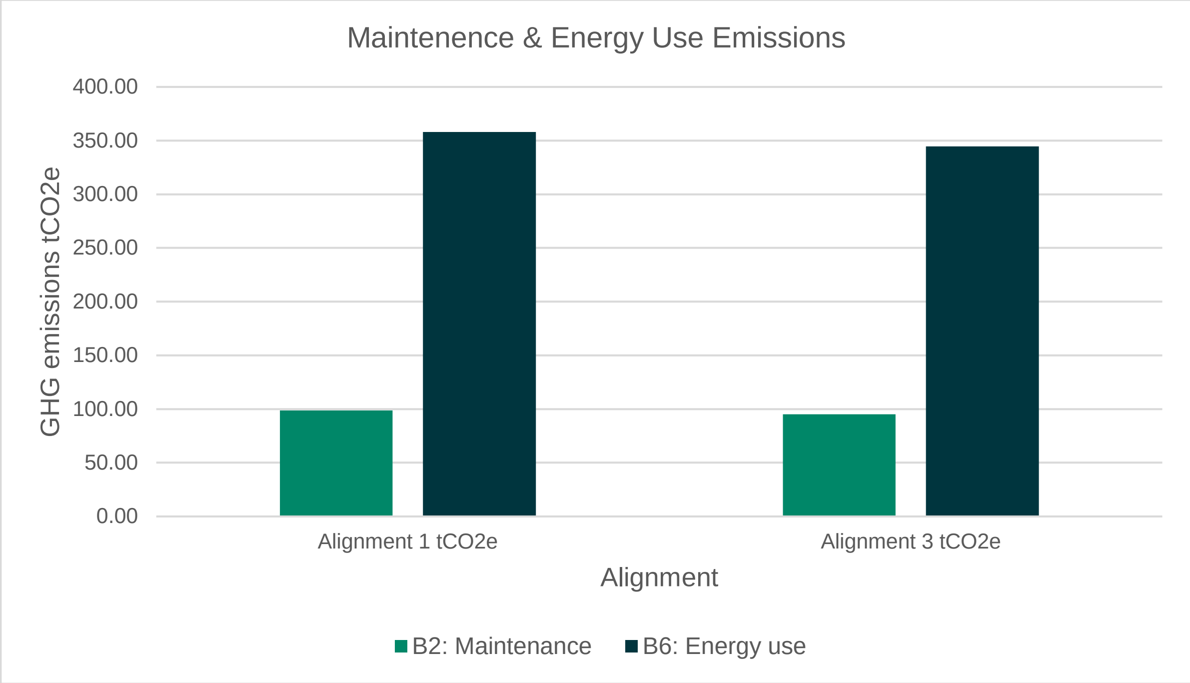

Figure 6 Comparison of GHG emissions associated with the maintenance and energy consumption during the operational stage.

Analysis of Results

4.11 The majority of the carbon emissions associated with the project arise from the product carbon emissions (A1-A3) modules, accounting for an average of 87% of the total GHG emissions across the four options, as shown in Table 1. After this, transport of materials (A4 (1)) accounts for an average of 8% across the four alignment options.

4.12 Following this, energy use (B6) accounts for 3% of emissions for Options 1a/1b and 2% of emissions for Options 3a/3b, followed by waste which makes up 2% of the overall lifecycle emissions. Worker travel (A4 (2)), construction activities (A5 (2)) and maintenance (B2) contribute 0-1% towards the total emissions.

4.13 As seen in Table 2, the construction of the bridge for Options 1a/1b and 3a/3b accounts for a large proportion of carbon emissions associated with the product stage (A1-3). The bridge design for Option 1a accounts for 79% of the total lifecycle emissions, and Option 1b accounts for 78% of total emissions. The bridge design for both Options 3a and 3b accounts for 87% of the total lifecycle emissions. The road design for Options 1a and 1b accounts for 5% of the total lifecycle emissions, whereas the road design for Options 3a and 3b accounts for 3% of the total lifecycle emissions.

4.14 It should be taken into consideration that the emissions associated with the bridge construction for both alignment options have been heavily based upon benchmarks and assumptions, and accounts for both the emissions from materials as well as the emissions from transport of materials. As stated, as a detailed design for the bridge construction has yet to be developed, a previous project has been used as a guide to the bridge dimensions. A very high-level benchmark has been used to calculate the approximate emissions per square meterage of bridge. The emissions value for the bridge construction provided within this report does not take into consideration the specific elements of the Hereford ERiC development and thus should be viewed with caution.

4.15 As stated previously, the emissions for transport of materials, worker travel, waste, and construction activities as part of the Construction Stage of the lifecycle modules have been developed using high level benchmarks and assumptions as no specific data was provided for the use in this GHG assessment. As such, the results of this assessment should be taken as a guide to the emissions associated with each alignment option, and not be viewed as necessarily accurate.

Qualitative Discussion of Road User Emissions

4.16 The emissions generated by users of the road development during operation are to be reported under the B1-9 Use Stage (B1) of the PAS 2080 boundaries[9] and have been scoped out of the above assessment due to the unavailability of data.

4.17 Road user emissions are those emitted by vehicles using the new road, and the emissions associated with knock-on effects in traffic flows and behaviours in the wider transport network. Road user emissions will be influenced by a number of factors which are discussed below.

4.18 With the introduction of the proposed ERiC, some traffic will redistribute to use the proposed ERiC instead of other routes. The difference in routes will impact on total vehicle-kilometres travelled. Redistribution impacts have been modelled for a forecast year of 2032 in the Hereford Transport Model (HTM) to inform the Strategic Outline Case (SOC). Options 1 and 3 were not considered separately within the modelling, just an indicative ERiC with a 30 mph speed limit and one with a 40 mph speed limit. As shown in Table 3, within the whole study area (HTM fully modelled area), overall a slight reduction in vehicle kilometres is anticipated, primarily in the PM peak. This is due to the ERiC providing a shorter route option for some journeys. This effect would tend to reduce carbon emissions. In Hereford city centre however, a slight increase in vehicle-kilometres is anticipated, which would tend to increase carbon emissions in that location.

Table 3 Forecast Vehicle Kilometres in the HTM Fully Modelled Area in 2032

Alignment	AM Peak Hour (08:00 – 09:00)	AM Peak Hour (08:00 – 09:00)	PM Peak Hour (17:00 – 18:00)	PM Peak Hour (17:00 – 18:00)
	Vehicle km	Difference vs Do-Nothing	Vehicle km	Difference vs Do-Nothing
Do-nothing	754,234	-	674,215	-
ERiC – 30mph	754,046	-188 (0%)	672,461	-1,754 (0%)
ERiC – 40mph	754,279	+45 (0%)	669,880	-4,335 (-1%)

4.19 The modelling reported above does not take into account the effects of modal shift that may be brought about by the proposed ERiC. It is an objective of the scheme to increase the mode share of active travel and public transport trips in the area. This effect would tend to reduce carbon emissions by further decreasing vehicle-kilometres travelled in private vehicles.

4.20 The modelling reported above also does not consider the effects of induced demand on the traffic network. Induced demand is the generation of traffic that occurs when the creation of transportation infrastructure releases latent demand. The effect of induced demand tends to increase carbon emissions by increasing vehicle-kilometres travelled in the study area.

4.21 Additionally, the introduction of ERiC is forecast to reduce congestion within the centre of Hereford, with reductions in journey times in both the AM and PM peak on 6 out of 9 city centre routes considered. The effect is forecast to be the same for the 30 mph ERiC and the 40 mph ERiC. The alleviation of congestion would tend to reduce carbon emissions as slower, stop-start traffic is associated with higher emissions than free-flowing traffic on urban roads. In areas where ERiC may cause or increase congestion carbon emissions would tend to increase.

4.22 In the absence of a fully quantified road-user emissions assessment, it is not possible to judge whether road user emissions will decrease or increase with the introduction of ERiC. As a precautionary measure it is assumed that road user carbon will increase with the introduction of ERiC due to induced demand, but that this effect will be relatively small due to counteracting effects from modal shift and congestion alleviation.

4.23 Road-user emissions are not one-time one-source events. They can be generated across the whole local traffic network, and continue over the whole use-phase of the road. For these reasons road-user emissions

[9] PAS 2080: 2023. Carbon Management in Buildings & Infrastructure [Revised PAS 2080:2023 | BSI (bsigroup.com)]

for a new road can be much larger than the associated embedded carbon but it is not possible to quantify this relationship for ERiC at this stage.

5. Recommendations

5.1 The following section outlines some guidance on how material selection can influence the total GHG emissions associated with the project development, as well as opportunities for emissions reductions within A1-A3 Product, A4 Transportation and A5 Construction Activity modules. As no specific data was provided relating to materials used in each alignment option, no specific recommendations on alternative lower carbon materials can be provided. Despite this, some general considerations and opportunities for carbon reduction associated with the product stage are provided below:

- Optimising ready-mix concrete design
- Choosing finish materials with low-embodied-carbon footprints
- Procuring steel with a higher-than-average recycled content where possible
- Sourcing structural steel with higher recycled content
- Choosing low-embodied-carbon glazing products
- Reducing structural system material needs
- Considering low-embodied-carbon or carbon-sequestering insulation options.
- Materials should be sourced from manufacturers with lower-than-average carbon emissions (based on environmental product declaration (EPD) data), focusing on concrete and steel elements.

5.2 A full review of the data gaps and assumptions within this report should be undertaken and addressed to update with project specific data (where available). Operational emissions are important to quantify as these can make up a significant portion of overall carbon emissions, given that the road development has an assumed lifetime of 40 years and will require consistent maintenance and energy consumption.

5.3 As the A1-A3 Product Carbon Emissions module is the category with the largest contribution to overall emissions, efforts to reduce emissions should be focused here as these represent the greatest opportunity for improvement. Nevertheless, all lifecycle stages should be considered for opportunities to reduce carbon emissions.

6. References

DEFRA BEIS 2023 emissions factors. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023 [Accessed on: 19.06.2023].

Hereford Transport Strategy Review (2020) https://councillors.herefordshire.gov.uk/documents/s50085035/Appendix%20A%20-%20Hereford%20Transport%20Strategy%20Review%20-%20Technical%20Report.pdf [Accessed on: 19.06.2023].

Herefordshire Council Local Transport Plan 2016 – 2031 Strategy. Available at: https://www.herefordshire.gov.uk/downloads/file/2912/local_transport_plan_2016-2031_strategy [Accessed on: 19.06.2023].

Inventory of Carbon & Energy (ICE) v3.0 Available at: https://ghgprotocol.org/Third-Party-Databases/Bath-ICE [Accessed on: 21.06.2023].

Lokesh, K., Densley-Tingley, D. and Marsden, G. (2022) Measuring Road Infrastructure Carbon: A ‘critical’ in transport’s journey to net-zero. Leeds: DecarboN8 Research Network.Available at: *Measuring-Road-Infrastructure-Carbon.pdf (decarbon8.org.uk) [Accessed on 21.06.2023].

National Highways Carbon Tool v2.5 Available at: https://nationalhighways.co.uk/suppliers/design-standards-and-specifications/carbon-emissions-calculation-tool/ [Accessed on: 19.06.2023].

PAS 2080: 2023. Carbon Management in Buildings & Infrastructure. Available at: https://www.bsigroup.com/en-GB/standards/pas-2080/ [Accessed on: 27.06.2023].

Royal Institution of Chartered Surveyors (RICS) (2017) Whole life carbon assessment for the built environment. Available at: https://www.rics.org/content/dam/ricsglobal/documents/standards/whole_life_carbon_assessment_for_the_built_environment_1st_edition_rics.pdf [Accessed on 21.06.2023].

aecom.com