Appendix A20.2: GHG Emissions

1.1 Construction, maintenance and operational needs

Methodology and assumptions

The Transport Scotland Roads Projects Carbon Tool

1.1.1 Transport Scotland has developed and implemented a Carbon Management System (CMS) as a suite of tools to measure Scope 1 (direct), 2 (indirect) and 3 (whole life cycle) carbon emissions associated with their construction and maintenance activities across their road and rail schemes.

1.1.1 The CMS fulfils two roles:

- it enables consistent and objective measurement and reporting of carbon emissions from Transport Scotland's construction and maintenance operations and schemes; and
- it supports design and construction optioneering.

1.1.2 The 2024 version of Transport Scotland's Road Projects Carbon Tool (version 1.4) is part of the Carbon Calculator and Assessment System suite of tools. The tool is used to estimate carbon emissions associated with civil and structural engineering projects, including road, rail and buildings. It is intended to be used throughout the design process, from outline design to detailed design, allowing for comparison of design options to be made.

1.1.3 Whole life carbon emissions can be estimated for projects based on the embodied carbon associated with the materials used, the transport of materials and waste, site plant energy consumption; and any operational energy and emissions associated with structural maintenance.

1.1.4 For this assessment, only emissions embodied within the materials used and those associated with cyclic maintenance have been reported based on the information currently available.

Information Used

1.1.5 Entries into the tool are based on the Design Manual for Roads and Bridges (DMRB) Stage 3 design information available at the time of the assessment. It is noted that elements of the design will continue to be refined throughout the detailed design process resulting in changes in material quantities to that presented herein.

1.1.6 Design information and waste information that was incorporated into this carbon assessment includes:

- information on earthworks required for the proposed scheme;
- detailed pavement specifications for the different sections of the proposed scheme;
- structures such as bridges, culverts and underpasses;
- drainage pipe and filter material;
- kerbs;
- signs, signals and communications;

- road markings
- road lighting;
- safety barriers;
- boundary fencing; and
- information on waste treatment and transport.

1.1.7 The initial step towards carbon management is to identify and map out the emissions sources that can be attributed to a project through its life cycle; management and reduction can only occur after this. Whilst the proposed scheme would aim to identify and account for as much carbon as possible, it is a more efficient approach to prioritise some sources over others, rather than calculating the absolute footprint of the project, as many components will have a negligible impact and offer limited opportunities for mitigation compared to the time, effort and cost involved in determining its carbon impact.

1.1.8 It should be noted that the Transport Scotland Roads Projects Carbon Tool is used to monitor carbon during construction, and therefore includes transport of materials to site and wastes from site within the reporting boundary.

Data used

1.1.9 Material quantities used to calculate emissions were obtained from the Bill of Quantities provided by the Design team.

1.1.10 Transport distances for construction materials were taken from the standard material availability values for the Highlands in the Transport Scotland Road Projects Carbon Tool. A conservative value of 100km was used for the transport of waste materials due to limited non-hazardous landfill capacity within the study area.

1.1.11 Replacement frequencies for materials were taken from a set of assumptions as advised by the project Design team.

1.1.12 Waste treatment and transport information was also used (see Chapter 14: Materials and Waste for more information).

1.1.13 The design information entered into the Transport Scotland Road Projects Carbon Tool for the construction stage is summarised in Table A20.2-1. The information presented in Table A20.2-1 applies a conservative approach and includes a 15% contingency.

1.1.14 The waste quantities and treatment methods entered into the Transport Scotland Road Projects Carbon Tool are summarised in Table A20.2-2.

Table A20.2-1: Design Information Incorporated into the GHG Assessment

Material types	Unit	Quantity
Civil Engineering Structures; Formwork / Shuttering; Plywood	m^3	1,127
Civil Engineering Structures; Steelwork; General steel	t	5,031

Material types	Unit	Quantity
Civil Engineering Structures; Paint; General paint	Litres	93
Civil Engineering Structures; Decorative stone; General stone	t	2,321
Civil Engineering Structures; Pre-cast Concrete; General concrete	t	2
Civil Engineering Structures; Pre-cast Concrete; High strength concrete	t	8,554
Civil Engineering Structures; Bricks and blockwork; Concrete blocks (Average)	no.	33,925
Bulk Materials; Asphalt; General Asphalt	t	181,535
Bulk Materials; Fill, aggregate and sand; General mixture	t	334,985
Bulk Materials; Concrete; General - C6/8 (Gen 0, ST1)	m^3	305
Bulk Materials; Concrete; General - C8/10 (Gen 1, ST 2)	m^3	433
Bulk Materials; Concrete; General - C20/25 (ST 5)	m^3	1,254
Bulk Materials; Concrete; General - C25/30	m^3	9,634
Bulk Materials; Concrete; General - C28/35	m^3	713
Bulk Materials; Concrete; General - C32/40	m^3	7,710
Bulk Materials; Concrete; General - C35/45	m^3	12,952
Bulk Materials; Concrete; General - C40/50	m^3	8,795
Bulk Materials: Cement and binders - Average CEM I, Ordinary Portland Cement (OPC)	t	2,973
Bulk Materials; Reinforcement steel; Steel bar and rod	t	8,727
Drainage; Plastic inspection chambers; 450mm diameter, up to 1.2m depth	no	22
Drainage; Plastic pipework (HDPE); 150mm diameter	m	5,174
Drainage; Plastic pipework (HDPE); 225mm diameter	m	10,709
Drainage; Plastic pipework (HDPE); 300mm diameter	m	8,419
Drainage; Plastic pipework (HDPE); 450mm diameter	m	9,291
Drainage; Plastic pipework (HDPE); 600mm diameter	m	386
Drainage; Plastic pipework (HDPE); 900mm diameter	m	2,724
Drainage; Precast concrete circular pipework; 225mm diameter	m	1,020
Drainage; Precast concrete circular pipework; 900mm diameter	m	1,373
Fencing, Barriers & Road Restraint Systems; Fence; Steel/wire/chain fence (includes posts)	m	644
Fencing, Barriers & Road Restraint Systems; Road Restraint System/ Safety Barrier; Steel RRS barrier single sided	m	21,836
Fencing, Barriers & Road Restraint Systems; Road Restraint System/ Safety Barrier; Steel RRS barrier double sided	m	10,188

Material types	Unit	Quantity
Fencing, Barriers & Road Restraint Systems; Paint or timber treatment; Solvent based paint	Litres	2,284
Street Furniture & Electrical Equipment; Traffic signs; Steel	m^2	1,537
Street Furniture & Electrical Equipment; Variable Message Signs (VMS); MS4 Sign	no	3
Street Furniture & Electrical Equipment; Road lighting and columns; LED light	no	52
Street Furniture & Electrical Equipment; Road lighting and columns; Steel columns 8m	no	17
Street Furniture & Electrical Equipment; Road lighting and columns; Steel columns 10m	no	35
Street Furniture & Electrical Equipment; Cable; Armoured cable / Power cable	m	2,820
Street Furniture & Electrical Equipment; Marker posts/signs; Aluminium marker sign	no.	2
Street Furniture & Electrical Equipment; Cable; Miscellaneous cable	m	12
Street Furniture & Electrical Equipment; Plastic cable ducting; 50mm diameter	m	22,368
Street Furniture & Electrical Equipment; Plastic cable ducting; 150mm diameter	m	7,198
Street Furniture & Electrical Equipment; Cabinets; Average roadside cabinet type	no	13
Street Furniture & Electrical Equipment; Cameras; Hard shoulder camera and steel pole	no	5
Street Furniture & Electrical Equipment; Cameras; Camera unit	no	3
Street Furniture & Electrical Equipment; Road Studs; Any type	no	4,815
Road pavement; Bitumen / surface treatment; Bitumen emulsion	t	7
Road pavement; Bitumen / surface treatment; Bitumen emulsion	t	489
Road pavement; Bitumen / surface treatment; TS2010	t	21,454
Road pavement; Kerb; Pre-cast concrete 125x150mm	m	6,856
Road pavement; Kerb; Pre-cast concrete 125x255mm	m	1,635
Road pavement; Kerb; Pre-cast concrete 125x305mm	m	5,377
Road pavement; Road markings; Thermoplastic road marking	t	6

Table A20.2-2: Waste Information Incorporated in the GHG Assessment and tCO_2e from Waste Treatment and Transport

Material type	Treatment method	Quantity (t)	Transport Distance (km)	Waste Treatment Emissions (tCO_2e)	Waste Transport Emissions (tCO_2e)
Site Clearance (Including Demolition)					
Aggregates	Recycle	82.3	100	0.1	1.0
Aggregates	Landfill	2.1	100	<0.1	<0.1
Asphalt	Recycle	211,407.2	100	208.2	2,545.7
Asphalt	Landfill	5,420.7	100	6.7	65.3
Concrete / brick	Recycle	3,154.4	100	3.1	38.0
Concrete / brick	Landfill	131.4	100	0.2	1.6
Metal	Recycle	486.3	100	10.3	5.9
Metal	Landfill	9.9	100	0.1	0.1
Wood	Re-use off site	13,101.6	100	0.0	157.8
Wood	Landfill	133.0	100	123.0	1.6
Wood	Recycle	63.8	100	1.4	0.8
Glass	Recycle	5.3	100	0.1	0.1
Glass	Landfill	3.4	100	<0.1	<0.1
Excavation					
Aggregates	Recycle	1,151,959.6	100	1,134.6	13,871.6
Aggregates	Landfill	29,537.4	100	36.4	355.7
Construction					
Aggregates	Recycle	32,887.3	100	32.4	396.0
Aggregates	Landfill	843.3	100	1.0	10.2
Asphalt	Recycle	11,903.5	100	11.7	143.3
Asphalt	Landfill	305.2	100	0.4	3.7
Concrete / brick	Recycle	5,442.1	100	5.4	65.5
Concrete / brick	Landfill	139.5	100	0.2	1.7
Metal	Recycle	432.3	100	9.2	5.2
Metal	Landfill	8.8	100	0.1	0.1
Plastic	Recycle	7.7	100	0.2	0.1

Material type	Treatment method	Quantity (t)	Transport Distance (km)	Waste Treatment Emissions (tCO_2e)	Waste Transport Emissions (tCO_2e)
Timber	Landfill	0.6	100	0.6	<0.1
Timber	Recycle	60.2	100	1.3	0.7
Totals				**1,586.6**	**17,671.6**

1.1.15 The estimation of GHG emissions from maintenance during the life cycle of the proposed scheme relied on the materials Bill of Quantities utilised for the construction phase calculations and assumed the following indicative replacement frequencies for materials in accordance with their expected design life:

- Civil Engineering Structures - >60 years
- Civil Engineering Structures; Paint - 25 years
- Asphalt Base Course - 40 years
- Asphalt Binder Course - 20 years
- Asphalt Surface Course - 10 years
- Fill, aggregate and sand Capping - >60 years
- Fill, aggregate and sand Sub-base - 40 years
- Fill, aggregate and sand General - >60 years
- General concrete - >60 years
- Sub-base concrete - 40 years
- Reinforcement steel - >60 years
- Drainage - >60 years
- Steel/wire/chain fence (includes posts) - 20 years
- Steel RRS barrier - 30 years
- Fencing Solvent based paint - 5 years
- Traffic signs - 25 years
- Variable Message Signs (VMS) - 25 years
- Road lighting and columns; LED light - 12 years
- Steel lighting columns - 25 years
- Street Furniture & Electrical Equipment; Cable - 25 years
- Street Furniture & Electrical Equipment; Plastic cable ducting - 40 years
- Street Furniture & Electrical Equipment; Cabinets - 20 years
- Street Furniture & Electrical Equipment; Cameras - 20 years
- Street Furniture & Electrical Equipment; Cameras; Camera unit – 20 years

- Road Studs - 2 years
- General bitumen / surface treatment emulsion - 40 years
- Surface course bitumen emulsion - 10 years
- Surface course bitumen TS2010 - 16 years
- Kerb - >60 years
- Thermoplastic road markings - 4.5 years

Land Use and Forestry

1.1.16 Land use change calculations took into consideration the GHG emissions produced from vegetation loss and soil disturbance during construction and potential changes in soil carbon and sequestration during the operational assessment period.

1.1.17 The landscape team provided mapped habitat types/ land uses in the study area.

1.1.18 Each habitat type was assigned a vegetation and soil carbon density value, as shown in Table A20.2-3, using Natural England's (2021) published values.

Table A20.2-3: Natural England's Soil and Vegetation Carbon Densities

Habitat Type	Soil Carbon (t C ha^{-1})	Vegetation carbon (t C ha^{-1})
100-year mixed native broadleaved woodland on mineral soil (to 1m)	151	203
30-year mixed native broadleaved woodland on mineral soil (to 1m)	151	114
Upland and lowland heathland	94	6
Neutral grassland	60	-
Arable/cultivated land	120	-

1.1.19 Within the construction area it was assumed that 100% of vegetation carbon would be lost and 25% of the soil carbon due to disturbance.

Table A20.2-4: Vegetation and Soil Carbon Lost during Construction

Factor	Total Tonnes of CO_2 Lost During Construction
Vegetation Carbon	21,659.9
Soil Carbon	6,648.6

1.1.20 For operational phase emissions, the remaining soil carbon for each habitat type was calculated (75% left after construction).

1.1.21 Proposed land uses were provided by the landscape team and a soil carbon value was assigned using Natural England's densities (Table A20.2-3). Proposed seeding areas used neutral grassland and arable/cultivated land soil carbon values. Proposed planting and woodland areas used the woodland soil carbon value of 151tC/ha.

1.1.22 The difference was calculated between the soil carbon remaining after construction and the soil carbon of the proposed land use. If the proposed land use had a lower soil carbon density than after construction effects had been accounted for, it was assumed the soil carbon would be lost. This process occurs quickly so it was assumed 100% was lost over the appraisal period (60 years). If there was a higher soil carbon density, the soil carbon will be gradually restored. This happens slowly and so 50% of the increase was allowed for in the 60-year operational assessment period.

1.1.23 The total soil carbon changes were summed to give the operational soil carbon change, as presented in Table A20.2-5.

Table A20.2-5: Operational Soil Carbon Change

Proposed Land Use	Operational Soil Carbon Change (tCO_2)
Seeding	3,745.6
Planting and Woodland	-744.5

1.1.24 For carbon sequestered by areas of woodland in the operation phase, the Woodland Carbon Code tool was used.

1.1.25 The biodiversity team provided information on the composition and spacing of tree species in areas within the CPO boundary. Various assumptions were made for areas of existing woodland based on habitat surveys but more detailed information was provided for proposed areas of woodland.

1.1.26 The Woodland Carbon Code tool calculates the carbon sequestered by woodland on an annual basis over a 100-year period from when they are planted, as shown in Table A20.2-6. For this assessment, the first 60 years was used when considering proposed areas of woodland. The average age of trees in the area was approximately 40 years old, so for existing areas of woodland the carbon sequestration from 40 to 100 years was used.

Table A20.2-6: Carbon Sequestered over 100 years

Years	Retained Woodland	Woodland Lost	Proposed Woodland
0-5			86
5-10			240
10-15			711
15-20			1,876
20-25			2,498
25-30			2,170

30-35			2,055
35-40			1,739
40-45	1,530	2,492	1,440
45-50	1,327	2,188	1,252
50-55	991	1,593	1,122
55-60	787	1,270	969
60-65	711	1,130	
65-70	579	910	
70-75	442	715	
75-80	396	639	
80-85	389	621	
85-90	338	540	
90-95	349	598	
95-100	256	400	
Total	**6,564**	**13,096**	**16,158**

1.1.27 The net change in carbon sequestration caused by changes in forestry was calculated by subtracting the total estimated carbon sequestered by proposed areas of woodland from the carbon which would be sequestered by lost areas of woodland. The total change is -3,063 tCO_2 (i.e. an increase in carbon sequestration).