A66 Northern Trans-Pennine Project
TR010062

3.4 Environmental Statement Appendix 7.1 Greenhouse Gas Assessment

APFP Regulations 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 3

June 2022

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

A66 Northern Trans-Pennine Project Development Consent Order 202x

3.4 ENVIRONMENTAL STATEMENT APPENDIX 7.1 GREENHOUSE GAS ASSESSMENT

Regulation Number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010062
Application Document Reference	3.4
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Version	Date	Status of Version
Rev 1	13 June 2022	DCO Application

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7.1 GHG Emissions Assessment

7.1.1 Introduction

7.1.1.1 This Appendix 7.1: GHG Emissions Assessment, presents the detailed quantifications of the greenhouse gas (GHG) emissions assessment and associated assumptions made in the Environmental Statement (ES), presented in ES Chapter 7: Climate (Application Document 3.2).

7.1.2 Construction Phase GHG Emissions Assessment – Summary

7.1.2.1 Table 1: Construction phase GHG emissions by scheme presents construction phase GHG emissions across each of the eight schemes.

7.1.2.2 Quantifications of GHG emissions are calculated using quantities of the relevant emissions activity multiplied by the relevant GHG emission factor to provide a quantification of GHG emissions in tonnes of carbon dioxide equivalent (tCO_2e).

7.1.2.3 Total routewide GHG emissions are presented at the bottom of Table 1: Construction phase GHG emissions by scheme.

Table 1: Construction phase GHG emissions by scheme

Scheme	PAS2080 module						Total GHG Emissions (tCO_2e)
	A1-A3	A4	A5			D	
	Materials Embedded (tCO_2e)	Transport to works site (tCO_2e)	Energy Use (tCO_2e)	Business & Employee Transport (tCO_2e)	Waste & Waste Transport (tCO_2e)	Land Use Change (tCO_2)	
M6 Junction 40 to Kemplay Bank	17,423	914	829	564	1,808	10,125	31,663
Penrith to Temple Sowerby	25,061	4,816	1,543	329	200	23,805	55,754
Temple Sowerby to Appleby	59,792	2,230	4,759	1,178	6,512	67,551	142,022
Appleby to Brough	63,835	3,970	4,100	703	10,501	60,512	143,621
Bowes Bypass	12,694	1,937	691	170	1,328	9,332	26,152
Cross Lanes to Rokeby	18,381	3,043	1,102	261	1,852	22,679	47,318
Stephen Bank to Carkin Moor	33,021	1,501	2,221	361	5,319	29,139	71,562
A1 (M) Junction 53 Scotch Corner	69	12	245	0	7	137	470
Total for module category	230,276	18,423	15,490	3,566	27,527	223,280	518,562
Total routewide construction GHG emissions (tCO_2e)							518,562

7.1.2.4 The GHG emissions associated with construction do not occur in the 'Do-Minimum' scenario. Do-Minimum construction emissions are assumed to be zero.

7.1.2.5 The approach taken to estimating Land Use Change GHG has been to model the loss of all carbon in soils and vegetation within the Order Limits during construction where land is changing from one habitat to another. In many cases habitats are changing as part of ecological improvements and will provide a greater biodiversity value, and greater potential for GHG sequestration as a result. However, these are modelled as a total loss of GHG during construction, followed by ongoing sequestration year-on-year during the operational phase. In many schemes the main area of GHG release during construction will be focused on the construction of the new route, with areas outside this either remaining similar in habitat or being improved. For the evaluation of significance a pessimistic approach has been adopted which assumes construction impacts (i.e. loss of stored carbon) across the full Order Limits, and no benefits accruing from new habitat creation during the operational phase (although, in practice, new habitats will provide a benefit).

7.1.3 Operational Phase GHG Emissions Assessment – Summary

7.1.3.1 Table 2: Operational emissions - Maintenance and refurbishment (B2-B5) sets out the estimated additional (net increase of) GHG emissions associated with Maintenance and refurbishment (B2-B5) during the 60 year study period.

Table 2: Operational emissions - Maintenance and refurbishment (B2-B5)

Maintenance and refurbishment (B2-B5)	Emissions (tCO_2e)		
	2029 modelled opening year	2044 modelled design year	Total over modelled 60-year operation (2029 – 2089)
M6 Junction 40 to Kemplay Bank	241[1]	241	14,461
Penrith to Temple Sowerby	275	275	16,514
Temple Sowerby to Appleby	408	408	24,499
Appleby to Brough	438	438	26,299
Bowes Bypass	128	128	7,684
Cross Lanes to Rokeby	222	222	13,328
Stephen Bank to Carkin Moor	311	311	18,683

[1] Values for emissions in a single year are based on replacement cycles specified within Table 5 then apportioned on an average basis assuming a 60 year study/appraisal period. This leads to the same value being present for both 2029 modelled opening year and 2044 modelled design year.

Maintenance and refurbishment (B2-B5)	Emissions (tCO_2e)		
	2029 modelled opening year	2044 modelled design year	Total over modelled 60-year operation (2029 – 2089)
A1 (M) Junction 53 Scotch Corner	2	2	141
Total	2,026	2,026	121,608

7.1.3.2 Table 3: Operational emissions - Land use and forestry (D) sets out the estimated removals of GHG from the atmosphere associated with Land use and forestry (D) during the 60 year study period.

Table 3: Operational emissions - Land use and forestry (D)

Land use and forestry (D)	Emissions (tCO_2e)		
	2029 modelled opening year	2044 modelled design year	Total over modelled 60-year operation (2029 – 2089)
M6 Junction 40 to Kemplay Bank	- 107[2]	- 107	- 6,449
Penrith to Temple Sowerby	- 256	- 256	- 15,347
Temple Sowerby to Appleby	- 531	- 531	- 31,888
Appleby to Brough	- 642	- 642	- 38,538
Bowes Bypass	- 63	- 63	- 3,760
Cross Lanes to Rokeby	- 283	- 283	- 16,991
Stephen Bank to Carkin Moor	- 417	- 417	- 25,041
A1 (M) Junction 53 Scotch Corner	- 1	- 1	- 57
Total	- 2,301	- 2,301	- 138,070

7.1.3.3 Table 4: Operational emissions - Vehicles using the highways infrastructure (B9)sets out the estimated additional (net increase of) GHG emissions associated with Vehicles using the highways infrastructure (B9) during the 60 year study period.

[2] Figure is based on 60 year carbon sequestration then apportioned to each year on an average basis. In practice the rate of sequestration will be non-linear. This leads to the same value being present for both 2029 modelled opening year and 2044 modelled design year. Negative values represent the capture of carbon in the soil arising from land use and forestry (i.e. negative GHG emissions).

Table 4: Operational emissions - Vehicles using the highways infrastructure (B9)

Vehicles using the highways infrastructure (B9)	Emissions (tCO_2e)		
	2029 modelled opening year	2044 modelled design year	Total over modelled 60-year operation (2029 – 2089)
'Do-minimum' scenario	919,696	676,859	42,875,927
'Do-something' scenario	955,034	705,422	44,657,477
Difference between Do-minimum and Do-something	+ 35,337	+ 28,563	+ 1,781,551

7.1.4 GHG Assessment Assumptions and Limitations

Assumptions

7.1.4.1 Table 5: GHG emissions assessment assumptions presents the assumptions within the GHG emissions assessment.

Table 5: GHG emissions assessment assumptions

Category	Assumptions
Construction Phase	
Transport distances (Materials)	Transport distances were provided by the buildability contractor for bulk material items on a scheme level basis, based on the preliminary design. For all other items it has been assumed as a reasonable worst case that all materials will need to be transported 50km by HGV (Heavy Goods Vehicle). This is based on the assumption that all materials can be sourced and delivered at a 'local' level. In the absence of appropriate benchmarks within Highways specific carbon modelling tools the definition of 'local' material transport distances is taken from the Environment Agency Carbon Calculator as representative of general levels of geographic availability for materials.
Earthworks	Earthworks estimates have been provided in volume (m3) and have been converted to mass (tonnes) using a conversion factor of 1.5 tonnes per cubic metre used for inert materials. This is consistent with the methodology used in ES Chapter 11: Materials and Waste (Application Document 3.2).
Earthworks	As the transfer of surplus excavation material between schemes (i.e. reuse of excavated material as fill elsewhere within the scheme) has not been confirmed at the time of the assessment it has been assumed that any deficit identified in the earthworks assessment will need to be imported. As with the material transport assumption above it has been assumed that earthworks material imports will be transported 50km by HGV. Similarly it has been assumed that any surplus of material will need to be removed from site. It has been assumed that any surplus material will be reused off site. As with the material transport assumption above it has been assumed that earthworks material will be transported 50km by HGV.

Category	Assumptions
	Both assumptions are likely to be a conservative approach, as reuse between schemes will be a key objective during construction to minimise export and import of materials.
Earthworks	An estimated % proportion of useable cut material requiring stabilisation has been provided by the buildability contractor based on the preliminary design and the Ground Investigation undertaken to date. The % proportion requiring stabilisation, on a conservative (worst case) basis, are as follows: M6 Junction 40 to Kemplay Bank Roundabout – 35% Penrith to Temple Sowerby – 35% Temple Sowerby to Appleby – 35% Appleby to Brough – 45% Bowes Bypass – 60% Cross Lanes to Rokeby – 60% Stephen Bank to Carkin Moor – 60% A1 (M) Junction 53 Scotch Corner - Scheme discounted from earthworks assessment due to the limited earthworks requirements. A number of stabilisation methods could be employed on the project. For the purposes of this assessment the stabilisation method has been assumed to be ground stabilisation using the addition and blending of Lime into the excavated soil. This is considered a reasonable worst-case assumption for the assessment. The blending proportion for Lime has been assumed at 8%, i.e. that the volume of Lime required for stabilisation will be to 8% by mass of the cut material requiring stabilisation.
Fencing & Barriers	Based on the design information currently available, design teams have confirmed that it is appropriate to assume that all fencing will be: National Highways Carbon Calculator category 'timber rail fence (all types, includes posts)'.
Fencing & Barriers	Based on the design information currently available, design teams have confirmed that is appropriate to assume that all noise barriers will be in the form of 2m high timber barriers.
Fencing & Barriers	Based on the design information currently available, design teams have confirmed that is appropriate to assume that safety barriers will be: National Highways Carbon Calculator category 'steel RRS (Road Restraint System) barrier double sided' and ' National Highways Carbon Calculator category 'steel RRS (Road Restraint System) barrier single sided'.
Road Pavements	Values for the sub-base courses have been allocated to the category 'Sub-bases - type 1 unbound mixture' for those materials present in the carriageway, hardshoulder and hardstrip. These values were provided in m2. The quantities have been converted to volumes by assuming a thickness of 330mm for mainline, 420mm for side roads and 400mm for the central reservation, design teams have confirmed that is an appropriate assumption. It has been assumed the subbase type 1 is equivalent to general quarried aggregate.

Category	Assumptions
	Values in cubic metres have then been converted to tonnes using the National Highways Carbon Calculator material density conversion factor of 2 tonnes/m3 for quarried aggregate.
Road Pavements	Values for the base courses have been allocated to the category 'Base - dense bitumen macadam (DBM50)' for those materials present in the carriageway, hardshoulder and hardstrip. These values were provided in m2. The quantities have been converted to volumes by assuming a thickness of 220mm, design teams have confirmed that is is appropriate assumption. It has been assumed the dense bitumen macadam has the same carbon factor as general asphalt. Cubic metres have been converted to tonnes using a material density conversion factor of 2.44 tonnes/m3 for asphalt (assumption provided by buildability contractor).
Road Pavements	Values for the binder courses have been allocated to the category 'Binder course - dense bitumen macadam (DBM50)' for those materials present in the carriageway, hardshoulder and hardstrip. These values were provided in m2. The quantities have been converted to volumes by assuming a thickness of 60mm, design teams have confirmed that is an appropriate assumption. It has been assumed the dense bitumen macadam has the same carbon factor as general asphalt. Cubic metres have been converted to tonnes using a material density conversion factor of 2.44 tonnes/m3 for asphalt (assumption provided by buildability contractor).
Road Pavements	Values for the surface courses have been allocated to the category 'surface courses – close grade macadam – thin' for those materials present in the carriageway, hardshoulder and hardstrip. These values were provided in m2. The quantities have been converted to volumes by assuming a thickness of 40mm, design teams have confirmed that is an appropriate assumption It has been assumed the dense bitumen macadam has the same carbon factor as general asphalt. Cubic metres have been converted to tonnes using a material density conversion factor of 2.44 tonnes/m3 for asphalt (assumption provided by buildability contractor).
Road Pavements	Based on the design information currently available it has been assumed that kerbs will be either: • National Highways Carbon Calculator category 'pre-cast concrete, 125x150mm' • National Highways Carbon Calculator category 'pre-cast concrete, 125x255mm'
Road Pavements	Length of road requiring thermoplastic road markings was provided in m and therefore been converted to volume for the National Highways Carbon Calculator assuming width of continuous road marking is 150mm (assumption taken from the A417 carbon assessment undertaken by Arup) and thickness of marking being 2.55mm (assumption provided by design teams). Volume has then been converted to tonnes using a material density conversion factor of 2,150kg/m3 (assumption taken from the A417 carbon assessment undertaken by Arup).

Category	Assumptions
Drainage	Quantity of plastic pipework was broken down into the following National Highways Carbon Calculator categories for the majority of schemes: • Plastic pipework 150mm diameter HDPE • Plastic pipework 225mm diameter HDPE • Plastic pipework 300mm diameter HDPE • Plastic pipework 450mm diameter HDPE • Plastic pipework 600mm diameter HDPE • Plastic pipework 900mm diameter HDPE Breakdown of quantity of plastic pipework by type was not available for the Temple Sowerby to Appleby and Appleby to Brough schemes at the time of the assessment. Quantity of pipe required was therefore calculated by mulitplying the approximate length of the alignment by three (i.e. both sides and the middle). As a worst case it has been assumed that all plastic pipework on these schemes will be National Highways Carbon Calculator category 'HDPE (high-density polyethylene), 900mm diameter'.
Drainage	It has been assumed that all culverts will be National Highways Carbon Calculator category 'precast concrete circular pipework, 1200mm diameter' (assumption provided by buildability contractor).
Drainage	It has been assumed that there will be 2 headwalls per culvert. It has been assumed that all headwalls will be National Highways Carbon Calculator category 'In-situ reinforced concrete'. It has been assumed that the volume of concrete in each headwall is 5.72m3 (assumption taken from the A417 carbon assessment undertaken by Arup).
Drainage	Quantity of manholes was broken down into the following National Highways Carbon Calculator categories: • Precast concrete manholes 1050mm diameter, up to 3m depth • Precast concrete manholes 1200mm diameter, up to 3m depth • Precast concrete manholes 1500mm diameter, up to 3m depth • Precast concrete manholes 1800mm diameter, up to 3m depth • Precast concrete manholes 1800mm diameter, 3m - 6m depth • Precast concrete manholes 2400mm diameter, up to 3m depth
Drainage	Based on the design information currently available it has been assumed that gullies will be National Highways Carbon Calculator category 'Precast concrete gully pots (heavy duty)'.
Drainage	Based on the design information currently available it has been assumed that channels will be National Highways Carbon Calculator category 'Precast concrete channel (heavy duty)'.
Drainage	Based on the design information currently available it has been assumed that petrol interceptors will be National Highways Carbon Calculator category 'Glass reinforced plastic GRP (Fiberglass)'.
Drainage	Based on the design information currently available it has been assumed that one precast concrete inspection chamber will be required per attenuation pond. As the type of chamber was not known at the time of assessment, a worst case assumption of 1000mm diameter at a depth of 1.2-3m has been used.

Category	Assumptions
Drainage	Where data on attenuation ponds was not provided by design teams it has been assumed that 100% of attenuation ponds area (m^2) will require polyethylene membrane.
Drainage	It has been assumed that 100% of attenuation ponds (by m2 area) will require sand. The attenuation pond estimates were provided in m2 and have therefore been converted to volume (m3) for the National Highways Carbon Calculator assuming a depth of 150mm (agreed with design teams). Volume has then been converted to tonnes using the National Highways Carbon Calculator material density conversion factor of 1.85 tonnes/m3 for sand.
Street Furniture	Based on the design information currently available it has been assumed that traffic signs will be National Highways Carbon Calculator category 'aluminium'.
Street Furniture	Based on the design information currently available it has been assumed that road lighting will be National Highways Carbon Calculator category 'LEDs lights'.
Street Furniture	Based on the design information currently available it has been assumed that steel columns will be National Highways Carbon Calculator category 'Steel columns – 10m'.
Street Furniture	Based on the design information currently available it has been assumed that marker posts will be National Highways Carbon Calculator category 'plastic marker post'. Assumed full length, 100m spacing.
Street Furniture	Based on the design information currently available it has been assumed that there will be road studs along each side of the road pavement on both sides (i.e. length of studs will equal 4 x the length of the alignment). It has been assumed studs will be 9m apart.
Civils structures	Quantities for 'Retaining Walls: In-Situ concrete piles' have been provided in tonnes. This has then been converted to m3 using the National Highways Carbon Calculator material density conversion factor of 2.4 tonnes/m^3 for concrete.
Civils structures	tCO_2e for retaining walls, overbridges, underbridges (with the exception of Troutbeck viaduct on Temple Sowerby to Appleby) and underpasses (with the exception of underpasses on Temple Sowerby to Appleby, Appleby to Brough and Stephen Bank to Carkin Moor) has been calculated in the National Highways Carbon Calculator using information provided by the design teams. Exceptions: Troutbeck viaduct (Temple Sowerby to Appleby) • An estimate of tCO_2e was provided by the design teams for Troutbeck Viaduct based on the high level carbon assessment undertaken for the Structures Options Report. Underpasses (Temple Sowerby to Appleby, Appleby to Brough and Stephen Bank to Carkin Moor) • tCO_2e for these underpasses has been estimated using tCO_2e provided for the Penrith to Temple Sowerby and Bowes Bypass schemes in the Structures Options Reports. The average tCO_2e per metre length on these schemes is 5.2 tCO_2e. The length of the underpasses where material

Category	Assumptions
	quantity was not provided (Temple Sowerby to Appleby, Appleby to Brough and Stephen Bank to Carkin Moor) was multiplied by this average factor.
Fuel and Energy	Construction stage fuel usage has been estimated based on assumptions of typical plant gangs from previous schemes and the current worst case earthworks assessment (assumption provided by buildability contractor). It has been assumed that 0.69 litres of fuel will be used per m^3 of earthworks material. It has been assumed diesel fuel will be used.
Fuel and Energy	Energy and water use associated with construction compounds has been provided by the buildability contractor based on data from previous schemes.
Business Transport	Employee commuting has been estimated based on assumptions of likely staff numbers. These estimates are based on data from previous schemes and assume: • A 25km each way journey distance average • Private vehicles will be used • 2 people will share each vehicle
Waste	It has been assumed that any surplus identified in the earthworks assessment will need to be removed for reuse off site (assumption taken from Chapter 11 Materials and Waste). It has been assumed that surplus will be transported a maximum of 50km by HGV.
Waste	It has been assumed that any deficit identified in the earthworks assessment will need to be brought in from offsite. It has been assumed that any additional material required will be transported a maximum of 50km by HGV.
Waste	Aligning with Chapter 11: Materials and Waste (and DMRB LA 110) it has been assumed that 10% of demolition and construction waste will be unsuitable for recovery/reuse. Therefore, 10% of the demolition and construction waste quantity has been assumed as National Highways Carbon Calculator category 'Mixed construction & demolition waste - landfill'. The remaining 90% has been inputted as National Highways Carbon Calculator category 'Mixed construction & demolition waste – recycled'.
Land Use Change	The assessment of GHG impacts associated with land use change has adopted a proportionate approach in line with the requirements of LA114. The following assumptions apply to considerations of carbon in habitats: • the carbon storage factors used in the quantification of land use change emissions are based upon the Natural England 2021[3] and natural England 2012[4] papers and their supporting assumptions and limitations. • carbon stocks lost due to the loss of habitat and soils has been calculated using the biodiversity net gain (BNG) baseline scenario and assuming mature habitats, which are in equilibrium (i.e. not sequestering further carbon and have reached their full carbon storage potential). It is assumed that all habitats are in a near-natural state. If any of the habitats are in a degraded state, their current carbon storage is likely to be lower than estimated.

[3] Natural England (2021) Carbon Storage and Sequestration by Habitat 2021 (NERR094).]
[4] Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources (NERR043).]

<table>
<tr><th>Category</th><th>Assumptions</th></tr>
<tr><td></td><td>
the assessment data sources used for carbon storage factors focus on the carbon storage of the identified habitat, including when possible, carbon dioxide, methane, and dissolved and particulate organic carbon and therefore in some cases may not fully account for the potential release of other GHGs, such as methane. This assessment assumes all carbon stored within the soil is oxidised and converted to carbon dioxide. In reality, it is possible that some carbon could be converted to methane, a more potent greenhouse gas. As a result, the GHG emissions from soil disturbance may be underestimated, however given the benchmarks available within the Natural England papers, this remains the most robust methodology for assessment of carbon in habitats.
similarly, no allowance has been made for any nitrous oxide released during land use change which may also lead to an underestimation of GHG from land use change.
the carbon stock values for woodland assumes a 30-year old age profile. The loss of trees older than 30-years old as a result of the development could mean the carbon stock loss has been underestimated.
the carbon stock values used for soil reflect disturbance of a varying soil depth, depending on the data available in the Natural England source documents. This ranges from the top 15 cm to 1 m. In reality, it is reasonable to expect the soil to be disturbed to a much greater depth during construction and therefore more carbon is likely to be released to the atmosphere. As a result, the GHG emissions from land use change may be underestimated.
All habitat types categorised as 'urban' are assumed to have no material carbon storage potential. In reality, some urban areas may contain trees and vegetation which have some carbon storage potential, however the density of vegetation in these habitat types is difficult to assess and assign a carbon storage factor.
</td></tr>
<tr><td colspan="2">Operational Phase</td></tr>
<tr><td>Maintenance and Refurbishment</td><td>Assumed replacement periods for key material types are set out in the table as follows based on a study period of 60 years:
<table>
<tr><th>Material type/application</th><th>Assumed replacement period (years)</th><th>Number of replacements in study period</th></tr>
<tr><td>Surface courses</td><td>20</td><td>2</td></tr>
<tr><td>Sub-base / base course</td><td>40</td><td>1</td></tr>
<tr><td>Fencing / sound barriers</td><td>30</td><td>1</td></tr>
<tr><td>Safety barriers</td><td>30</td><td>1</td></tr>
<tr><td>Concrete elements and structures</td><td>Not replaced in study period (60 years)</td><td>0</td></tr>
<tr><td>Drainage materials</td><td>Not replaced in stud period (60 years)</td><td>0</td></tr>
</table></td></tr>
<tr><td>Vehicles using the highways infrastructure</td><td>As noted in Section 7.6: Study Area of the climate chapter the Traffic Reliability Area (TRA) has been defined for the project by applying the scoping criteria included in DMRB LA 105. The modelled traffic data used in the</td></tr>
</table>

Category	Assumptions
	assessment of operational emissions from vehicles using the highways infrastructure has an opening year (2029).
Vehicles using the highways infrastructure	The assessment of road user emissions is based on considering traffic volumes for the Traffic Reliability Area (TRA) which reflects the widest road network over this traffic modelling is considered verified/reliable. Consideration of the long-term future emissions requires assumptions to be made on likely changes to the future efficiency and carbon intensity of road vehicles, informed by modelled projections. The TRA was defined as set out in National Highways (2022) 3.9 Combined Modelling and Appraisal Report. Emissions were calculated using the Emissions Factors Toolkit v11[5], which provides an assumption for the transition to low emission vehicles beyond 2030.
Land Use Change	The same assumptions for the calculation of land use change emissions within the construction phase apply to the operational phase, with the following additions: • The values given to habitat mitigation measures assume the habitats reach maturity within the lifetime of the development, including restoration of carbon stocks in soils, reach equilibrium (i.e. there is no further sequestration of carbon) and the habitat is in a healthy state. This could result in an overestimation of carbon stocks should there be any impact on the establishment, maturation or health of the habitats restored or created as part of mitigation for the proposed development. • The change in habitat types within the DCO boundary captures the full range of mitigation measures that are likely to have a carbon storage benefit.

Limitations

7.1.4.2 Table 6: GHG emissions assessment limitations presents the limitations of the GHG emissions assessment.

Table 6: GHG emissions assessment limitations

Category	Limitations
Overall assumption – material quantities	The assessment is based on quantities provided by the engineering design teams, based on the preliminary design, that reflect the best estimate of actual likely design and construction quantities. No allowance has been made to account for under-estimation or optimism bias within the design team quantification.
Civils Structures	As set out in the assumptions, tCO_2e for some underpasses has been calculated an average tCO_2 per m length of 5.2. This average is based on length of underpass and does not taken into account difference in width. Therefore, the actual carbon emissions associated with these structures will likely be higher than those presented.
Civils Structures	An estimate of tCO_2e was provided by the design teams for Trout Beck Viaduct. This estimate did not include emissions associated with transport of materials. Trout Beck Viaduct falls within the Temple Sowerby to Appleby scheme, therefore, the actual carbon emissions associated with structures for Temple Sowerby to Appleby will likely be higher than presented.

[5] Department for Environment, Food and Rural Affairs (Defra), 2021. Emissions Factor Toolkit]

Category	Limitations
Land Use Change	The following limitations apply to considerations of carbon in habitats: • The carbon storage factors used in the quantification of land use change emissions are based upon the Natural England 2021[6] and Natural England 2012[7] papers and their supporting assumptions and limitations. • Due to high uncertainty and variability in data on carbon storage in waterbodies and watercourses, they have been excluded from the assessment. Therefore, GHG emissions from land use change in the context of freshwater habitats may not be representative of actual emissions. • There is no direct mapping available between the Project habitat types and the habitat types for which carbon storage potential is available in the Natural England source papers. As a result, habitat carbon storage factors have been assigned to Project habitat types (biodiversity units) based on professional judgement, following a qualitative review of similarity from the available information on habitat types and an assessment of the closest match. • Similarly to the assumption in construction phase, the estimation of carbon storage in trees during operation is based on 30-year old age profile. The actual carbon sequestered over a longer study period of 60 years would be greater than is reported in the land use calculation. As tree cover is greater for the do-something scenario then this is a conservative approach.
Operational emissions / Analysis of emissions	Emissions drawn from the traffic modelling using the EFT v11 are provided in carbon dioxide (CO_2) not carbon dioxide equivalents (CO_2e). To provide GHG emissions estimates as CO_2e, carbon emissions data has been converted to CO_2e by applying an additional 1% of the CO_2 emissions. This conversion factor assumes petrol and diesel fuels are used in vehicles using the highway infrastructure and is based upon analysis of the BEIS Conversion factors for Fuels, comparing the difference of CO_2 and CO_2e emissions factors on 'Fuels', which gives an approximate 1% difference in the factors. This uplift of 1% has then been used to convert CO_2 to CO_2e for emissions from vehicles using the highways infrastructure.
Operational emissions	Operational emissions associated with road lighting have not been quantified due to a lack of design information. There are likely minimal direct emissions associated with operating the Project since the lighting of most schemes is minimal or not implemented (given the rural nature of much of the Project). In some cases where lighting is being provided, this is replacement of existing lighting. This would provide some operational benefit albeit due to the overall scale of other user emissions this benefit is likely to be marginal in terms of the overall GHG assessment. Similarly in the limited areas where new lighting is provided then this is similarly expected to be marginal in terms of overall operational emissions. On this basis power consumption has been assumed as negligible in the context of the scheme and therefore does not form part of the GHG emissions assessment.
Analysis of emissions	It is noted that the Design Year, the project's operational phase and assumed 60 year design life are beyond the Sixth Carbon Budget.

[6] Natural England (2021) Carbon Storage and Sequestration by Habitat 2021 (NERR094).]
[7] Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources (NERR043).

Category	Limitations
	Operational phase emissions have been assessed against the Sixth Carbon Budget (2033-37) as the Carbon Budget set furthest into the operational phase.

7.1.5 References

Natural England (2021) Carbon Storage and Sequestration by Habitat 2021 (NERR094).]

Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources (NERR043).]