Technical Review

Client: Cranbrook Basements Ltd.
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Project: Review of Eight Associates Technical Report on lifetime carbon analysis of basement extensions for London Borough of Kensington & Chelsea

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Executive Summary

MES have been commissioned by Cranbrook Basements Ltd. to undertake a review of technical documents submitted to the Planning Inspectorate by Royal Borough of Kensington & Chelsea (RBKC) in support of an application for a change of planning policy regarding basement extensions in RBKC's authority area.

The document being reviewed is: 'Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBKC ' produced by Eight Associates (EA) (09/07/2010).

The brief given to EA by RBKC was to analyse and compare the carbon intensity of both above ground extensions and subterranean developments. The analysis was to include whole life cycle impacts, including all stages of development from sourcing of materials through to the emissions from the building in use.

The EA report relies on just two case studies of which little detail is provided. This is not an adequate sample size to provide robust data for analysis.

The two case studies that are provided are described as 'typical' of their type. No evidence is provided in support of this, nor is adequate data provided to test the claims validity.

There are significant errors in the calculation of both embodied carbon dioxide and carbon dioxide emissions arising from construction.

There are serious irregularities identified in the methodology used to calculate operational carbon dioxide emissions. The most significant of these is the fact that the SAP2005 calculations on which the calculations are based do not relate to the case studies included in the report.

The review of the technical document 'Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBKC' produced by Eight Associates has found it to be littered with errors in both the calculations and methodology used and therefore its findings are unsound and any application for a change of planning policy made by RBKC which uses evidence that relies on the EA report should be viewed accordingly.

About *MES Energy Services*

***MES Energy Services* is an established consultancy practice specialising in providing sustainable building solutions throughout the UK.**

We offer a full range of specialist services for both residential and commercial buildings, from highly complex mixed-use developments through to small individual properties. We operate nationally from our head office in Newark in the Midlands and from our London office.

We are an industry leader in delivering a professional, accredited and certified service to a wide range of clients including architects, developers, contractors, housing associations & the public sector.

Employing highly qualified staff, our team comes from a variety of backgrounds within the construction industry with combined knowledge of surveying, engineering, planning, assessment, renewable energy, construction, development and research.

We are renowned for our creative thinking and always provide a high quality, honest and diligent service. We achieve long-term relationships with our clients with nearly all of our business coming from existing clients or recommendation.

Our services cover a wide range of areas, further details of which are listed below.

We also provide popular CPD seminars and workshops on sustainable development issues for architects, developers, contractors, engineers, planning and building regulations departments etc.

We maintain our position at the forefront of changes in regulations as well as technological advances through comprehensive staff training and CPD. Our clients, large or small, benefit from a cost effective, cohesive and fully integrated professional service.

Summary of Services

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- Display Energy Certificates (DECs)
- Heat Loss Assessments, Thermal Bridging Calculations
- U-Value Calculations, Fabric Energy Efficiencies (FEE)
- Residential & Commercial Energy Performance Certificates

Air Leakage Testing

- Residential Air Leakage Testing
- Commercial Air Leakage Testing
- Extractor and MVHR Testing and Commissioning

Building Assessment

- Code for Sustainable Homes & EcoHomes Assessments
- BREEAM & LEED Assessments
- PassivHaus Assessments
- Pre Assessment Reports and Advice

Water

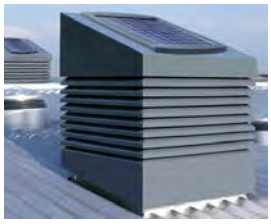
- Part G Water Efficiency Calculations
- Rainwater Harvesting Calculations and Design

Renewable Energy

- Renewable Energy Assessments
- Renewable Energy Consultancy

CPD Seminars

- Sustainable Development Seminars and Workshops
- Training



Ventilation

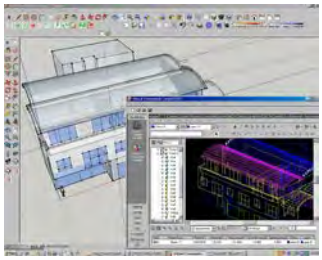
- Part F Ventilation Calculations
- Mechanical/Passive Ventilation with Heat Recovery - Design and Calculation
- MVHR and Extractor Testing and Commissioning

Planning

- Sustainability Statements
- Renewable Energy Reports
- Sustainable Planning Consultancy

Daylighting/SunCast & Right of Light

- Daylighting Analysis (CSH & BREEAM)
- SunCast Modelling and Analysis
- Right of Light Consultancy



Dynamic Simulation Modelling

- Thermal Modelling
- Ventilation Assessment
- Overheating and Solar Gain Analysis

Existing Buildings

- Building Pathology

- Analysis of Energy Use in Existing Buildings
- Energy/Water Efficiency Advice and Recommendations
- Post Occupancy Evaluations
- Thermal Imaging

Sustainable Building Consultancy

- Independent, professional and knowledgeable consultancy advice backed up by robust evidence and evaluation

About the Author

Chris Jones, BEng. MSc. (Technical Director)

Chris is the technical director at MES. He has an honours degree in Mechanical Engineering and a Master's degree in Energy Efficient & Sustainable Building.

Chris has over 15 years' experience in providing sustainable building solutions and he carries out a wide range of consultancy including renewal energy evaluations, sustainability statements and some of the more unusual work MES is called upon to undertake from time to time. He regularly works with some of the UK's top developers as well as housing associations and local authorities. Chris also heads our BREEAM and Code for Sustainable Homes team.

Section 1: Introduction

Royal Borough of Kensington & Chelsea (RBKC) Planning Department are in the final stages of a submission to the Planning Inspectorate to change the authority's current planning policy in relation to subterranean extensions to existing buildings. The report to be submitted to the Planning Inspectorate, "Basements Publication Planning Policy", sets out the authority's arguments for reducing the scale of subterranean extension that will be granted permission.

One of several arguments put forward by RBKC for a change to their current policy is a proposal that there are additional environmental impacts from basement extensions compared to more traditional above ground extensions. One of the environmental impacts proposed is the additional life-time carbon costs of such developments, which it is suggested are measurably greater than the lifetime carbon costs of more traditional extensions.

In support of RBKC's report, Eight Associates (EA) were commissioned to provide a life cycle carbon analysis of both above ground and subterranean extensions in order to compare life time carbon costs. EA's technical report: "Life Cycle Carbon Analysis of Extensions & Subterranean Development in RBK&C" was released on 09/07/2010 and forms an integral part of BBKC's submission to the Planning Inspectorate.

MES Energy Services have been commissioned by Cranbrook Basements Ltd. to undertake a critical review of the EA document.

Since the findings of the report are central to one of RBKC's key arguments for a change to the current planning policy, it is essential that the methodology used is robust and the calculations contained within it are accurate.

Section 2: RBKC Proposed policy change.

RBKC is undertaking a partial review of its Core Strategy. A proposal for a bespoke basement policy is part of this review and if adopted this will be included in the revised Core Strategy.

Proposed Policy CL7- Basements

The new policy proposed for inclusion in the revised Core Strategy is as follows:

All basements must be designed, constructed and completed to the highest standard and quality.

Basement development should:

a. *not exceed a maximum of 50% of each garden. The unaffected garden must be in a single area and where relevant should form a continuous area with other neighbouring gardens. Exceptions may be made on large comprehensively planned sites;*
b. *not comprise more than one storey. Exceptions may be made on large comprehensively planned sites;*
c. *not be built under an existing basement;*
d. *not cause loss, damage or long term threat to trees of townscape or amenity value;*
e. *not cause harm to the significance of heritage assets;*
f. *not involve excavation underneath a listed building (including pavement vaults) or any garden of a listed building, except for gardens on large sites where the basement would not involve extensive modification to the foundation of the listed building by being substantially separate from the listed building;*
g. *not introduce light wells and railings to the front or side of the property unless they are already an established and positive feature of the local streetscape;*
h. *maintain and take opportunities to improve the character or appearance of the building, garden or wider area, with external elements such as light wells, roof lights, plant and means of escape being sensitively designed and discreetly sited;*
i. *include a sustainable urban drainage scheme (SUDs), including a minimum of one metre of permeable soil above any part of the basement beneath a garden. Where the character of the gardens within an urban block is small paved courtyards SUDs may be provided in other ways;*

j. ensure that any new building which includes a basement, and any existing dwelling or commercial property related to a new basement, is adapted to a high level of performance in respect of energy, waste and water to be verified at pre-assessment stage and after construction has been completed;

k. ensure that traffic and construction activity does not harm pedestrian, cycle, vehicular and road safety, affect bus or other transport operations (e.g. cycle hire), significantly increase traffic congestion, nor place unreasonable inconvenience on the day to day life of those living, working and visiting nearby;

l. ensure that construction impacts such as noise, vibration and dust are kept to acceptable levels for the duration of the works;

m. be designed to minimise damage to and safeguard the structural stability of the application building, nearby buildings and other infrastructure including London Underground tunnels and the highway;

n. be protected from sewer flooding through the installation of a suitable pumped device.

Policy Justification

In July 2013 RBKC published a paper detailing the reasoned justification for the addition of a specific basement policy to the authority's Core Strategy. It is clear from this document that the number of planning applications being approved for development of this type is causing the authority to look again at its policy with regard to subterranean extensions. A number of concerns are highlighted in the RBKC paper a summary of which is as follows:

- Disturbance & disruption during construction
- Impact on the structural stability of surrounding buildings
- Character of rear gardens
- Sustainable drainage
- Impact on carbon emissions

With regard to the last of these, RBKC go on to say:

"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 an above ground development per square metre. This is because of the extensive use of concrete and particularly steel both of which have high embodied carbon. Climate change mitigation is a key policy in the London Plan which promotes sustainable design and construction (including avoiding materials with

a high embodied energy) and reducing carbon dioxide. Limiting the size of basements will therefore limit carbon emissions and contribute to mitigating climate change."

(Basements Publication Planning Policy- Partial Review of Core Strategy, RBKC July 2013, Paragraph 34.3.53)

The statements made in paragraph 34.3.53 are based on work carried out by EA and published in their document: "Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBK&C" commissioned by the borough to support the proposed policy change and published on 9th July 2010.

Section 3: Review of Eight Associates report methodology

Brief

The brief given to EA by RBKC was to analyse and compare the carbon intensity of both above ground extensions and subterranean developments. The analysis was to include whole life cycle impacts, including all stages of development from sourcing of materials through to the emissions from the building in use.

Review: This is a recognised method of assessing a building's (or any manufactured product's) environmental impact. Lifecycle carbon analysis provides a measureable value of environmental cost that can be replicated easily to allow comparison of different production/construction processes. In order for results of any comparison of alternative processes to be credible it is vital that the detail of the methodology is consistently applied or conclusions drawn from the results may be misleading and non-representative. There are various ways of assessing lifecycle carbon impacts that differ, in the main, with regard to the method of calculating the carbon cost of individual materials or processes. There is also variation in definition of lifecycle between methodologies. Clearly, it is important that, whichever method is chosen, the process is consistently applied throughout the study.

Case Studies

RBKC provided two case studies:

1) An example of a subterranean development
2) An example of a single storey above ground extension

Review: It is clear that the use of case studies to calculate the lifecycle carbon costs of real projects is a good method of determining any measurable difference between project types. (In this case, above ground & subterranean extensions)
However; in the EA report just two case studies are provided. This is not an adequate sample size to provide robust data for analysis.
The two case studies that are provided are described as 'typical' of their type. No evidence is provided in support this, nor is adequate data provided to test the claims validity. An application under the freedom of information act to RBKC by Cranbrook Basements Ltd. revealed that no such documentation was available.
Without data based on much larger sample sizes it is important to provide evidence to support the assumption that the case studies used are 'typical' of their type.

The following questions require answering before the data provided in the EA report should be given any weight:

1) What is the definition of 'typical' in relation to the case studies as used in the EA report?

2) How has the definition of 'Typical' as used in the EA report been derived?

3) How large was the subject group which was used to derive this definition?

4) Are the definition and the method used in its derivation robust?

5) Do the two case studies provided fit this definition?

Until these questions are answered satisfactorily it is impossible to assess the validity of the conclusions drawn in the report as the methodology used hinges on this. As it would appear no documentation exists to address these questions the methodology cannot be assumed to be sound.

Life-Cycle Modelling

Eight Associates modelled the two case studies taking into account:

1) Construction type

2) Volume of materials

3) Activity during construction works

4) Likely operational usage

Review: The methodology used must be consistently applied for any results to be valid. There is no single method of assessing lifecycle carbon costs; a number of alternatives are available which are equally valid. What is important is that the chosen methodology is used consistently. The methodology used by Eight Associates is valid only if applied consistently. In this regard, the details provided in the report bring into question as to whether this is the case (This will be discussed further later). The choice of case studies used in the study also affects the validity of the calculations. If there is doubt regarding the choice of case studies used then the robustness of the methodology for calculating lifecycle carbon cost is academic.

Analysis of Carbon Emissions

Whole life carbon emissions are broken down and the embodied carbon, carbon relating to construction works and the operational carbon provided.

Embodied carbon and site works calculations are based on drawings and construction method statements together with data from the Environment Agency and Bath University.

The operational carbon is calculated using SAP modelling and the methodology set out in Part L1B of Building Regulations based on an assumed life cycle of 30 years.

Review: Breaking down whole life carbon costs into embodied carbon, emissions from construction works and operational carbon is accepted practice. A number of sources are available for data relating to embodied carbon of construction materials. The database created by Bath University is well respected and widely used within the sector. The key to robust results is to ensure consistency within the calculations and to set a well-defined project boundary that can be replicated easily for all test samples (case studies). Calculation of carbon emissions from site works is a little more complex as defining the boundary can be more difficult. However, if the methodology used is consistent then comparable data will emerge. For the calculation of both embodied carbon and carbon associated with construction works the key is consistency.

The use of SAP modelling to assess operational carbon uses an established methodology which is widely used within the construction industry for demonstrating Part L1B Building Regulations compliance. SAP modelling estimates operational carbon emissions using an easily repeatable method. Deriving values for carbon emissions on a m^2 basis (something which SAP modelling does as standard), takes account of any small variation in size between case studies. It should be said though, that this has limits. Very small or very large extensions (or a significant difference in size between two case studies being compared) are likely to skew the data, even when figures are reduced to standard unit areas (m^2). The variation in proportion of fabric elements (walls, floors, roof, openings etc.) as a percentage of the total envelope will affect the way the building (or extension) performs.

In EA's report there is very little information provided regarding the detail of the SAP calculations used for establishing the operational carbon emissions. The only information given regarding the methodology is that: "*operational carbon is calculated using SAP modelling and the methodology set out in Part L1B of Building Regulations based on an assumed life cycle of 30 years*". Copies of the SAP2005 Worksheets have also been obtained from RBKC.

It is important to establish a clear methodology for the SAP modelling. What source is being used for the input data? Where there are differences in aspects of the specification that are not relevant to the purpose of the report; how are results adjusted to allow for this variation? This detail is crucial and as such it is important for the methodology to be transparent so that its validity can be checked

EA state that operational carbon emissions are based on a 30 year lifespan for the case study buildings. This would appear to be very short. A lifespan of around 60 years is more normally assumed for new constructions. No evidence is provided to support the decision to use an assumed 30 year lifespan and given the potential impact on the overall results this is an important omission. Reducing the assumed lifespan of the building reduces the impact of the operational carbon emissions on the total lifecycle emissions. In turn this increases the influence of the embodied carbon and emissions associated with construction activities. This could artificially skew the results in favour of one type of extension over another. When assessing the lifecycle carbon impact of heavyweight materials such as block work and concrete, its long lifespan should be taken into consideration. This is widely recognised by industry bodies including the Building Research Establishment. The Eight Associates methodology seems to be counter to this.

Comparative Analysis of Carbon Intensity

A comparison of life cycle emissions is made to indicate the respective carbon intensity of both above ground extensions and subterranean development.

Review: The issues highlighted previously regarding methodology impact directly on the reliability of the results of comparative analysis and any conclusions drawn from those results.

Section 4: Review of carbon lifecycle analysis

Embodied Carbon Calculations

Detailed calculations are included in Appendix 2. Two sets of data are included, one using the carbon factors as quoted in the EA report and a second using carbon factors form the ICE database produced by Bath University. This section contains a summary of those calculations.

Case Study 1:

There is an error in the calculation for the steel piling on page 14 of the EA report which results in an overestimation of embodied carbon:

The total weight of steel calculated for the steel pilings is 17,340kg.
The carbon factor for the steel is stated as being: 1.77kgCO_2/kg
The embodied carbon is stated as being: 35,295.57kgCO_2

The figure for embodied carbon should read 30,691.8kgCO_2 given the weight of steel and carbon factor quoted. (4.6tonnes less than stated in the report)

The embodied carbon figure used is 1.77kgCO_2/kg. The Inventory of Carbon and Energy (ICE) Lists the carbon factor for general UK steel with average recycled content as 1.37kgCO_2/kg and the carbon factor of UK steel pipe with average recycled content as the same (1.37kgCO_2/kg)

If this figure is used then the embodied carbon attributable to the steel pilings is in fact 23,755.8kgCO_2 or 11.54tonnes less than the figure stated in the EA report.

Case Study 2:

There are errors in the calculation for the wall construction on page 16 of the EA report which results in an underestimation of embodied carbon:

The wall height is quoted as being 2m. This affects the calculations for embodied carbon associated for the brick work, block work and insulation. Drawing No. 06 submitted with the planning application (PP/10/279/A) clearly shows the wall height as 2.6m. This increases the embodied carbon associated with these materials from 1821.21kgCO_2 to 2341.49kgCO_2, an increase of 520.28kgCO_2.

Drawing Nos. 01 and 06 (Appendix 1) also clearly show three structural steel beams will be required with a combined length of 12.67m. If

these are assumed to be of a typical size (203x203 in section with a weight of 86kg/m) then the combined weight is 1090.05kg. If a carbon factor of 1.77kgCO_2/kg is used this amounts to an additional 1,929.388kgCO_2. If the lower embodied carbon figure of 1.37kgCO_2/kg from ICE is used then this amounts to an additional 1493.37kgCO_2.

The embodied carbon calculations do not include for the below ground footings. Drawing No. 06 shows a foundation including a brick work wall of 0.425m in height and a concrete footing of 0.65mx0.7m. This amounts to an additional 2,925.11kgCO_2 of embodied carbon.

There is also some conflicting information regarding the roof covering used. The embodied carbon calculations on page 16 seem to assume concrete tiles are used with embodied carbon of 102.24kgCO_2. The summary information on page 10 lists slate as the roof covering with associated embodied carbon of 70kgCO_2. A photograph of the completed extension clearly shows a glass roof. (Appendix 3). For the basis of the recalculation in appendix 2 we have assumed slate tiles with a carbon factor of 0.06kgCO_2/kg

Nowhere in the EA report does the supporting structure of the roof seem to be accounted for.

Construction Phase Carbon Calculations

Case Study 1:

The work time-frame for the basement structure is stated as 6 Months. This is broken down as follows on page 1 of the CTMP report (Appendix 4).

- 1 Month Underpinning
- 1 Month Piling & Temporary works
- 2 Months Excavation
- 2 Months concrete casting

A further 9 months has been included for fit out. This increases very significantly the construction phase carbon figure. However, it is unclear as to whether all of this time should be attributed to the basement as the basement forms only part of the Project. The RBKC Planning Consent describes the works as: "Construction of New Basement beneath House and Garden and Erection of Extensions at Lower Ground, Ground and First Floor Levels and Alterations to the front Vaults" (Appendix 5)

Further to this, it is unclear as to whether the additional floor space that will be provided following construction of the above ground extensions has been taken into account in the EA report. If not the result of this will be an over estimation of construction phase carbon.

Finally, ES state that 1200m^3 of spoil will be removed from site. This figure relates to waste arising from the entire development including works unrelated to the Basement (RBKC Officer report on CTMP Paragraph 5.3.1.- Appendix 6). RBKC confirm that the total quantity of spoil to be removed is in fact 710m^3. This results in a reduction in the construction phase carbon of 722kgCO_2 compared to the figure quoted in the Eight Associates report.

Case Study 2:

The work time frame estimated for the above ground extension is 2 months. Although this is a small extension of just 10.35m^2, this would appear to be an optimistic assumption for which no supporting data is included in the Eight Associates report.

Operational Phase Carbon Calculations

No information is included in the report by EA regarding the methodology used for calculating operational carbon emissions other than that SAP modelling is used.

As there is no detail provided in the EA report an application was made to RBKC under the freedom of information act in order to obtain all supporting documentation regarding this issue. The only documents available are NHER DER2005 Worksheets for the two case studies which were subsequently obtained from RBKC. These are reproduced in full in Appendix 7.

As no documents seem to exist which detail the source of input data for the SAP2005 worksheets provided by BRKC it is impossible to comment on the detail of the calculations. However the provided worksheets highlight some clear and serious issues.

The EA report states the floor areas of the two case study projects to be 75.75m^2 for case study 1 (the subterranean development) and 10.35m^2 for case study 2 (the above ground extension). The floor areas in the SAP2005 worksheets are 80.00m^2 for the basement and 55m^2 for the extension.

Clearly the SAP2005 worksheets provided do not represent the case study buildings in the EA report.

The SAP2005 worksheets provided by RBKC model the basement and above ground extension as if they were stand-alone dwellings. This is clearly not the case; they are both extensions to existing dwellings and in order to correctly calculate the emissions attributable to the extension the whole dwelling must be modelled both with and without the new element. The difference between the emissions from the two models is the carbon dioxide attributable to the extension. Modelling the basement & extension as if they are stand-alone dwellings will give inaccurate results.

Due to the differing floor areas, emissions associated with domestic hot water vary between the SAP models. Energy for DHW is not relevant and its inclusion in any comparison will produce incorrect results. As there is no detail provided, it is impossible to know whether this was accounted for in the EA report.

It is stated in the EA report that the extensions were modelled in SAP using input data which assumed compliance with Part L1B. From an investigation of the worksheets provided by RBKC It would appear that standard U-values and heating systems were used in both cases. However, as no data is available detailing the assumed specification for the SAP modelling this cannot be verified.

Section 5: Conclusion

Methodology

Just two case studies are provided. This is not an adequate sample size to provide robust data for analysis.

The two case studies that are provided are described as 'typical' of their type. No evidence is provided in support this, nor is adequate data provided to test the claims validity.

In EA's report there is very little information provided regarding the detail of the SAP calculations used for establishing the operational carbon emissions other than a figure for the total CO_2 attributed to the operation of the building.

It is important to establish a robust methodology for the SAP modelling.

No information is provided by EA regarding the detailed methodology used, the only source of additional information is two SAP2005 worksheets obtained from RBKC under the freedom of information act.

The SAP worksheets provided by RBKC do not represent the case study buildings, the floor areas vary by up to 500% and as such the results of the operational carbon emissions must be assumed to be incorrect.

Even if it had been the case that the SAP2005 worksheets represented the physical attributes of the two case studies accurately, the methodology is unsound. The basement & extension modelled in the SAP worksheets are modelled as stand-alone dwellings. This will produce inaccurate results. The whole dwelling should have been modelled both with and without the new element.

EA state that operational carbon emissions are based on a 30 year lifespan for the case study buildings. This is very short. A lifespan of 60 year would be more likely. No evidence is provided to support the decision to use an assumed 30 year lifespan and given the potential impact on the overall results this is an important omission.

Without further information relating to the validity of the methodology used it would be unwise to give weight to the conclusions drawn in the EA Report and as such its reliability as supporting evidence for the application being made by RBKC for a change to planning policy is questionable at best.

Carbon Lifecycle Analysis

In addition to the weaknesses identified in the methodology used there are some fundamental errors in the calculation of lifecycle carbon emissions. Given the lack of detail provided it is impossible to replicate the calculations with any accuracy but if the errors identified in the calculations provided for embodied carbon are simply corrected then the result is as shown in Table 5a:

Table 5a: Embodied Carbon Calculations

Case Study	Eight Associates Calculation	Corrected figures
1 (Basement)	889.42kgCO_2/m^2	827.53kgCO_2/m^2
2 (Above Ground)	279.89kgCO_2/m^2	799.19kgCO_2/m^2

It is clear that although the basement case study is more carbon costly in terms of embodied carbon the difference between the two case studies is only around 2.5% rather than the 218% implied by the EA results.

Calculation of construction phase carbon emissions hinges on an accurate methodology for identifying activity attributable to the element of the works being assessed. In the case of case study 1 it is unclear how site works have been split between the subterranean extension and the above ground works (which formed a significant element of the project). Given the timescales assumed (6 months for construction of structural shell and 9 months for fit out) it would appear that all activity on site is attributed to the basement conversion, this should clearly not be the case.

It would appear that a similar assumption has been made with regard to spoil from the site and the carbon associated with its removal. As this is the case it is difficult to accept the accuracy of the figures quoted.

Operational Carbon Emissions

The use of SAP calculations as a valid method to estimate operational carbon emissions is not in question. However the SAP Worksheets provided by RBKC clearly do not represent the case study buildings and the methodology used; modelling the basement and extension as stand-alone dwellings is unsound. As such the results of the lifecycle carbon analysis produced by EA is incorrect.

Overall Conclusion

The methodology used in the Eight Associates report is fundamentally flawed. The case study sample size (one of each extension type) is in no way adequate to obtain robust useable results. Assumptions made are not backed up by any supporting evidence. There are errors in the calculations used to establish lifecycle carbon costs. The SAP calculations produced are not of the case study buildings.

The EA report does not provide robust supporting evidence to back up the claim being made by Royal Borough of Kensington & Chelsea that the additional life-time carbon costs of subterranean developments are measurably greater than the lifetime carbon costs of more traditional extensions. It should also be noted that the statement in paragraphs 34.3.53 of RBKC Basements Policy Publication Final; "The embodied carbon in basements is almost three times the amount of embodied carbon in an above ground development per square metre" is based solely on the findings of the EA report.

The methodology (and therefore findings) of EA's report: "Life Cycle Carbon Analysis of Extensions & Subterranean Development in RBK&C" is not sound. In relation to the RBKC application being put to the Planning Inspectorate for a change to planning policy; any argument being used that relies on the findings of this report should be weighted accordingly.

Appendices:

Appendix 1: Case Study Drawings

Appendix 2: Embodied Carbon Calculations

Appendix 3: Photograph of completed extension from Case Study 2

Appendix 4: CTMP Report

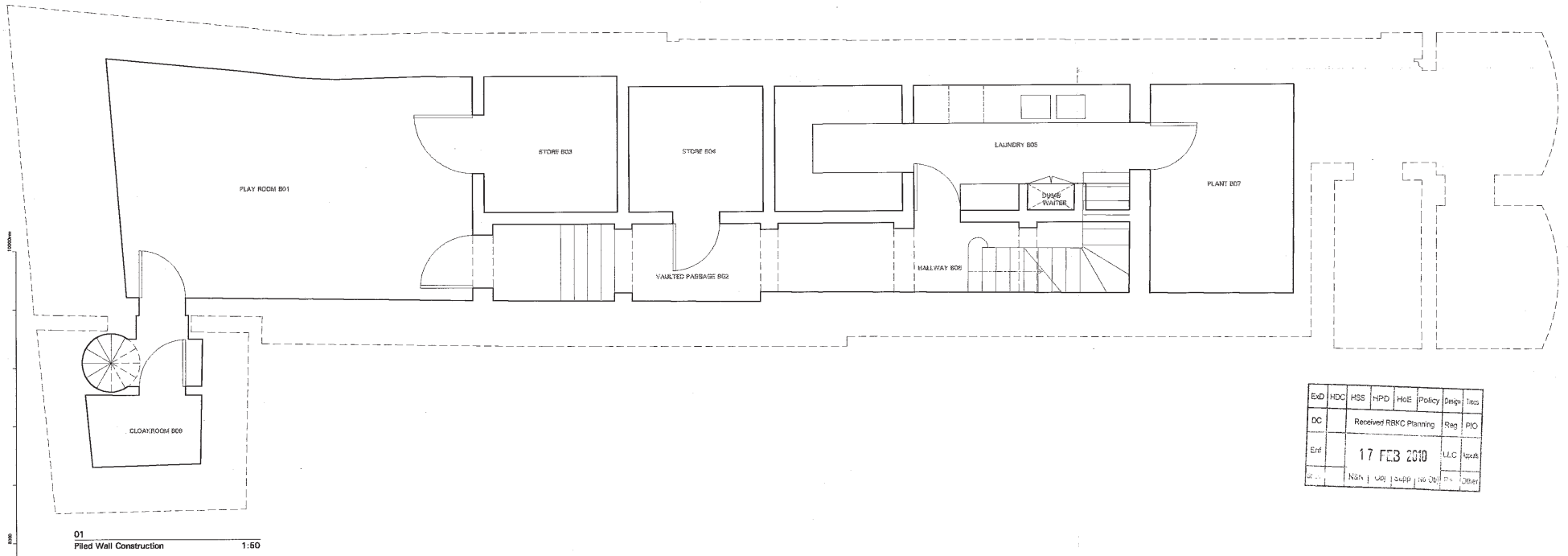
Appendix 5: RBKC Planning consent letter (Case Study 1)

Appendix 6: RBKC Case Officers Report (Case Study 1)

Appendix 7: SAP2005 Worksheets for operational carbon emissions (Case Study 1&2)

Appendix 1: Case Study Drawings

TIMOTHY HATTON ARCHITECTS



01
Piled Wall Construction 1:50

Rev A. 100127 Reduced basement below garden

44 MARKHAM SQUARE
0901 . P . 2 005 . 00 . A
Proposed Basement Plan
1:50 @ A2
October 2009
Issued for Planning
Drawn: ML
Checked:

Canal Floor
The Canal Building
Portobello Dock
342 Ladbroke Grove
London W10 5BU

T. + 44 (0)20 7727 2424
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MARKED	REVISION	DATE
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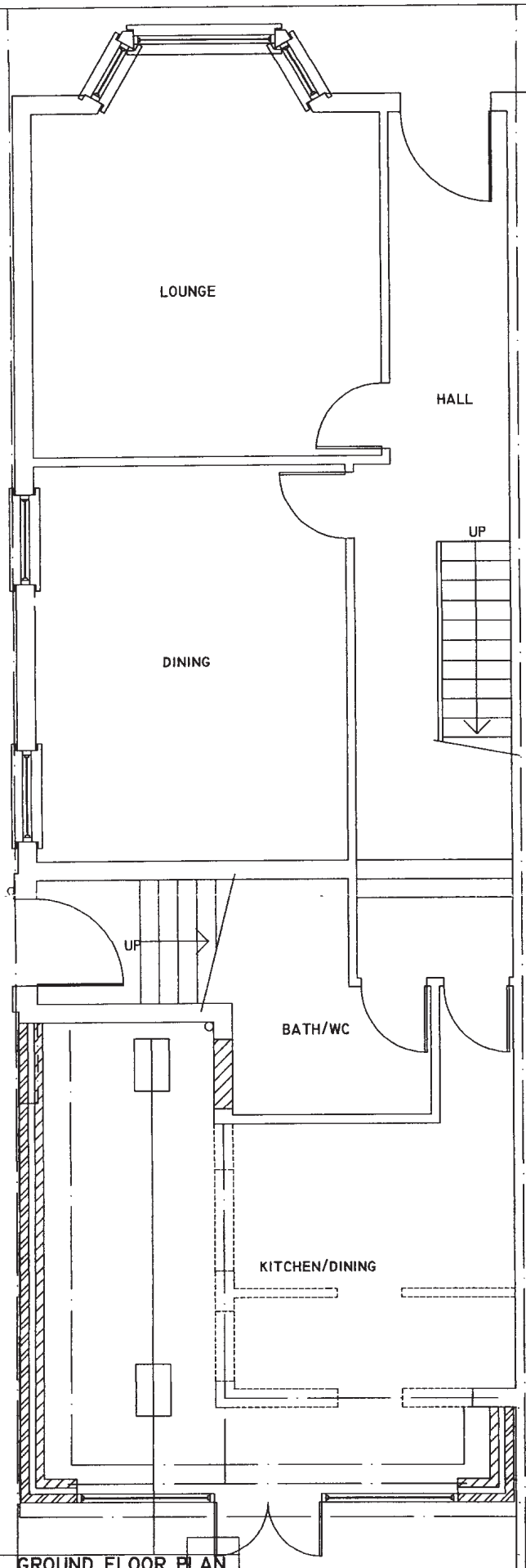


GROUND FLOOR PLAN

0 10M

Str Dev	Enf	DC	EXD
			HDC
N&N	09 FEB 2010	Received RBKC Planning	HSS
Obj			HPD
Supp			HoE
No Obj			Policy
Rev	LLC	Reg	Design
Other	Appeals	PIO	Trees

PP/10/00279
29 JAN 2010

PROJECT:
4 DALGARNO GARDENS
LADBROKE GROVE
W10 6AB

DRAWING TITLE:
PROPOSED GROUND FLOOR PLAN

CHECKED: DATE: JAN 10
DRAWN: SCALE: 1:100
DRAWING NUMBER: 01

Appendix 2: Embodied Carbon Calculations

Case Study - 1 44 Markham Square SW3 - Eight Associates

Element	M3	Weight M3	Total Weight - KG	Carbon Factor	Carbon Produced CO2
Steel Piling			17,340.00	1.77	35,295.57
Piling Concrete			103,809.00	0.136	14,118.02
Floors			90,720.00	0.161	14,605.92
Walls			32,256.00	0.074	2,386.94
Insulation	21.01	40	840.40	1.05	967.00
Total Carbon					67,373.46
Area of Basement					75.75
Carbon per M2					889.42

Case Study - 2 10 Dalgardo Gardens W10 6AB - Eight Associates

Element	Length	Height	Total Weight - KG	Carbon Factor	Carbon Produced CO2
Brick			5,168.00	0.22	1,136.96
Block			6,528.00	0.074	483.07
Insulation			191.60	1.05	201.18
Roof			1,248.00	0.06	74.88
Concrete Ground Floor Slab			6,216.00	0.161	1,000.78
					0.00
Total Carbon					2,896.87
Area of Extension					10.35
Carbon per M2					279.89

Case Study - 1A 44 Markham Square SW3 - Corrected version

Element	M3	Weight M3	Total Weight - KG	Carbon Factor	Carbon Produced CO2
Steel Piling			17,340.00	1.77	30,691.80
Piling Concrete			103,809.00	0.136	14,118.02
Floors			90,720.00	0.161	14,605.92
Walls			32,256.00	0.074	2,386.94
Insulation	21.01	40	840.40	1.05	882.42
Total Carbon					62,685.11
Area of Basement					75.75
Carbon per M2					827.53

Case Study - 2A 10 Dalgardo Gardens W10 6AB - Corrected Version

Element	M3	Weight M3	Total Weight - KG	Carbon Factor	Carbon Produced CO2
Brick Wall	3.536	1900	6,718.40	0.22	1,478.05
Block Wall	3.536	2400	8,486.40	0.074	627.99
Insulation	5.606	40	224.24	1.05	235.45
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	14,851.20	0.161	2,391.04
Foundation Brick	1.156	2100	2,427.60	0.22	534.07
Steel			1,090.05	1.77	1,929.39
Total Carbon					8,271.65
Area of Extension					10.35
Carbon per M2					799.19

Case Study - 1B 44 Markham Square SW3 - Corrected version
(ICE Database Carbon Factors)

Element	M3	Weight M3	Total Weight - KG	Carbon Factor	Carbon Produced CO2
Steel Piling			17,340.00	1.37	23,755.80
Piling Concrete			103,809.00	0.115	11,938.04
Floors			90,720.00	0.115	10,432.80
Walls			32,256.00	0.074	2,386.94
Insulation	21.01	40	840.40	1.05	882.42
Total Carbon					49,396.00
Area of Basement					75.75
Carbon per M2					652.09

Case Study - 2B 10 Dalgardo Gardens W10 6AB - Corrected Version
(ICE Database Carbon Factors)

Element	M3	Weight M3	Total Weight - KG	Carbon Factor	Carbon Produced CO2
Brick Wall	3.536	1900	6,718.40	0.22	1,478.05
Block Wall	3.536	2400	8,486.40	0.074	627.99
Insulation	5.606	40	224.24	1.05	235.45
Roof	0.52	2400	1,248.00	0.06	74.88
Concrete Ground Floor Slab	2.59	2400	6,216.00	0.115	714.84
Foundation Concrete	6.188	2400	14,851.20	0.115	1,707.89
Foundation Brick	1.156	2100	2,427.60	0.22	534.07
Steel			1,090.05	1.37	1,493.37
Total Carbon					6,866.54
Area of Extension					10.35
Carbon per M2					663.43

Appendix 3: Photograph of completed extension from Case Study 2

Case Study 2- 4 Delgardo Gardens showing glazed roof

Appendix 4: CTMP Report

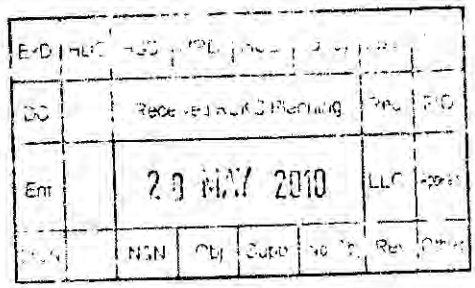
44 Markham Square: Construction traffic report

Prior to determination of the current application The Royal Borough of Kensington and Chelsea (RBKC) has requested a review of construction traffic based on their condition C104. The following report estimates the impact of construction traffic generated by the proposed works at 44 Markham Square, providing assumptions as to process, timescale and implementation. The information contained within this document will be subject to re-examination following contractor appointment and prior commencement of construction.

The attached drawing (0901.SK.100428.010) and swept path vehicle analysis (24132/SK01-06) respond to the core requirements identified within RBKC's condition C104. The following written document supports these documents and reflects the process undertaken in formulating this strategy.

Estimated timeframe:

It is proposed that the works will be undertaken over a 15 month period. This is broken down into the following sequence:



1 month underpinning

1 month piling and temporary works

2 months excavation

2 months concrete casting

9 months fit out works

Site establishment:

Removal of soil from site is shown on drawing 0901.SK.100428.010 via an enclosed earth conveyor. This will deposit site material into a skip concealed within a suspended bay. To prevent loss of access and to ensure pedestrian safety the pavement will be covered at all times using a high level gantry. The skip bay will be fully concealed with temporary access for skip removals and deliveries. The suspension of a second bay allows for safe loading and unloading whilst retaining vehicle access for cars and emergency vehicles when parked.

It is presumed that a piling rig and small digger will be driven from the Kings Road and access the site through the existing entrance points. Additional plant will include compressors, concrete mixers and small concrete pumps using short wheelbase lorry's matching the skip loaders chassis profile shown by the swept path analysis (SPA) 24132/SK02.

Temporary works will necessitate the delivery of steelwork providing support for the main house and propping of the piled walls during excavation. SPA 24132/SK05 represents the path of a flatbed truck and its impact on parking within the street. It is predicted that if used there will be 3 steel deliveries during the first two months on site. This will require a number of temporary parking bay suspensions based on the swept path analysis.

The appointment of a contractor is fundamental to providing an accurate assessment of the temporary works design. Further development could provide alternative methods of steel design that negates the need for additional temporary parking suspensions.

Scaffold delivery will utilise a shorter wheelbase vehicle to match the skip loader chassis and prevent further bay suspensions.

General deliveries during the entirety of the project will be via transit vans utilising the suspended bay for loading and unloading.

Spoil and waste removal:

Waste removal is the principal concern of this construction traffic report. The basement proposal creates the need for vehicle access beyond the requirements of an 'average' house refurbishment. This analysis has balanced vehicle loading capacity and subsequent access frequency in an effort to minimise impact on the local infrastructure.

It has been calculated that over the first 4 months approximately 1200 cubic meters of material will require removal from the site. This equates to 13 cubic meters of spoil being removed daily (Monday to Friday).

Based on the use of a small skip loader carrying a 6 yard skip (4.6 cubic meters) it would take 3 daily pickups to remove 13 cubic meters of waste. The choice of a skip loader ensures that no additional parking bays are affected as shown by the drawing SPA 24132/SK02. During loading and unloading the vehicle can be positioned so as to maintain road access to other vehicles at all times (as shown on drawing 0901.SK.100428.010 figure 5). By implementing a timing slot system waste can be removed quickly, with no vehicle stacking and during hours that avoid heavy traffic and school runs.

Following completion of the basement shell waste will be bagged and collected within the skip enclosure. Site waste can be removed using a transit or short wheelbase vehicle with no additional impact on parking bays or road access.

Concrete casting:

To avoid further suspended parking bays during periods of concrete works the proposal currently allows for onsite twin drum mixing and pumping. This component will again be subject to further development when a contractor has been appointed and is likely to form part of a conditions sign off process.

Reinforcement bars will be delivered in two deliveries with a vehicle size based on a skip loader chassis.

Structural steelwork:

The size of property and subsequent design limits steel lengths to 5m. Further design development with the contractor may remove the need for transportation by a large vehicle but it is assumed that all steels will be part of a single delivery.

In the event of a larger vehicle requiring access to Markham Square the attached drawing SPA 24132/SK06 illustrates that a car can still pass when such a large vehicle is unloading.

General Deliveries:

Over the estimated 15 month programme deliveries of material and equipment will be a regular requirement. Using transit vans and small wheelbase tippers no additional parking bays will require suspension. Vehicle numbers and frequency details will be provided upon the appointment of a contractor and is likely to form part of the conditions sign off process.

Furniture delivery may require the use of a removals van during the later stages of the project. The attached drawing SPA 24132/SK01 illustrates a removals vans swept path through the square. It is not envisaged that a single delivery would create the need to suspend bays and that with careful monitoring and safe Banksman manoeuvring such a vehicle could (with path adjustments) pass around the square safely and unhindered.

Vehicle routes and timings:

All construction vehicles will adhere to a strict vehicle slot call up system organised by the contractor. Vehicle routes beyond Markham Square and details of holding locations would require a specific response from a contractor and would be part of any future conditions sign off.

Traffic management drawing and Swept Path Analysis:

Drawing 0901.SK.100428.01: Provides detail of the local road infrastructure, the proposed site set up and a written response to the specific requirements listed within planning condition C104.

This is supported by a series of swept path analysis that represent varying construction vehicles as they track around the square. The analysis highlights the access difficulties faced when entering this road but has helped formulate the core principals of this report.

24132/SK01 Removals van:	This drawing shows that a removals van is unable to enter and leave the square on a single swept path without encroachment into additional temporary suspended parking bays. Although not a construction vehicle access will be required upon completion of the project and highlights how excessive on-street parking within Markham Square exacerbates access problems for all occupants.
24132/SK02 Skip loader:	The small skip loader is capable of entering and leaving the square without increasing the proposed temporary suspended bay closures.
24132/SK03 Transit tipper:	A long wheelbase transit tipper is unable to enter and leave the square on a single swept path without encroachment into additional temporary suspended parking bays.
24132/SK04 Concrete pump truck:	The large pump truck struggles to access the road and would require numerous bay suspensions. This has influenced the proposed integration of static mixing and pumping of concrete on site.
24132/SK05 Large flat bed:	Shows a large flat bed truck is unable to undertake a single swept path of the square without numerous temporary suspensions to parking bay. A review of steel design for propping and structure will reflect the need for delivery using a reduced vehicle size.
24132/SK06 Vehicle passing details:	This drawing presents a worst case scenario of a large parked vehicle unloading opposite the site. It shows that a large car can pass if necessary but bigger vehicles would be a concern. This report sets out options to avoid this scenario but if required the temporary suspension of a third bay would provide a parking zone that retains access for larger vehicles and emergency appliances.

Conclusion:

It is anticipated that planning condition C104 will be imposed on any future planning consent. The appointment of a contractor is vital when such a specific condition requires sign off. At this early stage this report presents a core theoretical response to the requirements of the conditions likely to be imposed that will form the basis of any condition sign off.

It is hoped that this methodology supported by the attached drawings provides a considered reaction to the issues of construction traffic generated by the proposed works at 44 Markham Square. Every effort will be made to ease pressure on the surrounding road infrastructure during the works but we feel we have shown that with careful thought and consideration concerns over safety and amenity can be allayed.

Appendix 5: RBKC Planning consent letter (Case Study 1)

Planning and Borough Development
Kensington Town Hall, Hornton Street, LONDON, W8 7NX

Executive Director Planning and Borough Development
Jonathan Bore

THE ROYAL BOROUGH OF
KENSINGTON
AND CHELSEA

- 8 JUL 2010

Timothy Hatton Architects,
342 Canal Building
Portobello Dock
LONDON W10 5BU

Web: www.rbkc.gov.uk/planning

Fax: 020 7361-3463
Direct Line: 020 7361 3260
My Ref DPS/DCPP/10/00656 /Q21/S54
UPRN No(s). 217056775/
Please ask for: South Area Team

Dear Sir/Madam,

TOWN AND COUNTRY PLANNING ACT 1990

TOWN AND COUNTRY PLANNING (GENERAL DEVELOPMENT PROCEDURE) ORDER 1995

Permission for Development (Conditional) (DP1)

The Royal Borough of Kensington and Chelsea hereby GRANTS PERMISSION for the development set out in the schedule below, subject to the stated Conditions and in accordance with the plans and information submitted.

Your attention is drawn to the enclosed information sheet.

SCHEDULE

DEVELOPMENT:	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.
SITE ADDRESS:	**44 Markham Square, LONDON, SW3 4XA**
RBK&C Drawing Nos:	PP/10/00656, PP/10/00656A, PP/10/00656B & PP/10/00656/C
Applicant's Drawing Nos:	0901.1000.01, 0901.P.1005.00, 0901.P.1005.01, 0901.P.1005.02, 0901.P.1005.03, 0901.P.1005.04, 0901.P.1010.01, 0901.P.1010.02, 0901.P.1015.01, 0901.SK.140410.01, 0901.P.2005.00.B, 0901.P.2005.01B, 0901.P.2005.02E, 0901.P.2005.03F, 0901.P.2005.04F, 0901.P.2005.05E, 0901.P.2090.01E, 0901.P.2090.02F, 0901.P.2085.01A, 0901.P.2085.02G, 0901.SK.160410.01
Application Dated:	15/02/2010
Application Completed:	08/03/2010

Application Revised: 26/4/2010, 08/06/2010 & 11/06/2010

FULL CONDITION(S), REASON(S) FOR THEIR IMPOSITION AND INFORMATIVE(S) ATTACHED OVERLEAF

CONDITION(S) AND REASON(S) FOR THEIR IMPOSITION

1. **The development hereby permitted shall be begun before the expiration of three years from the date of this permission. (C001)**
   Reason - As required by Section 91 of the Town and Country Planning Act 1990, to avoid the accumulation of unexercised Planning Permissions. (R001)

2. **The development hereby permitted shall not be carried out except in complete accordance with the details shown on the submitted plans, Nos. 0901.SK.140410.01, 0901.P.2005.00.B, 0901.P.2005.01B, 0901.P.2005.02E, 0901.P.2005.03F, 0901.P.2005.04F, 0901.P.2005.05E, 0901.P.2090.01E, 0901.P.2090.02F, 0901.P.2085.01A, 0901.P.2085.02G, 0901.SK.160410.01 . (C068)**
   Reason - The details are considered to be material to the acceptability of the proposals, and for safeguarding the amenity of the area. (R068)

3. **All work and work of making good shall be finished to match the existing original work in respect of material, colour, texture, and profile and, in the case of brickwork, facebond and pointing. (C071)**
   Reason - To preserve and enhance the character and appearance of the Conservation Area. (R072)

4. **The windows hereby approved shall be timber framed, double hung, sliding sashes, and so maintained. (C075)**
   Reason - To preserve and enhance the character and appearance of the Conservation Area. (R072)

5. **The conservatory hereby permitted shall be timber framed, painted, and so maintained. (C076)**
   Reason - To preserve and enhance the character and appearance of the Conservation Area. (R072)

6. **The roof of the lower ground floor and first floor extensions hereby permitted shall not be used at any time as a terrace without a further planning permission. (C080)**
   Reason - To protect the privacy and amenity of neighbouring property (R080)

7. **The development hereby permitted shall not be implemented until a Construction Traffic Management Plan has been submitted to and approved in writing by the Local Planning Authority. The statement should include:**

- **routeing of demolition, excavation and construction vehicles;**
- **access arrangements to the site;**
- **the estimated number of vehicles per day/week;**
- **details of any vehicle holding area;**
- **details of any vehicle call up procedure;**
- **estimates for the number and type of parking suspensions that will be required;**
- **details of any diversion, disruption or other abnormal use of the public highway during demolition, excavation and construction works;**
- **work programme and/or timescale for each phase of the demolition, excavation and construction works; and**
- **where works cannot be contained wholly within the site a plan should be submitted showing the site layout on the highway including extent of hoarding, pedestrian routes, parking bay suspensions and remaining road width for vehicle movements.**

The development shall be carried out in accordance with the approved Construction Traffic Management Plan.

Reason - In the interest of highway safety and to safeguard the amenity of the area.

8. **The development hereby permitted shall not commence until such time as a suitably qualified chartered engineer with membership of the appropriate professional body has been appointed to supervise the construction works throughout their duration. The appointment shall be confirmed in writing to the Local Planning Authority prior to the commencement of development. (C106)**

Reason - The details are considered to be material to the acceptability of the proposal, and for safeguarding the amenity of neighbouring residential properties. (R106)

9. **All work shall be carried out in accordance with the Considerate Constructors Scheme code of practice, and the details of the membership and contact details of the Considerate Constructors Scheme shall be clearly displayed on the site so that they can be easily read by members of the public. (C109)**

Reason - To limit the impact of construction upon the levels of amenity that neighbouring occupiers should reasonably expect to enjoy.

10. **Noise emitted by the operation of the plant or machinery, located within the plant area, shall not increase the lowest measured background LA90 (5min) in any octave band within any neighbouring premises at any time. If at any time the plant is unable to comply with this Condition, it shall be switched off and not used again until it is able to comply. (C57e)**
Reason - To protect the amenities of nearby occupiers. (R57e)

11. **Full particulars of the following shall be submitted to, and approved in writing by, the Local Planning Authority before the development hereby permitted commences, and the development shall not be carried out otherwise than in accordance with the details so approved:**

(a) a landscaping and tree/shrub planting scheme to include two trees of minimum 12-14cm girth.

Reason - To ensure the appearance of the development is satisfactory, and to safeguard the amenity of the area and to ensure that the appearance of the development is satisfactory, and to preserve the character and appearance of the Conservation Area.

12. **No development shall take place until there has been submitted to and approved in writing by the Local Planning Authority a scheme of landscaping which shall include indications of all existing trees and hedgerows on the land and details of any to be retained together with measures for their protection in the course of development. (C017)**
Reason - To ensure that the appearance of the development is satisfactory, and to preserve the character and appearance of the Conservation Area. (R017)

INFORMATIVE(S)

1. Conditional Planning Permission is hereby granted for the development as shown on the approved drawings. Any alteration to the approved scheme, resulting from the requirements of the Building Regulations or for any other reason, may require further permission. You are advised to consult the Directorate of Planning Services before work commences if this is the case. (I09)

2. Your attention is drawn to the Conditions of this Permission and to the Council's powers of enforcement, including the power to serve a Breach of Condition Notice under the Town and Country Planning Act 1990, as amended. You are advised that from the 6th April 2008 there is a formal system by which planning conditions should be discharged. The appropriate application

form can be downloaded from the Council's website (www.rbkc.gov.uk) or requested from the Planning Information Office at the Town Hall. In most instances there will be a fee associated with each request for the discharge of conditions. Please see the guidance notes and fee regulations on the Council's website or telephone 020 7361 3012 for further advice. (I10)

3. This property is within a Conservation Area. Building works should, therefore, be completed with great care. External facing work and detailed treatment should be finished in a manner sympathetic to the existing building. If there is any doubt about the way in which work should be carried out, you should consult the Directorate of Planning Services. (Tel. No. 020-7361-2465) (I11)

4. Alterations to boundary walls or railings, may require a further grant of planning permission. These features can be very important in the street scene. The Directorate of Planning Services (020-7361-2465) will be pleased to advise on appropriate designs. (I13)

5. Separate approval for the works hereby granted planning permission may be required by the Building Act 1984 and the Building Regulations 2000 (as amended), and the grant of planning permission does not imply that such approval will be given. The Director of Building Control, Town Hall, Hornton Street, W8 7NX should be consulted before works commence. (I21)

6. The Director of Transportation and Highways, Council Offices, Pembroke Road, London, W8 6PW (020-7341-5256) should be informed 28 days before any earth moving or abnormal use of highways adjoining the site commences so that arrangements for the routing of earth moving vehicles and cleansing the highway can be made. Contractors should be reminded that it is an offence to deposit mud on the public highway. If any spillage is not immediately cleared the Council will carry out the necessary cleansing and recharge the cost to the Contractor. (I27)

7. Demolition and building works are subject to the Control of Pollution Act 1974 and the Environmental Protection Act, 1990. The Council may impose appropriate controls over the construction methods, noise screening, and protection of site, noise, or hours of work and routing of construction traffic . You are advised to consult the Director of Environmental Health, Council Offices, 37 Pembroke Road, W8 6PW at an early stage. (I30)

8. Your attention is drawn to the British Standards Code of Practice for Demolition, and the Environmental Protection Act 1990

relating to nuisances, the observation of which should considerably reduce the risks and nuisance inherent in demolition work (particularly in relation to fire hazards arising from the practice of burning materials on site) both to operatives on site and to the general public. (I31)

9. You are required to give formal notice under Section 80 of the Building Act 1984 to the building control department that you intend to demolish the whole or part of a building. Such work should not commence until 6 weeks have elapsed or you have received a notice under Section 81 from the Council. (I60)

10. Thames Water requests that the Applicant should incorporate within their proposal protection to the property by, for example, the use of a non-return valve or other suitable device to avoid the risk of backflow at a later date, on the assumption that the sewerage network may surcharge to ground level during storm conditions.

11. The responsibility and any liability for the safe development of the site rests with the developer and/or landowner. Although the Council has used its best endeavours to determine this application on the basis of the information available to it, this does not mean that the land or adjoining land will necessarily remain free from instability. The Council's consideration has been only on the basis of the development proposed, and these considerations may be different in relation to any other development. The question of stability has been a material planning consideration and the resolution of this issue for the purposes of granting planning permission does not necessarily imply that the requirements of any other controlling authority would be satisfied and, in particular, the granting of planning permission does not give any warranty of support or stability for adjoining properties. (I63)

12. Please be aware that construction and demolition will be controlled by the Council under Section 60 and 61 of the Control of Pollution Act 1974. In particular, building work which can be heard at the boundary of the site should not be carried out on Sundays and Bank Holidays and shall only be carried out between the following hours: Monday to Friday 8:00 am to 6:30 pm and Saturday 8:00 am to 1:00 pm

(I67)

13. You are advised that it is the duty of the occupier of any domestic property to take all such measures available to him/her as are reasonable in the circumstances to secure that any transfer of household waste produced on the property is only to an authorised person or to a person for authorised transport purposes. This includes waste materials produced as a result of building works. You may check whether your waste

carrier is licensed on the DEFRA website. (I61)

14. You are advised that the acceptability of the Construction Traffic Management Plan required by Condition 7 will be determined in consultation with the Chairman of the Planning Applications Committee.

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.

SUMMARY OF REASONS FOR DECISION

You are advised that this application was determined by the Local Planning Authority with regard to the policies in the Council's Unitary Development Plan 2002, as amended 28th September 2007, and also with regard to the policies contained within the Proposed Submission Core Strategy, and was considered to comply with these policies. In particular, the following policy/policies were considered:

CD27	(ensure high standards of design and compatibility)
CD32	(resist subterranean development in six specified instances)
CD33	(resist significant loss sun/daylight
CD35	(protect privacy levels enjoyed by neighbours)
CD36	(prevent significant increases in sense of enclosure)
CD47	(to resist extensions in eleven specified situations)
CD48	(to resist conservatories in four specified situations)
CD61	(character/appearance of Conservation Areas)
CD62	(development in Conservation Areas)
CD80	(resist loss of trees)
CD82	(resist loss of trees unless dead or dying)
CL01	(Context and Character)
CL02	(New Buildings, Extensions & Modifications to Existing Build
CL03	(Historic Environment)
CL05	(Amenity)
CE01	(Climate Change)

The London Plan was taken into consideration. No policies were considered of particular relevance to this application.

Weight was also given to relevant local Supplementary Planning Guidance and Statements, including the **Chelsea** Conservation Area Proposals Statement. This document was prepared in line with Government guidance and adopted following public consultation.

The material circumstances of the case, including site history, location, and impact on amenities were considered.

In addition, consideration was given to the results of public consultation.

It was concluded that there was no impact upon the amenities of adjoining occupiers, or upon the character or appearance of the area, that would justify a refusal in this case.

The full report is available for public inspection at the Planning Information Office, Ground Floor, Town Hall, Hornton Street, London, W8 7NX.

Yours faithfully

Jonathan Bore
Executive Director, Planning and Borough Development

Appendix 6: RBKC Case Officers Report (Case Study 1)

ROYAL BOROUGH OF KENSINGTON AND CHELSEA
REPORT BY EXECUTIVE DIRECTOR,
PLANNING AND BOROUGH DEVELOPMENT

APP NO. CON/10/00656/
PLANNING APPLICATIONS COMMITTEE 11/12/2012
AGENDA ITEM NO. S100

SITE ADDRESS

44 Markham Square
LONDON
SW3 4XA

APPLICATION DATED	**27/03/2012**
APPLICATION COMPLETE	**28/03/2012**
APPLICATION REVISED	**05/07/2012** **13/07/2012** **27/09/2012** **04/10/2012** **29/10/2012** **16/11/2012**

APPLICANT/AGENT ADDRESS
Mr A Moffat
Albyns Limited
41 Paradise Walk
LONDON
SW3 4JL

LISTED BUILDING	**N/A**	**CONS. AREA**	**Chelsea**	**WARD**	**Hans Town**
CAPS	**Yes**	**ENGLISH HERITAGE**	**N/A**	**ART '4'**	**No**

CONSULTED	OBJECTIONS	SUPPORT	PETITION	COMMENTS
0	32	0	0	0

Applicant **Lune Blue**

PROPOSAL: **Discharge of conditions 7 (construction traffic management plan), 8 (confirmation of engineer appointment), 11 & 12 (landscape proposals) attached to planning permission PP/10/00656.**

RBK&C Drawing No(s):CON/10/00656, CON/10/00656/A , CON/10/00656/B, CON/10/00656/C, CON/10/00656/D, CON/10/00656/E & CON/10/00656/F

Applicant's Drawing No(s):
Condition 7
Construction Traffic Management Plan: Rev H (b) -14 Tonne Grab Lorry Version prepared byAlbyns London dated November 2012

Condition 11 and 12
MS-LP-002 Rev A and MS-LP-001 Rev A

RECOMMENDED DECISION: APPROVE the submitted details

1.0 BACKGROUND

1.1 Planning permission was granted on 8 July 2010 for 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. (Ref PP/10/00656).

1.2 The planning permission was subject to a number of pre-commencement conditions which required further information to be submitted and approved prior to development commencing.

1.4 Planning permission (Ref:PP/10/03842) was granted on 29 June 2011 for Erection of a rear extension at lower ground and ground floor levels; erection of rear addition to existing closet wing at first and second floor levels; new roof to match existing profile with new front and rear dormer windows; excavation and construction of a sub-basement level under the rear of property and garden area and alterations to front vaults at 36 Markham Square.

2.0 SITE

2.1 Markham Square is located on the northern side of King's Road. The Square consists of two principal terraces of buildings around a garden square.

2.2 Traffic circulates around the square in one-way direction, with entry to the Square at the eastern intersection with King's Road and the exit at the western intersection with King's Road.

2.3 The majority of Markham Square has parking on both sides of the carriageway. The width of the carriageway varies around Markham Square. At the entrance from King's Road the carriageway width is 3.515m, outside 44 Markham Square the carriageway width is 2.939m (excluding parking) and at the exit to King's Road the carriageway width is 3.533m. At the narrowest point (outside 6 Markham Square) the carriageway width is 2.445m.

2.4 The majority of the parking spaces in Markham Square are restricted to residents parking.

2.5 44 Markham Square is located on the eastern side of the Square.

3.0 PROPOSAL

3.1 The applicant has made two applications for approval of details reserved by conditions of the planning permission granted in July 2010 (PP/10/00656).

3.2 Application 1 was received on 28 March 2012 (Ref: CON/10/0656/ad) and seeks approval of the details required by conditions 11 and 12 (landscaping plans) and 7 (Construction Traffic Management Plan) of planning permission PP/10/00656.

3.3 Application 2 was received on 16 November 2012 (Ref: CON/12/04408) and also seeks approval of the details reserved by condition 7 (Construction Traffic Management Plan), with an alternative version of the Construction Traffic Management Plan.

3.4 Condition 11 requires the following:
Full particulars of the following shall be submitted to, and approved in writing by, the Local Planning Authority before the development hereby permitted commences, and the development shall not be carried out otherwise than in accordance with the details so approved:

(a) a landscaping and tree/shrub planting scheme to include two trees of minimum 12-14cm girth.

Reason - To ensure the appearance of the development is satisfactory, and to safeguard the amenity of the area and to ensure that the appearance of the development is satisfactory, and to preserve the character and appearance of the Conservation Area.

3.5 Condition 12 requires the following:
No development shall take place until there has been submitted to and approved in writing by the Local Planning Authority a scheme of landscaping which shall include indications of all existing trees and hedgerows on the land and details of any to be retained together with measures for their protection in the course of development. (C017)
Reason - To ensure that the appearance of the development is satisfactory, and to preserve the character and appearance of the Conservation Area. (R017)

3.6 Condition 7 requires the following:

The development hereby permitted shall not be implemented until a Construction Traffic Management Plan has been submitted to and approved in writing by the Local Planning Authority. The statement should include:

- **routeing of demolition, excavation and construction vehicles;**
- **access arrangements to the site;**
- **the estimated number of vehicles per day/week;**
- **details of any vehicle holding area;**
- **details of any vehicle call up procedure;**
- **estimates for the number and type of parking suspensions that will be required;**
- **details of any diversion, disruption or other abnormal use of the public highway during demolition, excavation and construction works;**
- **work programme and/or timescale for each phase of the demolition, excavation and construction works; and**

- **where works cannot be contained wholly within the site a plan should be submitted showing the site layout on the highway including extent of hoarding, pedestrian routes, parking bay suspensions and remaining road width for vehicle movements.**

The development shall be carried out in accordance with the approved Construction Traffic Management Plan.

Reason - In the interest of highway safety and to safeguard the amenity of the area.

Application 1

3.7 The Construction Traffic Management Plan (Revision H(b)) proposes the following:

- Delivery and collection vehicles ('Grab lorry') will access a storage/holding area at the south-west corner of Markham Square. No vehicles will access 44 Markham Square directly.
- Vehicles will approach Markham Square from the south-west and will reverse into the south-west corner of Markham Square with the use of a Banksman to control traffic and pedestrians.
- A 3 tonne tip dumper will collect and deliver materials and waste to the storage/handling area from 44 Markham Square
- The estimated timeframe for the works is 16 months
- Working hours of the site will be 8am – 5pm Monday to Friday and 9am – 1pm Saturday
- Vehicle deliveries will be restricted to Tuesday & Friday - 12pm – 4pm and Monday, Wednesday and Thursday – 9am – 4pm
- The maximum number of collections from the storage/holding area via the grab lorry will be 4 per week (during the excavation and underpinning stage of the work)
- The estimated dumper trips per week during the excavation and underpinning stage of the work will be 30
- A maximum of seven parking bays would be suspended

The plan has been subject to a number of amendments since it was originally submitted in March 2012. The most significant amendment was the relocation of the remote storage area from Markham Street to Markham Square.

3.8 The most recent amendment to the plan has relocated the storage handling area to an area opposite 3 and 4 Markham Square. This amendment was made to address concerns about the grab lorry damaging the trees located in the south west corner of the square at the junction with King's Road.

Application 2

3.9 The Construction Traffic Management Plan (Revision I) proposes the following:

- a small narrow 1.5 tonne flatbed truck to collect spoil and deliver materials to and from site. This vehicle has an overall width of approximately 1870mm
- Vehicles will approach site westbound along the King's Road and access the site in a forward direction.

- The truck will wait in the two suspended parking bays immediately outside the site and once fully loaded exit Markham Square in a forward direction
- The truck will go directly from the site to the waste recycling facility
- The estimated timeframe for the works is 16 months
- Working hours of the site will be 8am – 5pm Monday to Friday and 9am – 1pm Saturday
- Vehicle deliveries will be restricted to Tuesday & Friday - 12pm – 4pm and Monday, Wednesday and Thursday – 9am – 4pm
- The maximum number of collections from the flat bed truck per week will be 30 (during the excavation and underpinning stage of the work)
- Two parking bays would be suspended for the majority of the project
- Some of the 21 steel elements required for the development may need to be delivered using a larger vehicle. If this is the cases all other deliveries from will be suspended for that day.

4.0 PLANNING CONSIDERATIONS

4.1 The main considerations in relation to the Construction Traffic Management Plans are the impact of the proposal of safe and efficient operation of the highway, and upon the amenity of the area.

4.2 The main consideration in relation to the landscaping scheme is the effect upon the character and appearance of the Conservation area

4.3 The relevant policies to consider is CT1, CL3 and CL5 of the Core Strategy.

4.4 Further guidance on the impact of construction traffic during subterranean development can be found in paragraph 7.1.5 of the Subterranean Development Supplementary Planning Document. Guidance in para 7.1.5 includes the following:
The demolition, excavation and construction works required for subterranean development generates significant traffic. If not properly managed, these works may have a serious impact on parking availability, traffic flow, road safety, residential amenity and pedestrian convenience. It should be noted that the Council will expect construction works to be contained within the curtilage of the development site. Given the high levels of demand for parking and suspensions on-street the Council cannot guarantee that parking suspensions will be granted immediately. Such suspensions, if considered necessary by the Council, must be kept to a minimum in order to reduce the disruption to parking suspensions or other use of the highway is essential before such use will be permitted.

4.5 The Transport Supplementary Planning Document also includes guidance on construction traffic. Paragraph 8.1.3 of the SPD states:
It should be noted that the Council (and TfL where they are Highway Authority) will expect the construction works to be contained wholly within the curtilage of the development site. Given the high pressure on on-street parking provision, both in terms of parking demand and demand for suspensions, the Council cannot guarantee parking suspensions will be granted immediately. The length of time and the amount of spaces suspended must be kept to a minimum to avoid exacerbating parking pressure in the vicinity of the development. The developer will need to

demonstrate why any parking suspensions or other use of the highway is essential.

Application 1 Construction Traffic Management Plan

4.6 The Director of Highways and Transportation has commented on the Construction Traffic Management Plan (Rev H(b)).

The applicant has provided:

- A CTMP which provides viable solutions to minimise (as far as practically possible) the impact of construction traffic on the local environs.
- They have sought to minimise nuisance generated by delivery vehicles and spoil removal.
- Local traffic movements in the square are generally low, as such there will be limited disruption for residents.
- Residents parking will generally only be suspended to maintain the free passage of vehicles during loading operations
- In an emergency the Developer will remove any vehicle or plant that may be impeding emergency access as quickly as possible, in the same way that any vehicle delivering or visiting residents will be expected to be moved.
- The Developer will control traffic and pedestrians with a suitable number of banksmen, when traffic is stopped there is less chance of collisions.
- The local Traffic Police have been consulted and their comments have been incorporated within the CTMP proposals.
- The developer has confirmed the numbers of deliveries and removal operations and these are consistent with similar work of this nature.

4.7 The plan seeks to establish a reasonable and workable compromise between the operational requirements of the development and the parking and domestic needs of the Residents. The chosen method of delivery and spoil removal is essentially dictated by the narrow carriageway width and the existing dense parking arrangements within the square. The risks to the general public have been carefully considered and the residual risks are similar to other comparable developments within the borough. The applicant, through the CTMP, has demonstrated the need for the proposed parking suspensions, however the Council will need to will monitor their use to ensure they are commensurate with the construction activity being undertaken.

4.8 The level of parking suspensions and the extent of the management required to reach an acceptable arrangement is higher than normal for developments of this size. This is a function of the significant constraints placed on the construction activities by the geometry of the street. On balance and given the temporary nature of the disruption, the CTMP is consistent with CT1b and section eight of the Transport SPD.

4.9 The Council's Arboricultural Officer has commented that the relocation of the storage/holding area opposite 3 and 4 Markham Square will ensure that it is unlikely that the trees in the south west corner of the square would be damage. This has overcome the previous concerns that the grab lorry may damage the sycamore tree located in the south west corner of the square.

4.10 Given the size of vehicles to be used, the number of vehicle movements and the hours of operation of the site, the proposal for the management of construction traffic will not give rise to any significant impact on the amenity of surrounding residents.

Application 2 Construction Traffic Management Plan

4.111 The Director of Highways and Transportation has commented on the Construction Traffic Management Plan (Rev I).

Markham Square has a narrow carriageway that is lined with parking on both sides for most of its length. This makes servicing the site challenging and the preferred approach of limiting parking suspensions to the front of the site can only be accomplished with the use of small commercial vehicles.

The applicant has provided:

•A CTMP which seeks to mitigate (as far as practically possible) many of the residents' original concerns regarding the use of a remote storage compound.

- The Developer has sought to minimise nuisance and disruption within the Square by locating servicing facilities outside the frontage of the development site.
- Under this CTMP the site will be serviced by small commercial vehicles delivering and collecting from the highway immediately outside the property.
- Vehicle movements will increase slightly during some phases of the construction project under this option. However, as local traffic movements in the square are generally low residents should not be unduly disrupted.
- Residents parking will largely be unaffected apart from the loss of two spaces temporarily suspended outside the development site.
- Emergency Service vehicles will not be unduly disrupted, as normal vehicular access will be maintained around the Square. If required, the Developer will remove any vehicle or plant as quickly as possible.
- All construction components have been designed to be delivered using small vehicles and the Developer will generally only need to control construction traffic in the vicinity of the site. If occasional access is required for a large delivery vehicle, then additional parking suspensions (on the day) will be required. Through the parking suspension process an individual method statement would be required, including temporary traffic control. This procedure will apply to any property within the square requiring a large delivery or removal vehicle
- With small construction vehicles being proposed local Traffic Police do not need to be contacted.
- The developer has revised the numbers of construction deliveries and removal operations and these appear to be consistent with the reduced capacity of the smaller vehicles being proposed.

4.12 This version of the CTMP seeks to offer a reasonable and workable compromise between the operational requirements of the development and the parking and access needs of residents. The developer will use delivery vehicles especially chosen to navigate the narrow vehicular path around the square without the need for a remote storage compound.

4.13 The risks to the general public have been carefully considered and the residual risks are similar to comparable developments within the borough. The applicant, through this CTMP has reduced the need for extensive parking suspensions and limited those require to the vicinity of the site. This will be less disruptive for the majority of residents in the Square. Given the temporary nature of the disruption, the CTMP is consistent with CT1b and section eight of the Transport SPD.

4.14 Given the size of vehicles to be used, the number of vehicle movements and the hours of operation of the site, the proposal for the management of construction traffic will not give rise to any significant impact on the amenity of surrounding residents.

Application 1 – Landscaping Plan (Conditions 11 and 12)

4.15 A landscaping plan has been submitted which shows two trees of a 12-14cm girth. The Council's Arboricultural Officer has been consulted and is satisfied that with the proposal. Therefore the character and appearance of the Conservation area will be preserved.

5.0 REPRESENTATIONS RECEIVED

5.1 There is no statutory requirement for a planning authority to consult third parties regarding details submitted pursuant to a condition.

5.2 As outlined in Section 3 above, the Construction Traffic Management Plan (CTMP) has been subject to a number of revisions since originally submitted to the Council in March 2012. At various stages during the process, representations have been made to the Council regarding the proposed CTMPs. The representations summarised below relate to the most recent iterations of the plan which are the subject of this report, that is the proposal for a remote storage area in the south west corner of the Square (Application 1) and the small vehicle option (Application 2). Comments relating to previous iterations of the plan (e.g. locating the remote storage area in Markham Street) have not been reported, but are available on file. These include comments received from the Ward Councillors.

5.3 JMP Transport Consultants have prepared a detailed response to the application 1 CTMP on behalf the Markham Square Association. At the time of writing the Markham Square Association have not commented on application 2 however a number of the issues raised will be applicable to both plans. The response raises a number of concerns about the CTMP and concludes that the proposal is unacceptable. A detailed response to the concerns raised is outlined below. However, in summary, as outlined in Section 4 the construction traffic can be controlled safely with sufficient banksmen and signage.

5.3.1 **Underestimation of building quantities**

The CTMP submitted with the original planning application estimated that 1200 cubic metres of material would be removed from the site in the under pinning, piling and temporary works and excavation phases of the development. The plan did not specify whether the 1200 cubic metres

consisted solely of spoil or whether it included other waste. The current plans (i.e. Application 1 and 2) estimate 710 cubic metres of spoil will be removed during the excavation and underpinning stage of the development. A further 448 cubic metres of waste will be removed during the fit out works. Furthermore, the CTMP submitted for 36 Markham Square, which involves basement excavation under part of the existing house and rear garden, estimated 450 cubic metres of spoil would be removed. Therefore, the estimation of the spoil calculations appears reasonable. Furthermore the Director of Highways and Transport has commented that the scale of inaccuracy suggested would not alter our recommendation regarding the suitability of this CTMP.

5.3.2 **The CTMP proposals are inherently unsafe**

In response, moving traffic and building works are inherently safe, however the risks can be controlled. It is the Developer responsibility to assess and control all risks and their CTMP seeks to do this through measure including the use of banksmen and the suspension of parking bays.

5.3.3 **Servicing the remote compound is unsafe:**

The developer has agreed to use banksmen to control vehicles and pedestrians in King's Road, this is the normal way of maintaining road safety. Following discussions between the Highways Department and the Police it was agreed that vehicles accessing the compound should approach from the east and reverse in, thus avoiding a manoeuvre over the pedestrian crossing. The CTMP has been revised to reflect this arrangement.

5.3.4 **Vehicle Manoeuvring and Loading at the Compound with Create Delays**

There will be some delay when the lorries reverse in to the compound, however this should not be more than a few minutes. The Police did not want lorries to block the carriageway when loading spoil, so they will now park in line with the compound and load from this position (under Banksman control). Given the low number of traffic movements, there will be some minor delay for residents but not significantly so.

5.3.5 **Contractors vehicles driving around the square will damage parked car**.

The dumper will easily circumnavigate the square, and the developer will have to use suitably sized vehicles if delivering to the door, or if necessary arrange for parking suspensions for larger one-off deliveries. This is the same procedure which would apply to any property within the square requiring a large delivery or removal vehicle.

5.3.6 **Emergency Service Access:**

This is no different than for any other building development, Contractors vehicles will just drive away (with minimal delay) if an emergency situation arises.

5.3.7 **Affect on Residents Parking:**

As part of Application 1 there may be up to 6 or 7 bays that need to be suspended, the final figure will be determined when the development commences and traffic patterns can be established. The parking suspensions are a little disproportionate to the size of the development, but they are necessary due to the restrictions of the location.

5.3.8 **The CTMP is contradictory for example in details of how vehicles should approach the Square**:

The inconsistency identified by JMP have now been corrected in the latest version of the CTMP (Rev H(b)).

5.3.9 **JMP suggest that the CTMP should be rejected**:

In my view the plan seeks to establish a compromise between the operational requirements of the Developer and the Parking and Domestic needs of the Residents. The chosen method of delivery and spoil removal is essentially dictated by the narrow carriageway width and the existing dense parking arrangements within the square. The risks to the general public have been considered and the residual risks are similar to other comparable development within the borough.

5.4 JMP also submitted two further documents, a review of comparator sites in Kensington and Chelsea and a report on the impact on the trees in the south-west corner of the square. The application 1 CTMP has been revised and, as outlined in section 4.9, above it is unlikely that the trees in the south-west will be damaged by the current proposal. With regard to the comparator sites, the consideration is whether this proposal is acceptable and arrangement approved on other sites is of little relevance to the acceptability of the current proposals.

5.5 A large volume of correspondence has been received from residents of Markham Square and other residents of the Borough regarding these applications. A number of the issues raised have been covered by the JMP reports (outlined above). However the following further concerns have been raised:

5.5.1 **The use of the dumper truck to access the remote storage area will turn the whole of Markham Square into a building site.**

In response, the CTMP states that roads will be maintained in a clean and

safe condition for vehicular and pedestrian access throughout the works. Pavement areas will be brushed down and washed twice daily and immediately following any waste collections. At the most intense period of construction it is estimated that there will be 30 dumper truck trips around the square per week. Assuming that the trips are evenly spread across the working hours of the site, this equates to less than one trip per hour. In addition, the grab lorry will collect waste from the site 4 times per week during this period, less than once a day. These measures will help to limit the impact of construction on the square and should confine most of the impact to the immediate vicinity of the site.

5.5.2 **The development will create noise and disturbance**

Planning permission was granted for the development in July 2010. At that time conditions were recommended to, as far as possible, manage the impacts in terms of noise and disturbance. In particular condition X required the developer to be a member of the Considerate Constructors Scheme. Furthermore, the hours or work will be limited by the provisions of the CTMP currently under consideration. These applications relate solely to proposed CTMPs and as outlined above it is considered that the management of the construction traffic will not give rise to any significant impacts on the amenity of surrounding residents.

5.5.3 **Health and safety concerns relating to the 'whole square being used as a building site' and other safety concerns relating to scaffolding and construction matters**

Health and safety concerns, with the exception of traffic safety which is addressed above, are dealt with under other legislation.

6.0 RECOMMENDATION

6.1 Recommendation 1:
Approve the details submitted under application CON/10/0656/ad

6.2 Recommendation 2:
Approve the details submitted under application CON/12/4408

JONATHAN BORE
EXECUTIVE DIRECTOR, PLANNING AND BOROUGH DEVELOPMENT

List of Background Papers:

The contents of file CON/10/00656 save for exempt or confidential information in accordance with the Local Government (Access to Information) Act 1985.

Appendix 7: SAP2005 Worksheets for operational carbon emissions (Case Study 1&2)

DER 2005 Worksheet
Design - Draft

This design submission has been carried out by an Authorised SAP Assessor. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	0 0 0	Assessor number	1
Client		Last modified	07/07/2010
Address	Basement, Basement		

1. Overall dwelling dimensions

		Area (m²)		Average storey height (m)		Volume (m³)	
Lowest occupied		80.00	(1a) x	2.80	=	224.00	(1)
Total floor area	(1a) + (2a) + (3a) + (4a) =	80.00	(5)				
Dwelling volume					(1) + (2) + (3) + (4) =	224.00	(6)

2. Ventilation rate

		m³ per hour	
Number of chimneys	0	x 40 = 0	(7)
Number of open flues	1	x 20 = 20	(8)
Number of intermittent fans or passive vents	0	x 10 = 0	(9)
Number of flueless gas fires	0	x 40 = 0	(9a)

			Air changes per hour	
Infiltration due to chimneys, flues and fans	(7) + (8) + (9) + (9a) =	20	÷ (6) =	0.09 (10)
If a pressurisation test has been carried out, proceed to box (19)				
Number of storeys in the dwelling		N/A (11)		
Additional infiltration			[(11) - 1] x 0.1 =	N/A (12)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction				N/A (13)
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0				N/A (14)
If no draught lobby, enter 0.05, else enter 0				N/A (15)
Percentage of windows and doors draught stripped		N/A (16)		
Window infiltration			0.25 - [0.2 x (16) ÷ 100] =	N/A (17)
Infiltration rate			(10) + (12) + (13) + (14) + (15) + (17) =	N/A (18)
If based on air permeability value, then [q50 ÷ 20] + (10) in (19), otherwise (19) = (18)				0.34 (19)
Air permeability value applies if a pressurisation test has been done, or a design or specified air permeability is being used				
Number of sides on which sheltered				1 (20)
Shelter factor			1 - [0.075 x (20)] =	0.92 (21)
Adjusted infiltration rate			(19) x (21) =	0.31 (22)
Calculate effective air change rate for the applicable case:				
If balanced whole house mechanical ventilation			air throughput (in ach, see 2.6.6) =	0.30 (22a)
If balanced with heat recovery			efficiency in % allowing for in-use factor =	58.65 (22b)
a) If balanced mechanical ventilation with heat recovery			(22) + (22a) x [1 - (22b) ÷ 100] =	0.44 (23)
b) If balanced mechanical ventilation without heat recovery			(22) + (22a) =	N/A (23a)
c) If whole house extract ventilation or positive input ventilation from outside if (22) < 0.25, then (23b) = 0.5; otherwise (23b) = 0.25 + (22)				N/A (23b)
d) If natural ventilation or whole house positive input ventilation from loft				

if (22) >= 1, then (24) = (22); otherwise (24) = 0.5 + [(22)² x 0.5]	N/A	(24)
Effective air change rate - enter (23) or (23a) or (23b) or (24) in (25)	0.44	(25)

3. Heat losses and heat loss perimeter

	Net area (m²)		U-value		AxU (W/K)	
Doors	2.00	x	3.00	=	6.00	(26)
Windows*	1.00	x	2.44	=	2.44	(27)
Ground floor	75.00	x	0.25	=	18.75	(28)
Walls	125.80	x	0.25	=	31.45	(29)
Roof	75.00	x	0.25	=	18.75	(30)
Total area of elements	278.80	(32)				

**for windows and rooflights, use effective window U-value calculated as given in paragraph 3.2*

Fabric heat loss	(26) + (27) + (28) + (29) + (30) =	77.39 (33)
Thermal bridges - calculated using Appendix K		41.82 (34)
if details of thermal bridging are not known calculate y x (32) [see Appendix K] and enter in (34)		
Total fabric heat loss	(33) + (34) =	119.21 (35)
Ventilation heat loss	(25) x 0.33 x (6) =	32.37 (36)
Heat loss coefficient	(35) + (36) =	151.58 (37)
Heat loss parameter (HLP), W/m²K	(37) ÷ (5) =	1.89 (38)

4. Water heating energy requirements

		kWh/year
Energy content of hot water used from Table 1 column (b)		1846.35 (39)
Distribution loss from Table 1 column (c)		325.83 (40)
if instantaneous water heating at point of use, enter '0' in (40) to (45)		
for community heating use Table 1 (c) whether or not hot water tank is present		
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	N/A (41)	
Temperature factor from Table 2b	N/A (41a)	
Energy lost from water storage, kWh/year	(41) x (41a) = N/A (42)	
b) If manufacturer's declared cylinder loss factor is not known:		
Cylinder volume (litres) including any solar storage within same	0.00 (43)	
if community heating and no tank in dwelling, enter 110 litres in (43)		
otherwise if no stored hot water (this includes instantaneous combi boilers) enter 0 in (43)		
Hot water storage loss factor from Table 2, kWh/litre/day	0.00 (44)	
if community heating and no tank in dwelling, use cylinder loss from Table 2 for 50mm factory insulation		
Volume factor from Table 2a	0.00 (44a)	
Temperature factor from Table 2b	0.00 (44b)	
Energy lost from water storage, kWh/year	0.00 (45)	
Enter (42) or (45) in (46)		0.00 (46)
If dedicated solar storage is within cylinder, (47) = (46) x [(43) - (H11)] ÷ (43), else		0.00 (47)
Primary circuit loss from Table 3		0.00 (48)
Combi loss from Table 3a (enter 0 if not a combi)		600.00 (49)
Solar DHW input calculated using Appendix H (enter 0 if no solar collector)		0.00 (50)
Output from water heater	(39) + (40) + (47) + (48) + (49) - (50) =	2772.17 (51)
Heat gains from water heating	0.25 x [(39) + (49)] + 0.8 x [(40) + (47) + (48)] =	872.25 (52)
include (47) in the calculation of (52) only if a cylinder is in the dwelling or hot water is from community heating		

5. Internal gains

Watts

Lights, appliances, cooking and metabolic from Table 5	479.84	(53)
Reduction of internal gains due to low energy lighting using Appendix L	23.14	(53a)
Additional gains from Table 5a	10.00	(53b)
Water heating	99.57	(54)
Total internal gains	566.27	(55)

6. Solar gains

	Access factor Table 6d		Area (m²)		Flux Table 6a		gL Table 6b		FF Table 6c		Gains (W)	
North	0.77	x	1.00	x	29.00	x 0.9 x	0.72	x	0.70	=	10.13	(56)

Total solar gains	(56) + (57) + (58) + (59) + (60) + (61) + (62) + (63) + (64) = 10.13	(65)
Total gains	(55) + (65) = 576.40	(66)
Gain/loss ratio (GLR)	(66) ÷ (37) = 3.80	(67)
Utilisation factor from Table 7, using GLR in (67)	0.99	(68)
Useful gains	(66) x (68) = 571.33	(69)

7. Mean internal temperature

	°C	
Mean internal temperature of the living area from Table 8	18.86	(70)
Temperature adjustment from Table 4e, where appropriate	0.00	(71)
Adjustment for gains {[(69) ÷ (37)] - 4} x 0.2 x R = -0.05 *R is obtained from the 'responsiveness' column of Table 4a or Table 4d*		(72)
Adjusted living room temperature (70) + (71) + (72) =	18.81	(73)
Temperature difference between zones from Table 9	0.75	(74)
Living area fraction (0 to 1.0) living room area ÷ (5) =	0.25	(75)
Rest-of-house fraction 1 - (75) =	0.75	(76)
Mean internal temperature (73) - [(74) x (76)] =	18.25	(77)

8. Degree days

Temperature rise from gains (69) ÷ (37) =	3.77	(78)
Base temperature (77) - (78) =	14.48	(79)
Degree days, use (79) and Table 10	1894.82	(80)

9. Space heating requirement

	kWh/year	
Space heating requirement (useful) 0.024 x (80) x (37) =	6893.01	(81)

9a. Energy requirements - individual heating systems

Space heating

Fraction of heat from secondary/supplementary system using value from Table 11, Appendix F or Appendix N	0.10	(82)
Efficiency of main heating system, % *SEDBUK or from Table 4a or 4b, adjusted where appropriate by the amount shown in the 'efficiency adjustment' column of Table 4c*	85.00	(83)
Efficiency of secondary/supplementary system, % *use value from Table 4a or Appendix E*	100.00	(84)
Main fuel requirement, kWh/year [(1 - (82)] - (81) x 100 ÷ (83) =	7298.48	(85)
Secondary fuel requirement, kWh/year (82) x (81) x 100 ÷ (84) =	689.30	(85a)

Water heating

Efficiency of water heater, % *SEDBUK or from Table 4a or 4b, adjusted where appropriate by the amount shown in the 'efficiency adjustment' column of Table 4c*	85.00	(86)
Energy required for water heating, kWh/year (51) x 100 ÷ (86) =	3261.38	(86a)

Electricity for pumps and fans		kWh/year	
Each central heating pump from Table 4f		130.00	(87a)
Each boiler with a fan-assissted flue from Table 4f		0.00	(87b)
Warm air heating system fans from Table 4f		0.00	(87c)
Mechanical ventilation - balanced, extract or positive input from outside from Table 4f		181.35	(87d)
Maintaining keep-hot facility for gas combi boiler from Table 4f		0.00	(87e)
Pump for solar water heating from Table 4f		0.00	(87f)
Total electricity for the above equipment	(87a) + (87b) + (87c) + (87d) + (87e) + (87f) =	311.35	(87)

10a. Fuel costs - individual heating systems

	Fuel required kWh/year		Fuel price Table 12		Fuel cost £/year	
Main space heating	(85)	x	1.63	x 0.01 =	118.97	(88)
Secondary space heating	(85a)	x	7.12	x 0.01 =	49.08	(89)
Water heating (electric off-peak tariff)						
On-peak fraction, from Table 13 or Appendix F for electric CPSUs				0.00		(90)
Off-peak fraction			1 - (90) =	1.00		(90a)
On-peak cost	(86a) x (90)	x	0.00	x 0.01 =	0.00	(91)
Off-peak cost	(86a) x (90a)	x	0.00	x 0.01 =	0.00	(91a)
Water heating (other fuel)	(86a)	x	1.63	x 0.01 =	53.16	(91b)
Pump and fan energy	(87)	x	7.12	x 0.01 =	22.17	(92)
Energy for lighting, calculated in Appendix L	874.26	x	7.12	x 0.01 =	62.25	(93)
Additional standing charges from Table 12					34.00	(94)
Renewable and energy-saving technologies (Appendices M, N and Q)						
Energy produced or saved	0.00	x	N/A	x 0.01 =	0.00	(95)
Energy consumed	0.00	x	N/A	x 0.01 =	0.00	(96)
Total energy cost	(88) + (89) + (91) + (91a) + (91b) + (92) + (93) + (94) - (95) + (96) =				339.62	(97)

11a. SAP rating - individual heating system

Energy cost deflator	0.91	(98)
Energy cost factor (ECF)	2.23	(99)
SAP rating from Table 14	69	(100)
SAP band	C	

12a. CO_2 emissions - individual heating systems and community heating without CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Individual heating system						
Main space heating	(85)	x	0.194	=	1415.91	(101)
Secondary space heating	(85a)	x	0.422	=	290.89	(102)
Water heating	(86a)	x	0.194	=	632.71	(103)
Space and water heating *if negative, enter '0' in (107)*			(101) + (102) + (103) =		2339.50	(107)
Electricity from pumps and fans from (87) or (88*)	311.35	x	0.422	=	131.39	(108)
Energy for lighting from Appendix L	874.26	x	0.422	=	368.94	(109)
Renewable and energy-saving technologies (Appendices M, N and Q)						
Energy produced or saved	0.00	x	N/A	=	0.00	(110)
Energy consumed	0.00	x	N/A	=	0.00	(111)
Total CO_2			(107) + (108) + (109) - (110) + (111) =		2839.83	(112)

Dwelling CO_2 emission rate	(112) ÷ (5) =	35.50	(113)
EI rating		70	
EI band		C	

13a. Primary energy - individual heating systems and community heating without CHP

	Energy kWh/year		Primary energy factor		Primary energy kWh/year	
Individual heating system						
Main space heating	(85)	x	1.150	=	8393.26	{101}
Secondary space heating	(85a)	x	2.800	=	1930.04	{102}
Water heating	(86a)	x	1.150	=	3750.59	{103}
Space and water heating *if negative, enter '0' in {107}*			{101} + {102} + {103} =		14073.89	{107}
Electricity from pumps and fans from (87) or (88*)	311.35	x	2.800	=	871.78	{108}
Energy for lighting from Appendix L	874.26	x	2.800	=	2447.93	{109}
Renewable and energy-saving technologies (Appendices M, N and Q)						
Energy produced or saved	0.00	x	N/A	=	0.00	{110}
Energy consumed	0.00	x	N/A	=	0.00	{111}
Primary energy			{107} + {108} + {109} - {110} + {111} =		17393.60	{112}
Primary energy, kWh/m²/year			{112} ÷ (5) =		217.42	{113}

DER 2005 Worksheet
Design - Draft

This design submission has been carried out by an Authorised SAP Assessor. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	0 0 0	Assessor number	1
Client		Last modified	07/07/2010
Address	Extension, Extension		

1. Overall dwelling dimensions

		Area (m²)		Average storey height (m)		Volume (m³)	
Lowest occupied		55.00	(1a) x	2.55	=	140.25	(1)
Total floor area	(1a) + (2a) + (3a) + (4a) =	55.00	(5)				
Dwelling volume					(1) + (2) + (3) + (4) =	140.25	(6)

2. Ventilation rate

		m³ per hour	
Number of chimneys	0	x 40 = 0	(7)
Number of open flues	1	x 20 = 20	(8)
Number of intermittent fans or passive vents	0	x 10 = 0	(9)
Number of flueless gas fires	0	x 40 = 0	(9a)

			Air changes per hour	
Infiltration due to chimneys, flues and fans	(7) + (8) + (9) + (9a) =	20	÷ (6) =	0.14 (10)
If a pressurisation test has been carried out, proceed to box (19)				
Number of storeys in the dwelling		1 (11)		
Additional infiltration			[(11) - 1] x 0.1 =	0.00 (12)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction				0.35 (13)
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0				0.00 (14)
If no draught lobby, enter 0.05, else enter 0				0.00 (15)
Percentage of windows and doors draught stripped		100 (16)		
Window infiltration			0.25 - [0.2 x (16) ÷ 100] =	0.05 (17)
Infiltration rate			(10) + (12) + (13) + (14) + (15) + (17) =	0.54 (18)
If based on air permeability value, then [q50 ÷ 20] + (10) in (19), otherwise (19) = (18)				0.54 (19)
Air permeability value applies if a pressurisation test has been done, or a design or specified air permeability is being used				
Number of sides on which sheltered				2 (20)
Shelter factor			1 - [0.075 x (20)] =	0.85 (21)
Adjusted infiltration rate			(19) x (21) =	0.46 (22)
Calculate effective air change rate for the applicable case:				
If balanced whole house mechanical ventilation			air throughput (in ach, see 2.6.6) =	N/A (22a)
If balanced with heat recovery			efficiency in % allowing for in-use factor =	N/A (22b)
a) If balanced mechanical ventilation with heat recovery			(22) + (22a) x [1 - (22b) ÷ 100] =	N/A (23)
b) If balanced mechanical ventilation without heat recovery			(22) + (22a) =	N/A (23a)
c) If whole house extract ventilation or positive input ventilation from outside if (22) < 0.25, then (23b) = 0.5; otherwise (23b) = 0.25 + (22)				N/A (23b)
d) If natural ventilation or whole house positive input ventilation from loft				

if (22) >= 1, then (24) = (22); otherwise (24) = 0.5 + [(22)² x 0.5]	0.61	(24)
Effective air change rate - enter (23) or (23a) or (23b) or (24) in (25)	0.61	(25)

3. Heat losses and heat loss perimeter

	Net area (m²)		U-value		AxU (W/K)	
Windows*	3.00	x	1.85	=	5.56	(27)
Ground floor	30.00	x	0.25	=	7.50	(28)
Walls	34.50	x	0.25	=	8.63	(29)
Roof	30.00	x	0.25	=	7.50	(30)
Total area of elements	97.50	(32)				

**for windows and rooflights, use effective window U-value calculated as given in paragraph 3.2*

Fabric heat loss	(26) + (27) + (28) + (29) + (30) =	29.18 (33)
Thermal bridges - calculated using Appendix K *if details of thermal bridging are not known calculate y x (32) [see Appendix K] and enter in (34)*		14.62 (34)
Total fabric heat loss	(33) + (34) =	43.81 (35)
Ventilation heat loss	(25) x 0.33 x (6) =	28.06 (36)
Heat loss coefficient	(35) + (36) =	71.87 (37)
Heat loss parameter (HLP), W/m²K	(37) ÷ (5) =	1.31 (38)

4. Water heating energy requirements

		kWh/year
Energy content of hot water used from Table 1 column (b)		1507.17 (39)
Distribution loss from Table 1 column (c) *if instantaneous water heating at point of use, enter '0' in (40) to (45)* *for community heating use Table 1 (c) whether or not hot water tank is present*		265.97 (40)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	N/A (41)	
Temperature factor from Table 2b	N/A (41a)	
Energy lost from water storage, kWh/year	(41) x (41a) = N/A (42)	
b) If manufacturer's declared cylinder loss factor is not known:		
Cylinder volume (litres) including any solar storage within same *if community heating and no tank in dwelling, enter 110 litres in (43)* *otherwise if no stored hot water (this includes instantaneous combi boilers) enter 0 in (43)*	0.00 (43)	
Hot water storage loss factor from Table 2, kWh/litre/day *if community heating and no tank in dwelling, use cylinder loss from Table 2 for 50mm factory insulation*	0.00 (44)	
Volume factor from Table 2a	0.00 (44a)	
Temperature factor from Table 2b	0.00 (44b)	
Energy lost from water storage, kWh/year	0.00 (45)	
Enter (42) or (45) in (46)		0.00 (46)
If dedicated solar storage is within cylinder, (47) = (46) x [(43) - (H11)] ÷ (43), else		0.00 (47)
Primary circuit loss from Table 3		0.00 (48)
Combi loss from Table 3a (enter 0 if not a combi)		499.51 (49)
Solar DHW input calculated using Appendix H (enter 0 if no solar collector)		0.00 (50)
Output from water heater	(39) + (40) + (47) + (48) + (49) - (50) =	2272.65 (51)
Heat gains from water heating *include (47) in the calculation of (52) only if a cylinder is in the dwelling or hot water is from community heating*	0.25 x [(39) + (49)] + 0.8 x [(40) + (47) + (48)] =	714.45 (52)

5. Internal gains

	Watts
Lights, appliances, cooking and metabolic from Table 5	356.96 (53)

Reduction of internal gains due to low energy lighting using Appendix L	14.19	(53a)
Additional gains from Table 5a	10.00	(53b)
Water heating	81.56	(54)
Total internal gains	434.32	(55)

6. Solar gains

	Access factor Table 6d		Area (m²)		Flux Table 6a		gL Table 6b		FF Table 6c		Gains (W)	
North East	0.77	x	3.00	x	34.00	x 0.9 x	0.72	x	0.70	=	35.63	(57)

Total solar gains (56) + (57) + (58) + (59) + (60) + (61) + (62) + (63) + (64) =	35.63	(65)
Total gains (55) + (65) =	469.95	(66)
Gain/loss ratio (GLR) (66) ÷ (37) =	6.54	(67)
Utilisation factor from Table 7, using GLR in (67)	0.94	(68)
Useful gains (66) x (68) =	439.99	(69)

7. Mean internal temperature

	°C	
Mean internal temperature of the living area from Table 8	18.88	(70)
Temperature adjustment from Table 4e, where appropriate	0.00	(71)
Adjustment for gains {[(69) ÷ (37)] - 4} x 0.2 x R =	0.42	(72)
R is obtained from the 'responsiveness' column of Table 4a or Table 4d		
Adjusted living room temperature (70) + (71) + (72) =	19.30	(73)
Temperature difference between zones from Table 9	0.52	(74)
Living area fraction (0 to 1.0) living room area ÷ (5) =	0.36	(75)
Rest-of-house fraction 1 - (75) =	0.64	(76)
Mean internal temperature (73) - [(74) x (76)] =	18.97	(77)

8. Degree days

Temperature rise from gains (69) ÷ (37) =	6.12	(78)
Base temperature (77) - (78) =	12.85	(79)
Degree days, use (79) and Table 10	1526.94	(80)

9. Space heating requirement

	kWh/year	
Space heating requirement (useful) 0.024 x (80) x (37) =	2633.77	(81)

9a. Energy requirements - individual heating systems

Space heating

Fraction of heat from secondary/supplementary system using value from Table 11, Appendix F or Appendix N	0.10	(82)
Efficiency of main heating system, %	85.00	(83)
SEDBUK or from Table 4a or 4b, adjusted where appropriate by the amount shown in the 'efficiency adjustment' column of Table 4c		
Efficiency of secondary/supplementary system, %	100.00	(84)
use value from Table 4a or Appendix E		
Main fuel requirement, kWh/year [(1 - (82)] - (81) x 100 ÷ (83) =	2788.70	(85)
Secondary fuel requirement, kWh/year (82) x (81) x 100 ÷ (84) =	263.38	(85a)

Water heating

Efficiency of water heater, %	85.00	(86)
SEDBUK or from Table 4a or 4b, adjusted where appropriate by the amount shown in the 'efficiency adjustment' column of Table 4c		
Energy required for water heating, kWh/year (51) x 100 ÷ (86) =	2673.70	(86a)
Electricity for pumps and fans	kWh/year	

Each central heating pump from Table 4f	130.00	(87a)
Each boiler with a fan-assissted flue from Table 4f	0.00	(87b)
Warm air heating system fans from Table 4f	0.00	(87c)
Mechanical ventilation - balanced, extract or positive input from outside from Table 4f	0.00	(87d)
Maintaining keep-hot facility for gas combi boiler from Table 4f	0.00	(87e)
Pump for solar water heating from Table 4f	0.00	(87f)
Total electricity for the above equipment (87a) + (87b) + (87c) + (87d) + (87e) + (87f) =	130.00	(87)

10a. Fuel costs - individual heating systems

	Fuel required kWh/year		Fuel price Table 12		Fuel cost £/year	
Main space heating	(85)	x	1.63	x 0.01 =	45.46	(88)
Secondary space heating	(85a)	x	7.12	x 0.01 =	18.75	(89)
Water heating (electric off-peak tariff)						
On-peak fraction, from Table 13 or Appendix F for electric CPSUs				0.00		(90)
Off-peak fraction			1 - (90) =	1.00		(90a)
On-peak cost	(86a) x (90)	x	0.00	x 0.01 =	0.00	(91)
Off-peak cost	(86a) x (90a)	x	0.00	x 0.01 =	0.00	(91a)
Water heating (other fuel)	(86a)	x	1.63	x 0.01 =	43.58	(91b)
Pump and fan energy	(87)	x	7.12	x 0.01 =	9.26	(92)
Energy for lighting, calculated in Appendix L	536.24	x	7.12	x 0.01 =	38.18	(93)
Additional standing charges from Table 12					34.00	(94)
Renewable and energy-saving technologies (Appendices M, N and Q)						
Energy produced or saved	0.00	x	N/A	x 0.01 =	0.00	(95)
Energy consumed	0.00	x	N/A	x 0.01 =	0.00	(96)
Total energy cost	(88) + (89) + (91) + (91a) + (91b) + (92) + (93) + (94) - (95) + (96) =				189.23	(97)

11a. SAP rating - individual heating system

Energy cost deflator	0.91	(98)
Energy cost factor (ECF)	1.42	(99)
SAP rating from Table 14	80	(100)
SAP band	C	

12a. CO_2 emissions - individual heating systems and community heating without CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Individual heating system						
Main space heating	(85)	x	0.194	=	541.01	(101)
Secondary space heating	(85a)	x	0.422	=	111.15	(102)
Water heating	(86a)	x	0.194	=	518.70	(103)
Space and water heating *if negative, enter '0' in (107)*				(101) + (102) + (103) =	1170.85	(107)
Electricity from pumps and fans from (87) or (88*)	130.00	x	0.422	=	54.86	(108)
Energy for lighting from Appendix L	536.24	x	0.422	=	226.29	(109)
Renewable and energy-saving technologies (Appendices M, N and Q)						
Energy produced or saved	0.00	x	N/A	=	0.00	(110)
Energy consumed	0.00	x	N/A	=	0.00	(111)
Total CO_2			(107) + (108) + (109) - (110) + (111) =		1452.00	(112)
Dwelling CO_2 emission rate				(112) ÷ (5) =	26.40	(113)

EI rating	81
EI band	B

13a. Primary energy - individual heating systems and community heating without CHP

	Energy kWh/year		Primary energy factor		Primary energy kWh/year	
Individual heating system						
Main space heating	(85)	x	1.150	=	3207.00	{101}
Secondary space heating	(85a)	x	2.800	=	737.46	{102}
Water heating	(86a)	x	1.150	=	3074.76	{103}
Space and water heating *if negative, enter '0' in {107}*				{101} + {102} + {103} =	7019.21	{107}
Electricity from pumps and fans from (87) or (88*)	130.00	x	2.800	=	364.00	{108}
Energy for lighting from Appendix L	536.24	x	2.800	=	1501.47	{109}
Renewable and energy-saving technologies (Appendices M, N and Q)						
Energy produced or saved	0.00	x	N/A	=	0.00	{110}
Energy consumed	0.00	x	N/A	=	0.00	{111}
Primary energy				{107} + {108} + {109} - {110} + {111} =	8884.68	{112}
Primary energy, kWh/m²/year				{112} ÷ (5) =	161.54	{113}