Teddington Direct River Abstraction

Preliminary Environmental Information Report

Appendix 17.1 – Carbon emissions estimation approach

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Appendix 17.1 – Carbon emissions estimation approach

A.1 Introduction

A.1.1 This appendix summarises the approaches used at the Preliminary Environmental Information (PEI) Report stage to estimate greenhouse gas (GHG) emissions associated with the Teddington Direct River Abstraction Project (hereafter referred to as 'the Project').

A.1.2 Where it was practical and proportionate to do so (e.g. where industry recognised emissions factor are available), emissions have been estimated of the seven GHGs that directly contribute to climate change, namely:

a. Carbon dioxide (CO_2)

b. Methane (CH_4)

c. Nitrous oxide (N_2O)

d. Hydrofluorocarbons (HFCs)

e. Perfluorocarbons (PFCs)

f. Nitrogen trifluoride (NF_3)

g. Sulphur hexafluoride (SF_6)

1.1.1 As each of these GHGs have a different Global Warming Potential (GWP), emissions of GHGs have been expressed throughout this appendix as emissions of carbon dioxide equivalent (CO_2e), i.e. the equivalent amount of CO_2 with the same GWP. Hereafter, therefore, and to be consistent with the terminology used in relevant national, regional and local policy, emissions of GHGs are referred to as 'carbon' emissions.

1.1.2 In line with Institute of Environmental Management and Assessment (IEMA) guidance (IEMA, 2022), calculations of carbon emissions have used data consistent with the whole-life carbon modular approach and lifecycle stages and modules defined in BS EN 15978 (British Standards Institution, 2011).

1.1.3 Details of the approaches used to estimate carbon emissions during the construction (including any demolition) and operation phases of the Project are set out in the following sections.

A.2 Construction phase

Product stage (embodied carbon in construction materials) – Modules A1–A3

A.2.1 Embodied carbon (i.e. carbon associated with the production of goods and materials) was estimated using emission factors from the Applicant's in-house Engineering Estimating System (EES). The EES contains embodied carbon values for different elements and components of water resources projects, derived by the Applicant, which can be used to estimate carbon emissions for a future project based on the proposed type, number and size of different elements and components.

A.2.2 Carbon factors extracted from the EES were assigned to the proposed elements and components which form part of the Project to provide a preliminary, top-down estimate of embodied carbon emissions. As noted within paragraph 17.5.13 of Chapter 17: Carbon, a more detailed and refined calculation approach will be followed within the Environmental Statement (ES).

Transport of construction materials to site – Module A4

A.2.3 Carbon emissions associated with the transport of construction materials to the draft Order limits (and associated return journeys) were estimated using preliminary estimates of the quantities of key raw materials which would be required to construct the Project derived by the Applicant. These estimated material quantities were then converted (where required) to masses in tonnes using assumed material densities, as shown in Table A.1. To note, the tables of material quantities and estimated carbon emissions presented in this document (and Chapter 17: Carbon) contain values rounded to the nearest whole number to improve readability. As such, the sum of these values does not necessarily add up to the total values reported in the table, which are calculated from the raw data prior to any rounding.

Table A.1 Estimated quantities of key raw materials

Material type	Quantity	Units	Assumed material density (tonnes/m^3)	Estimated mass (in tonnes)
Cement powder	5,490	tonnes	-	5,490
Pre-cast concrete	18,010	m^3	2.4	43,224
Ready-mix concrete	27,730	m^3	2.4	66,552
Steel	10,350	tonnes	-	10,350
			Total	125,616

Source: The Applicant

A.2.4 The transport distances shown in Table A.2 were then assumed for each material type based on Royal Institution of Chartered Surveyors (RICS) guidance (RICS, 2024).

Table A.2 Assumed transport distances of key raw materials

Material type	RICS transport scenario	km by road
Cement powder	Locally manufactured (general), e.g. aggregate, earth, asphalt	50
Pre-cast concrete	Nationally manufactured, e.g. structural timber, structural steelwork, reinforcement, precast concrete	120
Ready-mix concrete	Locally manufactured (ready-mixed concrete)	20
Steel	Nationally manufactured, e.g. structural timber, structural steelwork, reinforcement, precast concrete	120

Source: Default transport scenarios for UK projects, Whole life carbon assessment for the built environment (RICS, 2024)

A.2.5 It was assumed that all construction materials would be transported to the draft Order limits by road using Heavy Goods Vehicles (HGVs). The emission factors shown in Table A.3 for freighting goods were therefore used to estimate transport emissions associated with laden (to site) and unladen (from site) HGV movements, respectively, to account for return journeys. Emissions associated with extraction, refining and transportation of the raw fuels before they are used to power the transport mode (i.e. Well to Tank (WTT) emissions) were also included using the emission factors shown in Table A.4.

A.2.6 The emission factors for laden HGV movements are in the form of kg CO_2e per tonne km (i.e. the amount of carbon emitted to transport one tonne of goods over one kilometre). The mass of each key raw material shown in Table A.1 was therefore multiplied by the relevant assumed transport distance shown in Table A.2 before being multiplied by the relevant emission factor shown in Table A.3 and Table A.4 to estimate carbon emissions associated with laden HGV movements.

A.2.7 The emission factor for unladen HGV movements is in the form of kg CO_2e per km (i.e. the amount of carbon emitted by an unladen HGV travelling one km). To estimate the total number of km travelled by unladen HGVs, the mass of each key raw material shown in Table A.1 was therefore divided by an assumed average load of 7.5 tonnes before being multiplied by the relevant assumed transport distance shown in Table A.2. The total estimated km travelled by unladen HGVs was then multiplied by the relevant emission factor shown in Table A.3 and Table A.4 to estimate carbon emissions associated with unladen HGV movements.

Table A.3 Construction materials HGV transport emission factors

Type	Emission factor	Units
All HGVs (average laden)	0.09752	kg CO_2e / tonne.km
All HGVs (unladen)	0.64392	kg CO_2e / km

Source: Freighting goods, GHG reporting: conversion factors 2024 (Department for Energy Security and Net Zero (DESNZ), 2024)

Table A.4 Construction materials HGV transport emission factors (Well to Tank)

Type	Emission factor	Units
All HGVs (average laden)	0.02359	kg CO_2e / tonne.km
All HGVs (unladen)	0.15527	kg CO_2e / km

Source: WTT – delivery vehs and freight, GHG reporting: conversion factors 2024 (DESNZ, 2024)

A.2.8 To estimate transport emissions which would occur at a 'local' level (i.e. within the areas administered by the London Borough of Richmond upon Thames (LBR), Royal Borough of Kingston upon Thames (RBK) and London Borough of Hounslow (LBH)), carbon emissions within 20km of the draft Order limits were disaggregated from those which would occur further afield (i.e. at a regional or national level).

Fuel consumption (employee transport) – Module A5

A.2.9 In order to provide a preliminary estimate of carbon emissions associated with construction worker travel during the construction phase, an estimate was made of the total number of construction worker trips and assumptions made regarding the likely travel distances of construction workers.

A.2.10 Based on the conservative assumption that all of these workers would travel to site via car, carbon emissions were estimated using the total estimated travel distance (in km) and the emission factors shown in Table A.5 and 0.

A.2.11 To estimate construction worker transport emissions which would occur at a 'local' level (i.e. within the areas administered by LBR, RBK, LBH), carbon emissions within 20km of the draft Order limits were disaggregated from those which would occur further afield.

Table A.5 Construction worker transport emission factor

Type	Emission factor	Units
Average car (unknown fuel)	0.16691	kg CO_2e / km

Source: Business travel – land, GHG reporting: conversion factors 2024 (DESNZ, 2024)

Table A.6 Construction worker transport emission factor (Well to Tank)

Type	Emission factor	Units
Average car (unknown fuel)	0.04399	kg CO_2e / km

Source: WTT – pass vehs and travel – land, GHG reporting: conversion factors 2024 (DESNZ, 2024)

Fuel and electricity consumption (on-site plant and machinery) – Module A5

A.2.12 In order to provide a preliminary estimate of carbon emissions associated with the use of on-site plant and machinery during the construction phase, a preliminary estimate was made of total associated electricity and diesel consumption. Consumption-based emission factors were then used to estimate resulting carbon emissions.

A.2.13 For example, a preliminary estimate was made of the electricity which will potentially be consumed by the Tunnel Boring Machine (TBM) required to construct the Project recycled water conveyance tunnel based on its potential power demand and estimated annual hours of operation. Year-specific consumption-based electricity emission factors (DESNZ, 2023) were then used to estimate resulting carbon emissions as summarised in Table A.7.

Table A.7 Estimated TBM electricity consumption and associated emission factors

Year	Estimated TBM power consumption (kWh)	Grid average industrial consumption-based emission factor (kg CO_2e / kWh)
2030	9,849,600	0.048
2031	7,315,200	0.040

Sources: Estimated TBM Power Consumption (the Applicant); Consumption-based emission factors (DESNZ, 2023)

A.2.14 To account for WTT emissions associated with UK electricity generation and transmission and distribution (T&D), WTT emission factors for 2024 (DESNZ, 2024) were interpolated by the Applicant to the relevant year (i.e. 2030 and 2031) based on the corresponding forecast reduction in grid average industrial consumption-based emission factors (DESNZ, 2023) over the same time period. The derived factors for 2030 and 2031 are shown in Table A.8.

Table A.8 Estimated WTT emission factors for UK electricity generation

Year	WTT UK electricity (generation)	WTT UK electricity (T&D)
2024	0.0459	0.00397
2030	0.0150 (interpolated)	0.0013 (interpolated)
2031	0.0126 (interpolated)	0.0011(interpolated)

Sources: WTT – UK electricity, GHG reporting: conversion factors 2024 (DESNZ, 2024), Interpolated values derived by the Applicant

A.2.15 A preliminary estimate of the total quantity of diesel consumed by on-site construction plant and equipment (in litres) was made by:

a. Collating a list of the items of diesel-fuelled plant and equipment which would potentially be used to construct the Project, based on the Applicant's previous experience of similar projects

b. Assigning likely power ratings (in kW) to each item of diesel-fuelled plant and equipment based on manufacturers' information for similar items of plant and equipment

c. Estimating likely operating hours for each item of plant and equipment based on the estimated duration of associated activities and assumed 'on-times' (i.e. the proportion of the time during each activity that each item of plant and equipment would be in operation)

d. Using the resulting estimated energy demand (in kWh) to estimate fuel consumption (in litres) based upon assumed loading factors (in %) and fuel use factors (in g/kWh) derived on behalf of the Department for Transport (AEA Technology, 2004) and an assumed fuel density for diesel of 0.84kg/litre

A.2.16 The resulting estimated total fuel consumption (539,540 litres) was then used to estimate associated carbon emissions using a factor of 2.75541kgCO_2e/litre for gas oil and a WTT factor of 0.62665kgCO_2e/litre (DESNZ, 2024).

A.2.17 It should be noted that these estimates are considered indicative, as they are based on an early understanding of potential construction activities and associated plant and equipment, as well as assumptions made at the time of writing.

Treatment and disposal of waste materials – Module A5

A.2.18 Quantities of waste materials were estimated based on preliminary estimates of:

a. Waste spoil arisings

b. Waste construction materials (based on the quantities of key construction materials set out in Table A.1 and assumed wastage rates (as set out in Table 11.11 of Chapter 11: Materials and Waste))

c. Concrete from demolition activities

A.2.19 These estimated waste quantities were then converted (where required) to masses in tonnes using assumed material densities, as shown in Table A.9, with waste spoil arisings assumed to be primarily London Clay.

Table A.9 Estimated quantities of waste materials

Material type	Quantity	Units	Material density (t/m^3)	Mass (in tonnes)
Waste spoil arisings	207,550	m^3	1.9	394,345
Cement powder (wastage)	275	tonnes	-	275
Pre-cast concrete (wastage)	90	m^3	2.4	216
Ready-mixed concrete (wastage)	1,387	m^3	2.4	3,328
Steel (wastage)	207	tonnes	-	207
Concrete (demolition)	3,160	m^3	2.4	7,584
			Total	**405,954**

Source: The Applicant

A.2.20 It was then conservatively assumed, at this PEI Report stage, that all waste materials would be disposed of via landfill. Carbon emissions associated with waste treatment were therefore calculated using an emission factor of 1.23393kgCO_2e/tonne (or 1.26435kgCO_2e/tonne for steel) sourced from UK Government GHG Conversion Factors for Company Reporting (DESNZ, 2024).

Transport of waste materials from site – Module A5

A.2.21 It was assumed that all waste materials would be transported from the draft Order limits by road using HGVs. The emission factors shown in Table A.10 for freighting goods were therefore used to estimate transport emissions associated with unladen (to site) and laden (from site) HGV movements, respectively, to account for both the inward and return journeys. Emissions associated with extraction, refining and transportation of the raw fuels before they are used to power the transport mode (i.e. WTT emissions) were also included using the emission factors shown in Table A.11.

A.2.22 The emission factors for laden HGV movements are in the form of kg CO_2e per tonne km (i.e. the amount of carbon emitted to transport one tonne of goods over one kilometre). The mass of each waste material shown in 0 was therefore multiplied by an assumed regional disposal distance of 80km (from RICS guidance (RICS, 2024)) before being multiplied by the relevant emission factor shown in Table A.10 and Table A.11 to estimate carbon emissions associated with laden HGV movements.

A.2.23 The emission factor for unladen HGV movements is in the form of kg CO_2e per km (i.e. the amount of carbon emitted by an unladen HGV travelling one km). To estimate the total number of km travelled by unladen HGVs, the mass of each waste material shown in Table A.1 was therefore divided by an assumed average load of 28.5 tonnes before being multiplied by an assumed regional disposal distance of 80km (from RICS guidance (RICS, 2024)). The total estimated km travelled by unladen HGVs was then multiplied by the relevant emission factor shown in Table A.10 and Table A.11 to estimate carbon emissions associated with unladen HGV movements.

Table A.10 Waste materials HGV transport emission factors

Type	Emission factor	Units
All HGVs (fully laden)	0.07240	kg CO_2e / tonne.km
All HGVs (unladen)	0.64392	kg CO_2e / km

Source: Freighting goods, GHG reporting: conversion factors 2024 (DESNZ, 2024)

Table A.11 Waste materials HGV transport emission factors (Well to Tank)

Type	Emission factor	Units
All HGVs (fully laden)	0.01757	kg CO_2e / tonne.km
All HGVs (unladen)	0.15527	kg CO_2e / km

Source: WTT – delivery vehs and freight, GHG reporting: conversion factors 2024 (DESNZ, 2024)

A.2.24 To estimate waste transport emissions which would occur at a ‘local’ level (i.e. within the areas administered by LBR, RBK, LBH), carbon emissions within 20km of the draft Order limits were disaggregated from those which would occur further afield (i.e. at a regional level (i.e. between 20km and 80km)).

A.3 Operation phase

Maintenance – Module B2

A.3.1 Maintenance emissions were estimated as 1% of estimated carbon emissions for Modules A1–A5 (as per RICS guidance (RICS, 2024).

Repair – Module B3

A.3.2 Repair emissions were estimated as 25% of B2 maintenance emissions for relevant items except for mechanical, electrical and plumbing items, where 10% of estimated A1–A3 carbon emissions was assumed (as per RICS guidance (RICS, 2024)).

Replacement – Module B4

A.3.3 Replacement embodied carbon emissions were estimated using the Applicant’s EES and the assumed design lives and replacement frequencies for each broad asset class shown in Table A.12 over the assumed 60-year operational lifetime of the Project.

Table A.12 Assumed design lives and number of replacements by asset class

Asset class	Assumed design life (years)	Assumed number of replacements (over 60 years)	Data source
Tunnels and shafts	120	-	The Applicant
Civil structures and building structural elements	60	-	The Applicant
Pipelines	50	1	The Applicant
Mechanical and electrical plant	20	2	The Applicant
Control and instrumentation systems	7	8	The Applicant
Computer systems	7	8	The Applicant
Analytical and process instruments	10	5	The Applicant
Power cabling	25	2	The Applicant
Steel/timber Glass Reinforced Plastic structures	30	1	ACWG
Landscaping	30	1	ACWG
Media	10	5	ACWG

Sources: The Applicant, Cost Consistency Methodology – Technical Note and Methodology (All Company Working Group (ACWG), 2022)

A.3.4 Emissions associated with the transport of raw materials and construction processes resulting from replacement activities were estimated by applying the ratio of estimated transport and construction process emissions (Modules A4 and A5) to embodied carbon in construction materials (Modules A1–A3), to estimated embodied carbon emissions associated with replacement activities.

A.3.5 These emissions were therefore not estimated directly, but inferred based on estimated emissions for the construction phase. This is considered a worst-case assumption given that the magnitude and intensity of construction activities and processes for the construction phase (and associated emissions) are likely to be greater than those associated with replacement activities.

Electricity consumption – Module B6

A.3.6 Emissions associated with operational energy consumption were estimated using estimated annual energy consumption (2,959,186kWh) and year-specific grid average consumption-based emission factors (DESNZ, 2023), for 2032 (commissioning and performance testing) and for each year over the 60-year assessment period (2033–2092).

A.3.7 To account for WTT emissions associated with UK electricity generation and T&D, WTT emission factors for 2024 (DESNZ, 2024) were interpolated by the Applicant to the relevant year based on the corresponding forecast reduction in grid average industrial consumption-based emission factors (DESNZ, 2023) over the same time period.

A.3.8 The emission factors used are shown in Table A.13.

Table A.13 Operational electricity emission factors

Year	Operational electricity emission factors (kg CO_2e / kWh)			
	Grid average industrial consumption-based	WTT UK electricity generation (interpolated)	WTT UK electricity T&D (interpolated)	Total
2032	0.032	0.0099	0.0009	0.0423
2033	0.025	0.0079	0.0007	0.0336
2034	0.020	0.0063	0.0005	0.0270
2035	0.019	0.0061	0.0005	0.0260
2036	0.019	0.0059	0.0005	0.0254
2037	0.018	0.0056	0.0005	0.0237
2038	0.017	0.0054	0.0005	0.0231
2039	0.016	0.0051	0.0004	0.0218
2040	0.015	0.0049	0.0004	0.0207
2041	0.015	0.0046	0.0004	0.0198
2042	0.014	0.0044	0.0004	0.0188
2043	0.009	0.0028	0.0002	0.0118
2044	0.008	0.0026	0.0002	0.0110
2045	0.008	0.0024	0.0002	0.0102
2046	0.007	0.0023	0.0002	0.0100
2047	0.005	0.0016	0.0001	0.0069
2048	0.005	0.0016	0.0001	0.0067
2049	0.003	0.0010	0.0001	0.0042
2050 onwards	0.002	0.0008	0.0001	0.0032

Sources: Consumption-based emission factors (DESNZ, 2023), WTT – UK electricity, Interpolated values derived by the Applicant

Consumption of chemicals – Module B8

A.3.9 Emissions associated with chemical consumption were estimated using estimated annual chemical consumption (435 tonnes/yr of ferric sulphate) and an emissions factor of 0.167kgCO_2e/tonne sourced from the Carbon Accounting Workbook v18 (UK Water Industry Research, 2024).

A.3.10 Emissions were estimated for 2032 (commissioning and performance testing) and for each year over the 60-year assessment period (2033–2092).

A.4 Uncertainty

A.4.1 The emissions estimates described above are based on an early design phase for the Project and predicted or estimated quantities, and therefore are subject to some uncertainty. There is no standardised or established guidance for addressing uncertainty in carbon estimates for the water industry in a consistent way. On this basis, a 15% contingency factor, as recommended by RICS (RICS, 2024), has been applied to the estimated carbon emissions for all lifecycle stages and modules to provide a more conservative assessment.

A.5 Next steps

A.5.1 As the design of the Project is developed, and further information becomes available, updated and refined estimates of whole-life carbon emissions associated with the Project will be made.

A.5.2 Details of the approaches used to inform these updated and refined estimates will be reported in the ES.

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Thames Water