Critical Report Review

'Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBK&C' – Eight Associates, July 2010

August 2013

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‘Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBK&C’ – Eight Associates, July 2010

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This document has been prepared and checked in accordance with Waterman Group’s IMS (BS EN ISO 9001: 2008, BS EN ISO 14001: 2004 and BS OHSAS 18001:2007))

Issue	Date	Prepared by	Checked by	Approved by
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Comments

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EXECUTIVE SUMMARY

Waterman was commissioned by Cranbrook Basements to carry out a critical review and recalculations of the claims made in a report produced by Eight Associates in July 2010: '*Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBK&C' (hereafter referred to as the Eight Associates Report).* The Eight Associate's Report was produced to support the proposed changes to planning policy within the Royal Borough of Kensington and Chelsea (RBKC).

Following a review of the above report, Waterman identified a significant number of inaccuracies and miscalculations surrounding the assessment of the lifecycle carbon of both the basement and the extension. The Eight Associates report is inconsistent in its approach and the calculations, resulting in uncertainty in the robustness of its conclusions. In particular, the following key issues were identified in relation to the assessment:

- The calculations of embodied carbon in the extension do not take into account the carbon emissions from the foundations and steel beams, which represents a substantial proportion of the development. The inclusion of these elements increases the embodied carbon for the extension by 168%.
- The calculations of embodied carbon for the extension use a wall height of 2m, whereas the drawings included in the planning application show the wall height as 2.6m. The use of the correct wall height increases carbon associated with the extension by up to 30%.
- The most recent carbon conversion factors were published in 2011. These updated factors take account of the use of a larger proportion of recycled steel and concrete and therefore are lower than the ones used by Eight Associates. The use of lower conversion factors in the calculations for steel and concrete in the basement would produce significantly lower embodied carbon values.
- Eight Associates assumes an overall timeframe for completion of the basement work of 15 months, but in the experience of both Waterman and Cranbrook, a basement of this size and nature would take approximately 10 months to complete. A reduction in the works timeframe of the basement would reduce the carbon emissions from the basement case study used.
- Eight Associates' assessment is based on the assumption that 1,200m^3 of spoil was removed, but the Construction Traffic Management Plan (CTMP) states that 750m^3 of spoil is expected. It is unknown whether the higher figure originates. However, if 750m^3 of spoil were used in the calculations, this would result in a reduction in carbon emissions by 40%.
- There are no waste values for the construction of the extension. At least some waste would be produced during construction and some spoil would be generated from excavations of the foundations. The addition of these values would increase the construction phase carbon of the extension, although the exact figures cannot be calculated based on the available information.
- The SAP calculations for operational carbon emissions of the extension are not representative of the case study used in the Eight Associates report. A development with a floor area of 55m^2 was used, when the extension in the Eight Associates report has a floor area of 10.35m^2. As this is a completely different case study to the one used in the Eight Associates report, assumptions made about the operational carbon of the Dalgarno Gardens extension are unlikely to be accurate.
- A number of inconsistencies have been noted in the SAP calculations for the basement, including that the calculations show only one sheltered side when a basement would be expected to have at least three. The inclusion of more sheltered sides would reduce the operational carbon. Furthermore, the basement is shown to have a roof, through which heat could escape; however, it is expected that in reality the basement would be insulated by the rooms above it, thereby reducing operational carbon. Section 9 of the SAP document shows a gas boiler in the basement, but according to the Sustainability Code Assessment, submitted as part of the planning application, the development will have a Ground Source Heat Pump, representing a lower carbon technology.

Re-calculations of embodied carbon (outlined in Section 3) were made by the incorporation and correction of the errors identified above and show that the construction of the extension actually results in the emissions of only 3.4% fewer carbon emissions than the basement. Further reductions in the carbon emissions from the basement may be expected if additional information to cover some of the points raised in this report was provided.

It is considered that more robust assessment and calculations are required to provide firm conclusions on the comparative carbon intensity between residential basement and aboveground extensions. Following this assessment, the statement made in paragraph 34.3.53 of RBKC's Basements Policy Publication may have to be reviewed to accurately reflect the findings of this analysis.

CV of Report Reviewer

Chris Illman

Senior Sustainability Consultant

Waterman Energy, Environment & Design Ltd

Profile

Chris is currently a Senior Sustainability Consultant for Waterman EED. He previously headed up the BREEAM and Commercial departments at Energist UK. He has excellent technical knowledge and experience across the full range of BREEAM schemes in addition to an in depth understanding of Carbon Footprinting, Low Carbon Design, Building Regulations and Part L requirements.

As part of the Waterman's sustainability team Chris is a BREEAM Accredited Professional and a licensed BREEAM assessor in a number of schemes, including Commercial, Education, Bespoke and International Bespoke.

Qualifications: BSc (Hons) MSc AIEMA BREEAM AP

Key Skills

- **Licensed BREEAM Commercial Assessor**
- **Licensed BREEAM International Assessor**
- **Licensed BREEAM Bespoke Assessor**
- **Licensed BREEAM Education Assessor**
- **BREEAM Accredited Professional**
- **Extensive Sustainability and Carbon Design Experience**

Project Experience:

Project	Details
Finsbury Circus	To support the re- development of Finsbury Circus, assessments of carbon and energy consumption were undertaken to inform the design. The design was analysed to identify areas where carbon and energy could be reduced, whilst not impacting on the operational capacity of the development. Working as part of a multi-disciplinary team the design incorporates features which encourage low energy design, reduce water consumption and improve social wellbeing. **Client: Real Estate Investments**
Siemens, Hull	Currently working with Siemens Wind Power to deliver a BREEAM 'Excellent' and LEED 'Gold' rated Office and Factory development. The design incorporates a number of sustainability features including; the incorporation of a wind turbine, reuse of existing dockland, and enhancement of biodiversity. The orientation and layout of the design has been developed to improve productivity, whilst reducing the CO_2 emissions generated during production. **Client: Siemens Real Estate Plc**
MTC Ansty, Warwickshire	Currently working with Morgan Sindall to reduce the Contractors site carbon emissions as part of delivering wider sustainability measures for the site. An BREEAM 'Excellent' rating has been awarded for the new state of the art research and development complex, outside Coventry. **Client: Morgan Sindall**
Siemens Relocation, Lincoln	The new factory and office development for Siemens achieved an BREEAM Outstanding and BREEAM 'Excellent' rating respectively. Siemens sustainability policies are reflected in the design through the use of Photo-Voltaic panels, and rain water harvesting. Key operational metrics are being recorded in order to establish the difference between design and operational value. **Client: St Modwen on behalf of Siemens Real Estates Plc**
Kelaty House, Wembley	Working with Londonnewcastle to develop the proposals for a new mixed use development in the heart of Wembley. The design includes a Hotel, Student Accommodation, and Retail space. We are working in the capacity of Sustainability Consultants and BREEAM assessors to maximise the sustainability credentials of the site. A sustainability statement has also been produced to support the planning application. The design includes minimising reliance on mains water consumption, the selection of low and zero carbon technologies based on life cycle analysis, and the enhancement of ecology. **Client: Londonnewcastle**

1. Introduction

Waterman was commissioned by Cranbrook Basements to carry out a critical review and recalculations of the claims made in a report produced by Eight Associates in July 2010: *Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBK&C.* The report was produced to support the proposed changes to planning policy within the Royal Borough of Kensington and Chelsea (RBKC). The SAP calculations for operational carbon were provided by RBKC in a Freedom of Information request, but only a high level review has been done as part of the agreed scope of works.

RBKC is undertaking a partial review of their Core Strategy and the Basements Publication Planning Policy is currently under consultation, ending 3 September 2013. In the consultation document, the Council highlights issues in relation to the noise impacts and disturbance during the construction of basements from traffic and plant and equipment, as well as concerns about the structural stability of nearby buildings. Following the consultation, RBKC will look to amend their policies to limit the construction of basements to a single-storey and place a number of other restrictions and red tape around planning applications for basements.

Paragraph 34.3.53 of the consultation document states that *"the carbon emissions of basements are greater than those of above ground developments per square metre over the building's life cycle. The embodied carbon in basements is almost three times the amount of embodied carbon in above ground development per square metre."* These claims are based on the Eight Associates report, dated July 2010, which compares the lifecycle carbon of a real-life example of a basement construction, in comparison to that of an aboveground extension. The purpose of this report is to highlight the errors made in the Eight Associates report and suggest that the difference between the embodied carbon of the two developments may not be as significant as the report concludes.

Section 4 of the Eight Associates report describes the two case studies used, which are as follows:

- Case study 1 is the subterranean development at 44 Markham Square. The existing building is a five-storey Georgian house that plans to incorporate a proposed subterranean basement of around 75m^2 internal floor area, as well as rear extensions at lower ground, ground floor and first floor levels.
- Case study 2 is a small extension to 4 Dalgarno Gardens. The existing building is a two-storey three-bed terrace that plans to build a single storey 10.35m^2 extension to the rear of the building.

This report aims to review the assumptions and raw data utilised by Eight Associates as well as their carbon calculations, conclusions and findings presented in the abovementioned report.

This report has been undertaken by Waterman carbon specialists, with input from structural engineers, in order to provide an informed review of the Eight Associates Report.

A CV of Chris Illman, reviewer of this report, has been included in the Executive Summary to this report. The findings of the critical review are detailed in section 2 below and re-calculations of embodied carbon are presented in section 3.

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2. Key Findings

The following section identifies the key findings of the critical review of the Eight Associates report and highlights the implications of the errors identified on the carbon calculations and conclusions of the report. Recommendations for corrections have also been made where required.

Table 1. Findings of the critical report review

Finding/Issue	Implications	Effect on CO_2 Footprint
2.1 Carbon Factors		
2.1.1 Steel and Concrete		
The carbon conversion factors used within the Eight Associates report have been taken from the Bath University Inventory of Carbon and Energy (ICE) V1.6, dated 2008. It should be noted that there is a more recent publication from Bath University from 2011 and therefore the factors used in this report may be out of date. At the time of the Eight Associates report (July 2010), these conversion factors were not published, but more recent data could now be incorporated. It was identified during the review that lower conversion factors could have been used for the carbon calculations of steel piling and concrete in Case Study 1. The conversion factor used by Eight Associates for steel piling is given as 1.77 $kgCO_2/kg$, which is based on the factor for UK average steel and includes a recycled content of 42.7%. The more up to date 2011 ICE provides a carbon conversion factor of 1.37 $kgCO_2/kg$, which reflects the EU average recycled content of 59%. Furthermore, the conversion factor used for concrete piling in the report is 0.136 $kgCO_2/kg$, which is based on RC25 concrete with 0% cement replacement. It is proposed that it would have been more appropriate to use a conversion factor for blended concrete, such as 0.115 $kgCO_2/kg$, based on RC25/30 with 30% cement replacement. This would reflect the trend towards using blended concrete in piling, as opposed to a pure concrete.	A lower conversion factor for steel piling can now be used (as is reflective of current construction trends), which result in a reduction of the carbon emissions associated with Case Study 1. The following calculations show the potential reductions when using the most recent and more relevant carbon conversion factors for steel and concrete (1.46 and 0.115 respectively): *Element* / *Original* / *Re-calculated* Steel / 30,691.8 / 23,755.8 Concrete / 14,118.0 / 11,938.0 Using the carbon factors in the most recent literature, 22.6% and 15.4% less embodied carbon is attributed to the steel and concrete within the basement structure, respectively.	**Potential reduction in the embodied carbon of the basement by 22.6% for steel and 15.4% for concrete.**
2.1.2 Roof		
Conflicting conversion factors have been used for the roof calculations for Case Study 2: the calculations on page 16 refer to concrete tiles with a conversion factor of 0.13 $kgCO_2/kg$, while the summary table on page 10 refers to slate roof tiles with a conversion factor of 0.06 $kgCO_2/kg$. The development description on page 7 of the report refers to an "*insulated slate roof to match existing building*". The Design and Access Statement as part of the planning application for 4 Dalgarno Gardens states that the roof will be comprised of slate tiles.	It is assumed that the roof is comprised of slate tiles with a conversion factor of 0.06 $kgCO_2/kg$ and, therefore, this does not have any impact on the final calculations for the extension, as the conversion factor for slate is used for the final conclusions of the report. However, such an inconsistency places doubt on the robustness of Eight Associates' conclusions.	**No direct effect on the Eight Associates conclusions.**
2.2 Construction Assumptions		
2.2.1 Omitted Elements		
Case Study 2 is based on calculations of embodied carbon from the following aspects of	The incorporation of foundation materials, steel and the ground floor concrete	**Increase in the embodied**

Finding/Issue	Implications	Effect on CO_2 Footprint
construction: brickwork, blockwork, insulation materials and roof materials. It is noted that that the calculations do not take into account carbon emissions from foundation concrete, foundation brickwork or steel beams that would be required in order to open up the extension for open plan. It is estimated that three steel beams would be required for the extension and the weight factor has been taken from Tata Steel literature. Furthermore, the description of Case Study 2 on page 7 of the report includes an "insulated ground floor concrete slab", which has been omitted from the breakdown of calculations at the rear of the report but included in the summary section on page 10.	slab will significantly raise the embodied carbon of the extension. The following calculations show the additional carbon in that should be included within the final figure: Foundation concrete 2,391.04 Foundation brickwork 534.07 Steel 1,929.39 Total omitted emissions 4,854.50 Total per m^2 469.03 The full calculations for these materials can be found in Section 3 below. When compared to the total embodied carbon originally provided for Case Study 2 by Eight Associates (279 $kgCO_2/m^2$) it is apparent that the omission of the carbon emissions from the building foundations, steelwork and ground floor concrete has a significant impact on the overall results of this study. The final conclusion of the Eight Associates report – that basements emit three times more carbon than extensions – is based on calculations from only a fraction of the total embodied carbon associated with an extension and when all materials are taken into account, the embodied carbon from both developments is approximately the same (see section 3 of this report).	**carbon of the extension by 168%.**
2.2.2 Wall Height		
The calculations for Case Study 2 show a wall height of 2 metres, when the section drawing of the extension (drawing number 06) clearly shows a wall height of 2.6 metres.	Calculations with a 2m wall as opposed to the actual 2.6m wall will have resulted in lower embodied carbon emissions from Case Study 2 than is correct. These emissions have been re-calculated for brick, block and insulation using a 2.6m high wall. The following carbon emissions were obtained: Brick 1,137.00 1,478.05 Block 483.07 627.99 Insulation 201.18 235.45 The inclusion of the correct wall height has increased embodied carbon from the use of these materials by 29% for brick, 30% for block and 17% for insulation.	**Increase in the embodied carbon of the extension by up to 30%.**
2.3 Construction Phase Carbon Calculations		
2.3.1 Works Timeframe		
The time taken to construct both structures has a significant effect on construction phase carbon emissions. The following timeframes have been given by Eight Associates for the construction phases:	A shorter timeframe for construction on Case Study 1 would be likely to result in lower carbon emissions, as per option 1 in the box opposite. The following calculations have been done using more appropriate timescales (10 months and	**Potential reduction in the construction phase carbon of the basement by**

Finding/Issue	Implications	Effect on CO_2 Footprint
• Case Study 1 – 6 months for underpinning, excavation, piling and concrete casting; 9 months for fit-out works; total of **15 months**. • Case Study 2 – **2 months** for the build. A total construction time of 15 months is too long for the basement alone and it is noted that the planning application for 44 Markham Square (ref: PP/10/00656) describes the development as: *"Construction of new basement beneath house and garden and erection of rear extensions at lower ground, ground and first floor levels and alterations to the front vaults."* Therefore, it is considered possible that Eight Associates has taken into account the construction and fit-out of the rest of the development of 44 Markham Square in addition to the basement. However, this cannot be determined for certain without further information from Eight Associates. In Cranbrook's experience, a basement of this size and nature should take 40 weeks (approx. 10 months) to complete, with 30 weeks (approx. 7.5 months) for the excavation and 10 weeks (approx. 2.5 months) for the fit-out. Waterman's structural experts have concurred that Cranbrook's timeframe is more realistic for development of this size and nature. It is considered, therefore, that one of two options would be more appropriate to take into account the aboveground extension works at Markham Square: 1. The timeframe for the construction phase of Case Study 1 should be reduced to 10 months; or, 2. The construction phase carbon is divided by the combined floor area of the basement and the aboveground extension to the property, to take into account the larger area for construction and fit out. This would produce a lower rate of construction phase carbon per square metre. Furthermore, the 2 month period given for the construction of the extension is considered to be slightly too short for a standard extension and this should be extended to 3 months to provide more representative results.	3 months, respectively): *Original* / *Re-calculated* Case Study 1: 30,000 / 20,000 Case Study 2: 4,000 / 6,000 It is clear from the above calculations that a shorter timescale for construction of the basement would result in significantly less carbon generated and that a longer timescale for the extension would also affect the results. A re-calculation for Case Study 1 using option 2 has not been done due to uncertainty in the floor area of the aboveground extension at 44 Markham Square. However, with a construction time period of 15 months and a larger floor area, construction phase carbon would be significantly reduced.	**33%.** **Potential increase in the construction phase carbon of the extension by 50%.**

Finding/Issue	Implications	Effect on CO_2 Footprint

2.3.2 Waste

Eight Associates state that 1,200m^3 of spoil will be removed from the site as part of the construction phase for Case Study 1. However, the Construction Traffic Management Plan (CTMP), which can be found in the planning file for 44 Markham Square on RBKC's website, states on page 7 that 710m^3 of spoil will be removed from site as a result of excavation works. The source of the 1,200m^3 figure is unknown and as the CTMP was written prior to the works taking place, it is possible that a larger volume of spoil was removed than was predicted. The reason behind this discrepancy cannot be confirmed without further information. In addition, carbon emissions from waste have been completely omitted from Case Study 2. Although there is likely to be very little excavation waste in comparison to Case Study 1, the laying of foundations would displace small amounts of earth and therefore would result in some spoil being removed from site. The report also assumes 10% of construction material from the basement would be waste and this is unlikely to be any different for the extension. Carbon emissions from waste from the construction of the extension should have been taken into account.	A smaller volume of spoil produced during the excavation of the basement would result in fewer carbon emissions from Case Study 1. The following calculations have been done with 750m^3 spoil generated from the construction of the basement: Case Study 1 808 482 A re-calculation for Case Study 2 of the carbon emissions from waste cannot be done due to lack of data on the amount of spoil removed from site and the volume of construction materials (the volume given in the report is considered to be only a fraction of the actual construction materials – see section 2.2 above).	**Potential decrease in the carbon generated by waste products from the basement by 40%.** **Potential increase in the carbon generated by waste from the extension (calculation cannot be done).**

2.4 Operational Carbon Calculations

Eight Associates claim that the Standard Assessment Procedure (SAP) methodology that has been used to calculate the operational carbon emissions over the lifetimes of the developments, produced a difference of 36% between the emissions from Case Study 1 (1,065 $kgCO_2/m^2$) and Case Study 2 (780 $kgCO_2/m^2$). These results have been extrapolated over a 30 year period and represent 35.5 $kgCO_2/m^2$ and 26 $kgCO_2/m^2$ per year. Analysis of the calculations provided by RBKC shows that the case studies and assumptions used are not consistent with the case studies in the report. The basement used for the SAP calculations has a floor area of 80m^2, while the extension used has a floor area of 55m^2. The calculations done in relation to the extension are not likely to be representative of the 10.35m^2 extension in the Eight Associates study. Furthermore, the SAP methodology for extensions, as defined under Part L1b, requires the existing dwelling with a Part L defined notional extension to be compared against the existing dwelling with the proposed extension. The performance of the existing dwelling, therefore, has an impact on the overall carbon emissions for the dwelling. Unless the same performance specification has been used for both case studies, then direct comparisons cannot be made. A high level review by Waterman identified the following additional discrepancies in the SAP calculations include: • The basement calculations show only one sheltered side has been incorporated, when it is likely that there would be at least three sheltered sides in the subterranean basement. Additional sheltered sides would reduce heat loss and gain and therefore reduce operational carbon;	It is considered extremely unlikely that an aboveground extension with 50% glazed roof, a glass wall and various doors and windows, would be more energy efficient than an entirely subterranean development with no external openings, very little thermal loss or gain through the walls or floors and the installation of Ground Source Heat Pumps, which represents a renewable source of heat. The implications of this are likely to be that the carbon emissions of the basement are would be lower than those quoted in the Eight Associates report. Furthermore, the SAP calculations are based on case studies with different floor areas to those used in the Eight Associates report, in particular the extension, and therefore assumptions about the operational carbon performance of both developments may not be entirely accurate.	**Potential decrease in the operational carbon of the basement.** **Potential increase in the operational carbon of the extension.**

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Finding/Issue	Implications	Effect on CO_2 Footprint
• The basement calculations indicate the inclusion of a roof for the entire basement area, when in fact there would be rooms situated above the basement, thereby reducing heat loss and gain and reducing operational carbon; • Section 9 of the calculations indicates the presence of a gas boiler in the basement, whereas the Sustainability Code Assessment (Timothy Hatton Architects, February 2010) which accompanies the planning application for 44 Markham Square, clearly states that Ground Source Heat Pumps will be used in the development. This represents a source of renewable energy and would reduce operational carbon.		
2.5 Arithmetical Errors		
A number of arithmetical errors in the calculations have been identified on page 14 of the report. The multiplication of the total weight of the steel piling used in Case Study 1 by the carbon emissions factor has produced an incorrect solution. The report states: 17,340 ×1.77 = 35,295.57 $kgCO_2$, when in fact this results in a total of 30,691.8 $kgCO_2$. The volume of the insulation materials is cited as 21.01m^3, but a figure of 22.97 has been used in the calculation to determine the total weight. The total weight is shown as 919kg, when the correct weight should be 840.4kg. This resulted in an incorrect carbon calculation of 919 × 1.05 = 967 $kgCO_2$, the correct figure for which should be 882.42 $kgCO_2$.	None, as the errors made on pages 14 and 15 have been corrected in the summary section on page 8 and conclusions made in the Eight Associates report do not incorporate these errors. However, the existence of these inconsistencies brings the validity of the Eight Associates report into question.	**No direct effect on the Eight Associates conclusions.**
A further arithmetical error has been made on page 17 of the report, which states that the CO_2 from the construction phase of Case Study 2 is 6000 $kgCO_2$, which should be 4000 $kgCO_2$, as the carbon factor is 2000 and the works timeframe is 2 months (2 × 2000 = 4000).	None, as the error made on page 17 is corrected in the summary on page 11.	**No direct effect on the Eight Associates conclusions.**

3. Re-calculation of Embodied Carbon

Taking into account the points raised above, the carbon emissions from each of the Case Studies has been re-calculated. These re-calculations amend only those in the Eight Associates report that have been found to be factually incorrect and does not incorporate those findings that are speculative or require further clarification, including:

- More preferable carbon emissions factors (section 2.1);
- Changes in the works timetable (section 2.3.1);
- The volume of spoil removed from Case Study 1 and the small amount of spoil likely to have been removed from Case Study 2 (section 2.3.2).

The re-calculations have included the omission of foundation materials, steelwork and the ground floor concrete slab from embodied carbon from Case Study 2, the omission of construction waste materials from Case Study 2 and the incorrect wall height used in the Case Study 2 calculations.

Case Study 1

Table 2. Eight Associates embodied carbon calculations for Case Study 1 – 44 Markham Square, as displayed on page 14 of the report.

Element	Volume (m^3)	Weight Factor (kg/m^3)	Total Weight (kg)	Carbon Factor ($kgCO_2/kg$)	Embodied Carbon ($kgCO_2$)
Steel Piling	N/A - 120 piles @ 5m	28.9 kg/m	17,340.00	1.77	35,295.57
Piling Concrete	43	2403	103,809.00	0.136	14,118.02
Floors	37.8	2400	90,720.00	0.161	14,605.92
Walls	13.44	2400	32,256.00	0.074	2,386.94
Insulation	21.01	40	840.40	1.05	967.00
Total Carbon					**67,373.46**
Carbon per m^2					**889.42**

Table 3. Amended embodied carbon for 44 Markham Square – amendments are highlighted in grey.

Element	Volume (m^3)	Weight Factor (kg/m^3)	Total Weight (kg)	Carbon Factor ($kgCO_2/kg$)	Embodied Carbon ($kgCO_2$)
Steel Piling	N/A - 120 piles @ 5m	28.9 kg/m	17,340.00	1.77	30,691.80
Piling Concrete	43	2403	103,809.00	0.136	14,118.02
Floors	37.8	2400	90,720.00	0.161	14,605.92
Walls	13.44	2400	32,256.00	0.074	2,386.94
Insulation	21.01	40	840.40	1.05	882.42
Total Carbon					**62,685.11**
Carbon per m^2					**827.53**

The amendments made above are corrections of arithmetical errors that were made in the calculations but were corrected in the summary tables of the report. For the steel piling carbon calculation, the values for weight and the carbon factor were incorrectly multiplied, resulting in a figure that was too high. During the calculation process for insulation, an incorrect volume of 22.97 m^3 was used to multiply by the weight factor, resulting in errors down the rest of the calculation and an embodied carbon result that was higher than it should have been.

Case Study 2

Table 4. Eight Associates embodied carbon calculations for Case Study 2 – 4 Dalgarno Gardens, as displayed on pages 10 and 16 of the report.

Element	Length (m)	Height (m)	Volume (m^3)	Weight Factor (kg/m^3)	Total Weight (kg)	Carbon Factor ($kgCO_2/kg$)	Embodied Carbon ($kgCO_2$)
Brick	13.6	2.0	2.72	1900	5,168.00	0.22	1,136.96
Block	13.6	2.0	2.72	2400	6,528.00	0.074	483.07
Insulation			4.79	40	191.60	1.05	201.18
Roof			0.52	2400	1,248.00	0.06	74.88
Concrete Ground Floor Slab			2.59	2400	6,216.00	0.161	1,000.78
Total Carbon							**2,896.87**
Carbon per m^2							**279.89**

Table 5. Amended embodied carbon calculations for Case Study 2 – amendments are highlighted in grey.

Element	Length (m)	Thickness (m)	Height (m)	Volume (m^3)	Weight Factor (kg/m^3)	Total Weight (kg)	Carbon Factor ($kgCO_2/kg$)	Embodied Carbon ($kgCO_2$)	Workings / Explanation
Brick	13.6	0.1	2.6	3.536	1900	6,718.40	0.22	1,478.05	2.6m wall height
Block	13.6	0.1	2.6	3.536	2400	8,486.40	0.074	627.99	2.6m wall height
Insulation				5.606*	40	224.24	1.05	235.45	13.6m length × **2.6m** high = 35.36m^2 + Roof 10.35m^2 + Floor 10.35m^2 = 56.06m^2 × 0.1m thick = 5.606
Roof				0.52	2400	1,248.00	0.06*	74.88	
Concrete Ground Floor Slab				2.59	2400	6,216.00	0.161	1,000.78	
Foundation Concrete				6.188	2400	14,851.2	0.161	2,391.04	13.6m length × 0.65m deep × 0.7m wide = 6.19m^3 × 2400kgm^3 = 14,851.20kg
Foundation Brick					2100	2,427.60	0.22	534.07	13.6 m length × 0.425m high × 0.1m wide × 2 wall skins = 1.156m^3 of Brick
Steel					86 kg/m	1,090.05	1.77	1,929.39	Beam A (4.575m) + Bm B (4.95m) + Bm C (3.15m) = 12.675m × 86kg/m = 1090.05kg**
Total Carbon								**8,271.65**	
Carbon per m^2								**799.19**	

*Discrepancies in this carbon factor throughout the report mean that this could be higher if the roof is concrete rather than slate.

**The beam lengths have been estimated based on the plans for the extension. The plan and workings are included as Appendix A to this report.

The above amendments incorporate the correct wall height of 2.6m, which has affected the embodied carbon emissions from brick, block and part of the insulation (wall insulation). Furthermore, the addition of foundation concrete, foundation brick and steel has significantly added to the overall carbon emissions from the construction of the basement.

Re-calculation has only been done for embodied carbon within the construction materials and from this, it is apparent that while embodied carbon in the basement remains higher than that of the extension, this represents a much smaller difference than previously seen. Table 6. Comparison of both case studies' embodied carbon per m2 from the Eight Associates report and the re-calculations below compares the two sets of results.

Table 6. Comparison of both case studies' embodied carbon per m^2 from the Eight Associates report and the re-calculations

	Eight Associates Total	Waterman Total
Case Study 1	889.42	827.53
Case Study 2	279.89	799.19

The results from the Eight Associates report represent over three times more carbon emissions from embodied carbon in a basement compared to an extension, but Waterman's corrections have yielded a figure for embodied carbon in an extension that is much closer to that of a basement, our calculations present a 3.4% difference in embodied lifecycle carbon emissions between the two developments. Further reductions in embodied carbon from the basement would also be likely if up-to-date conversion factors were used.

Furthermore, the above calculations do not take into account the potential amendments to the calculations of construction phase and operational carbon, as detailed in section 2 of this report. It is expected that from the reductions in waste volumes from Case Study 1, the omission of construction waste from Case Study 2 and discrepancies in the SAP calculations for operational carbon, the result will be lower values for the lifecycle carbon of the basement in comparison to the extension.

4. Conclusion

The Eight Associates report contains a significant number of inaccuracies, some with larger implications than others, which casts significant doubt on the robustness of its conclusions. The primary error with the most significant implications on the conclusions of the study was the omission of the foundations and the steelwork in the calculation of the embodied carbon in the extension (Case Study 2). Furthermore, the Eight Associates report omits the production of any waste materials from the construction of the extension, states a higher than expected volume of spoil from the basement construction, uses an incorrect wall height for the extension and makes various arithmetical errors. Other issues for debate, that could affect the carbon footprints of the developments include conflicting carbon conversion factors for the extension roof material, a works timeframe for the basement that is considered to be too long, and SAP calculations for operational carbon that do not accurately reflect the case studies used in the Eight Associates report. It should further be noted that since the completion of this report, new carbon conversion factors have been published, which are based on more up-to-date construction material description and their use would further impact the findings of the report.

The results of re-calculations that include the omitted elements of the extension and the correct wall height, have shown that the extension actually emits only 3.4% fewer carbon emissions over its lifecycle than the basement. Further reductions in the carbon emissions from the basement could be expected if all of the points raised in this report are addressed. Further analysis of the points made is necessary to address the issues that could not be confirmed in this report due to absent or partial information.

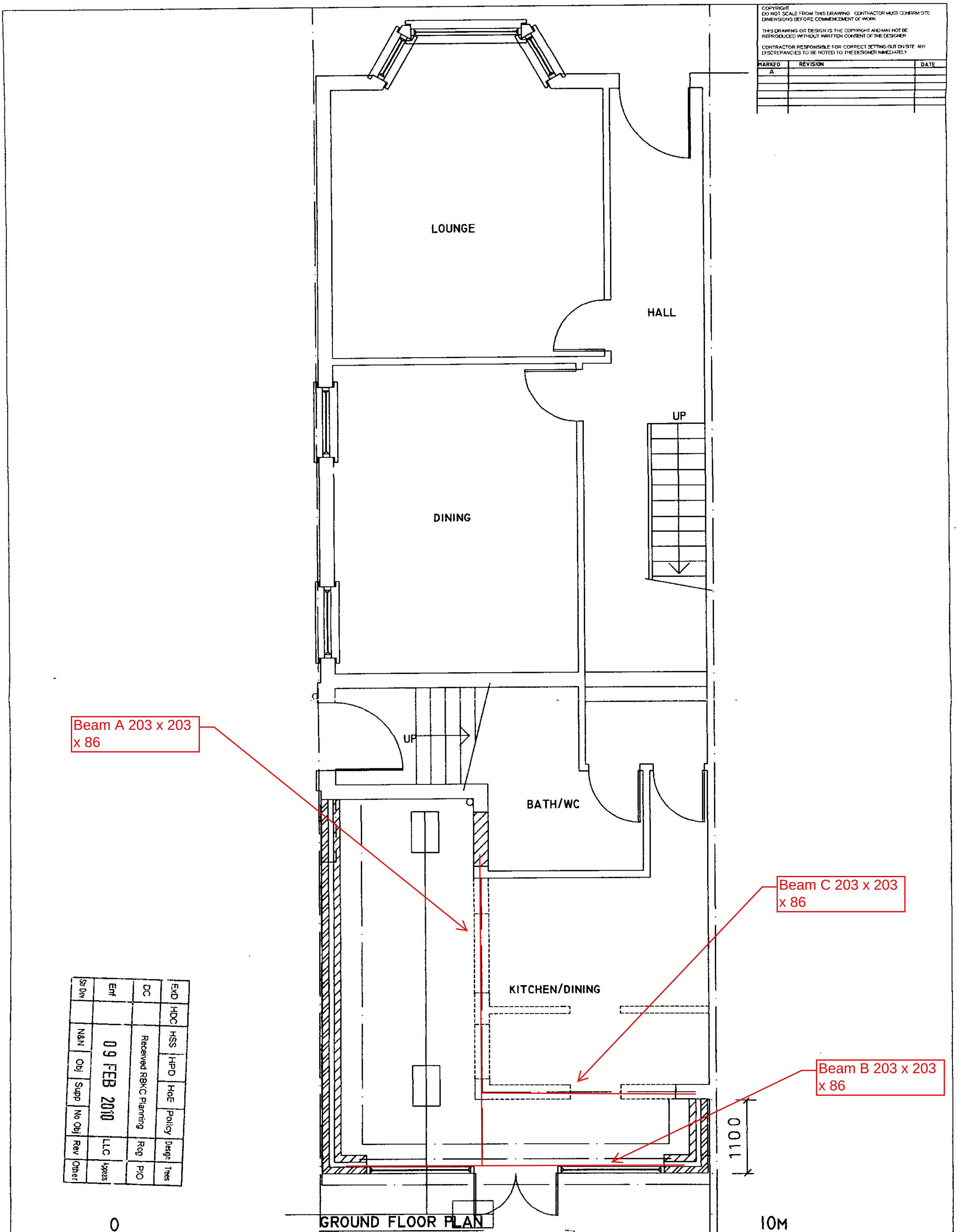
Based on the information above, it is considered that the statement made in paragraph 34.3.53 of RBKC’s Basements Policy Publication is based on deficient and incomplete lifecycle carbon calculations and the Eight Associates report is not considered to present a robust basis for such an argument. Further analysis and benchmarking of projects would be beneficial to determine the true impact of the developments’ on carbon emissions. Following such assessment, the RBKC statement may have to be reviewed.

waterman

APPENDICES

Appendix A Proposed Groundfloor Plan for 4 Dalgarno Gardens with Workings

MARKED	REVISION	DATE
A		



GROUND FLOOR PLAN

PROJECT:
4 DALGARNO GARDENS
LADBROKE GROVE
W10 6AB

DRAWING TITLE:
PROPOSED GROUND FLOOR PLAN

PP/10/00279
29 JAN 2010

CHECKED:		DATE:	JAN 10
DRAWN:		SCALE:	1:100

DRAWING NUMBER:
01

UK and Ireland Office Locations